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Sooshin Choi Editors

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Yong Gu Ji
and
Sooshin Choi

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Preface

This book focuses on a positive emotional approach in product, service, and system design and emphasizes aesthetics and enjoyment in user experience. This book provides dissemination and exchange of scientific information on the theoretical and practical areas of affective and pleasurable design for research experts and industry practitioners from multidisciplinary backgrounds, including industrial designers, emotion designer, ethnographers, human-computer interaction researchers, human factors engineers, interaction designers, mobile product designers, and vehicle system designers.

This book is organized in eleven sections which focus on the following subjects:

I. New Approaches in Affective and Pleasurable Design
II. Kawaii/Kansei/Affective Value Creation
III. Pleasurable Design for Diverse Users in Asia
IV. Affective User Experience
V. Kansei and Emotions in Design
VI. Pleasurable Design on Support Technology for Elderly and Disabled
VII. Methods for Emotional Design
VIII. Usability in IT devices
IX. User Centred Design
X. Cognition and Emotion in Serious Gaming Design
XI. Emotional Design and Product Longevity

Sections I through III of this book cover new approaches in affective and pleasurable design with emphasis on diversity, value creation, cultural and traditional contexts, and ergonomics and human factors. Sections IV through VII focus on design issues in product, service, and system development, human interface, emotional aspect in UX, and methodological issues in design and development. Sections VIII and XI handle user centred and emotional design approaches in diverse areas, i.e. biosignals, textiles, and clothing, and emerging technologies for human interaction in smart computing era. Overall structure of this book is organized to move from special interests in design, design and development issues, to novel approaches for emotional design.

All papers in this book were either reviewed or contributed by the members of Editorial Board. For this, I would like to appreciate the Board members listed below:

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This book is the first approach in covering diverse approaches of special areas and including design and development methodological researches and practices in affective and pleasurable design. I hope this book is informative and helpful for the researchers and practitioners in developing more emotional products, services, and systems.

Yong Gu Ji

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Editor

Section 1

New Approaches in Affective and Pleasurable Design

Transforming Physiological Data from a Generic Sensor to a Specialised One for Affect Detection

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ABSTRACT

Continuous reduction on hardware costs has been bringing the opportunity to employ cheap sensors to measure physiological data. However, this comes at a price of capturing some noisy information, which most likely would compromise both analysis and interpretation of the raw results. This paper investigates the reliability of a generic and a specialised sensor on capturing heart rate data and the challenge of extracting meaningful information from it for affect detection. A controlled stimulus in a laboratory setting is performed, in which participants play different levels of the game Tetris while their signal variations are observed. Since only the generic sensor does not reproduce the expected behaviour, filtering techniques are proposed to approximate its signal to the specialised one. Experimental results confirm that this goal is achieved by applying either "Grubbs' test"' for outliers detection or "three-sigma rule". Such transformations highlight the need of filtering techniques for affective computing because they avoid misinterpretation of the results, as well as it represents a starting point towards finding a ground-truth to link possible user affect and physiological data.

Keywords: Affective Computing, Physiological Data, Sensor Comparisons, Emotions, Ground-truth Data Set

INTRODUCTION

Modelling user affect is a challenging and instigating task due to the complexity of understanding features from individuals. However, characteristics such as facial expressions and self-report statements could lead to misleading interpretations of current emotional states, i.e. a "fake"' smile representing happiness or a person completing a questionnaire when in a hurry. The use of physiological data represents an alternative to overcome this issue, since their signals are mostly involuntary. Their association with previously mentioned features would provide a more reliable interpretation of user affect.

Research efforts have been made to check possible links between emotional states and physiological data (Ben-Shakhar et al., 2007; Bailenson et al., 2008; Stemmler and Wacker, 2010; Park and Kim, 2011; Elices et al., 2012; Veld et al., 2012; Critchley et al., 2013). However, the reliable capture of information on users' affective state based solely on physiological data is still a remote goal. An important issue to highlight is the quality of captured signals by sensors, which might be producing noisy information due to their reduced hardware costs.

This paper focuses on the process of capturing heart rate signals (*HR*) as physiological data and the challenge of extracting meaningful information from it. The aim is to collect signals from different sensors, i.e. a generic and a specialised one, checking their reliability when users are exposed to controlled stimuli in a laboratory setting. Signals are compared and a filtering transformation from a generic to a specialised one is proposed. This study mainly emphasise the need of filtering techniques for affective computing, which represents an essential starting point to do further investigation on the identification of possible patterns on making links between physiological information and emotional states, since collected data should be accurate and purposeful. Upcoming studies have the ultimate goal of establishing a ground-truth dataset for subsequent learning and automatic recognition of user affect.

Background, Aims and Contribution

Affective Computing (AC) is "computing that relates to, arises from, or deliberately influences emotions" (Picard, 1995), as initially coined by Professor R. Picard (Media Lab, MIT). It has been gaining popularity rapidly in the last decade because of its significant potential in the next generation of human-computer interfaces. One goal of affective computing is to design computer systems that can recognize and respond in a rational and strategic fashion to real-time changes in user affect (e.g., happiness, sadness), cognition (e.g., frustration, boredom) and motivation, as represented by for example speech, facial expressions, physiological signals, and neurocognitive performance. Achieving the aspirations of the very young field of AC is a strongly multidisciplinary challenge with key contributions from Psychology, Human Factors, Computer Science and other disciplines. Recent years have seen a large expansion in the body of research in and around AC (Chanel et al., 2009; Al-Mulla et al., 2011), in particular from a Computer Science perspective (Calvo and DMello, 2010), highlighting the need for engagement across disciplines to align emotion theories proposed in the Psychology literature with current modelling techniques in Computer Science.

The study discussed in this paper has been launched as a multidisciplinary research project to establish foundations for the investigation of AC, in particular from a computational intelligence point of view. It is driven both by insights from Psychology as well as the potential of modern data aggregation and interpretation techniques from Computer Science. The key challenges across disciplines are:

- Psychology and Human Factors: What is emotion and how can we interpret physiological information in this context?
- Computer Science: How do we automatically recognize "emotions" from multiple uncertain information sources?

Creating a ground-truth dataset to link emotional states with physiological data is not a straight forward task, as previously discussed in (Moratori et al., 2013). Many issues could be related with experiment design (e.g., intensity of the applied stimuli, workload) and/or data capture (e.g., faulty or inaccurate sensors). This paper mainly focuses on checking the reliability of different sensors on capturing Heart Rate data to reflect possible user affects. These signals are collected, analysed and compared among them. The main contribution of this study is to discuss the process of collecting meaningful physiological data for AC and possible filtering strategies to acquire more reliable information.

The remainder of this paper is organised as follows. The next section introduces the investigated problem, followed by the experiment description which defines the experimental methodology and presents, analyses and discusses the obtained results. The last section concludes the paper and describes future work.

PROBLEM STATEMENT

A series of carefully crafted pre-experiments has been done to investigate physiological data for user affect. The following contexts have been analysed as stimuli: (*C1*) user behaviour when visualising a sequence of pre-rated images from the groups of emotions "happy", "neutral" and "sad" and, (*C2*) levels of stress when playing a Tetris game with a continuous increasing workload.

ElectroCardioGram data *ECG* is captured by wireless Shimmer sensors (Burns et al., 2010) during the stimuli. Subsequently, heart beats per minute are extracted from this signal generating heart rate data (*HR*). Results from these initial experiments show that noisy signals are present for both contexts. Figure 1 (a)-(b), illustrates the

presence of large peaks for *C1* and *C2*, respectively. Due to the nature of the stimuli, no drastic changes on *HR* are expected on a small period of time because no strong physical effort is required during the performance of task, i.e. in general, increasing levels of stress lead to a gradual increase of the *HR* over time. These results highlight a possible accuracy issue with the applied sensor.

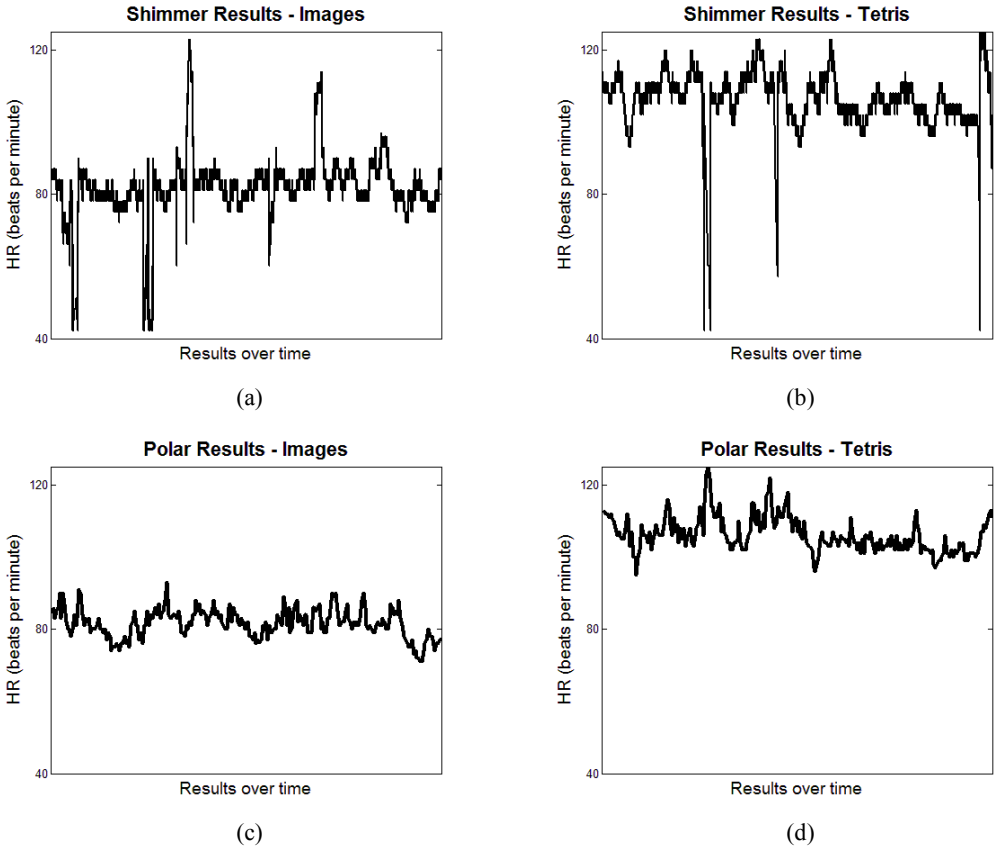

Figure 1. *HR* signals from Shimmer (a)-(b) and from Polar (c)-(d)

Polar sensor has been used by several researchers to monitor *HR* activity (Gamelin et al., 2006; Kent et al., 2009; Weippert et al., 2010; Quintana et al., 2012; Santos et al., 2013) and, consequently, this more specialised device has been employed to check the reliability of the acquired signals. Results from Polar resemble the expected behaviour, since no drastic changes on *HR* are observed overtime, as in Figure 1 (c)-(d) for both contexts. For instance, this smooth behaviour reflects slightly changes on *HR* when the user sees different groups of images on *C1*, or when moving between different levels of Tetris on *C2*.

Because of the practicability of conducting experiments and avoidance of repeating the same proceeded tasks, a step forward would be apply a filtering technique to transform the original signal into one that is similar to Polar, which would provide a reliable signal even from a generic wireless device as Shimmer.

EXPERIMENT DESCRIPTION

The investigated context relies on playing the game Tetris due to its interactive, engaging and continuous demanding nature, which facilitates the immersion of users while performing required task, i.e. progressing through different levels of the game. *ECG* and *HR* values are collected in parallel from both Shimmer and Polar, respectively. Note that Polar originally delivers *HR* data and Shimmer signals have to be post-processed to count heart beats, in which *ECG* data is transformed into *HR* values. More details about this post-processing procedure can be found in (Moratori et al., 2013). A time window of 20 minutes is predefined to observe 11 participants playing the game, with a recording sampling rate of 0.5Hz. Subsequently, comparisons overtime time are done among sensors, in which a deviation value *Dev* is calculated to represent the sum of the absolute differences between signals from Shimmer and Polar.

Two filtering techniques are then applied to reduce possible noisy data from Shimmer aiming to reduce deviating values. The first one (*F1*) is based on “Grubbs' test” (Grubbs, 1969) and the second (*F2*) on “three-sigma rule” (Upton and Cook, 2008). *F1* detects outliers based on the calculation of a “Z” value for each considered sample, which measures the distance to the mean divided by the standard deviation. Subsequently, each “Z” is compared with tabulated “Z critical” values defined by Grubbs, which checks if there is less than a 5\% chance to find an outlier so far from the others by chance alone. Conversely, *F2* has a more straight-forward approach in which deviations are detected when values are larger than three times the standard deviation. Note that both *F1* and *F2* are tested separately and the process of detecting outliers is repeated until no improvements are observed for *Dev*.

Analysis and Results

Overall results obtained by both filtering techniques *F1* and *F2* are shown in Table 1. In general, averages and standard deviations from transformed Shimmer and raw Polar are reasonably approximated. Decreasing *Dev* values reflect the outlier detection. Contrariwise, these values remain unchanged when deviations are not present or cannot be identified. The total average in Table 1 indicates that both transformations are able to deliver smaller deviations. A graphical representation with data from participant 1 is presented in Figure 2 (a)-(b), in which outliers are detected using *F1* and *F2*, respectively. Additionally, Figure 2 (c) illustrates an example when deviations are absent from the original signal captured for participant 9.

Exceptions were observed for participant 2, 4 and 8 with slightly increasing *Dev* because no prediction technique is applied on replacing outliers, which means that they are simply substituted by the average value of the curve. Figure 3 shows this behaviour when the outlier on the instant 77 is detected for participant 4. Note that replacing the outlier by the average leads to a transformed curve that is slightly more distant to Polar at this specific time. In such cases, a transformation of the *HR* signal is not required since no relevant changes are observed on the final results.

Table 1. Average, standard deviation and *Dev* values for Polar and Shimmer

	Raw values					*F1*			*F2*		
	Polar		Shimmer			Shimmer			Shimmer		
Participant	Average	Std	Average	Std	*Dev*	Average	Std	*Dev*	Average	Std	*Dev*
1	81.59	4.01	76.99	18.48	2332.00	81.95	3.15	713.00	81.63	3.83	813.87
2	60.31	5.19	61.41	5.41	524.00	61.27	5.15	551.00	61.26	5.15	552.18
3	76.50	5.32	77.08	4.85	1169.00	77.08	4.85	1169.00	77.08	4.85	1169.00
4	57.27	2.42	58.24	3.24	438.00	58.10	2.95	443.00	58.09	2.95	445.29
5	51.75	2.04	53.63	6.69	1030.00	52.32	2.79	691.00	52.33	2.79	696.20
6	~~77.53~~	~~4.93~~	~~72.98~~	~~45.63~~	~~9109.00~~	~~72.98~~	~~45.63~~	~~9109.00~~	~~72.98~~	~~45.63~~	~~9109.00~~
7	72.19	2.91	74.08	3.57	628.00	74.08	3.57	628.00	74.08	3.57	628.00
8	73.64	5.07	75.09	5.06	757.00	74.90	4.78	780.00	75.09	5.06	757.00
9	71.67	4.64	72.63	5.02	511.00	72.57	4.93	511.00	72.63	5.02	511.00
10	80.55	9.45	74.81	17.73	2711.00	80.58	3.48	1144.00	80.05	3.71	1245.81
11	106.18	4.96	100.34	22.39	2814.00	107.13	5.60	1259.00	106.52	5.88	1375.08
Total average	73.17	4.60	72.43	9.24	1291.40	74.00	4.12	788.90	73.87	4.28	819.34

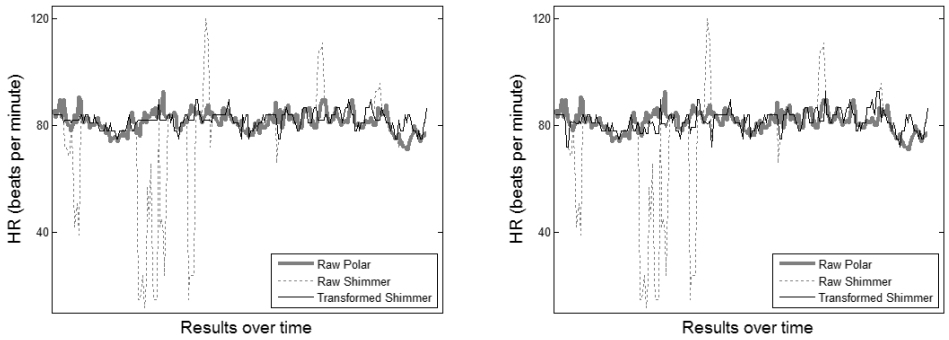

Figure 2. Outliers detection using *F1* and *F2* transformations (a)-(b), respectively; and no presence of deviating values (c)

In general, slightly better performance is observed for *F1* because "Grubbs' test" not only considers standard deviations and averages values, but also the t-distribution of the curve (Barnett and Lewis, 1994).

The presence of unchanged large standard deviation values after applying *F1* and *F2* indicates that the original signal is not a good representative of the observed feature. For instance, shimmer data from participant 6 reflects pure noise, even with an apparent similarity with Polar observing only its *HR* averages results, as in Figure 4. Such cases are detected and samples are automatically disregarded.

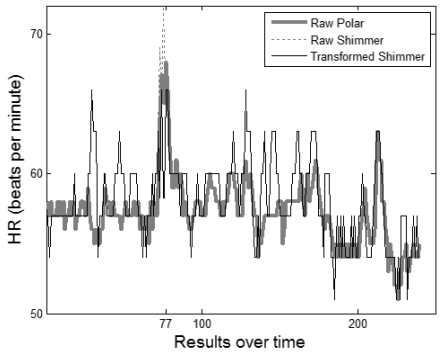

Figure 3. Slightly increasing *Dev* after removing outliers on the instant 77

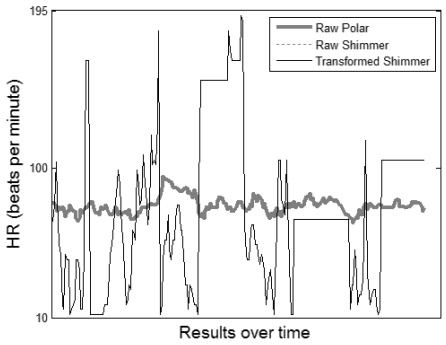

Figure 4. Example of data with pure noise captured by Shimmer

In order to check the relevance of the proposed transformations, an additional comparison with a straight average line from Shimmer is investigated. The goal is to confirm that smaller deviations can be found from both *F1* and *F2*, while relevant signal variations are kept. Figure 5 shows a graphical representation of this comparison, using 95% confidence interval plots. The dot indicates the average value on the whole set of samples obtained by the corresponding *Dev* value in the x-axis. The vertical lines denote the 95% confidence interval of the mean value. Statistical differences are immediately detected when there is no overlap between the confidence intervals of two or more instances.

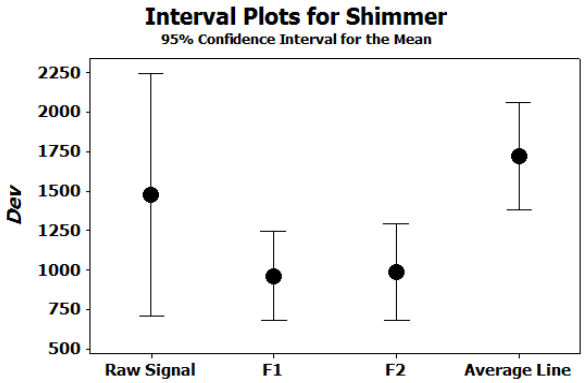

Figure 5. Comparisons between raw signal, *F1*, *F2* and average line from Shimmer; the x-axis shows each of these instances; the y-axis shows the mean (dot) and 95% confidence interval (vertical bars) of *Dev*

According to the interval plots in Figure 5, *F1* and *F2* are the most competent with respect to *Dev*. As expected, both filtering methods are statistically superior to the average line. However, they not statistically distinct from raw Shimmer, even having the ability to deliver smaller *Dev* values, as previously stated using overall results from Table 1. Note that small *HR* variations are commonly observed for AC experiments due to nature of the required tasks, which are, in general, not physically demanding (Poli et al., 2007; Quintana et al., 2012).

Given the results in Table 1 and the additional comparison with average lines, it is confirmed that it is possible to transform a noisy signal from a generic *HR* sensor as Shimmer into a more specialised one as Polar, since they are reasonably approximated for the AC context.

CONCLUSIONS AND FUTURE WORK

This paper checks the reliability of different sensors, i.e. a generic and a specialised one, on capturing heart rate (*HR*) and the challenge of extracting meaningful information from it toward recognising possible user affects. Users are exposed to a controlled stimulus in a laboratory setting while their physiological data is recorded by both sensors. The task is to play different levels of the game Tetris, in which only small variations are expected on the captured signal due to the nature of this required task. Not surprisingly, the specialised sensor reproduces the expected behaviour while the generic one delivers outliers. Consequently, filtering techniques are proposed to approximate collected signals from both devices, i.e. data from the generic sensor is post-processed to generate signals that are similar to the specialised one. Both applied techniques, namely "Grubbs' test" for outliers detection and "three-sigma rule", succeed on this approximation. Note that such transformations are highlighted as essential because they avoid misinterpretation of the results. This contribution represents an essential starting point to do further investigation on the identification of possible patterns on user affect, since observed data should be accurate and purposeful. Future work aims to test different prediction techniques to replace outlier values and the reliability investigation of different physiological data such as galvanic skin responses (*GSR*) and signals from electromyography (*EMG*)

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Imitated Mind Uploading by Using Electroencephalography

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ABSTRACT

In recent years, technology of brain-computer interface has been developed, and the technology has potential extensibility in combination with ubiquitous environments. In science fiction, an idea that personality is copied to a computational device by scanning brain activity, called mind uploading, ghost dubbing, and so on, has been frequently represented. If the idea becomes realized in a future ubiquitous world, design of highly human-friendly interfaces is expected. In this study, as a step towards realizing the idea, we proposed a method to imitate the mind uploading by using electroencephalography (EEG). We proposed a novel method to extract and digitize an essential feature of the EEG signals by using Hilbert-Huang transform (HHT) and symbolic dynamics analysis. A sequence of symbols was obtained from each of the EEG measurement. Then, we constructed 2nd-order Markov sources from the symbol sequences. Both of the cluster analysis and identification tests by human subjects revealed that the Markov source successfully represented both personal invariants and inter individual differences in EEG signals. In sum, we concluded that the imitated mind uploading can be realized by using EEG signals.

Keywords: Mind Uploading, Electroencephalography, Hilbert-Huang Transform, Symbolic Dynamics Analysis

INTRODUCTION

In recent years, technology of brain-computer interface (BCI) has been developed, and the technology has potential extensibility in combination with ubiquitous environments (Saeki, Komaki, and Horie, 2013). In science fiction, an idea that personality is copied to a computational device by scanning brain activity, called mind uploading, ghost dubbing, and so on, has been frequently represented. If the idea becomes realized in a future ubiquitous world, design of highly human-friendly interfaces is expected. In this study, as a step towards realizing the idea, we proposed a method to imitate the mind uploading by using electroencephalography (EEG).

We recognize that the mind uploading can't be realized as the science fiction by the BCI technology at present, especially by using the noninvasive technology. The present technology to measure brain activity and to decode the brain activity gave us insufficient information to copy personality. On the other hand, as known as the Eliza effect, it has been well known that human has tendency to assume that computer behaviors are analogous to human behaviors. We hypothesize that human can assume that a computer behavior are analogous to behavior of a particular person when brain activity of the parson is somehow embedded in the computer behavior. In this sense, we consider that the mind uploading can be realized by the BCI technology at present. We call this imitated mind uploading.

In this study, we propose a simple example of imitated mind uploading. We use EEG as the simplest technology to measure brain activity. We measured EEG signals twice from three subjects. We proposed a novel method to extract and digitize an essential feature of the EEG signals by using Hilbert-Huang transform (HHT) and symbolic dynamics analysis. A sequence of symbols was obtained from each of the EEG measurement. Then, we constructed 2nd-order Markov sources from the symbol sequences. Finally, we evaluated whether the Markov

source represents both personal invariants (within the two measurements in each subject) and inter individual differences (among the three subjects) in EEG signals by calculating distances among the Markov source. We also conducted identification tests to examine whether human can recognize personal invariants and inter individual differences from motion of an object which was generated by the Markov sources.

DIGITAL MODELING OF EEG SIGNALS

Measuring EEG Signals

Three volunteers of twenties, subject A, subject B, and subject C, participated in experiments. We measured EEG two times, run 1 and run 2, for each subject. Thus, six data sets were collected. While the participant was seated on a comfortable chair and was in eye-opened and relaxed condition, EEGs signals were measured during 150 s, and the middle 128 s was used for analysis. By using a compact EEG headset (Emotiv, EPOC), the EEG was amplified with a 0.2-45Hz band pass filter and a 50Hz notch filter, and sampled continuously at 128Hz in 16 bits. We used electrodes attached on the participants' scalps at the sites of T7, T8, P7, and P8 of the international 10-20 system. The four sites were selected from 14 electrode sites of the compact EEG headset, because the four sites had little artifacts.

Extracting and Digitizing an Essential Feature of the EEG Signals

We proposed a novel method to extract and digitize an essential feature of the EEG signals by using HHT and symbolic dynamics analysis. On a physiological mechanism of EEG generation, it is known that a local group of pyramidal neurons which receive post-synaptic potentials from other part of the brain becomes a source of EEG, and which part of axons (surface or depth) receives the post-synaptic potentials decides polarity (positive or negative) of EEG signals. Thus, we assumed the most essential feature of the EEG signals might be their polarity. Because the polarity can be digitized as one bit, we can extract a sequence of the two symbols, '0' as negative and '1' as positive, from the polarity of EEG signals.

Hilbert-Huang Transform

EEG signals fluctuate and are composed of multiple rhythms each of which has a narrow frequency band, that is, theta wave, alpha wave, beta wave, gamma wave, and so on. It is known that different frequency bands reflect different neuronal functions. Thus, we should define the polarity not on EEG signals directly but on the rhythms separately. In this study, we treated the alpha band, 8 to 12 Hz, which increases in the relaxed condition.

The HHT has recently been developed for analyses of nonstationary signals (Huang et al. 1998). In the HHT, a nonstationary signal is first decomposed into a set of analytical signals called the intrinsic mode functions (IMFs), each of which has a narrow frequency band, by the Empirical Mode Decomposition (EMD), and then the IMFs are transformed to analytical signals, which take complex number, by the Hilbert Transform (HT), and instantaneous amplitude, instantaneous phase and instantaneous frequency of each analytical signals are obtained. It has been studied that EEG signals can be decomposed into the multiple rhythms, and the alpha band can be extracted as one of IMFs (Takizawa and Horie, 2012).

Thus, we decompose the measured EEG signals into IMFs by the HHT, and extracted the alpha band from the IMFs. Figure 1 shows an example of EEG signal and its decomposition into IMFs by the EMD. A period of 5 s in the EEG signal at T7 site in the run 1 of the subject A was illustrated. The horizontal axes indicate time [msec] and the vertical axes indicate voltage [μVolt]. The EEG signal was decomposed into nine IMFs and a residue. The top column shows an EEG signal, and the second to the last columns show the first to the fifth IMFs respectively. The sixth to ninth IMFs and the residue were not shown in the Figure 1. The second IMF (imf2) had the alpha band. It was common across all EEG signals in the six data sets that the second IMFs had the alpha band. Thus, we selected the second IMF for further analyses. Figure 2 shows examples of the second IMFs of the six data sets at the T7 site. The horizontal axes are time [msec] and the vertical axes are voltage [μVolt]. The alpha rhythms were observed in the IMFs.

Symbolic Dynamics Analysis

The second IMFs were transformed to analytical signals by the HT. For each analytical signal, instantaneous phase

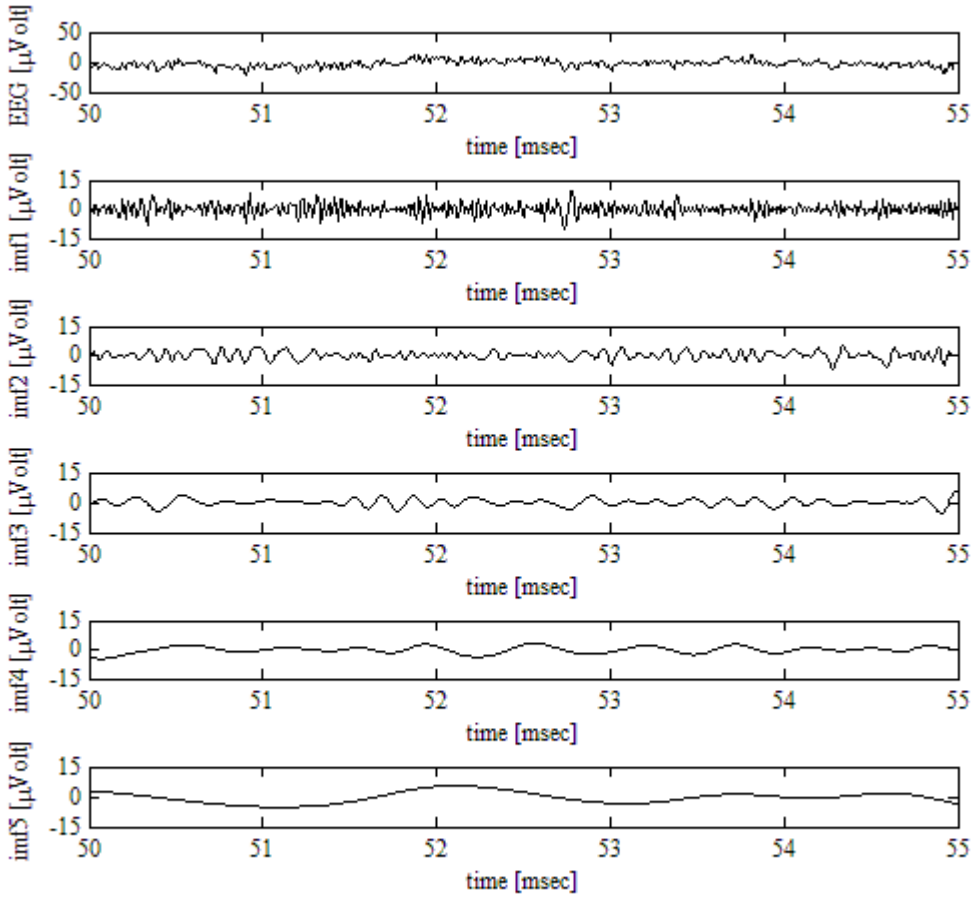

Figure 1. An example of EEG signal and its decomposition into intrinsic mode functions by the empirical mode decomposition.

and instantaneous frequency were calculated. We can define polarity of the analytical signals as the polarity of its real part. When the second IMF is positive (negative), its analytical signal is on the right (left) half-plane. We can encode the polarity into two symbols, '0' as negative and '1' as positive. The definition of the polarity is same as the binary phase encoding. We call this digitization phase encoding. The proposed method is a kind of symbol dynamics analysis, in which a continuous signal is transferred to a series of symbols. The symbol dynamics analysis has been studied for analyses of physiological signals.

Before the encoding, temporal coarse-graining of the analytical signals is required. In the alpha band, the polarity changes every 50ms in average. Then, with the sampling rate of 128Hz, the same polarity continues 6.4 times in average. This is over sampling. Thus, we conducted temporal coarse-graining of the analytical signals. For each second IMF, a characteristic time scale was defined as a median of its instantaneous frequencies. Then complex vectors of the analytical signal were averaged in every one fourths of the characteristic time scale. Figure 3 shows an example of analytical signal transformed from the second IMF (left side) and its temporal coarse-graining (right side). The second IMF was extracted from the EEG signal at T7 site in the run 1 of the subject A. The temporal coarse-graining shows moderate sampling. The illustrations of temporal coarse-graining were similar across all EEG signals in the six data sets.

After the temporal coarse-graining, we encoded the polarity into the two symbols. Figure 4 shows an example of a sequence of symbols obtained by the phase encoding. The sequence of symbols was obtained from the EEG signal at T7 site in the run 1 of the subject A. The illustrations of a sequence of symbols were similar across all EEG signals in the six data sets.

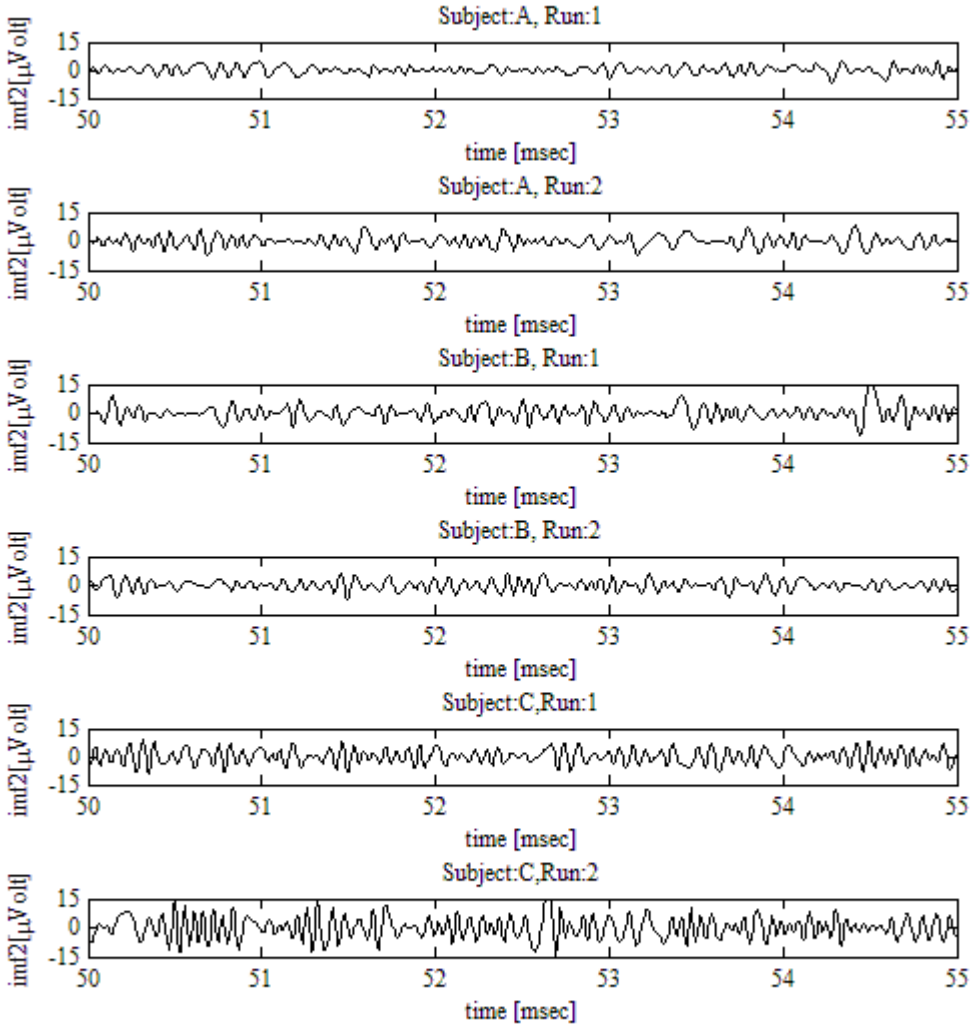

Figure 2. Examples of the second intrinsic mode functions which have the alpha bands.

Note that the one fourths of the characteristic time scale was optimal. We calculated entropy of the 2nd-order Markov sources, which were modeled from sequences of symbols as mentioned below, with each levels of temporal coarse-graining, which were defined as one half to one eighths of the characteristic time scale. Entropy decreases when the temporal coarse-graining results to under or over sampling. Figure 5 shows changes of entropy depending on the levels of temporal coarse-graining for every subject. The horizontal axes are the levels of temporal coarse-graining. The vertical axes are entropy [bit/symbol]. Each line with dots represents entropy obtained from each run of each subject. Entropy became maximal at the one fourths of the characteristic time scale.

In this study, the EEG signals were measured when the subjects were in relaxed condition. Thus, the EEG signal can be regarded as a stationary process. The stationary process can be modeled as a Markov source. Thus, we constructed 2nd-order Markov sources from the symbol sequences. We used the 2nd-order Markov source as a simple model, though higher order Markov sources may be more suitable for modeling the symbol sequences. Figure 6 shows state transition matrices of the 2nd-order Markov sources which modeled symbol sequences obtained from EEG signals at the T7 site for each run of each subject. State transition probability of the Markov sources was represented in the gray scale, white as 0 and black as 1. The illustrations of state transition matrices were similar across all electrode sites.

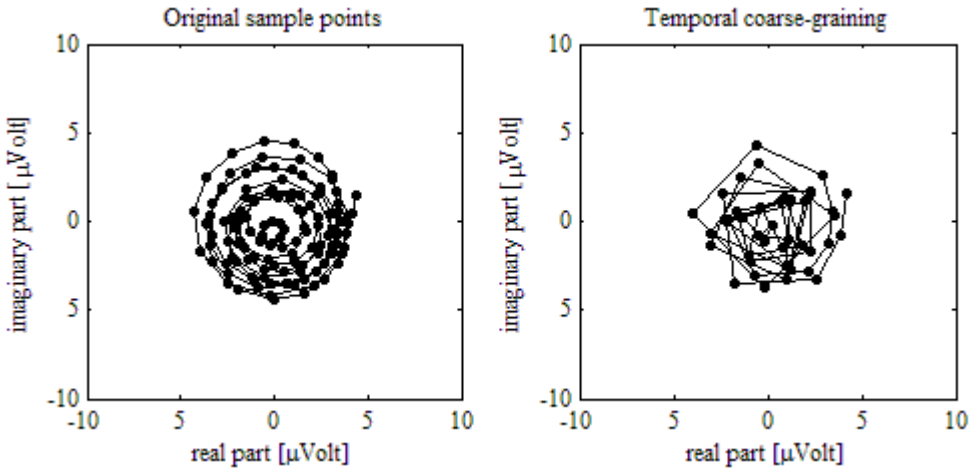

Figure 3. An example of analytical signal transformed from the second intrinsic mode function and its temporal coarse-graining.

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Figure 4. An example of a sequence of symbols obtained by the phase encoding.

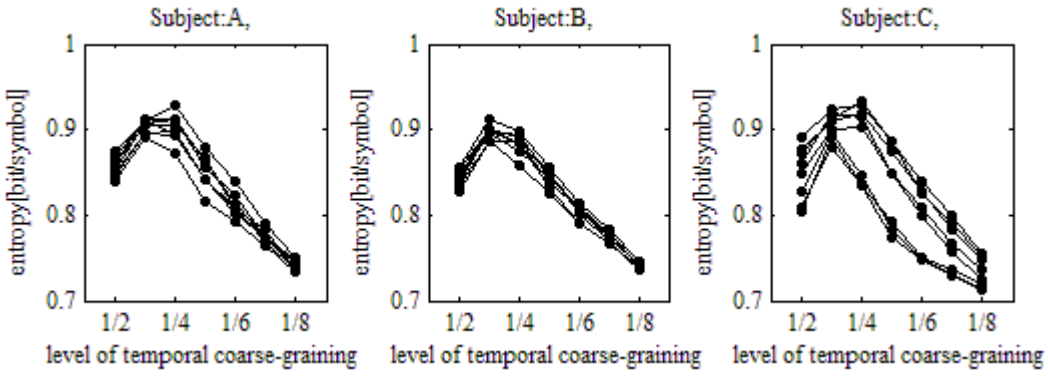

Figure 5.Optimal time scale in the temporal coarse-graining.

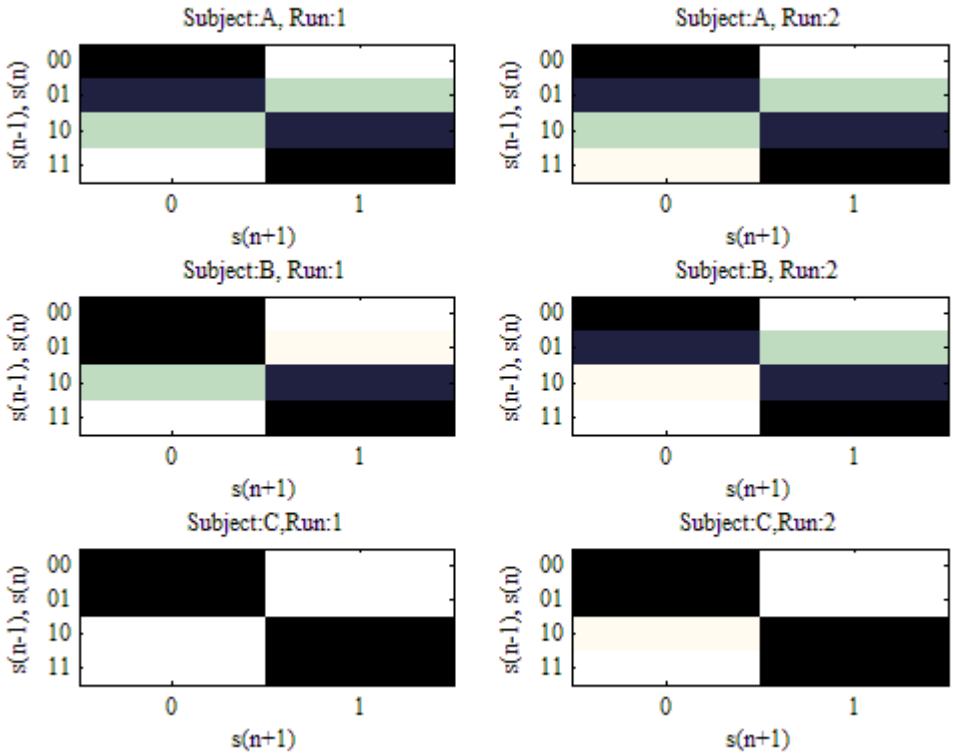

Fig. 6 State transition matrices of modeling EEG signals at T7 for each subjects and each runs.

EVALUATION OF INDIVIDUALITY IN THE MODEL

Quantitative Evaluation

EEG signal characteristics are changed according to individual differences. If the EEG signal characteristics can be sufficiently modeled by the Markov source, we might discriminate the individuals from the Markov source quantitatively. We evaluated whether differences among the Markov sources represent both personal invariants and inter individual differences. We calculated Kullback–Leibler divergence among the Markov sources as a naturally defined distance. Then, we conducted cluster analysis among the Markov sources based on the Kullback–Leibler divergence. Figure 7 shows a dendrogram obtained from the cluster analysis. The result was obtained from EEG signals at the T7 site. The horizontal axis represents the Kullback–Leibler divergence. In the dendrogram, branches are grouped according to the three subjects. The result shows that the Markov sources successfully represent both personal invariants and inter individual differences. However, the clustering analyses were failed with electrode sites of T8, P7 and P8. For example, Figure 8 shows a result from EEG signals at the T8.

Identification Tests

We also conducted identification tests to examine whether human can recognize personal invariants and inter individual differences from motion of an object which was generated by the Markov sources. Three volunteers participated in the tests. Figure 9 shows an example of the identification task. The subjects were shown motion and its trajectories of seven objects. Each Markov source generated 500 symbols. Each objects moved according to the sequence of symbols. The object moved forward left (right) when the symbol was 0 (1). The participants were forced to choice one object from the six objects (in the second and the third column) as an object which was most similar to the target (the top column) in their behaviors. The participants performed 10 trials. For all trials, the motion of target was generated by the Markov source which modeled the EEG signal at the T7 site in the run 1 of

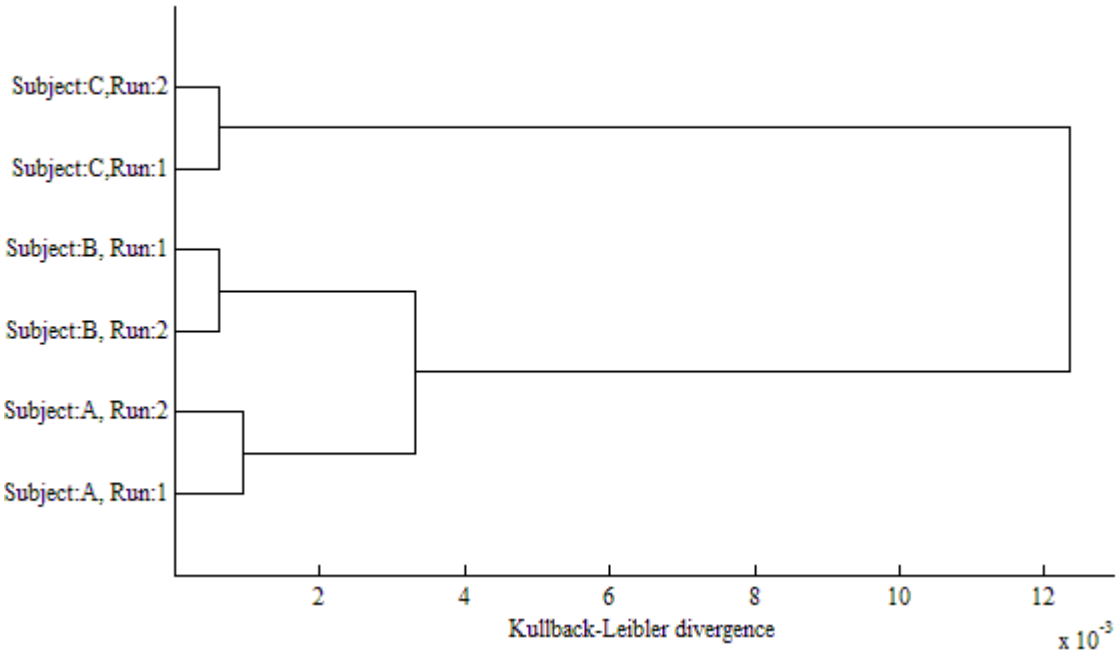

Fig. 7 Cluster analysis for the Markov sources which modeled EEG signals at T7.

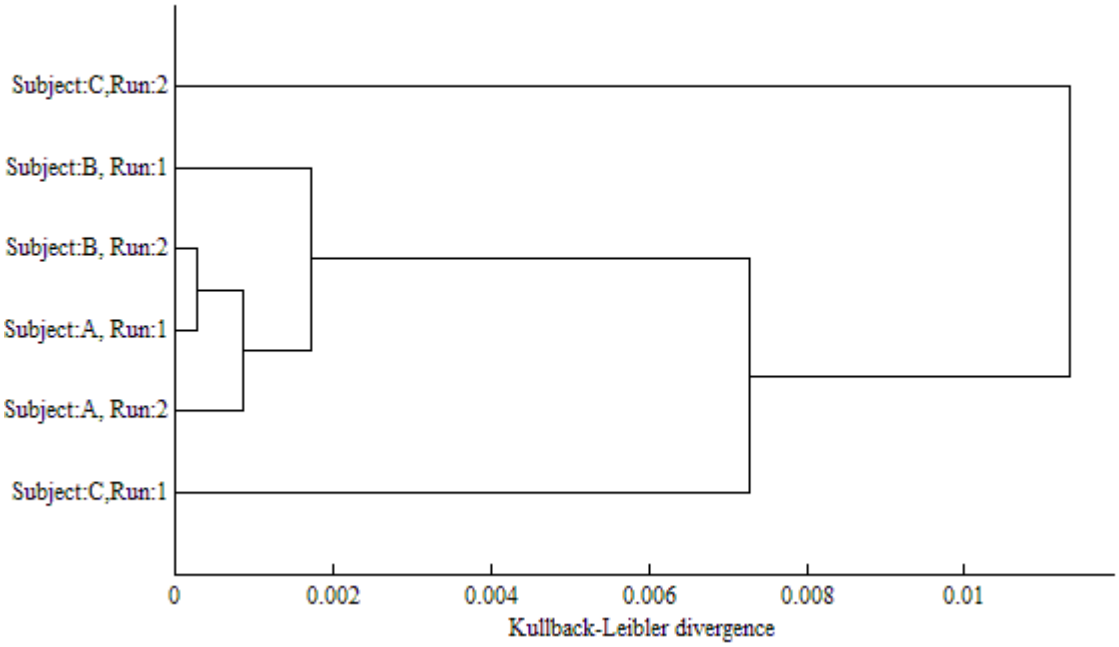

Fig.8 Cluster analysis for the Markov sources which modeled EEG signals at T8.

the subject A. The motions of the six objects were generated from the EEG signals at the T7 sites in the six data sets. Figure 10 shows performances of the three subjects. Black, gray and white squares represent frequencies of choices of the three subjects respectively. Choice of the run 1 of the subject A was the successful identification in the identification of measurement (left side). Choice of run1 or run2 of the subject A was the successful identification in the identification of subject (right side). In all subjects, for the both identification, frequency of correct choice was over chance level. The result shows the subject could recognize personal invariants and inter individual differences from motion of the object which was generated by the Markov sources.

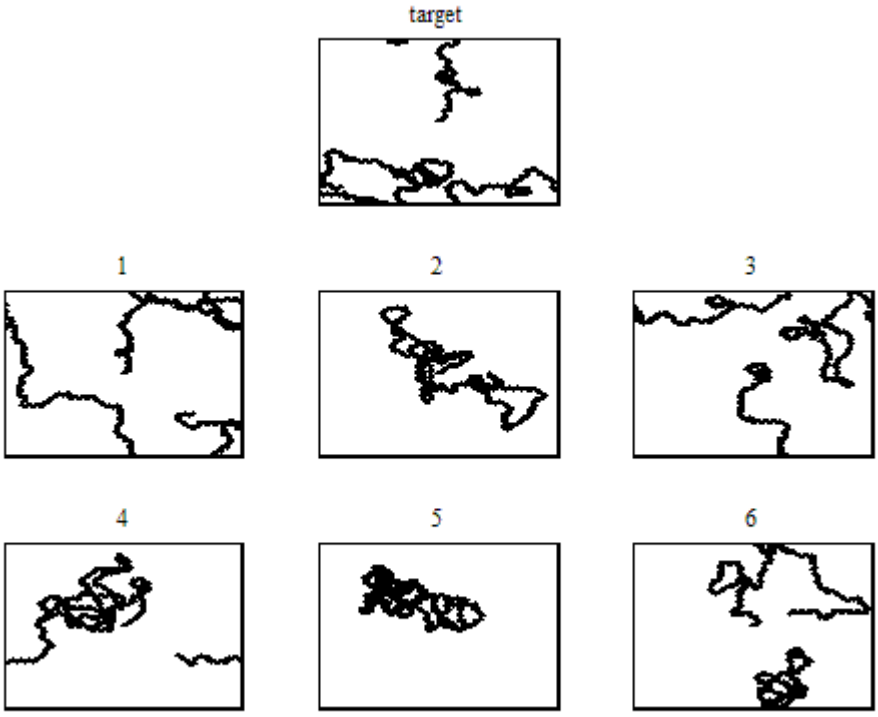

Figure.9 An example of the identification test.

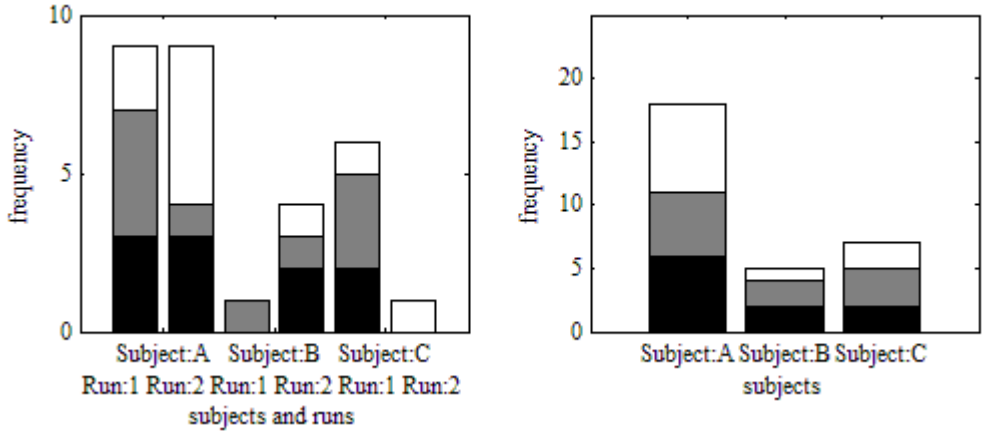

Figure.10 Performance of the identification test.

CONCLUSIONS

In this study, we propose a simple example of imitated mind uploading. We proposed a novel method to extract and digitize polarity of the EEG signals by using Hilbert-Huang transform (HHT) and symbolic dynamics analysis. Then, we constructed 2nd-order Markov sources from the symbol sequences obtained from the EEG signals. Both of the cluster analysis and identification tests by human subjects revealed that the Markov source successfully represented both personal invariants and inter individual differences in EEG signals. In sum, we concluded that the imitated mind uploading can be realized by using EEG signals.

One of the conceivable applications with use of the imitated mind uploading is to make motion of a toy robot from a family living apart or from a star. If we can assume that behavior of the robot is analogous to behavior of the family or the star, we can live with who we want to be together ubiquitously.

In future work, evaluation with many electrodes, many subjects, other mental tasks, and modeling by higher order Markov sources are required.

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Someone to Talk To

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ABSTRACT

This paper reflects upon the challenges surrounding the efforts in recognizing and classifying user's affective state. A suitable set of rules for contextual valence shifting has a central role in the proposed lexical-based approach for automatic emotion detection, which utilizes a diverse set of publicly available lexical resources. To evaluate the strengths and weaknesses of the embedded algorithm for word valence assignment, an experimental study with a suitable dataset was conducted and the performance results are discussed. A prototype multimodal mobile application that steers the conversational dialogue aligned with user's affective states will also be presented.

Keywords: Automatic Emotion Detection, Affective Lexical Analysis, Contextual Valence Shifters, Emotional Intelligence

INTRODUCTION

The growing interest in the topics of individual and social behavior has generated an extensive research aimed at capturing such behavior. Future research opportunities that are expected to tackle the challenges of perceptive, cognitive and affective aspects of interaction design in novel ways. Guiding the interaction aligned with "human nature" holds great potential to be fruitfully applied to areas from e-learning and personalized recommendation engines to persuasive technologies and social collaboration.

Heralding emotions as a crucial component in a number of high-level cognitive activities, such as memory, decision making and social cognitive abilities, Damasio's work on the biological origins of consciousness (Damasio, 1999) has shown that emotions, uniquely defined in each person by a complex and rich plethora of inner neural and body states, delineate and pervade our behavior, thoughts and actions. Our knowledge of the phenomenon might have been deepened on some levels, though recognition of invisible and visible manifestation of human affective states is a challenging computational task; not an easy task for humans too. How difficult is to express your emotions or describe the emotional state of others? Face recognition, speech pattern analysis, physiological sensors technologies and semantic lexical analysis are expected to lead the way toward affective interaction design.

Computational linguistics approaches have been applied to a range of challenging problems with impact outside the language technology field, including affective interaction. Language use has long been a favorite testing ground for a number of theories in psychology, psychiatry and criminology relating the emotions to causes of different kinds of behavior. A variety of approaches have been proposed, which make exclusive use or a fusion of the following techniques: statistical lexical analysis, lexicons of affective words and phrases, contextual-based rules to resolve the word sense disambiguation, and machine learning techniques for training classifiers for emotion assessment. In the wake of the results from related studies, our research proposes a lexical-based method that utilizes publicly available

lexical resources. The strength of the word emotional valence plays a pivotal role in our approach for detecting the dominating emotion. Our current attention has been given to the contextual relations between words in a sentence that can change the direction or neutralize the initially assigned emotional valence of a word.

Exhibiting emotional intelligence towards your conversational partner is what humans do; by being able to sense, interpret and adapt to users' emotions the systems can generate responses, offer comfort and advice or just be "someone to talk to". This research examines the ways in which intelligent technologies may facilitate detection of six basic emotions through lexical analyses of user's reflections on her daily experiences and affective states as a basis for emphatic response and potentially helpful suggestions by the system. This paper discusses the two essential parts of our research: (1) a lexical-based approach for real-time emotion detection; and (2) a multimodal Android application that is developed to provide the user with a comfortable way to express her emotions through dialog with the system. The results of our initial exploratory study of the performance and potential usability advantages of the proposed method will be presented. Future research directions for strengthening our research will be indicated. We consider the results of the performance evaluation of our method to be strong evidence that in conjunction with our previous research on personality prediction (Markovikj et al., 2013) points to the potential of lexical analysis of user-generated text in modeling users (e.g., personality traits, affective states).

RELATED RESEARCH

The problem of affective analysis of text has received a considerable research attention in the intelligence community in the last decade. In a literature review we can identify recurring approaches to the problem of interest, drawing both on lexical-based (Calvo and Sunghwan, 2013; Strapparava and Mihalcea, 2008; Chaumartin, 2007) and machine learning techniques (Inkpen et al. 2009; Kim and Valitutti, 2010). Carlo Strapparava and Valitutti have laid the background to a large number of research related to sentiment and emotional analysis from the perspective of language clues as a predictor of inner emotional state (Strapparava and Valitutti, 2004). A gold standard dataset of 1250 news headlines with emotion annotations, SemEval 2007 task, was created and subjected to analysis from numerous systems for automatic emotion evaluation. Six emotional categories namely, anger, surprise, happiness, sadness, disgust and fear were to be detected.

Few systems have been proposed in (Strapparava and Mihalcea, 2008), which have utilized a lexicon of direct and indirect affective words, mainly extracted from WordNetAffect, and a variation of Latent Semantic Analysis (LSA). The algorithm based on detection of the presence of WN-Affect lexicon has shown best results in terms of average precision 38.28%, although exhibited very low recall (avg. 1.54). The results of the three LSA-based approaches have shown significantly lower precisions below 10% and high recall spanning from 66.72 to 90.22 depending over emotions. A different dataset consisted of 8761 emotion-annotated blogs from LiveJournal.com was used for training a Naïve Bayes classifier, which have exhibited average precision and recall, 12.04% and 18.01, respectively.

The work closely related to our research is University of Paris 7 (UPAR 7) system that has participated in the same SemEval 2007 emotion annotation task and reported an average precision of 27.6 % and recall of 5.68 (Chaumartin, 2007). While reaching for similar publicly available resources and tools for emotion lexical analysis, the method underlying UPAR 7 system is quite different. Individual word rating that deeply relies on WordNet synsets, detection of contrasts (sentiment of "good" vs. "bad"), and global sentence rating were at the core of the system that obtains high accuracy results, on average 89.43%.

There are few mobile applications exploring objectives related to the one envisioned in our research. The feasibility of crowdsourcing is investigated in (Morris and Picard, 2012) as a way of assisting people when dealing with stressful situations. On demand human workforce as opposed to affective computation is employed to detect and respond to users' emotional states. Another Android application, Emotion Sense, that offers users a way to be aware of the reasons for their mood change is a result of a research exploring the relations between smartphone sensing technologies and behavior change interventions (Lathia et al., 2013). In the third related work, users' usage patterns on Twitter are proposed as a method for detecting emotions (Herdem, 2012). Few hypothetical scenarios that suggest contacts with friends when a user needs emotional support are discussed. The system is yet to be realized and tested.

RESOURCES AND TOOLS FOR AFFECTIVE LEXICAL ANALYSIS

A set of publicly available resources and appropriate tools have been used in our system for automatic emotion detection; some of them previously reported in related studies, although our algorithm depends on a unique combination of custom implementations and modified methods to suit the objective of our study. A short introduction of the lexical resources and tools and rationale for their inclusion follows:

WordNet-Affect[1], an extension of WordNet that contains a subset of synsets representing moods, situations eliciting emotions or emotional responses is frequently used in sentiment and emotion text analysis (Strapparava and Valitutti, 2004). A subset of the lexicon, containing the affective words directly referring to the six emotional states of interest – joy, sadness, anger, fear, disgust, and surprise, were used in our system.

AFINN-111[2], a list of 2477 English words and phrases annotated with their valence rating, an integer value between -5 and 5.

Stanford parser offers highly optimized Probabilistic Context-Free Grammars (PCFG), lexicalized dependency parsers and lexicalized PCFG parser for performing lexical analysis of a sentence (De Marneffe and Manning, 2012). Finding typed dependencies i.e. grammatical relations between the words in a sentence has provided assistance in the semantic (contextual) analysis of a text.

Java API for WordNet (JAWS) have been used by our system to retrieve data and find the base form of a given word from the WordNet database, version 2.1 and 3.0.

SharpNLP provides a collection of natural language processing tools. In particular, sentence splitter, tokenizer, part-of-speech (POS) tagger, and grammatical word tagging (e.g., adverbs, adjectives, verbs, pronouns) have been incorporated in our algorithm for affective text analysis.

OUR LEXICAL-BASED APPROACH FOR AUTOMATIC EMOTION DETECTION

The process of emotion detection goes through several stages as presented in Figure 1, each one requires a selection of suitable technique or a tool. The processing starts by comparing the user input against the *lexicon of phrases*, which is a list of all phrases in AFINN list with the inclusion of our own addition of 20 phrases deemed to be relevant to our research (e.g., pass away). By identifying the affective phrases first, a potential source for mistakes in affective valence assignment has been avoided; the interpretation of a phrase could be quite different if the words of a phrase are processed separately.

Once the recognition of affective phrases is performed, a set of preprocessing techniques from SharpNLP is employed to extract the affective words from the user input. The incorporated techniques for preprocessing include *sentence detection*, so that each sentence is processed independently starting with a *tokenization* i.e. extracting words from sentences. Then, *POS tagging* of words is performed to identify their corresponding grammatical types. In our initial investigation, only the verbs, nouns, adjectives and adverbs are included in the subsequent semantic analysis.

WordNet API is used to get the *base form of a word*. Our custom stemmer was employed to reduce a word to its root, which is matched against our *lexicon of affective words*. The lexicon combines the words from two resources: all words related to the the six emotions from WordNet Affect and all words from the Afinn list. Six valences are assigned to each word, one for each emotion under investigation. The initial valence is calculated using the following formula:

[1] http://wndomains.fbk.eu/wnaffect.html
[2] http://www2.imm.dtu.dk/pubdb/views/publication_details.php?id=6010

$$Valence = 5 + 3*Afinn_val,$$

where ***Afinn_val*** is the the absolute value of the valence assigned by the Afinn list. The *valence assignment* by which the negative sign of the Affnn valences is eliminated, making the range of valences to span between 5 and 20, reflects our current objective, namely to detect the most prominent emotion in user input as opposed to its sentiment polarity.

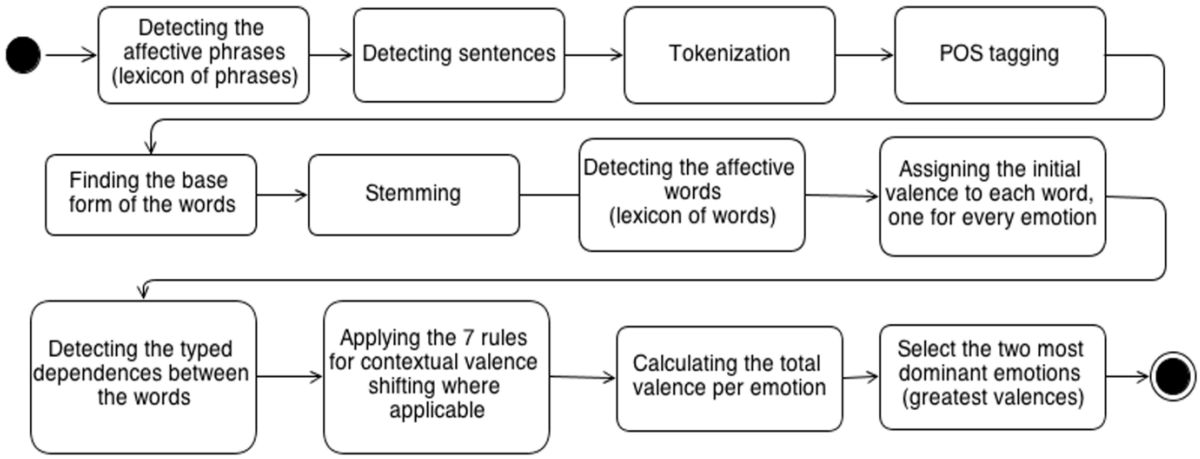

Figure 1. Steps in the lexical-based approach for automatic emotion detection

Rules for Contextual Valence Shifting

Stanford typed dependency parser was employed to identify the grammatical relations between the words in a sentence. There are 53 grammatical relations between a governor and a dependent (De Marneffe and Manning, 2012), only those related to our *seven rules for contextual valence shifting* were considered. Adding or subtracting a predetermined number of points following the rules underlying our method adjusts the valences as follows:

Negations. If a positively valenced word is in relation with a negation (e.g., not, never, nothing, none, neither), its valence is shifted into the valence of the opposite emotion, if such an emotion exists (e.g. opposite of joy is sadness). The valence is modified towards a neutral position, if the opposite emotion does not exist.

Amplifiers. The positive valence of a word is raised by 5, if the word is in a relation with a lexical item that intensifies its positive attitude (e.g., deeply, always, best, clearly, strongly).

Attenuators. If a word is in relation with a lexical item that lowers its emotion strength (e.g., rather, lack, least), its valence is lowered by 5.

Neutralizers. If a word is in relation with a connector word (e.g., however, although, but), its initial valence is neutralized, set to 0.

Root: If a word is identified as a root of the dependency graph of a sentence, 6 points are added to its previously assigned valence. Not to belittle or even diminish the importance of the emotions carried by other words while overemphasizing the sentence root, we have opted for increasing the valence by addition, which is quite different from the multiplication rule (3-5 times) adopted by UPAR7 system (Chaumartin, 2007). We put forward again the notion that our approach seeks to find the dominant emotion as opposed to detect the general attitude i.e., sentiment expressed in the user input.

Negative shifters. If a word is in relation with a verb (e.g., fail, omit, neglect) or a noun (e.g., failure, neglect) that modifies the initial valence of the word in the opposite direction, its valence is changed with the valence of the opposite emotion, if such emotion exists. In addition, the associated valence for anger of the word is increased by 5, to reflect the fact that something was expected by the user but had failed to realize, which can often attribute to

feelings such as aggravation and frustration, in our coarse-grained classification closely related to anger.

Conditional tense. If a sentence is written or spoken in conditional tense and the relations between a word and the verb "would" is auxiliary, then the valence of the word is set to 0.

The final stages in the algorithm are dedicated to calculating the total valence for the entire text. The valences of the words are aggregated (summed) into six scores, one for each of the six emotions, each score is normalized by dividing it by the maximum valence value. The two topmost emotions (greatest valences) are selected to characterize the user input in an affective sense.

PERFORMANCE EVALUATION

The ISEAR[3] (International Survey on Emotion Antecedents and Reactions) project, a collaborative endeavor directed by K. R. Scherer and H. Wallbott, has produced a dataset that was used for evaluating the performance of our algorithm. The ISEAR dataset is a collection of a large reference corpus of personal reports on situations related to seven emotions – joy, fear, anger, sadness, disgust, shame and guilt, which were solicited from more than 3000 students from all over the world. For the purpose of exploring the performance standing of our method, we have used a subset of the ISEAR dataset that relates to joy, fear, anger, sadness, and disgust. In the absence of test data for the sixth emotional category, surprise, additional set of data was obtained from another dataset, "Classic literary tales annotated for affective contents" [4]. The final dataset consisted of 5287 annotated statements with the following distribution over the six emotions: 1265 - anger, 1023 - fear, 1081 - sadness, 756 - disgust, 1068 - joy, 94 - surprise.

We would like to note that in the current implementation of the algorithm, two situation may arise causing the system to fail in detecting the primary emotion: 1) if the two topmost emotions represent two opposing emotions of the spectrum, and 2) if the two emotions have very close valences (less than 10%). A confusion matrix in Table 1 shows the classification results for the testing dataset; the grey-shaded cells along the diagonal refer to the correctly classified cases, while the other numbers represent the misclassified cases. We could trace limitations in the performance of the typed dependency parser, which resulted in 495 (9.36%) unidentified cases. Close inspection of data has confirmed the existence of 501 (9.4% of the misclassified cases) to belong to the second conflicting situation in which the two topmost emotions had valence differences below 10% (margin set by the designers). The likeliest explanation of the rather high percentage of such cases could be the fact that people frequently express multiple emotions when reflecting on events and happenings in their life (e.g., when discussing death of a close one, the dominant emotion may be sadness, alongside anger or fear). We are currently exploring a hybrid approach that relies on employing machine learning techniques to complement our approach and eliminate the problems related to misclassified cases for future explorations.

Table 1: Confusion matrix for the six emotions

	Surprise	***Anger***	***Joy***	***Sadness***	***Fear***	***Disgust***	***None***
Surprise	90	0	0	1	1	0	2
Anger	3	1180	29	13	6	3	31
Joy	1	7	901	8	11	1	139
Sadness	1	15	92	893	2	1	77

[3] http://www.affective-sciences.org/system/files/ webpage/ISEAR.zip.
[4] http://people.rc.rit.edu/~coagla/affectdata/

Fear	12	15	41	17	835	3	100
Disgust	1	15	83	18	21	472	146

The results presented in Table 2 show high accuracy for five emotions on average 0.83. The best performance metrics correspond to the emotion categories of *surprise, anger* and *joy*; one could postulate the reason being the frequent use of words strongly indicative of the three emotions. The classifier was not as accurate for *disgust* 0.62 and the recall appeared to be on the low side as well (0.76). The result is inline with the performance metrics reported in the related research. The lack of differences in the metrics for *disgust* may in part reflect the fact that possible targets for this emotion are wide-ranging and very subjective (e.g., food, insects, horrible events); what is a source for *disgust* for one person could be an amusement to another.

The results suggest that the lexicon-based approach in combination with the rules for adjusting valence, based on context analysis inspired by the work of L. Polanyi and A. Zaenen (Polanyi and Zaenen, 2006), improves the performance of the affective assessment. A study presented in (Calvo and Sunghwan, 2013) reports on the performance evaluation of one dimensional and three categorical methods for emotion detection, employed with four datasets including the two used in our study. Our results show better precision for the four emotion categories in common. In terms of recall, our method yields better performance for *fear*, 0.89 as opposed to 0.263 obtained by their dimensional method, and *sadness*, 0.92 as opposed to the reported 0.491. We report very close recall values for *anger* and *joy* to the ones reported in their study (1 and 0.98, respectively).

Table 1: Accuracy, precision and recall for each emotion and their average

Emotion	**Accuracy**	**Precision**	**Recall**
surprise	0.96	0.52	0.97
anger	0.93	0.81	0.97
joy	0.84	0.55	0.86
sadness	0.83	0.77	0.92
fear	0.82	0.72	0.89
disgust	0.62	0.95	0.76
Average	**0.83**	**0.72**	**0.90**

Comparative performance analysis of the results of our exploratory study with other related research studies is challenged as usual by the differences in datasets. The performance results of ours, and the related studies point to the challenges in emotional assessment. Finding the valence of the words and phrases in any given text is just a starting point in the process of detecting the most prominent emotion (Morsy and Rafea, 2012; Ghazi et al., 2012). New challenges arise in the analysis; the foremost among these is the difficulty in semantic interpretation of a text that requires inclusion of additional indicators of word properties (Osherenko, 2008; Smith and Lee, 2012). Word sense ambiguity is an obstacle to any semantic lexical analysis, which merits the inclusion of additional contextual indicators of word property. Multi-entity topics, identifying the target of a sentiment and complex sentence structures that do not necessarily reveal user's emotion in actual situations, but rather speculations, other people's opinion, irony, etc. invite further research efforts.

The research on affective analysis points to the challenges in emotional assessment. Word sense ambiguity is an obstacle to any semantic lexical analysis, which merits the inclusion of additional contextual indicators of word property. We are continuing to refine the mechanisms for contextual analysis and explore the feasibility of considering other discourse features that may attribute to higher performance gains in emotion assessment.

MULTIMODAL MOBILE WELL-BEING APPLICATION

Identifying the emotions of a person based on her description of events, experiences, opinions or interests can be helpful for personalizing and guiding the interaction dialogue in a manner that is sensitive and adaptive to the user's affective states. To demonstrate the usefulness of our approach, an Android mobile application *TalkToMe* was developed as a first attempt in a realization of an envisioned application that cares about users' mental welfare and promotes healthy habits for alleviating everyday stress.

Our prototype application uses the Facebook SDK to extract personal information (e.g., name, gender, work- or study- related data, birthday, hobbies, events). A user can log into the application as anonymous or by using her Facebook account, which determines the extent to which the interaction will be personalized. The application employs speech recognition and text-to-speech technologies supported by Android to provide a multimodal interface for interacting with the user.

The dialogue starts with a personalized greeting (e.g., *Good evening, Kiril*) and a return greeting response from the user is expected for further interaction. The greeting phase is usually followed by a question about the day, aligned with the contextual Facebook data, such as the name of employer or school (e.g., *Today is Wednesday. How was your day at GS1*?). If Facebook connection is blocked, general contextual information such as time of day, day of the week, holiday is used (e.g., *How was your day? Did you have a nice weekend?*). A good bye greeting from the user at any time will close the application. The dialogue progresses respecting the boundaries on how far the user wants to elaborate. The system offers no advice or suggestion if the user does not welcomes it; a "No" or a 15 sec user's inactivity is considered a closure of the discussion on a certain topic.

All user utterances or typed text is analyzed by the system for automatic emotion detection, which is an implementation of our lexical-based approach as a web service. The communication with the service is realized with JSON objects. The processing time requires 5-10 sec depending on the text length. Being mindful of potential concerns related to privacy, trust and misuse, our current version does not store the history of user's conversations, although the potential for their inclusion in our further research efforts will be explored.

In case the system encounters the two previously mentioned situations related to too close or opposing emotions, the system does not favor either one and postpones the detection of the dominant emotion, waiting further responses from the user i.e., by encouraging the user to elaborate on her previous statement. If the system is successful in discriminating between emotions and detects the dominant one, it replies with one of the predefined set of statements, questions or suggestions that has been compiled in consultation with an expert in psychology, with a long expertise in working with post-trauma patients. System's responses are nonjudgmental, randomly selected from a set of statements appropriate to the detected emotion (fig. 2).

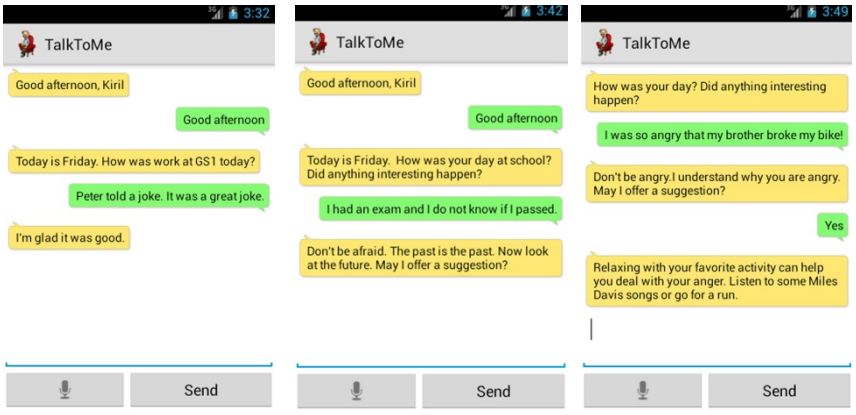

Figure 1. Excerpts of the communication dialogue for three different emotions: joy, fear and anger

A selection of popular motivational quotes from movies and books are included to accompany the system's response attuned with the detected emotion. System responses follow very general recommendations:

- Sharing user's happiness (e.g., "*Good, I'm glad that you're happy*.").
- Being compassionate and empathetic when they are sad (e.g., " *Sorry to hear that*.").
- Suggesting a positive perspective when dealing with difficult events (e.g., *"Look at the brighter side of things*").
- Suggesting offline social encounters with friends, or relaxing with a favorite activity (watching a movie, sports, reading a book) to alleviate stressful situations.
- Instead of negativity or focusing on failures when dealing with fear, the system reminds the user to recognize her strengths (e.g. "*Don't be afraid of your fears. They're not there to scare you, but to let you know that something is worth it*").
- When the dominant emotion is disgust, ignoring the cause or making a change is proposed (e.g. "*You have to identify the problem and try to solve it or ignore it.*").

An exploratory usability study was conducted with 24 participants with varying background experience. The age of the participants span between the ages of 12 to 66. Each participant has been asked to use the application for a number of tries over several days; each trial lasting for a short period of time, no more than 15min. Summarizing the results of the qualitative analysis, we would like to emphasize the high users' satisfaction with the way the interface initiates and carries the conversation. The system responses were rated high for their variety, wit and potential helpfulness. The multimodal interaction and the "word bubble" graphical interface were found to be engaging and a comfortable setting for sharing their reflections on the events and their inner feelings. Voice pattern recognition techniques offer a potential for complementing the current text-based method for emotion detection. The early results of the formative evaluation and overall qualitative gains are currently analyzed for reporting in a separate research paper. A large-scale long-term usability study under controlled experimental condition is in place

CONCLUSIONS

This paper explores the feasibility of real-time detection of six emotions using a lexical-based approach for affective analysis. A multimodal mobile application promoting mental health and well being by inviting people to share some reflections on their current emotional state have been developed to demonstrate the potential usefulness of the proposed approach. We have reported the encouraging performance results that merits further research efforts. While we do not believe that persuasive technologies can substitute the need for a human-human conversation or a professional help when required, we conclude that future advances in affective interaction will require uniting experts from a number of different fields, from sociology and psychology to linguistic and computer science.

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Exploring the Innovation Application of Web Camera Based on Business Models - Taking Parent-Baby Communication as an Example

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ABSTRACT

In the high technique modern society, there are many ways to communicate with others. People anticipate the technology could not only connect to others but also help to sustain the relationship of family or friends. Recently, people turn to take internet as the main way to communicate. On the other side, in the phenomena of low fertility, the market in babies and children will be important in the future. This research wants to start from the existing web-video and web-communication technology and figures out the new ways to apply this technology in parent-baby communication or interaction. As one of the device in web-vision technology, web-camera is the device that being chosen to use in this research. Apply this technology in parent-baby communication. Let family realistically use this device, and have an interview to understand the experience that family use this device. After the interview, analyze the result and find possible way that applying this web-vision technology in parent-baby communication. Finally, use existing business models to think new application, and explore the innovation application of web-camera in parent-baby communication.

Keywords: web-video, parent-child communication, innovation application

INTRODUCTION

The study aims to explore the innovation application of web-camera based on business model. There are some trends in modern society. In the high technique modern society, there are many ways to communicate with others. People could use various ways to connect to others. Since the development of technology, people increase their demand and anticipant in communication. They anticipate the technology could not only connect to others but also help to sustain the relationship of family or friends. That means, the user's demand is not only in function side, but also for feeling the experience in connection and interaction with others. Besides, demands on translating messages, pictures and videos increase greatly. Recently, since the internet is convenient and cheap, people turn to take internet as the main way to communicate. On the other side, in the phenomena of low fertility, parents are willing to spend more money on their child. Because of the raising trend of purchasing power, the market in babies and children will be important in the future.

There are two main purposes

(1)To understand the process and experience of how families use web-cameras. Then, find out possible application of web-vision technology.

(2)To figure out the connection between innovative applications and business models and consider if they have business potential in the market.

In the first point, this purpose helps us to understand the value and some important functions that families find out

after using web-camera. In the second point, after realizing what families thought about the device, we discuss possible innovative application and combine with business models.

LITERATURE REVIEW

Business models

(1) Circular flow model

In this model, supposing a simple single market situation in a country. As shown in the figure (Figure1) which was simplified by us, there are only household and firm in this market without considering government. Besides, although the household and the firm are in a large amount in reality, we suppose all the households are same and so as the firms. It also means that there are not any transactions between all the households and between all the firms. All these supposes are great different from real situation but it is a sufficient way to simplify and understand the content of market economy. Taking Fiture1 to illustrate the circular flow model, the rectangles in left and right side are two economic unit in the market - the households and the firms, the rectangles in the top and the bottom are goods and services market and factor market. As shown in this graph, the households supply factor to factor market and get income which was used to buy goods and services in goods and services market. In the other hand, the expenses of the households become the income of the firms, then the firms could use these income to buy the capitals which are needed in producing products and services. Finally, the costs of these capitals go back to the households as their working income. The illustration is according to the inside circle which stands for the currency flow. In the meanwhile, the outside circle is stand for the goods flow. When the market economy is not affected by anything, this circulation would continue again and again (UBC Wiki, 2011). There is other study talked about circular flow model in similar way (Beggs, n.d.). In the circular flow model, we could understand that the whole market economy is the result of multiple benefits with the circulation of comedy and currency. After understanding the circular flow model, try to find out that is there any similar cases also generate benefit with the circulation of comedy and currency. Afterward, take a famous auction website as an example to analyze the way that they could make multiple benefits and manage in a long-term.

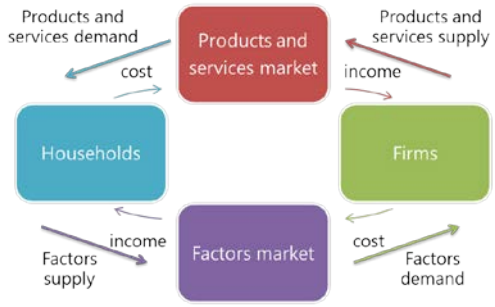

Figure1. Circular flow model (Tsai & Chang, 2008)

(2)Auction website - E-Bay

E-Bay provides a virtual platform which is a platform could buy and sell between buyers and sellers. From the idea of circular flow model, we use a figure (Figure2) to present the way E-Bay manage. The auction website, the buyers, and the sellers stand for different three economy units separately. In the picture, the arrows turn out two circulations showing the expense and income of three units. The buyers buy merchandises form sellers through auction website, and the sellers take the income to pay the fee of post their comedy in this auction website. To auction website, they have to spend money on managing their website for absorbing a large amount of buyers and sellers and attracting buyers buy merchandises from sellers in the auction website (Collier, 2011). This is a multiple benefit model to make more than two economy units could benefit. The auction website build a platform between buyers and sellers and make a profit for three parties. It is a vital reason to sustain this model running smoothly.

Figure2. Multiple benefit model- E-Bay (Lee, 2013)

Innovation applications of web-vision technology

In web-vision technology, there are some applications about web-vision technology. There is a case that apply web-vision technology in creative way (Figure3). Two Taiwanese Lee and Chen (2012) who participate Red dot design award bring out an innovation idea to apply web-camera. Beginning from a simple idea, they think the possibility to use the athlete's perspective to see the baseball game. As a result, they figure out a mini web-camera that could be pressed on the athlete's cloth and combine smartphone, application and wireless signal transportation. The audience could scan the QR code from the tickets and watch the game in the athlete's perspective. Besides, the innovation application also could use in the strategy discussion between the team members to review the game in different angles.

Other case is BH I.concept fitness equipment (Figure4). The fitness equipment company BH release a series of running machine and fitness bicycle which combine an application - Run on the Earth designed by Google map(BH, 2013). The users could put their PDA or smartphone on the machine and by downloading the application they could choose various routes and enjoy their running with street scenery in different countries. This function also could be connected to the big screen to bring more wonderful experience to the customers (BH, 2012).

Another case is Virtual Box. The service provider use internet and vision to build a system for passing information, picture, video, and so on. The users use computer and PDA (Personal d Digital Assistant) to interact. The idea of this design comes from a traditional game – hide and seek. The rule of this game is that one person should go to find out the virtual objects which have been hidden by other person already. There is a graph to illustrate the process of virtual box. As shown in the figure (Figure5), there are five phrases in virtual box. Through this design parents and child could interact with each other. After trying this game, most of the participants (parents and grandparents) really enjoy the process of this game. Some parents and grandparents mention in the interview that they are closer to their children and have a really excellent experience in this game (Davis & Skov & Stougaard & Vetere, 2007).

Others cases are talked in several studies. For example, picture blog to let family members share pictures and experience in the platform and every family members could get information easily from the platform (Dalsgaard at al., 2007).

Figure3. FANs Cam (Lee and Chen, 2012)

Figure4. BH I.concept fitness equipment (BH, 2013)

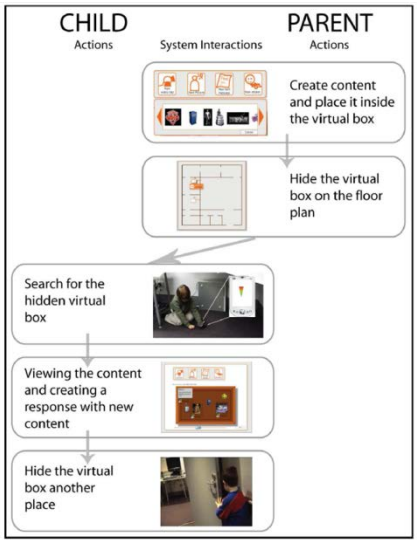

Figure5. Action and interaction flow for Virtual Box. "Hider"(Parents) interactions to the right and "Seekers"(Child) interactions to the left.(Davis & Skov & Stougaard & Vetere, 2007)

METHOD

The research methods which would be used in this study show as a figure (Figure6). In the beginning, we would ask our interviewees to use the web-camera to watch their babies for about one week. At the same time, we would give them some small tasks to take some pictures or videos for us. At the end, when those families finish using the web-camera, we would have an interview to ask them the experience about the device. In this study, there are three methods used to collect and analyze data. In data collection side, semi-structured interview and observation are two methods used to gain the data from the interviews. In the other hand, grounded theory is a vital method which used to analyze the data. Based on the grounded theory, it could help us to find the results from the interviews.

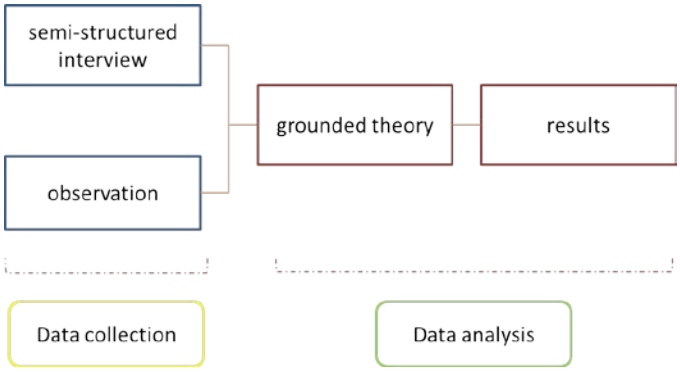

Figure6. Research method (Lee, 2013)

Data collection

In data collection part, there are two methods help us to collect the data. The semi-structured interview is the method that makes some structure before interview. When the interview carries on, the interviewee would follow the structure but allow some changes in the interview. There is the outline of the interview questions. On the other side, observation is also an important way to collect the data. The pictures and videos are nice elements to collect and could be analyzed to support interview result. There is a table (Table1) reveal the content about five interview topics which is related to our research questions, the examples of interview questions, the data resources and methods, and the anticipation which present the possible data we might gain from the interview.

Table1. Data collection (Lee, 2013)

Interview topics	Interview questions example	Data sources and methods	Anticipation
(a) Is there something special happening in the week?	(a1) Please describe something interesting that make you remember most, such as special behaviors or movements of baby?	(1) interview parents (2) documentary analysis pictures and videos	(1) Interview will provide how parents see or feel something interesting or special in the week (2)Analysis of pictures and videos will reveal the important moment which something special happen.
⋮	⋮	⋮	⋮
(d) What possible applications are related to the web-cam?	(d) Please think about any possible applications of web-cam and give the reason why you think those applications are helpful to you.	(1) interview parents	(1) Interview will provide possible applications which interviewees think about by using the web-cam.

Data analysis

In data analysis part, grounded theory is the method used to illustrate the result. Grounded theory could reveal important contents from the interview by coding (Flick, 2009). There is a figure (Figure7) which reveals the process of data analysis. First, transform the entire interview recording to transcript. Second, do open coding and list all coding beside the transcript. Third, do axial coding and class different types of codes. Fourth, do selective coding to find the connection between different categories. Finally, draw the story lines to analyze the conceptual model and answer the research questions. This is a reversible process. If there are any problems generating, the coding process should be repeated again and again until the result could answer the research question.

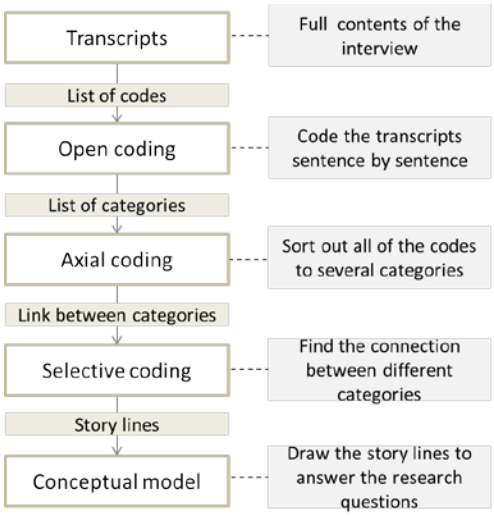

Figure7. Grounded theory (Lee, 2013)

RESULT

These are three family cases in our research. In here, we take one case as an example to illustrate our interview results. The result is including recording data analysis and pictures observation. The recording data analysis would conclude important elements through four phrases. Besides, the pictures observation reveals some interesting moments of the babies.

Case 1

(1) Axial coding

There are eight categories of codes- A-Function related, B-Baby behaviors, C-Parent related, D-Possible application, E- Different ways to communicate, F-Setting location, G-Privacy, and H-Affordable rent. We take two categories as examples in this part. There are few branches in every category. In A- Function related group, A1- drawbacks, A2- important functions and A3- not use web-cam are included in this group. The codes are included in A1- drawbacks such as 1-difficult to set up, 41-remote control function isn't sensitive enough, and 83- only one people could use the application in the same time. In B- Baby behaviors group, B1- special behaviors, B2- imitation, B3- drinking milk and B4- sleeping observation are four branches included in this group. The codes are included in B1- special behaviors such as 9- baby's special behaviors, 12- high value of special behaviors, 46- record funny movements, and 48- precious baby's behaviors, usually once only. By axial coding, we could sort out all of our codes to eight categories and several branches within these categories.

A- Function related	B- Baby behaviors
A1- drawbacks 1- difficult to set up 41- remote control function isn't sensitive enough 83- only one people could use the application in the same time A2- important functions 5- web-cam can change the model between day and night 38- remote control function is vital 92- voice could increase the experience of the scene ambiance A3- not use web-cam 10- human limited, machine anytime 26- use general camera to take a picture 62- use cellphone to record in time	B1- special behaviors 9- baby's special behaviors 12- high value of special behaviors 46- record funny movements 48- precious baby's behaviors, usually once only B2- imitation 24- imitate parents' behaviors 29- baby wakes first, wears mother's glasses covertly 35- high learning ability of baby B3- drinking milk 52- use special movement to drink B4- sleeping observation 43- baby is in deep sleeping when his stomach up and down slightly 64- comfortable posture to sleep 67- baby could change their posture in sleeping to breath

Figure8. Two categories of axial coding (Lee, 2013)

(2) Selective coding

There are five main parts of codes- A-Function related, B-Baby behaviors, C-Parents' related, D-Possible application and E-Different ways to communicate. In selective coding part, it is important to find the links between different categories and branches. There are two examples to show the result of selective coding. As shown on Figure7 and Figure8, there are various connections between big parts and small groups. Some of them which relate to other parts or groups use general blue line while the others of them which are cause-effect relationship use blue arrow. There are two groups about C1-parents' status and C2-parents' feeling in C-Parents' related part. C2-parents' feeling can be influenced by B-Baby behaviors part which includes B1-special behaviors and B4-sleep observation in it. In A-Function related part, there are three groups about A1-drawbacks, A2-important functions and A3-not use web-cam. The code G-privacy issue is related to A1-drawbacks. On the other hands, the group E2-web-cam is related to A-Function related part.

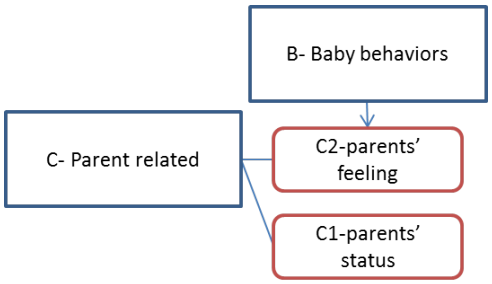

Figure9. Selective coding (a) (Lee, 2013)

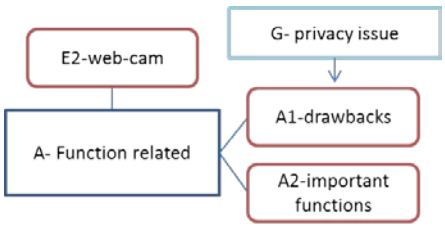

Figure10. Selective coding (b) (Lee, 2013)

(3) Conceptual model

As shown on these graphs, five research questions (a), (b), (c), (d), (e) could be explain in different parts and groups. There are various connections between big parts and small groups. Some of them which relate to other parts or groups use general blue line while the others of them which are cause-effect relationship use blue arrow.

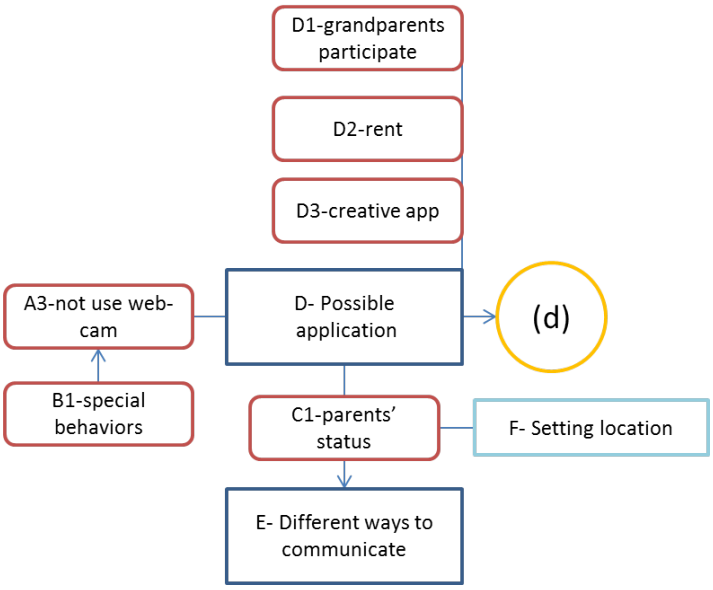

Figure11. Story line (d) (Lee, 2013)

In D-Possible application part, there three groups about D1-grandparents participate, D2-rent and D3-creative app. In the meanwhile, some B1-special behaviors would bring about the phenomenon A3-not use web-cam and A3-not use web-cam may generate D-Possible application. Besides, C1-parents' status which also generate D-Possible application is related to the code F-setting location and affect part E-Different ways to communicate and part D-Possible application. All these D-Possible application could influence the result of research question (d)- What possible applications are related to the web-cam?

(4) Pictures

There are some pictures which we gained from the family. They mention that it is not easy to capture baby's special behaviors. Since the parents have no idea when their baby would have special behaviors, it is really hard to prepare a camera and take a picture all the time. There is an example in the figure below (Figure 11). The two pictures in Figure 11 were not taken by the web-camera but a phone camera. The parents talked about that sometimes they found some special behaviors of their baby which usually flashed suddenly and shortly. As a result, when they saw those special behaviors, they had to find a camera and take a picture instantly. Otherwise, those special behaviors of their baby were usually onetime thing and were hard to be seen in the future. The left picture presented that baby woke up first and imitated parents to put glasses on their face when the mother was sleeping beside him. This picture was taken by the father who found out this moment suddenly and took his phone camera to record this cut movement. The right picture revealed that baby drank with his foot holding the bottle tightly. The father told us that baby held the bottle with his hands first and slowly released the hands to use the foot to hold the bottle. It was the first time they saw this interesting movement. The other two pictures in Figure13 are taken when baby fell asleep. The father told us that it is enjoyable to see his baby sleeping. He said it would make people feel peaceful when looking baby in sleeping. Besides, the father mentioned the function that he could take a picture or see the baby in dark room. He thought it is really a nice function because he could see the baby without opening the light and waking up the baby.

Fugure12. Special behaviors (imitate and drinking milk) (Lee, 2013)

Figure13. sleeping observation (Lee, 2013)

Innovative applications

After interview and analyze the data, we find some important elements from those families. Those families provided us the experience and feeling that they use the web-camera Those informations that they talked about in the interviews are very helpful to inspire us think about the innovative applications of web-camera. There are three innovative applications of web-vision technology that we figure out after considering the needs of the families.

(1) Rent the service

Based on circular flow model, we think that there could have a flow between family and mobile application company. Family could use their old cellphone as web-camera and settle on the seat. In the way, cellphone could work just like the functions which web-camera has. We think this kind of service would be provided in the form of mobile application. People could enjoy similar functions without out buying web-camera. All they need to do is that rent the mobile applications and download to their devices such as cellphone, pad, or computer. The mobile application company has to secure the operation of their mobile application and provide related service to their customers (Figure14).

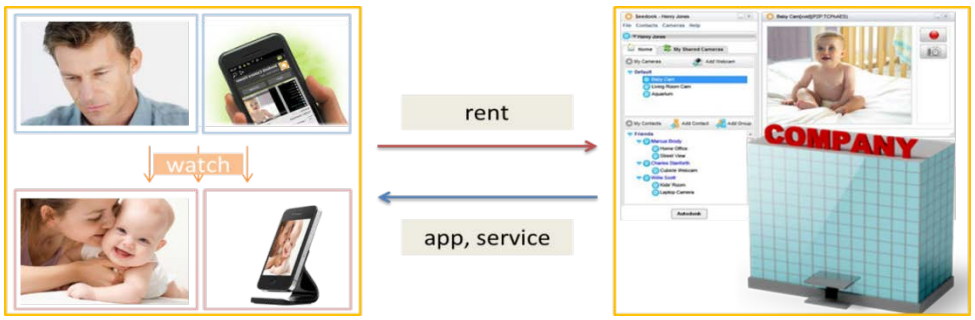

Figure14. Rent the service (Lee, 2013)

(2) Apply in the hospital

When baby get sick and has to stay in the hospital, parents and other family members are usually nervous and anxious. As a result, we think that the web-camera could be applied in this situation to help family to take care and understand baby's condition. With the web-camera family members could enter the application and see the baby anytime they want even in the midnight. Although they couldn't stay beside the baby, they could also concern about baby's condition (Figure15).

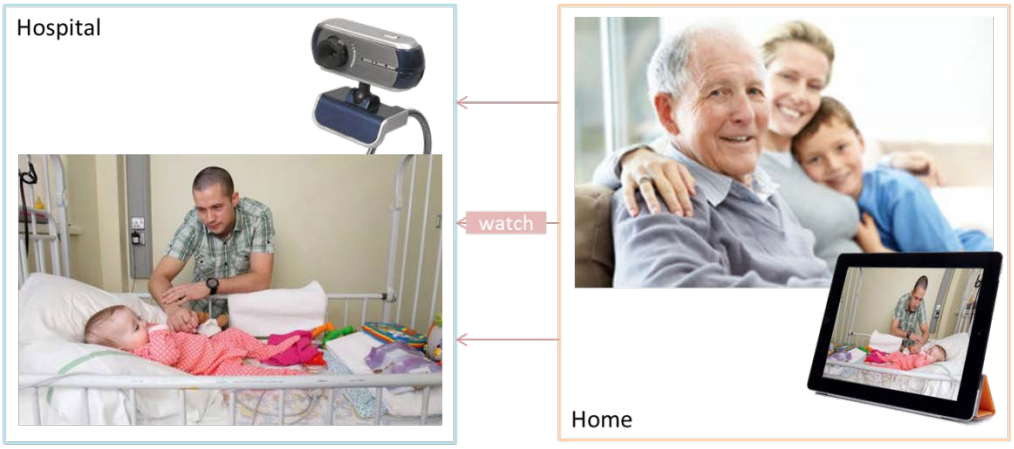

Figure15. Apply in the hospital (Lee, 2013)

(3) Combine with the stroller

The idea comes from the event data recorder. Through analogy, it flashes in our mind that we could set the web-camera in the stroller. With this device many cute and interesting behaviors of baby could be recorded when parents bring baby out. Besides, family members who are not stay with baby in the same time could also watch the cute pictures and videos. For example, father who works busy or grandparents who don't live with grandchild could enjoy these precious images in baby's daily life. It could help to increase their feeling of participating baby's life (Figure16).

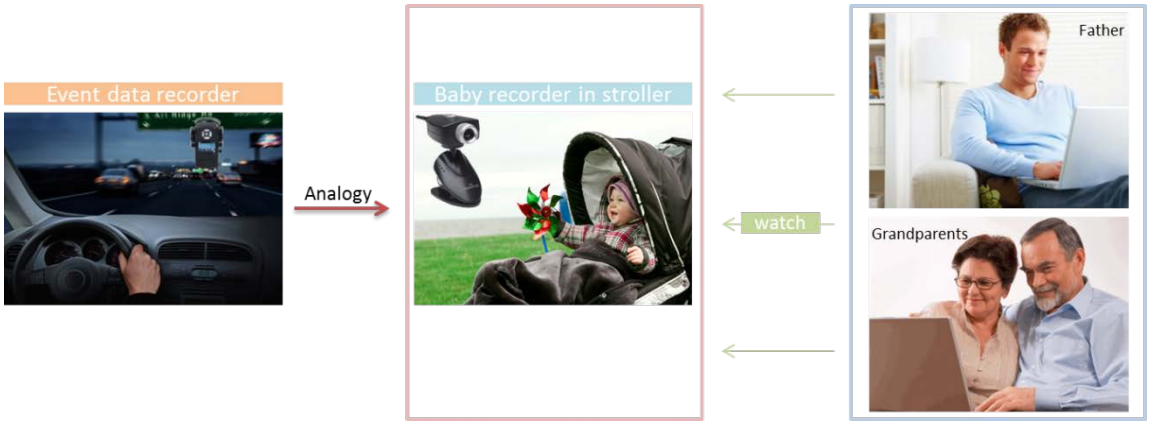

Figure16. Combine with the stroller (Lee, 2013)

DISCUSSION AND CONCLUSIONS

In this study, we anticipate finding innovative application of web-vision technology. At the present stage, there are three families participate in our study and were interviewed by us. Through the interviews it reveals much information about how those families feel about using web-camera to watch their babies and what the most important things about using this device. By observation and interview we figure out some innovative applications about web-vision technology. Besides, one of them is based on business model which might have business potential in the future. Since these innovative applications are based on the opinions which were provided by the interviewees,

we think it would be helpful to families which have babies. At the next phrase, after figuring out these innovative applications, we anticipate using business models to certify that these innovative applications could have business potential in the future and take these innovative applications to ask the thought of our interviewees.

There are some deficiencies about our study. Those innovative applications which we figure out are hard to judge by criteria if they are useful or helpful to the families. We could just use the second interview or some business models to check if these innovative applications could be helpful and have potential in the future. Besides, we think web-vision technology could be used very well in many other sides. Our study only focuses on parent-baby side and we strongly believe that there are more innovative applications in other situations.

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Effect of Age on Superimposition of Head-Up Display

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ABSTRACT

In this paper, we investigate the effect on superimposition of the HUD (Head-Up Display) in a driving environment. The semi-transparent properties of HUD lead to the superimposition which means the overlap between HUD's graphics and an environmental object. Especially, the elderly may have difficulties with driving in a HUD environment because of their loss of cognitive and physical capability. Therefore, we performed the experiment to investigate the effect of age on superimposition in a HUD environment. Participants (elderly, non-elderly) performed the driving task in high and low superimposition level (two simulated road conditions). The result showed that each group's glance duration was significantly increased in a HUD environment. Moreover, the elderly's glance duration showed more increasing in a HUD environment than the non-elderly.

Keywords: Head up display, elderly, superimposition, performance

INTRODUCTION

During driving, driver should constantly check the variable information such as driving-related information and environment information in order to avoid risk and drive safely. Thus, as driving assistance system, information system in vehicle is variously developed to provide the safety and convenience for driver. Especially, head up display (HUD) is gradually applied to new cars as a typical technology of IVIS in accordance with the design guidelines. The HUD is a transparent display and windshield is used as HUD's display area. The HUD projected information on a front windshield in driver's field of view.

Several literature studies have been found on the benefits of the HUD. Liu & Wen (2004) studied the effect of the usage on information displays (HUD, HDD) for driver in two road condition (low, high driving load road). The results showed that drivers in a HUD condition were quicker to respond to road information from display, had less mental stress and had better performance than in a HDD condition. In Gish et al. (1999) study, subjects performed the three tasks (speed monitoring task, navigation task and warning detection task) on information display (HUD, HDD). The author found that drivers in a HUD condition reacted quickly to road events in a HDD condition. Sojourner and Antin (1990) found that Driver in a HUD condition is quicker in responding to the information for salient cues of driving scene than in a HDD condition. Also, several studies (Briziarelli & Allan, 1989; Kato et al., 1992; Sprenger, 1993) found that driver showed the reduction of checking time in a HUD condition.

However, semi-transparent properties of HUD raise a doubt about the positive effects. The semi-transparent properties of HUD lead to the superimposition that is overlapped between HUD's graphics and environmental object (Tangmanee & Teeravarunyou, 2012). This properties may influence the driver distraction, visibility of the display interface, etc., which lead to an increase in glance duration and greatly influence the driver safety.

Especially, Elderly may be vulnerable to a HUD environment because of the loss of physical and cognitive capability. These drivers showed the rapidly growing group in terms of "a driving population" and "a total driving distance" (ball et al., 1993). Generally, elderly experience the loss of eyesight with the increasing age (Rubin et al., 1997; Vitale et al., 2006 and Owsley, 2011). Elderly showed the decrease of the amount of information that human can be processed in given time with the increasing age (Pauzie et al., 1989). These loss leads to the difficulties in

driving, as well as using an in-vehicle information system (Dingus et al., 1997; Kirasic, 2000). For example, elderly have difficulties in using the information system such as navigation (Dingus et al., 1997; Kirasic, 2000). These difficulties greatly influence driver's mobility (McCarthy, 2005). Moreover, Merat et al. (2005) referred that the IVIS is designed without careful consideration for the difficulties of elderly. Thus, considering the capability of elderly is required to design the HUD.

Human acquire the information through variable sensory organ. The most of environment information is received from the vision that is general sense to get the information (Jung & Kee, 1996, Masih-Tehrani &Janabi-Sharifi, 2008). The loss of vision can be applied to driver utilizing IVIS. Because driving is the representative task of vision (Owsley et al., 2013), information design in terms of visual characteristics is essential and should be considered.

Shaheen & Niemeier (2001) studied five kinds of physical disability for elderly. In the research, the older drivers experience the problem of not selecting important information from unnecessary information in terms of selective attention. The author referred that the reduction of attention leads to the difficulties of visual search. Parasuraman & Nestor (1991) found that the decline of selective attention is shown to be highly correlated with the rate of driving accidents. Pauzie(1989) mentioned the following two driving behavior on the visual display in terms of age. First, elderly showed the increase of glance duration and fixation time. This means the decrease of forward-looking time when elderly used the information display. Next, elderly showed the decrease of the amount of information that can be processed in given time. These visual defects of elderly raise some doubt about the positive effects on superimposition in a HUD environment.

Through previous research, we found the various merits and demerits of HUD. Especially, the effect of HUD didn't be confirmed for elderly. Therefore, this study investigates the effects of age on superimposition of the HUD in a driving environment.

METHOD

Participants

In this experiment, subjects are screened for information processing ability through pre-test and a total of 25 subjects participated (12 elderly: the 65-year-old or older, 13 non-elderly). The mean age of elderly is 69.5 years old (SD = 3.5). The mean visual acuity of elderly is in the left eye 0.97 (SD = 0.24) and the right eye 0.95 (SD = 0.28). The elderly are two of the past experience of cataract surgery. The mean age of non-elderly is 28.2 years old (SD = 2.7). The mean visual acuity of non-elderly is in the left eye 0.89 (SD = 0.38) and the right eye 1.00 (SD = 0.37). The non-elderly didn't have eye disease.

Apparatus

The experiment environment is set up considering usage environments of the HUD. We utilized a HUD that is full color head-up display. The model provide a virtual image of 4.5 inch (9.9 x 5.5cm), 400x240 resolution and a 3,100~26000ch/m brightness. The steering wheel is Logitech driving force GT model that include the button at either side. The task is present to 50 inches HD TV in front of subject. To measure glance behavior, SMI mobile eye tracking Glasses 2.0 were used. We set up the basic environment of experiment based on following study. Freeman (2011) designed the usage environment of HUD. The distance between the subject and the HUD image is 1.5m and the HUD is located under the 4~12 degree from the eye position of the driver.

Stimuli

The superimposition phenomenon of HUD occurs through overlapping between HUD's graphics and environment object such as vehicle, road marking and pedestrian. Thus, we controlled the driving scenes by modifying the stimuli level of environment object in the projected area of HUD's graphics. The stimuli levels depend upon the number of objects of projected area and the degree of frequency of overlapping between HUD's graphics and environment object. For example, figure 1(left) is high stimuli level that presents the high frequency of overlapping between HUD's graphics and environment object. Figure 1(right) is the condition of low stimuli that presents the low frequency.

Figure 1.Stimuli level: high (left), low (right)

Task

In this study, we used the dual-task methodology to investigate the efficiency for HUD. Subjects performed the primary driving task and simultaneously secondary task. In general, the primary task is made up of the operation of the steering wheel, acceleration and brake pedal in viewing the front. The selected primary task is the tracking task that George et al. (1999) used. We transformed the task that driver consistently control the tracking box from particular location of line to tracking target by using the steering wheel. Tracking target is located in the center of display and tracking box move from side to side randomly.

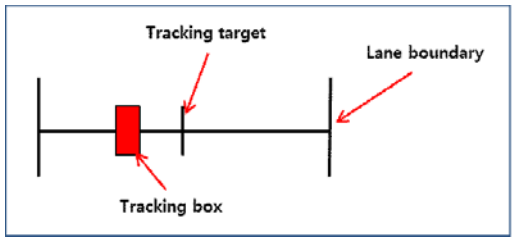

Figure 2.The example of tracking task

Several researchers used a method of evaluating secondary task performance between HUD and HDD (Gish et al., 1999; Wittmann et al., 2006). The method is that subjects respond to whether or not the information of display is correct by using the button of steering wheel at either side. For reference, the selected secondary task is the speed monitoring task that drivers check the current speed (figure 3, right) of vehicle and speed limit (figure 3, left), and respond to a condition by using the button of steering wheel at either side. Subject press the corresponding side button for bigger value. For example, subject press the right side button if the number of figure 3 (right) is bigger than figure 3 (left).

The HUD interface of most vehicle manufacturers is perpendicularly arranged for current speed and speed limit. In this study, the steering wheel button is horizontally arranged. Thus, the speed information is horizontally arranged because we thought that elderly may be difficulty to respond to perpendicular arranged information than horizontal.

Figure 3.The example of speed monitoring task

Procedure

Subjects (non-elderly, elderly) conducted speed monitoring task in two road conditions (high and low superimposition level) based on tracking task. Each participant is allocated randomly to each of the experimental conditions. The display area is classified as primary task and stimuli area. The figure 2 is located in the center area of display. The other area is stimuli area and the secondary task is presented in the red area of figure 1 with the warning sound. Before experiment, subjects were allowed to interact with simulation for 20 minutes in order to avoid the case that subjects don't know what to do.

Subjects fixed their eye on the center area of front to perform the primary task and continuously control the location of tracking box by using the steering wheel. And, when a controlled situation is presented with beeps via speakers, participants conducted secondary task during the primary task. The warning sounds occur randomly 10 times at intervals from 20s to 40s in each condition (high and low superimposition level). A total experiment time is about 1 hour. Each condition takes about 6-minute and the time interval between each condition takes about 5minute.

Measurement

The measurement of primary task is tracking error that is the gap between the tracking target and tracking box. The outcome is standard deviation of distance from tracking target to tracking box. In the experiment, we assumed that primary task didn't influence as a solo task and the values of tracking error are not different from any experiment condition because drivers performed the secondary task in a moment. Thus, we focused on the situation of dual task that subject conducted the secondary task during the primary task.

In the research, the dependent variables are secondary task performance and gaze behaviors. The measurements of secondary task are response time and accuracy. The response time is defined as the time from presenting the warning sound to pressing the button of steering wheel. The accuracy is defined as the correct ratio of answer for secondary task. The measurement concerning the visual distraction is selected as glance duration that was utilized at the several studies (Green, 1999, May et al., 2005; Zwahlen et al., 1988;). Zhang et al. (2006) found the reliability of the glance duration as the index measuring the visual distraction. Chiang et al. (2004) measured the glance duration as method to observe the driver behavior When driver performed the input task by using navigation system in road condition. The research defined the glance duration that is the total time of the fixation time which gaze the display, and the transition time that move between the display and road. Also, ISO (15007-1) is presented for glance duration as quantitative measurement for visual demand Caused by secondary task. In this study, Glance duration is defined as the total time from taking eye off the center area of display during tracking task to taking eye on the center area after checking the speed information.

RESULT

We performed t-test to examine the difference between superimposition level in a HUD environment and conducted univariate analysis to examine the interaction effect between age and superimposition level. As expected, the values of tracking error are not different from any experiment condition. Thus, the result analysis of primary task is not included.

Comparison of the HUD under the different stimuli

The results of superimposition level for non-elderly are summarized in Table 1. The glance duration was found to be significant with p=.000. The glance duration of high superimposition level was taken more 252ms than low level. The response time and accuracy did not show a significant effect (α= 0.05).

Table 1.Results of superimposition level for non-elderly

Measurement	Superimposition level		t-value	p-value
	Low	High		
Response time (ms)	1686	1757	-1.747	.082
Accuracy (%)	98.46	97.41	.622	.540
Glance duration (ms)	686	898	-4.535	.000***

*: P < .05; **: p < .01; ***: P < .001

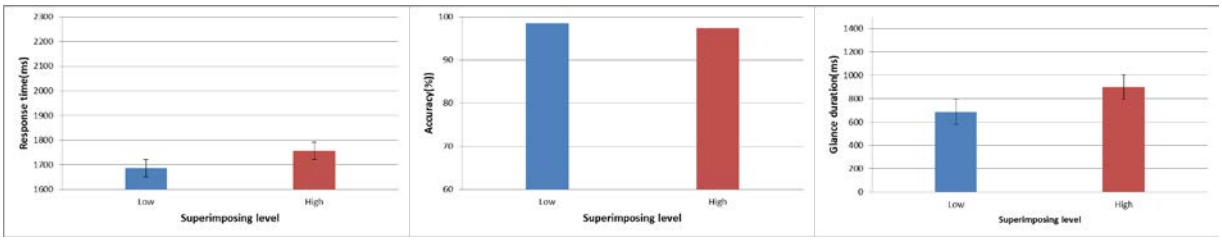

Figure4.Results of superimposition level for non-elderly

The results of superimposition level for elderly are summarized in Table 2. All measurement were found to be significant (α= 0.05). The response time of high superimposition level was taken more 183ms than low level (*p*=.000). The accuracy of high superimposition level was decreased more 10.83% than low level (*p*=.028). The glance duration of high superimposition level was taken more 353ms than low level (*p*=.000).

Table 2.Results of superimposition level for elderly

Measurement	Superimposition level		t-value	p-value
	Low	High		
Response time (ms)	1986	2169	-4.604	.000 * * *
Accuracy (%)	96.57	85.74	2.457	.028 *
Glance duration (ms)	924	1277	-9.526	.000 * * *

*: P < .05; * *: p < .01; * * *: P < .001

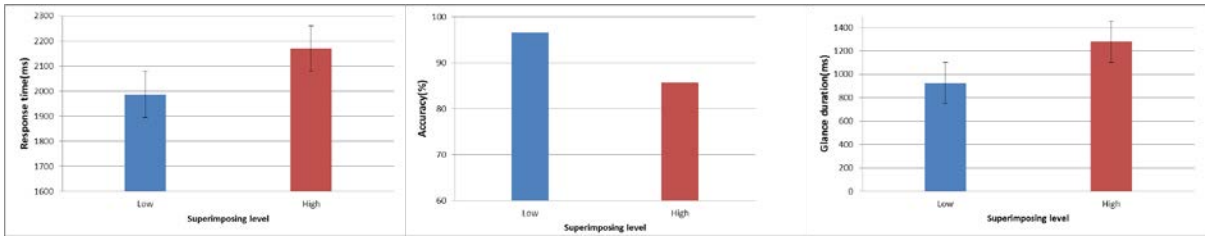

Figure5.Results of superimposition level for elderly

Difference between the effects of stimuli

The results of interaction effect between age and superimposition level are summarized in Table 3. The effect of elderly on the superimposition level is significant than non-elderly in terms of response time (F=4.727, *p*=.030) and accuracy (F=4.420, *p*=.041). The glance duration did not show a significant effect at α= 0.05 (F=2.518, *p*=.114).

Table 3.Results of interaction effect between age and superimposition level

Interaction effect	Measurement		
	Response time (ms)	Accuracy (%)	Glance duration (ms)
Age X Superimposition level	.030 *	.041 *	.114 *

*: P < .05; * *: p < .01; * * *: P < .001

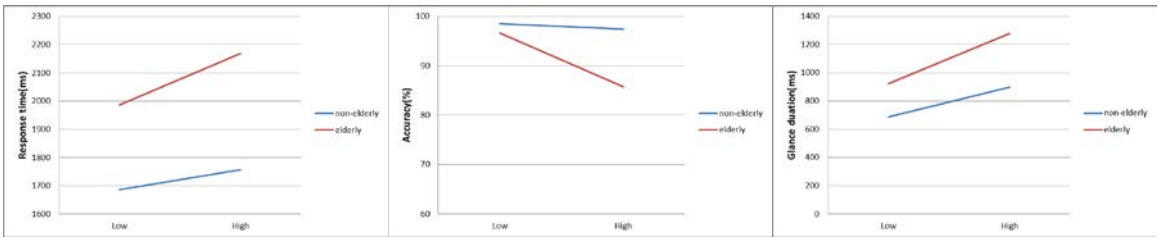

Figure6.Results of interaction effect between age and superimposition level

CONCLUSIONS

We found that high superimposition level have a negative effect on the glance duration in a HUD environment. As the superimposition level increase, all age group showed the increase of glance duration. The increase of glance duration means the increase of the demanded time responding to the projected information in a HUD environment. Especially, elderly is more sensitive to superimposition than non-elderly in terms of response time and accuracy.

Several studies have found the benefits of the HUD in terms of response time. But, we found the negative aspects on the superimposition of HUD. The HUD will be carefully designed on problem of superimposition by text information because of the elderly's loss of physical and cognitive capability. However, if the defects of HUD are compensated, the HUD is expected to be significant benefit for elderly (Dingus et al., 1997; Kirasic, 2000).

The vehicle manufacturers suggest the full windshield HUD as the future technology. They try to design for the graphic types and the location of HUD. The provided information of HUD includes simple sign, text, warning information, etc. This interface have relevance to superimposition because of the information is required for visibility. Therefore, The HUD should be designed by considering the negative effects on superimposition of the projected information in a HUD environment.

In this study, we have the limitation that didn't suggest the design method for HUD. Also, the text information of HUD influences superimposition, but we didn't verify the effect of graphic types on superimposition level. Further study is minimizing the superimposition of HUD, optimizing the location of HUD and verifying the effect of graphic types on superimposition.

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Section 2

Kawaii/Kansei/Affective Value Creation

Evaluation of Kawaii Size by Measuring ECG

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ABSTRACT

Kawaii, which represents an affective value, includes such positive meanings as cute, lovable, and small. In the 21st century, the affective values of industrial products are becoming more important. However, since few studies have focused on kawaii attributes, we are systematically analyzing kawaii products themselves: the kawaii feelings evoked by the shapes, colors, sizes, textures and tactile sensations caused by the materials of such products. In this paper, we refocused on kawaii sizes and performed experiments using both Augmented Reality and Virtual Reality to evaluate a virtual object's kawaii sizes by questionnaires and electrocardiograms (ECGs).

Keywords: Kawaii, Affective value, Augmented Reality, Virtual Reality, Size, ECG

INTRODUCTION

In Japan, the cute aesthetic is exploited by many organizations and for many purposes, including police mascots and warning signs for dangerous areas. Such Japanese kawaii characters as Hello Kitty and Pokemon have become popular all over the world. Although using cute to motivate and inform people might seem strange, Cheok et al. argued that Japanese *kawaii* does offer potential because it embodies a special kind of cute design, which reduces fear and makes dreary information more acceptable and appealing (Cheok et al., 2008). However, since few studies have focused on kawaii attributes, we are systematically analyzing the kawaii interfaces themselves: kawaii feelings caused by such attributes as shapes, colors, and materials. Our aim is to clarify a method for constructing a kawaii interface from our research results. Since kawaii might be an important kansei value for future interactive systems and the industrial products of Asian industries, we experimentally obtained interesting tendencies about such kawaii attributes as shapes (Ohkura, Konuma, Murai, and Aoto, 2008), colors (Komatsu and Ohkura, 2011), and sizes (Ohkura, Goto, Higo and Aoto, 2010).

Although questionnaires are the most common method of affective evaluation, they suffer from the following demerits:

- linguistic ambiguity;
- possibility of confusing the experimenter and/or participant intentions in the results;
- interruption in the system's input/output stream of information.

Thus, to compensate for these questionnaire shortcomings, we examined biological signals because they offer the following merits:

- can be measured as physical quantities;
- resistant to the influence of experimenter and participant intentions;
- can be measured continuously without interruption.

Some studies have focused on emotions using biological signals. However, most dealt with mental stress or simulator sickness, which are considered negative sensations (e.g., Ishii et al. 2008, Collet, Averty, and Dittmara 2009, Webb et al., 2010). Some studies on nonnegative sensations addressed relaxation or comfort (e.g., Poessel, Ahrens, and Hautzinger, 2005, Kawashima, 2006, Orini et al., 2010), which are more static than such dynamic feelings as excitement. Thus, since scant previous research exists on dynamic and positive feelings such as excitement, we experimentally evaluated such affective feelings using biological signals (Ohkura et al., 2009, Aoto and Ohkura, 2007, Ohkura et al., 2010, Ohkura, 2010) and utilized them to evaluate kawaii feelings (Ohkura, Goto, Higo and Aoto, 2010).

In this study, we refocused on kawaii sizes to obtain new knowledge using Augmented Reality. In our experiment, we compared the virtual and real environment results of virtual objects employing questionnaires and ECGs.

EXPERIMENTAL METHOD

In our experimental setup, we employed a 42-inch LCD 3D monitor (Hyundai Corp.) and polarized glasses to stereoscopically show virtual objects in a virtual environment (VR) (Figure 1). The distance between the monitor and each participant was 1.0 m. In a real environment, we employed 3D see-through glasses (Wrap920AR, Vizix Corporation) to stereoscopically show the virtual objects (AR) (Figure 2). We set the marker for the AR display in each participant's left hand. The distance between the participants and their hands was 0.5 m.

Participants watched an object in VR or AR and evaluated its kawaii score. Each object's shape was set as a cube and its color as red-yellow (orange) based on the results of our previous experiments (Ohkura, Konuma, Murai, and Aoto, 2008) (Komatsu and Ohkura, 2011). Each object's size, which implies a particular visual angle, was set to one of four (Table 1) both in VR and AR again based on our previous work (Ohkura, Goto, Higo and Aoto, 2010). Figures 3 and 4 display virtual objects in VR and AR. We randomly showed these four objects to our participants, who evaluated the kawaii scores for each on a seven-point Likert scale: -3: extremely not kawaii, 0: neutral, +3: extremely kawaii.

We measured the ECGs both before and while observing the objects using RF-ECG (Wireless Vital Sign Sensor from Micro Medical Device, Inc.) (Micro Medical Device, Inc., 2014). ECGs must be measured before observing them to normalize the heart rate averages while observing them for each participant.

Figure 1. VR setup

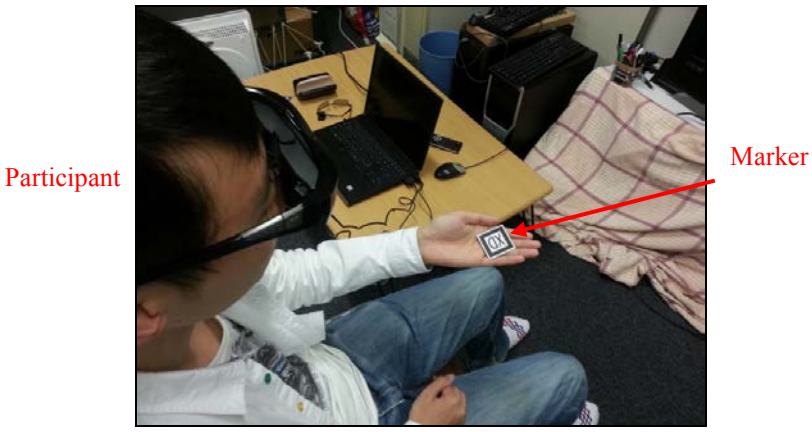

Figure 2. AR setup

Table 1: Visual angles of virtual objects both in VR and AR

Number	1	2	3	4
Visual angle (°)	2.3	4.6	9.1	18.2

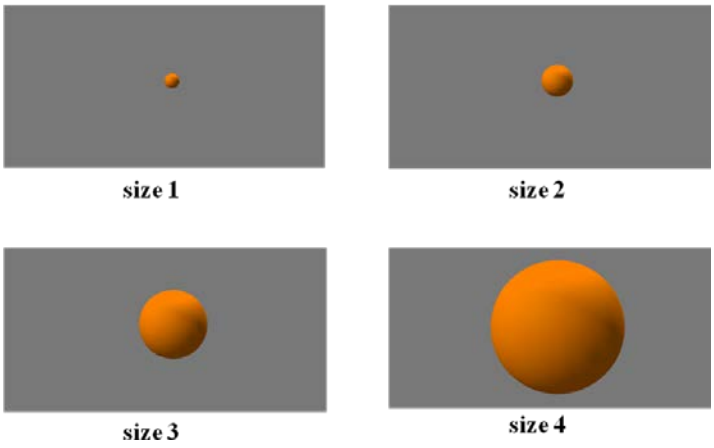

Figure 3. Displays of virtual objects in VR

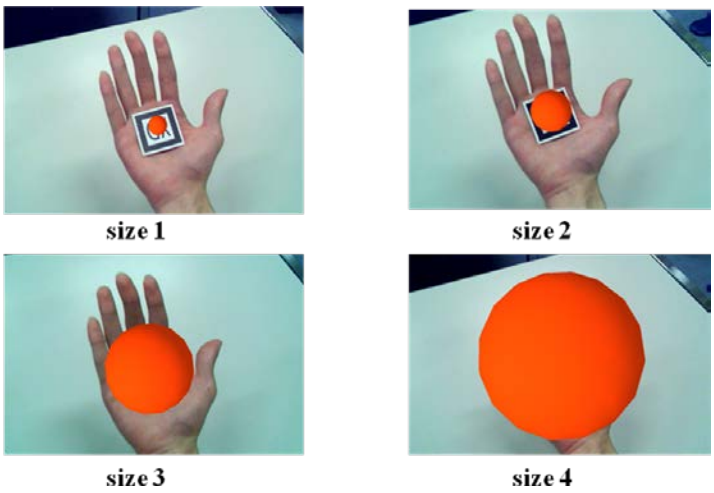

Figure 4. Displays of virtual objects in AR

EXPERIMENTAL RESULTS AND DISCUSSION

Our experiments were performed with eight female and eight male student volunteers in their twenties.

Figure 5 exhibits the questionnaire results, where the horizontal axis shows the ratios of the kawaii scores and the vertical axis shows each object's size in VR. The averaged scores for the kawaii scores show that smaller objects tend to be perceived as more kawaii in VR, which is the same result as in a previous experiment (Ohkura, Goto, Higo and Aoto, 2010). The results of a two-factor analysis of variance for VR show that the main effect of size is significant at the 1% level, but not the main effect of gender.

Figure 6 shows the questionnaire results for AR. The averaged scores for the kawaii scores in AR show the same results as in VR. The results of a two-factor analysis of variance for AR show that the main effect of size is significant at the 1% level, but not the main effect of gender.

Figure 7 compares the averaged kawaii scores for each size between VR and AR, where the vertical axis shows the averaged kawaii scores. The correlation coefficients between object sizes and kawaii scores are higher in AR than VR, implying that the AR result is stronger than the VR result.

Figure 8 shows an example of a recorded ECG in our experiment. The R-R interval is defined as the time interval between the two R waves of the ECG. In this experiment, we computed the R-R interval from an ECG measured at a sampling rate of 100 Hz. The heart rate (HR), which is defined as the number of heart beats per minute, was computed as the inverse of the R-R interval. HR was normalized to cancel the individual differences by subtracting the averaged values before watching for each participant.

Figure 9 compares the averaged HRs for each size between VR and AR, where the vertical axis shows the normalized HR averages. The correlation coefficient between the object sizes and the normalized HR averages in AR is -0.341, whose absolute value is larger than that in VR. This implies that the HR in AR is more strongly related to the object's size than in VR.

The correlation coefficient between the kawaii scores for each object and the normalized HR averages in AR is 0.455, which is larger than that in VR. This suggests that the HR in AR is more strongly related to the kawaii scores than that in VR.

In addition, we divided the normalized HR data into the following two groups: the kawaii group with kawaii scores above 0 and the non-kawaii group whose scores were below 0. The data with 0 scores were omitted from our analysis. From the unpaired t-test results of the differences between the mean values of the two groups, the normalized HR showed a significant difference at the 1% level in AR, but no difference in VR; the heart rates of the kawaii group were significantly faster than those of the non-kawaii group in AR, suggesting that looking at a kawaii object is more exciting than looking at a non-kawaii object. This result resembles our previous research related to biological signals (Ohkura et al., 2010, Ohkura, 2010).

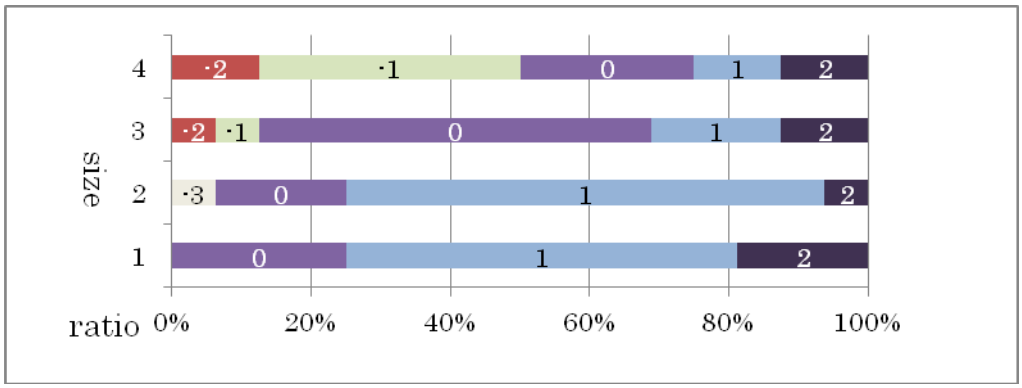

Figure 5. Questionnaire results for VR

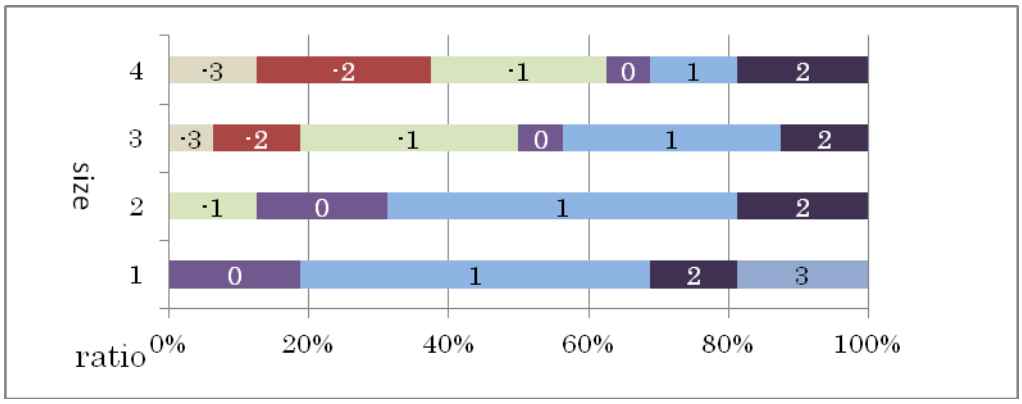

Figure 6. Questionnaire results for AR

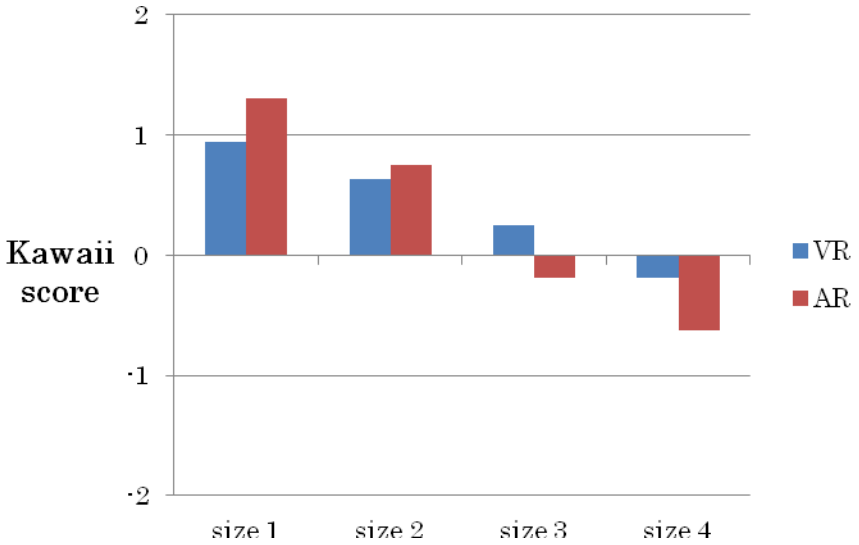

Figure 7. Comparison between VR and AR of averaged questionnaire scores

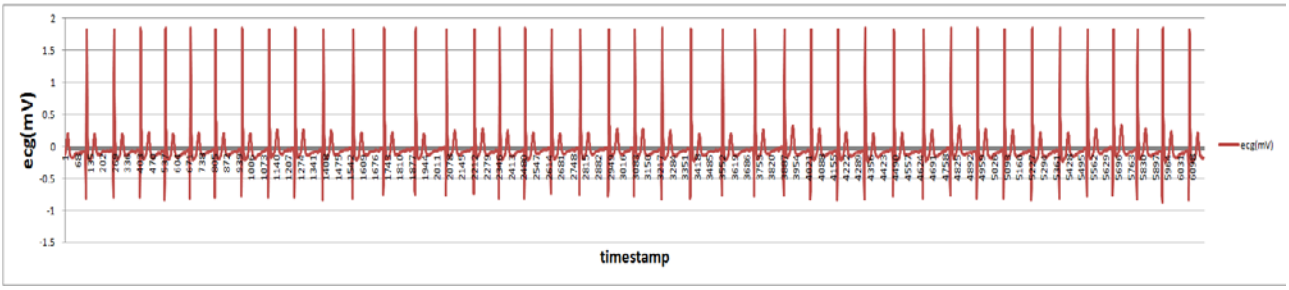

Figure 8. Example of ECG

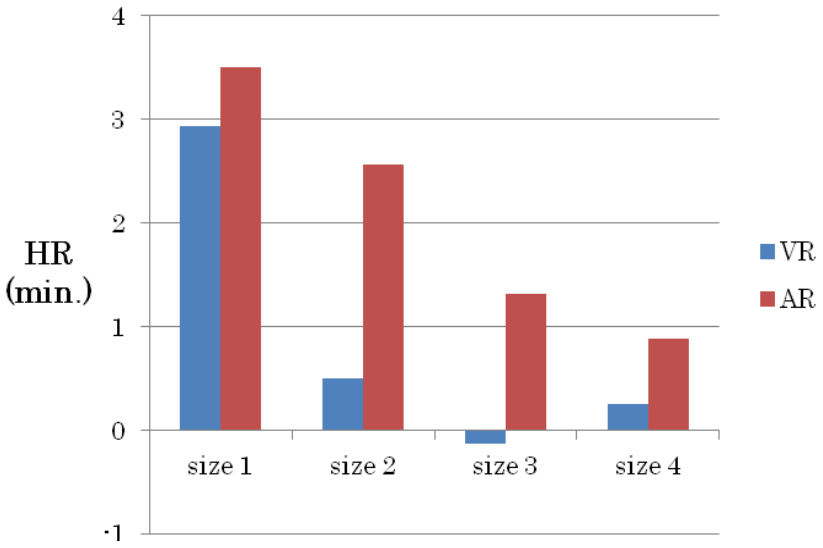

Figure 9. Comparison between VR and AR of normalized HR averages

CONCLUSIONS

We experimentally clarified the relation between kawaii sizes and ECGs both in VR and AR. Our results suggest that smaller objects are more kawaii in both environments. In addition, the kawaii scores and heart rates for each object's size are more strongly related in AR than that in VR.

We have already performed another experiment to determine the optimum size of kawaii objects and concluded that there a limit size exists for objects, even if the smaller object is more kawaii in general (Ohkura and Yamasaki, 2014).

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Physiological Responses Caused by Kawaii Feeling in Watching Photos

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ABSTRACT

"Kawaii" is a Japanese word that represents an emotional value; it has positive meanings, such as cute, lovable, and small. In the 21st century, the emotional value accounts for a large part of consumers' preference. The kawaii feeling might become a key factor for creating affective and pleasurable designs. In a behavior of watching photos, we have subjective, intuitive and strong preference based on our emotional values. In this study, as a study on the kawaii feeling, we conducted experiments to examine whether physiological responses of the brain can be measured when participants get the kawaii feeing in watching photos by the event-related potential (ERP) technique. We measured electroencephalogram of the participants while they were shown kawaii photos, uninteresting photos, and mosaic images. We found that event-related potentials were elicited in response to showing the kawaii photos and the uninteresting photos, while the mosaic photos did not elicit a particular response. ERPs elicited by the kawaii photos had the positive deflection in comparison with ones evoked by the uninteresting photos after about 300-400 msec from onsets of presenting the photos. We concluded that the physiological responses of the brain can be measured when participants get kawaii feeing in watching photos.

Keywords: Kawaii Feeling, Event-Related Potentials, Photos

INTRODUCTION

"Kawaii" is a Japanese word that represents an emotional value; it has positive meanings, such as cute, lovable, and small. In the 21st century, the emotional value accounts for a large part of consumers' preference. The kawaii feeling might become a key factor for creating affective and pleasurable designs. Thus, investigation on the kawaii feeling is important.

In previous studies on the kawaii feeling, systematic analyses on kawaii objects and kawaii interfaces revealed that the kawaii feeling is caused by attributes such as shapes, colors, materials, and combinations of the attributes (Ohkura and Aoto, 2010). The studies further revealed that physiological responses such as changes in heart beat or changes in electroencephalogram (EEG) were evoked by the kawaii feeling (Ohkura, Goto, Higo, and Aoto, 2011).

In our daily life, we get the kawaii feeling when we find kawaii objects or the kawaii attributes in common scenery. Especially in a behavior of watching photos, we have subjective, intuitive and strong preference based on our emotional values. Thus, as a progress of the studies on the kawaii feeling, it is valuable to investigate the kawaii feeling occurred in watching photos. We have reported that physiological changes in heart beat were evoked by the

kawaii feeling (Yanagi, Yamasaki, Yamariku, Takashina, Hirayama, Horie, and Ohokura, 2013).

In this study, we conducted experiments to examine whether physiological responses of the brain can be measured when participants get the kawaii feeing in watching photos. As the physiological responses, we measured event-related potentials (ERPs) which directly reflects the response of the brain.

MATERIALS AND METHOD

Visual Stimuli Subjectively Selected by Participants

Two volunteers of twenties participated in the experiments. The participants subjectively selected five photos with which they had kawaii feeling (kawaii photos). They also selected five photos with which they did not had the feeling (uninteresting photos). The photos were collected from the internet. Photos of animals, faces of humans, cartoon characters or objects were typically selected for the kawaii photos. Photos of tools, furniture, buildings, or scenery were typically selected for the uninteresting photos. The photos were converted to monochrome images and edited to fit within the 720 (W) x 540 (H) pixel frame. Mosaic images composed of 24(W) x 18(H) blocks were generated by shuffling segments of the five kawaii photos and ones of the five uninteresting photos.

Presenting the Visual Stimuli in the Oddball Paradigm

We measured EEG of the participants while they were shown the kawaii photos, the uninteresting photos, and the mosaic images. The participants were comfortably seated. The visual stimuli were presented on a screen of a laptop computer (the 1366 (W) x 768 (H) pixel frame in a 15.6 inches screen) situated in front of the subjects. The three types of visual stimuli were presented in random order as the oddball paradigm, in which the kawaii photos and the uninteresting photos appeared infrequently as deviant stimuli while the mosaic images appeared frequently as standard stimuli. In the sequence of the visual stimuli, each of the five kawaii photos and the five uninteresting photos appeared twice, and the 343 mosaic images appeared. Each of the visual stimuli, embedded in the center of a black background, was presented for one second. A red cross was superimposed in the center of the screen to restrict eye movements across the screen. The participants watched the sequence of the visual stimuli passively. The top-left corner of the visual stimuli flickered for each visual stimulus to provide trigger signals for onsets of presenting the visual stimuli. The onsets were detected by a light detector sensor and used for alignment of ERPs.

EEG Recordings and ERP Derivation

Electrodes were attached on the participants' scalps at the sites of Fz, Cz, Pz, and C4 of the international 10-20 system. Vertical and horizontal electrooculograms (EOGs) were recorded from electrodes below the left eye (VE) and outer canthus of the right eye (HE). All electrodes were referenced to a right mastoid. Impedance at each electrode site was less than 5k ohms. The EEG was amplified by a DC amplifier (Melon Technos Co. Ltd., 8ch amplifier) with a 0.16-100Hz band pass filter and a 50Hz notch filter, and sampled continuously at 1000Hz in 16 bits by a data recorder (NF Corporation, EZ7510).

The EEG signals were divided into epochs beginning at 200 msec before the onset of presenting the visual stimuli and ending at 1000 msec after the onset. Trials with artifacts were eliminated by visual inspection of the EOG and EEG recordings. For each type of visual stimuli, the epochs of EEG signals were aligned from the onset with 200 msec pre-onset baselines and averaged to detect ERP waveforms. The ERP waveforms were smoothed for plotting.

RESULTS

We found that ERPs were elicited in response to showing the kawaii photos and the uninteresting photos, while the mosaic images did not elicit a particular response. The ERPs elicited by the kawaii photos and ones elicited by the uninteresting photos had different waveforms. The waveforms of the ERPs were varied across the participants. It is a common tendency across the participants and notable that the difference between the ERPs elicited by the kawaii photos and ones evoked by the uninteresting was found after about 400 msec from the onsets of presenting the

photos. We show results of the two participants in Figures 1-12. Note that the results of the two subjects were typical across results of preliminary experiments, which were conducted with another two participants.

Participant A

Results of a participant (participant A) are shown in Figures 1-6. After the artifact rejection, numbers of remaining epochs of the kawaii photos, ones of the uninteresting photos, and ones of the mosaic images were 9, 8, and 235 respectively at all of the electrodes. Figures 5 and 6 show trials with eye artifacts were successfully eliminated. Figures 1-4 compares the ERP waveforms from the three conditions, the condition of the kawaii photos (kawaii condition), one of the uninteresting photos (uninteresting condition), and one of the mosaic images (mosaic condition) at each electrode site. X-axis and Y-axis represent time [msec] and amplitude of ERPs [μV] respectively. 0 msec on the x-axis represents the onset of presenting the visual stimuli.

Differences between the kawaii condition and the mosaic condition are characterized by a positive component. In the response, a peak of positive deflection appeared at about 400 msec after the onset in the kawaii condition. The positive deflection in the kawaii condition decayed slowly. Differences between the uninteresting condition and the mosaic condition are also characterized by a positive component. The amplitude of the positive component appeared in the uninteresting condition was smaller than one in the kawaii condition, and decayed immediately. Consequently, differences between the kawaii condition and the uninteresting condition are characterized by a positive deflection in the kawaii condition in comparison with the uninteresting condition. The differences appeared after about 400 msec from the onset. The results were commonly appeared at all of the electrode sites.

Participant B

Results of a participant (participant B) are shown in Figures 7-12. After the artifact rejection, numbers of remaining epochs of the kawaii photos, ones of the uninteresting photos, and ones of the mosaic images were 8, 10, and 274 respectively at all of the electrodes. Figures 11 and 12 show trials with eye artifacts were successfully eliminated. Figures 7-10 compares the ERP waveforms from the three conditions at each electrode site. Axes in Figures 7-12 are same with ones of Figures 1-6.

Differences between the kawaii condition and the mosaic condition are characterized by a positive component. In the response, a peak of positive deflection appeared at 300-400 msec after the onset in the kawaii condition. The positive deflection in the kawaii condition decayed slowly. Differences between the uninteresting condition and the mosaic condition are also characterized by a positive component. The amplitude of the positive component appeared in the uninteresting condition was smaller than one in the kawaii condition, appeared later than the positive component in the kawaii condition, and decayed immediately. Consequently, differences between the kawaii condition and the uninteresting condition are characterized by a positive deflection in the kawaii condition in comparison with the uninteresting condition. The differences appeared after about 300 msec from the onset. The results were commonly appeared at all of the electrodes.

DISCUSSION

It was revealed that both the kawaii photos and the uninteresting photos elicited the positive component in the two participants. We suspect that the positive component may reflect attention to appearing the photos. The mosaic images had no information of original images. Thus, infrequent appearance of both the kawaii photos and the uninteresting photos might elicit a brain response to pay attention to the photos. It has been well studied that paying attention caused P300 responses (Dujardin, Derambure, Bourriez, Jacquesson, and Guieu, 1993). Thus, we assume the positive component observed in this study to be a type of the well-known P300 responses, although these latencies were slightly later than P300.

It was revealed that the differences in the brain response between the kawaii condition and the uninteresting condition appeared after about 300-400 msec from the onsets of presenting the photos. Though timings of appearing the differences were varied across the participants, the positive deflection in the kawaii condition in comparison with the uninteresting condition was common across the participants. We suspect that the differences in ERPs after about 300-400 msec from the onset may reflect differences in emotional responses between the kawaii condition and the

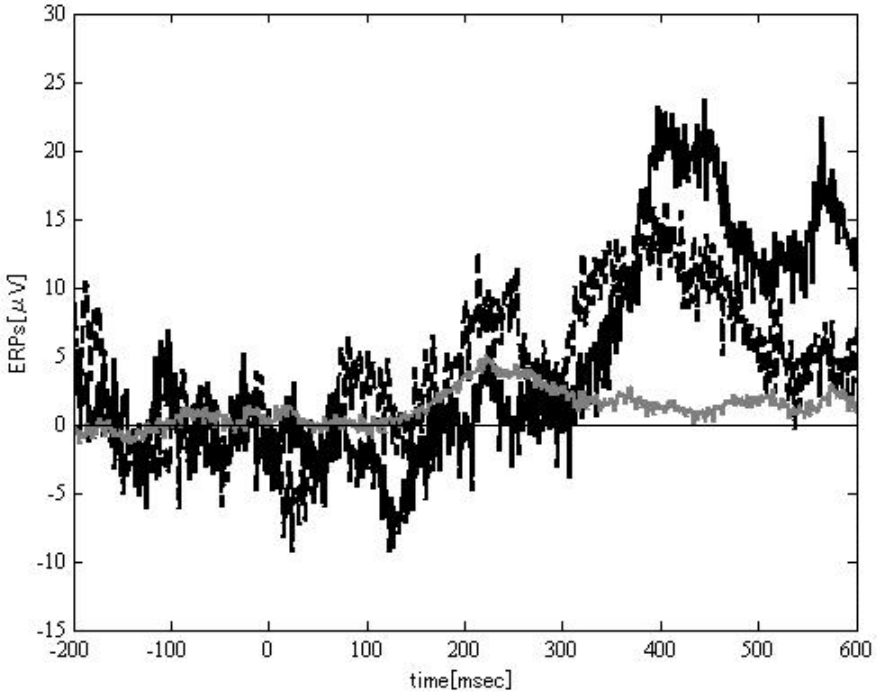

Figure 1. ERPs elicited by the kawaii photos (a black solid line), the uninteresting photos (a black dashed line), and the mosaic images (a gray solid line) at the electrode site of Fz in the participant A.

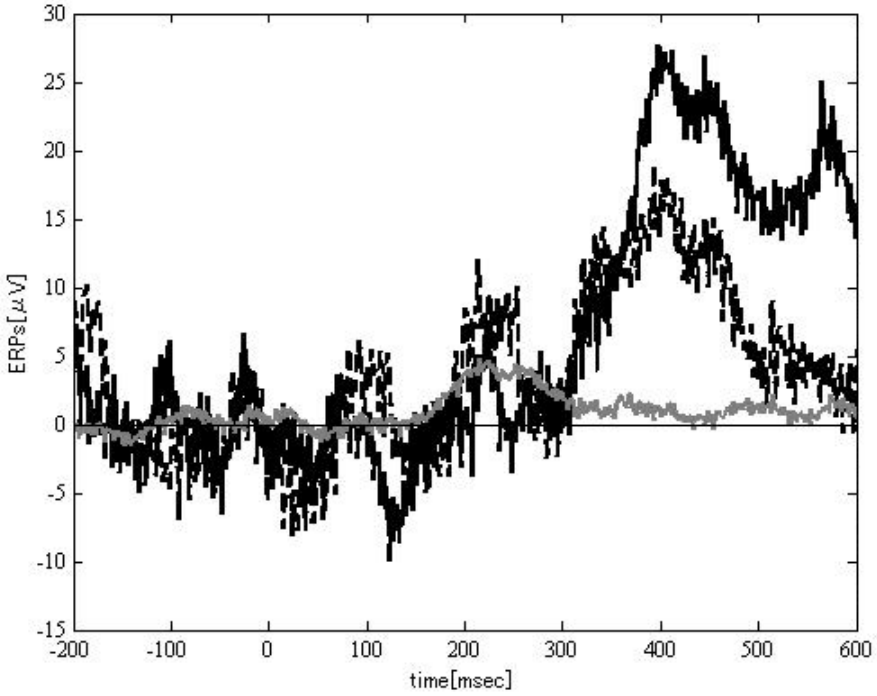

Figure 2. ERPs elicited by the kawaii photos (a black solid line), the uninteresting photos (a black dashed line), and the mosaic images (a gray solid line) at the electrode site of Cz in the participant A.

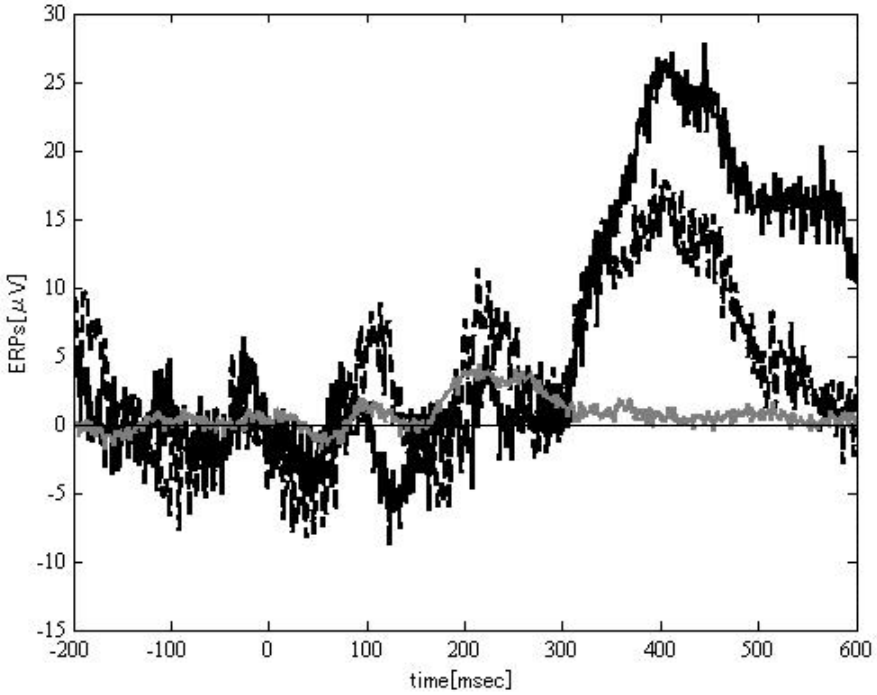

Figure 3. ERPs elicited by the kawaii photos (a black solid line), the uninteresting photos (a black dashed line), and the mosaic images (a gray solid line) at the electrode site of Pz in the participant A.

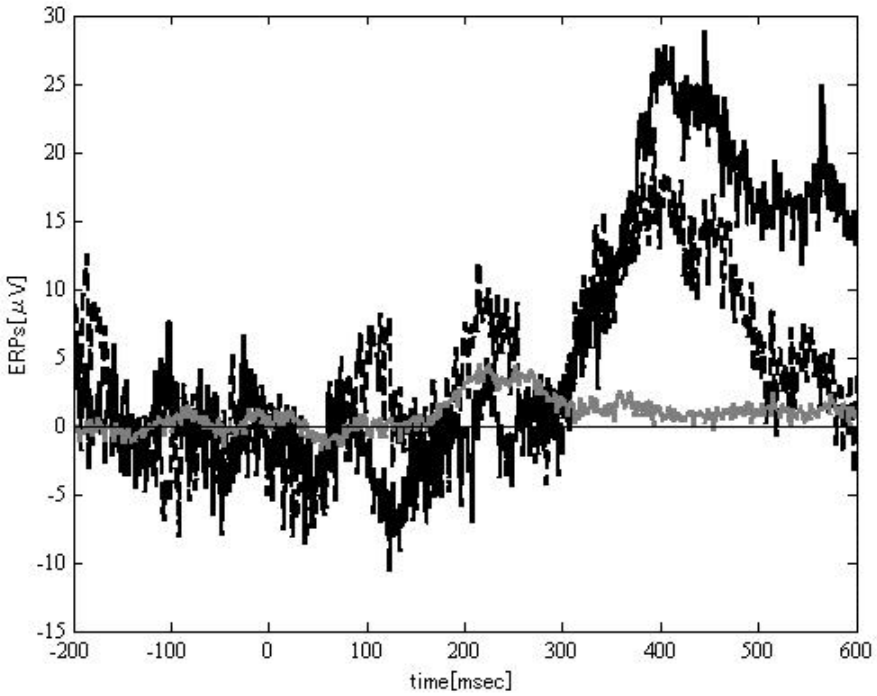

Figure 4. ERPs elicited by the kawaii photos (a black solid line), the uninteresting photos (a black dashed line), and the mosaic images (a gray solid line) at the electrode site of C4 in the participant A.

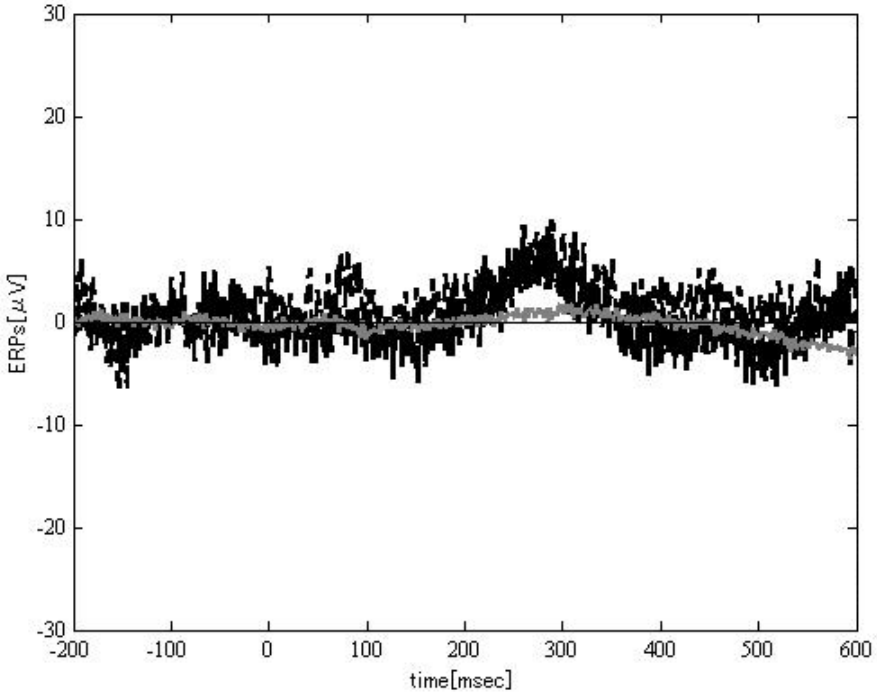

Figure 5. EOGs elicited by the kawaii photos (a black solid line), the uninteresting photos (a black dashed line), and the mosaic images (a gray solid line) at the electrode site of HE in the participant A.

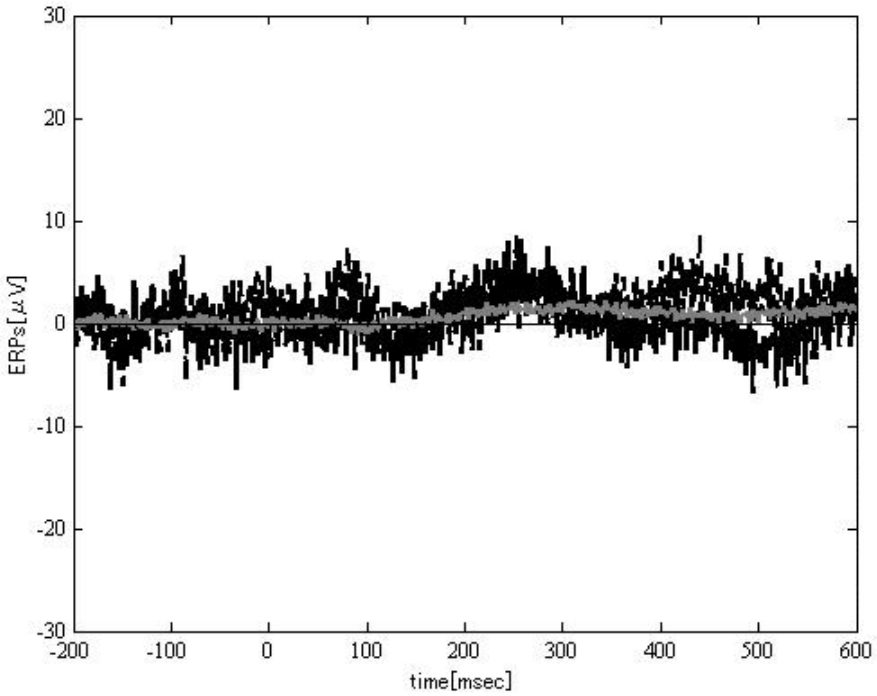

Figure 6. EOGs elicited by the kawaii photos (a black solid line), the uninteresting photos (a black dashed line), and the mosaic images (a gray solid line) at the electrode site of VE in the participant A.

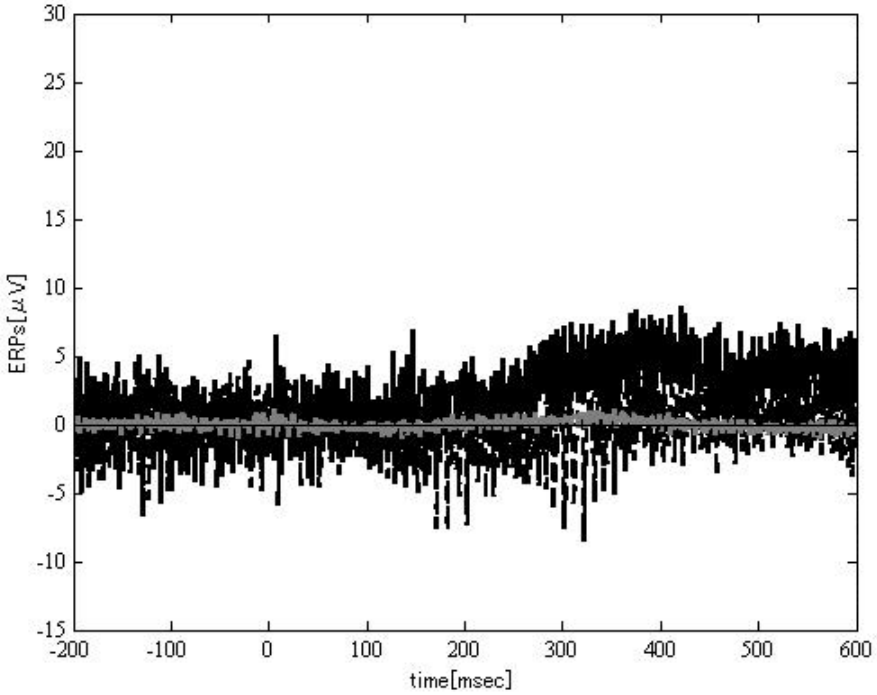

Figure 7. ERPs elicited by the kawaii photos (a black solid line), the uninteresting photos (a black dashed line), and the mosaic images (a gray solid line) at the electrode site of Fz in the participant B.

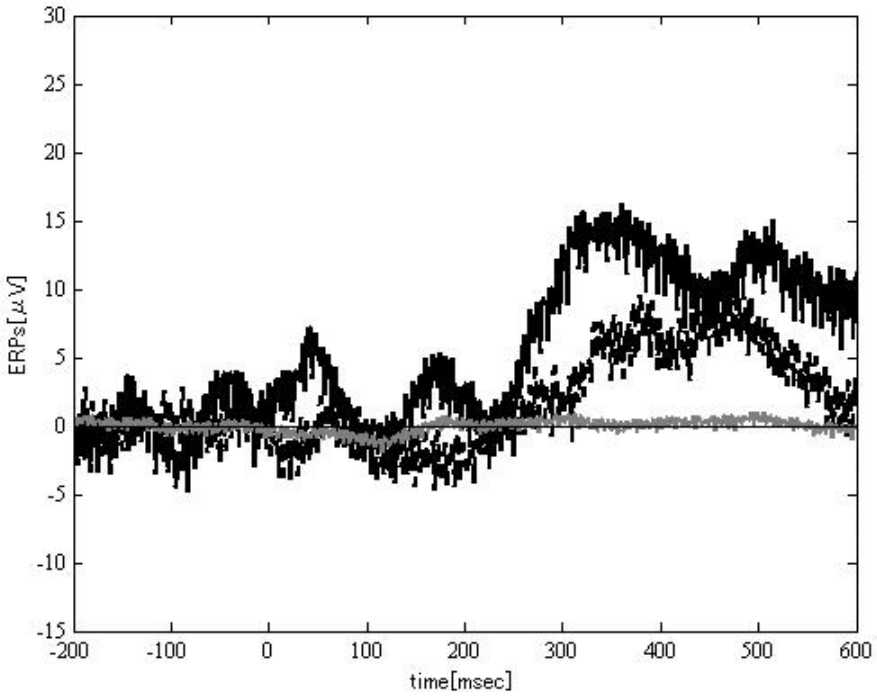

Figure 8. ERPs elicited by the kawaii photos (a black solid line), the uninteresting photos (a black dashed line), and the mosaic images (a gray solid line) at the electrode site of Cz in the participant B.

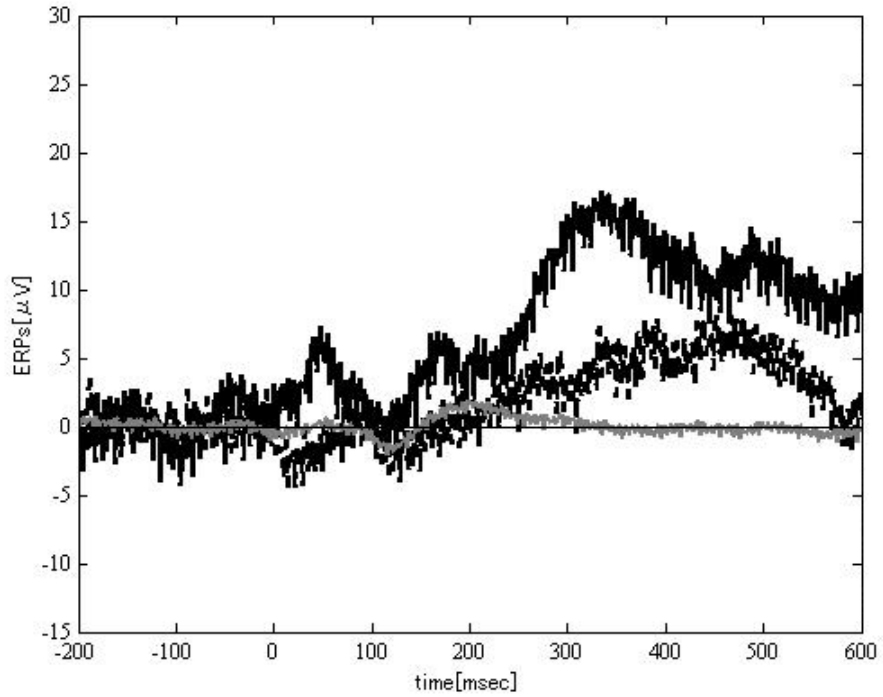

Figure 9. ERPs elicited by the kawaii photos (a black solid line), the uninteresting photos (a black dashed line), and the mosaic images (a gray solid line) at the electrode site of Pz in the participant B.

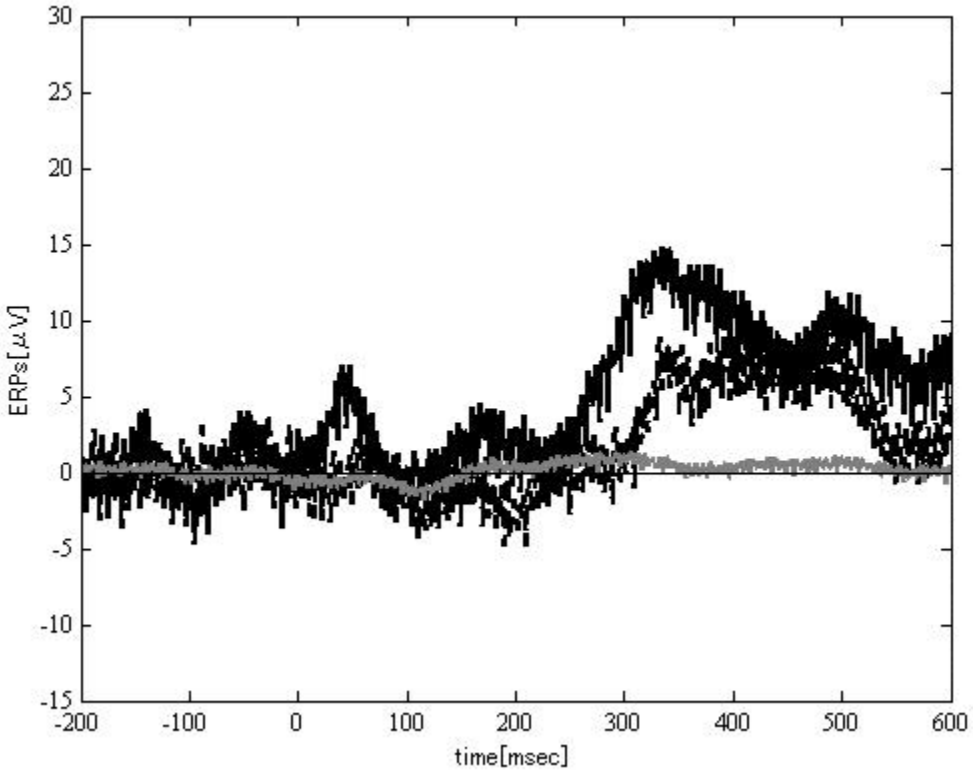

Figure 10. ERPs elicited by the kawaii photos (a black solid line), the uninteresting photos (a black dashed line), and the mosaic images (a gray solid line) at the electrode site of C4 in the participant B.

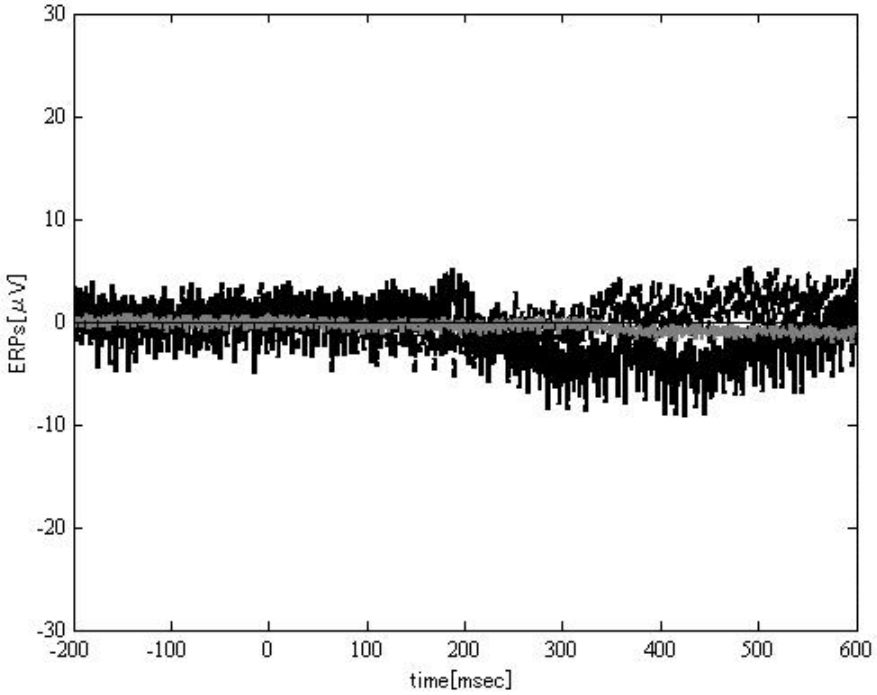

Figure 11. EOGs elicited by the kawaii photos (a black solid line), the uninteresting photos (a black dashed line), and the mosaic images (a gray solid line) at the electrode site of HE in the participant B.

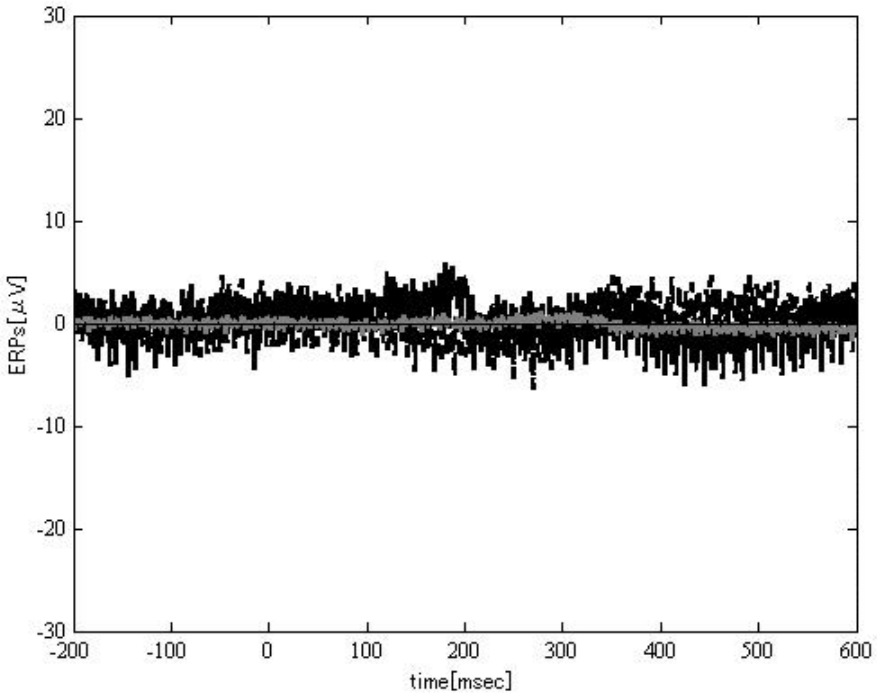

Figure 12. EOGs elicited by the kawaii photos (a black solid line), the uninteresting photos (a black dashed line), and the mosaic images (a gray solid line) at the electrode site of VE in the participant B.

uninteresting condition. Long lasting potentials, especially in positivity, appearing when participants attend to emotional pictures has been well studied in emotional research (Olofssona, Nordina, Sequeirab, and Polichc, 2008; Simola, Torniainen, Moisala, Kivikangas, and Krause, 2013). Our results showed variability in timings of appearing the positive deflection. Variety in how individuals evaluate the kawaii feeling has been reported (Ohkura, Komatsu, Tivatansakul, Settapat, and Charoenpit, 2012). Thus, we suspect that the variability in timings of appearing the positive deflection may be caused by the individual differences in the kawaii feeling to the kawaii photos. In general, a brain response occurred after about 300-400 msec from an onset of a stimulus represents higher cognitive processes for the stimulus rather than early perceptual processes for the stimulus. In sum, our results suggested that the higher cognitive functions might be involved in the emotional responses of the kawaii feeling in the brain when we watching photos, and the involved cognitive functions might vary across individuals.

CONCLUSIONS

In this study, we conducted experiments to examine whether physiological responses of the brain can be measured when participants get the kawaii feeing in watching photos by using the ERP technique. We found that ERPs were elicited in response to showing the kawaii photos and the uninteresting photos, while the mosaic photos did not elicit a particular response. It is a common tendency across the participants and notable that the difference between the ERPs elicited by the kawaii photos and ones evoked by the uninteresting was found as the positive deflection in the kawaii condition in comparison with the uninteresting condition after about 300-400ms from onsets of presenting the photos. We discussed that the observed ERP waveforms were characterized by the positive component, which may reflect paying attention to the photos, and the positive deflection appearing after about 300-400 msec from the onsets of showing the photos, which may reflect emotional responses of the kawaii feeling. In sum, we concluded that the physiological responses of the brain can be measured in ERPs when participants get kawaii feeing in watching photos. Statistical evaluation of ERPs is required in our future work. Our results further suggested that we might be able to identify when we get kawaii feeling in watching photos, based on the physiological responses. The identification of getting kawaii feeling can be applied for the implementation of emotion driven digital camera (Takashina, Yanagi, Yamariku, Hirayama, Horie, and Ohokura, 2014).

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The Role of the Designer in the Affective Design Process: the Principle of Accordance

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ABSTRACT

Affective Design is gaining much attention from academic research and companies. In this paper, a research framework for assessing Innovation through Affective Design is presented. Moreover, Affective Design is correlated to Participatory Design through some definitions. The importance of an Affective approach during the earliest phases of design process is motivated. This study introduces Affective Design as a powerful approach in order to manage interactive Virtual Prototyping (iVP) methodology. The paper deals with issues regarding the great variability that iVP offers: the questions raised find answer in the notion of Accordance, which is defined on the basis of Product Semantics. A tool to implement iVP methodology with this approach is here presented. Finally, the results of a pilot study, qualitatively tested to assess the tool usability, are described.

Keywords: Affective Design, Interactive Virtual Prototypes, Experience Design, Accordance, Experience Map

INTRODUCTION

Over recent years, Affective Design gained an increasing attention from academic research. Considerable has been the effort to establish a solid theoretical framework. Since the seminal works in the field (Picard, 2000; Norman, 1988), Affective Design has been considered an effective approach for understanding not only the users' needs, but also the design process. It pays specific attention to the subtle qualities and meanings of human-product interaction, which are useful attributes to explain some dynamics of design thinking. The great interest in Affective Design can be explained through different aspects. First, designers' and users' perspectives are inherently different, even though designers always tend to empathize with people. De Bono explained (De Bono, 2009): *"it is always useful to evaluate new ideas with little enthusiasm coming from users. Designers always think that users will be enthusiastic of a new idea as its creators are: yet, this never happens"*. In a market constantly overwhelmed by new products, companies need new strategies to differentiate from competitors and gain the preferences of consumers. The main issue is to understand how people perceive (and choose) the products to design. Secondly, a good understanding of the users' point of view is essential to avoid potential failures: some choices may appear the most appropriate according to the design team, but they can reveal to be tremendous mistakes when the product enters the market. An example is the

unsuccessful story of Alixir collection of "functional food" promoted by the Barilla company. Alixir was launched as the new line of healthy food, specifically thought for a target of wealthy, conscious and middle-aged consumers. Barilla invested 10M € in Research & Development, including the study of packaging design. However, as soon as they entered the market, they faced such a failure that within few months, the firm withdrew all the products. Among other reasons, a big mistake was the choice of using total, shiny black for the product packaging. The design team explained that black has been chosen to give a minimal and elegant appeal. Although the packaging did remind of luxury goods, its total black appearance was inappropriate, especially in in the Italian culture, where black is strongly associated with death and mourn. A total-black surface on a food packaging that is supposed to be healthy generates suspicion and doubts. In conclusion, Alixir packaging was a mistake that could have been avoided by testing consumers' preferences.

Another important aspect is timing: it is extremely important to understand users' preferences as soon as possible (see Figure 1). The earlier design changes occur in product development, the less their impact costs (Folkestad & Johnson, 2001). User tests are useful to understand how the consumers will perceive the product, to depict their emotions, and finally to assess their preferences.

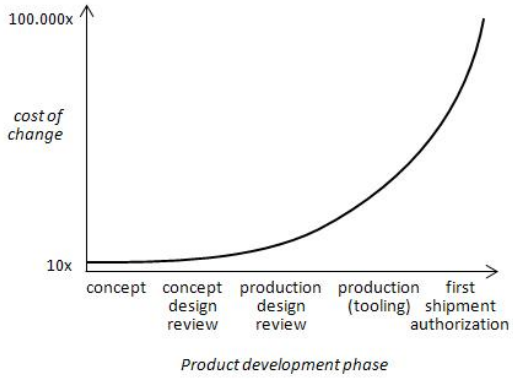

Figure 1. Cost of design changes in relation to the product development phase. (Folkestad & Johnson, 2001)

Products need to increase their perceived value to stand out from competitors'; companies must look for new strategies in order to assess *innovation* and create new successful products. For a long time *innovation* has been merely identified with the act of researching new technologies. Consumer satisfaction opened a new vision centered on people's emotions and preferences (Rampino, 2011). Among the different theories of innovation, this study adopts the definitions introduced by Verganti (2006), who distinguished among different drivers of innovation: a market-pull for *incremental* innovation, a technology push and a design-driven approach for *radical* innovation (see Figure 2a). Incremental innovation refers to improvements within a given frame of solutions (i.e. better design of something that already exists), while radical innovation carries a change of frame (i.e. creating something that is brand new). Verganti went a step further, by demonstrating that radical innovation could come about through a change of meaning, not only from a technology finding (Norman & Verganti, 2014). The Innovation Matrix presented by IDEO (2010) similarly differentiates between *incremental, evolutionary* and *radical* innovation. The former is described as a solution built on existing offerings with familiar users; evolutionary innovation deals with creating new offerings or new users while holding the other constant. Revolutionary innovation means instead to create disruptive solutions able to tackle both new users and new offerings (see Figure 2b).

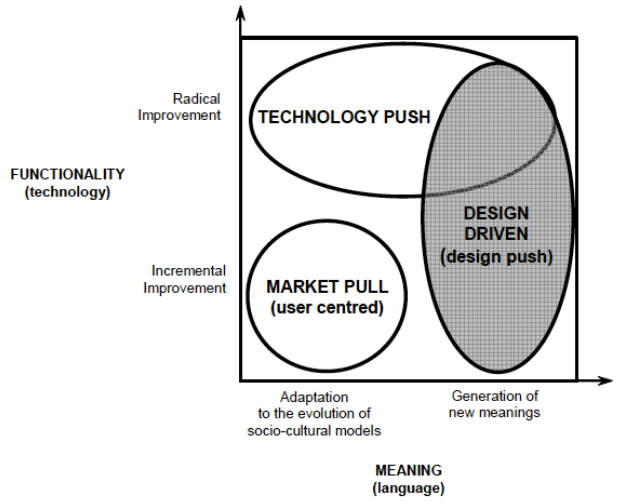

Figure 2a. Drivers of Innovation (Verganti, 2006).

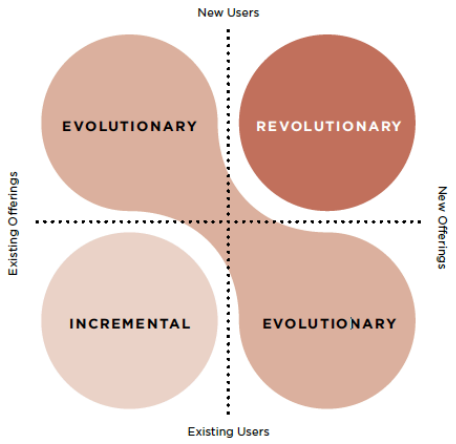

Figure 2b. Innovation Matrix (IDEO, 2010)

Affective Design, paying attention to users' emotions, needs and preferences reveal, is considered a good strategy in order to foster innovation. Looking at both Verganti's and IDEO's matrixes shown in Figure 2a-2b, Affective Design could be applied at each definition of innovation. For incremental innovation, it surely can help in understanding the fine-tuning of product features, due to its intrinsic user-centered nature. For evolutionary innovation, Affective Design may be a tool to depict people desires, giving new meanings to products; besides it may also support the introduction of a brand-new technology. Dealing with radical innovation is indeed more complex: it seems that radical innovation is not directly related with a careful analysis about people's emotions and needs (Norman & Verganti, 2014). Yet, Affective Design and User Experience are still emerging disciplines, striving for a structured and complete modeling: it is feasible that in the next years, both of them will develop increasingly, becoming suitable to foster radical innovation too.

Affective Design and User Experience

Crilly, Moultrie and Clarkson (2004) provided a useful model to describe User Experience. In that model, they distinguished from *aesthetic impression*, *semantic interpretation* and *symbolic association* as three different aspects of user cognitive response to the product. A product experience always encounters a reaction, i.e. a change in people's affective state that can be attributed to human-product interaction (Russel, 2003; Desmet & Hekkert, 2007). This change results in an action, rejecting or moving forward to the product. The final consequence is, whether the product elicits positive experiences, a feeling of pleasure and satisfaction within the user.

This study focuses on the relation between product features and their semantic meaning; *"there is always a meaning that goes beyond the function of an artifact"*(Barthes, 1957). Products have a meaning and a language they speak with, in form of product attributes (Krippendorff, 2004). Krippendorff started from these assumptions to formulate the notion of Product Semantics. He defines Semantics as *"a systematic inquiry into how people attribute meanings to artefacts and interact with them accordingly"* and *"a vocabulary and methodology for designing artefacts in view of the meanings they could acquire for their users and the communities of their stakeholders"* (Krippendorff & Butter 1984). The second definition addresses a possible

"vocabulary" made of sensory cues, i.e. product features, through which products express a particular meaning. Similarly, Hassenzahl (2004) refers to *product descriptors* as a range of features and attributes that equally contribute to communicate the intended product. Crilly et al. (2004) operate a distinction between product semantics and *symbolic association*, differentiating what the product communicate about itself (such as functions, limits, affordance) from what it tells about the external world (the user, the socio-cultural context, etc.). Although it is important to point out this difference, this study chooses to follow Krippendorff definition of Product Semantics. We will further investigate the relation between product descriptors and product meaning and how designers manage Product Semantics.

Experience evaluation and Prototyping

User Experience can be described through five properties. It is *subjective*, as it depends on users' personal background and feelings; it is *holistic*, comprising perception, action, motivation and cognition. Experiences are *situated*: they refer to a particular context. They are *dynamic*, as they change over time: in human-product interaction, there is a "before", a "during" and an "after" attributed to a particular experience. Finally, experiences have a valence: they can be either *positive or negative* (Hassenzahl, 2010). The variety of approaches to the topic reflected in a great number of existing tools, which have been developed to connect the users' preferences and perceptions to the design product (Vermeeren, Roto, Obrist, Hoonhout & Väänänen-Vainio-Mattila, 2010). These methods are of type user-centred, focusing on Affective Design. They all include users in the process of product development, in order to evaluate the User Experience and subsequently modify the product design. This can be done at different stages of the product development process: as mentioned before (see Figure 1), the sooner the better it can affect the product design. During recent years, some studies tried to introduce users' insights soon after idea generation, by testing physical or virtual prototypes and mock-ups. From this perspective, Affective Design can be considered a participatory approach: indeed, Participatory Design aims at involving users at the very beginning of the design process, recognising in people powerful sources of inspiration. It uses different techniques accordingly to the result it is supposed to reach. Participatory Design may apply various design prototyping techniques such as storyboards, scenarios, sketches, mock-ups. It may also focus on human-product interaction within the real context, using quick ethnography tools. Starting from the surface, it is possible to dig deeper into people's tacit and latent needs with generative techniques (see Figure 3). These tools guide the user through small steps to construct and express deeper levels of knowledge (Visser, Stappers, Van Der Lugt & Sanders, 2005).

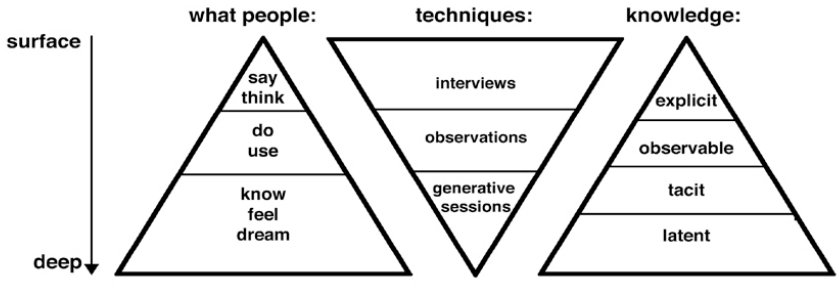

Figure 3. Different levels of knowledge about experience are accessed by different techniques. (Visser et al., 2005)

Some case studies show how the Participatory Design approach significantly contributes to Affective Design (Gaver, Dunne & Pacenti, 1999; Battarbee & Koskinen, 2005). Involving users in the design process is useful to assess users' preferences towards one product feature or

another, but it could also give a broader view on what is meaningful for them. In generative techniques, users are seen as a source of design notions, useful to sparkle brand-new ideas. Generative sessions picture users' insights and translate them into design guidelines. Despite the great number of methods and tools supporting generative techniques, all of them still base on a quick-and-dirty prototyping attitude, which limits their application. A greater integration with other prototyping techniques (i.e. virtual prototypes and digital mock-ups) and a systematic approach would largely benefit to Participatory design, in order to find application in Affective Design studies.

INTERACTIVE VIRTUAL PROTOTYPES AND AFFECTIVE DESIGN

Interactive Virtual Prototyping (iVP) emerged during recent years as an evaluation methodology for product concept phase (Bordegoni, Cugini & Ferrise, 2013). Interactive Virtual Prototypes can be used either for verifying the behavior of a designed product and for evaluating possible variations in interaction experiences. In this way, experience is assessed understanding users' preferences. In both cases, iVPs increase their potential if used in a continuous design-validation loop, where users' opinions directly influence product design. iVPs are significantly increasing their realism and fidelity, through the setting of multimodal and multisensory environments that stimulate different sensory channels. In this way, users are able to test a virtual prototype obtaining a real-time feedback. iVPs offer the great opportunity to change quickly and without effective costs the product features, such as the shape, the color, the sound, the force feedback of interactive components etc. In addition, it is possible to measure the response of the users to these changes, combining iVPs with users' preference evaluation methods (Ferrise, Ambrogio, Gatti, Lizaranzu & Bordegoni, 2011). However, this system offers a limitless variability, for product features can get any value or configuration, which of course is neither practically feasible nor measurable with users. So a major question for interactive Virtual Prototyping methodology is to understand if (and how) it is possible to set the range of variables to be tested. This study proposes to answer some questions of the like: how can we manage variability? How can the designer set the correct range of parameters?

Managing the Affective Design Process

The problem of variability in interactive Virtual Prototyping corresponds to the intrinsic ambiguity of design thinking. Peirce defined abduction as the form of reasoning that best describes design thinking (Roozenburg & Eekels, 1995). In abduction, the challenge is to figure out "what" and "how" to create "something" that leads to the aspired value we want to communicate with the product. Dorst (2011) reports that, if students and novice designers seem to randomly generate answers for both the "how" and the "what", experienced designers tend to have much more effective strategies to tackle the creative challenge. He introduces also the general concept of frame: *"framing is the term commonly used (...) for the creation of a standpoint from which problematic situation can be tackled"* (Dorst, 2011). Although frames are often mistaken with simple metaphors, they are in fact complex notions that include a specific set of values. Dorst compares frames to the phenomenological concept of themes, which are essentially sense-making tools. The definition of frames is an important activity for designers, because it influences all the subsequent choices within the product development. Yet, it is largely considered as an informal activity. Designers find this activity particularly useful to get the "*richness of the problem area*" (Dorst 2011). A frame, according to the values it has to communicate, refers to a specific imaginary of expressive qualities. These qualities are declined coherently to the design frame within the product development.

In this framework, we define the principle of **Accordance,** used by Design Team to manage all the subsequent steps of product development. Accordance is essentially a principle of coherence that is followed by designers in declining all the product features through a chosen Design Strategy. Design Strategy corresponds to the notion of frames expressed by Dorst, but we introduce this term to emphasize the systemic aspect of frames and their driving role through the design process.

Design Team and Accordance

We define Design Team as the people actively working in the product development. During recent years, the complexity of Experience Design required the participation of experts from various disciplines, such as psychologists, anthropologists, neuroscientists, bio-medics and others. In this paper, we have decided to focus only on the role of the following three actors, i.e. marketing, design and engineering experts. Designers and marketing experts are used to design thinking, although they start from different points of view. Marketers express a project frame with metaphors, mainly in the form of linguistic expressions. Designers usually integrate metaphors with a visual approach, through the use of sketches, inspirational images, moodboards, mock-ups etc. Engineering experts traditionally suffer from a difficulty in translating these apparently vague and ambiguous metaphors into product characteristics. We would like to point out that, due to representation issues, this paper consider marketing, design and engineering skills as separated entities. During last years, however, boundaries have been fading out, paving the way for a greater integration among the disciplines, and, finally, for a profitable cooperation between the members of Design Team. Until now, however, it is widely recognized that there is a lack of communication within the Design Team: backgrounds are so different that the members simply do not share the same specific language.

Because of such different perspectives, we can define three categories of Accordance, which correspond to each point of view. Marketing experts follow a principle of accordance, which is different from designers' and engineers'. They look for *Placement Accordance*: a product must be coherent to its brand vision, specific for a target, distinguished by competitors. Apple's iPhone is a perfect example of Placement Accordance, where every single detail gives the feeling of high-tech, luxury and outstanding quality that corresponds exactly to the Apple marketing strategy. Engineers and R&D departments follow instead a principle of *Technical Accordance*, where all the functional and technological parameters must be coherent to each other. Proper examples are mechanical instruments, such as the Planetarium of Milan star projector, where all the parts are technically and functionally coherent to each other. Designers, ultimately, apply a *Semantic Accordance* approach: once the Design Strategy has been defined, the product must express a specific character. In order to make it explicit, product features and attributes must be declined accordingly to their semantic meaning. The Bombino refrigerator by Smeg, for example, has been inspired by an iconic imaginary of the 60s: all the product features communicate a vintage appeal, recalling the soft and rounded shapes typical of the 60s style (see Figure 4).

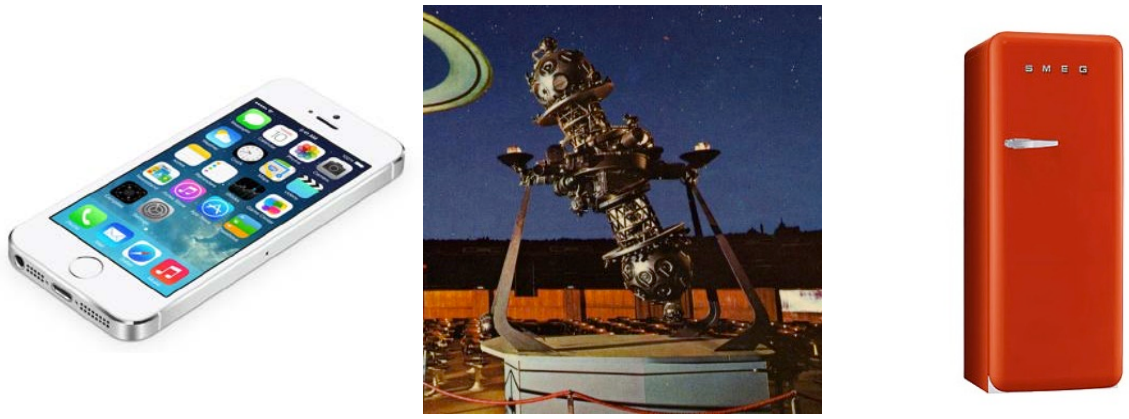

Figure 4. Examples of Placement, Technical and Semantic Accordance

From these examples we can understand that there is a common principle of coherence among Design Team members. However, while Placement and Semantic Accordance share the metaphoric attitude and an intrinsic qualitative nature, Technical Accordance refers to pragmatic and quantitative parameters. These differences generate the difficulties we mentioned above.

Accordance in Design Methodology

In order to further explain the concept of Accordance, and how it can affect the interactive Virtual Prototyping methodology, it is necessary to contextualize it in the product development process (see Figure 5). After the company launches the project Brief (1) and the limitations are defined (2), the Design Team proceeds in defining a Design Strategy that will guide all the subsequent stages of the project. During the Idea Development phase (3), the Design Strategy is deconstructed into a set of sensory qualities and inspirations that describes it. Usually, designers perform this step through moodboards and styleboards. At this point, a Virtual Prototype or a Digital Mock-up is built, in order to proceed with user testing and assess users' preferences. This is the moment when members of the Design Team experience the greater difficulty in understanding each other: the idea is still not formalized; yet the range of parameters to be tested with users must be set. Through this research framework, we propose the integration of a tool, specifically designed to support Design Team members in this phase.

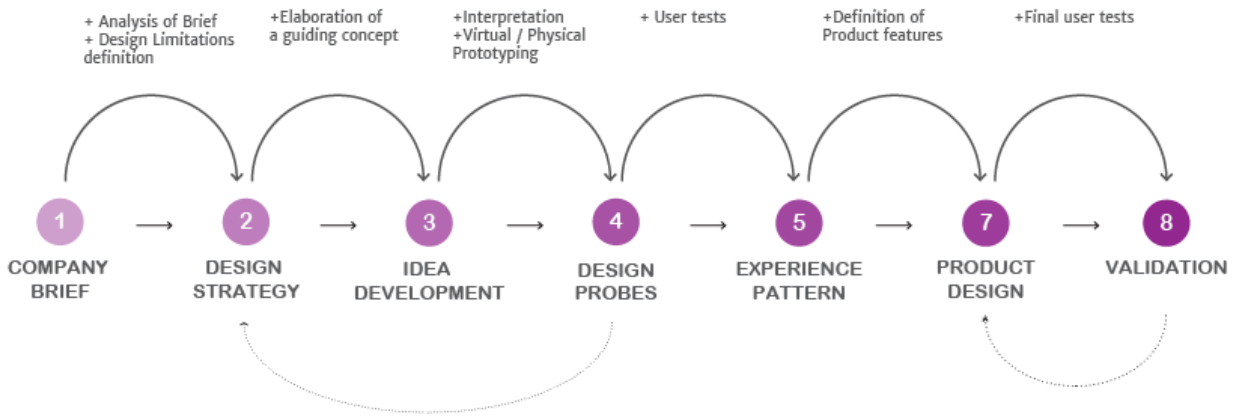

Figure 5. Product Design Methodology

MAPPING OF EXPERIENCE

The tool here presented is the Experience Map, specifically aimed at facilitating the communication between members of the Desgin Team in setting an iVPs User Experience test. As mentioned before, iVPs offer an infinite range of possibilities, which has to be filtered and handled in some way: we propose to apply the notion of Accordance to support the Design Team at this stage of the process. By choosing a Design Strategy, the interaction vocabulary must be declined coherently: in this way, we limit the number of possibilities to be tested with iVPs. However, this step requires designers and engineers to translate the Design Strategy, made of visual and linguistic metaphors, into a set of quantitative parameters.

The Experience Map aims at helping designers in deconstructing the Design Strategy into a list of attributes, evaluating them from 1 to 5. These attributes are still qualitatively defined, but the main goal of Experience Map is to generate more awareness in designers and engineers while selecting the correct range of parameters. The tool is composed by different elements (see Figure 6a):

- Two different hemispheres, referring to *intrinsic* properties (i.e. the product physicality) and *extrinsic* properties (i.e. related to the human-product interaction). In these hemispheres, some attributes and features are disposed in an adapted radar graph.
- An external circle of slots where designers can add inspirational images.
- An external circle of slots where designers can insert keywords referred to the Design Strategy.

Inspirational images and keywords have been added to help designers in visualizing the Design Strategy. Designers are used to work with visual content: by including images and keywords and visually connecting them to a set of features, the tool provides a greater usability for designers.

Figure 6a. The Experience Map.

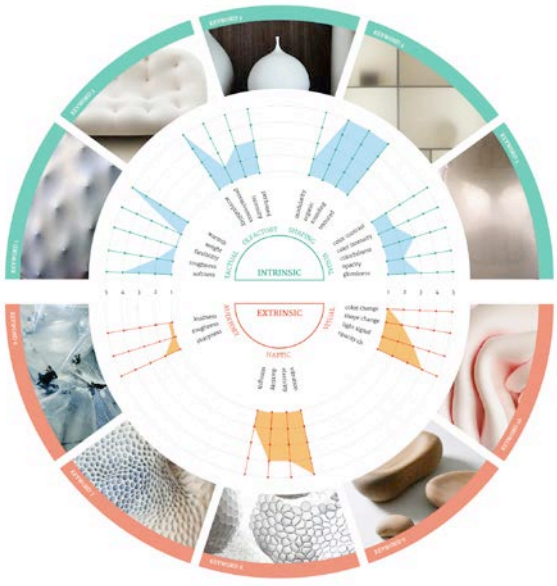

Figure 6b. The Experience Map describing "*care*" concept

Character, Properties, Attributes and Features

Referring to Hassenzahl's notion of product descriptors (Hassenzahl, 2004), we introduce properties among character and attributes. Properties group under them attributes, which are again divided into different features. This properties, attributes and features included in the map have been defined through literature review, as reported below. All the features find correspondences in quantitative parameters that can be used to set iVPs testing. Until now, the value ranked by the designer does not correspond to a quantitative range of parameters; however, a possible future development would be to undertake such a categorization, which will make the Experience Map more effective. Some of the features maintain their technical term, while others have been translated to their folk meaning.

The Experience Map (see Figure 6a) is composed by:

- **Intrinsic properties**:
    - *Tactual attributes*:
        - Softness, roughness, flexibility, weight, warmth (Karana, Hekkert & Kandachar, 2009);
    - *Olfactory attributes:*
        - Acceptability, pervasiveness, intensity (Malnar, 2004), perfumed (Karana et al., 2009)
    - *Shaping attributes:*
        - Modularity, organic, rounding, textured;
    - *Visual attributes:*
        - Color contrast, color intensity, colorfulness, opacity, glossiness (Karana et al., 2009)
- **Extrinsic properties:**
    - *Auditory attributes:*
        - Loudness, roughness, sharpness (Malnar, 2004)
    - *Haptic attributes:*
        - Vibration, elasticity, ductility, strength (Malnar, 2004)
    - *Visual attributes:*
        - Color change, shape change, light signal, opacity change (Colombo & Rampino, 2013)

We provide an application of the Experience Map as an example, concerning the redesign of a new laundry machine. The chosen Design Strategy wishes to communicate the idea of taking care of clothes as if they were hand-washed. The Design Strategy is summarized in the word *care.* The concept is described with the Experience Map (see Figure 6b), which deconstructs an imaginary of soft, warm, organic and fading appearance into intrinsic and extrinsic properties.

Testing the Experience Map

In this Section we present a pilot study aimed at assessing designers' feedback on the Experience Map. We chose to run a qualitative test in a reverse modality: instead of asking participants to represent a Design Strategy through the Experience Map, they were asked to describe some

objects using the map. The Experience Map has been integrated with two other tools taken from literature: the Innovation Matrix (IDEO, 2010) and the Interaction Vocabulary (Diefenbach, Lenz & Hassenzahl, 2013) (see Figure 7). The latter in particular is similar to the Experience Map: however, it focuses on the human-product interaction describing its character, while the Experience Map makes a step further by analyzing the product features. The Interaction Vocabulary has been also added as a reference for evaluating possible difficulties in using the Experience Map. The test was run with 10 healthy participants, aged 24-50, 4 men and 6 women. Moreover, participants were selected to guarantee a widespread sample of design skills and expertise. They were 2 MSc students, 3 junior designers, 3 senior designers and 2 expert designers (15+ years of professional experience). Some of them are specially keen on technical aspects of product design, some others prefer the creative stage of the process, and others have interest on aesthetics and styling. The objects to describe have been picked with a variety of characters and they include: a toaster, with 60s-like style; an ergonomic and playful pen; an innovative scent dispenser made of cardboard; a smartphone. The tasks they were asked to perform are: 1. Define a keyword that describes the product character; 2. Evaluate all the product features through the Experience Map, rating them from 1 to 5, in accordance with the Likert scales. While performing the tasks, they were encouraged to think aloud, in order to take note of possible insights. At the end of the test, participants were asked to fill in a questionnaire, evaluating the Experience Map for its visual clarity, consistency, accuracy, usability and their satisfaction when using the map. Some open questions were also provided at the end of the questionnaire.

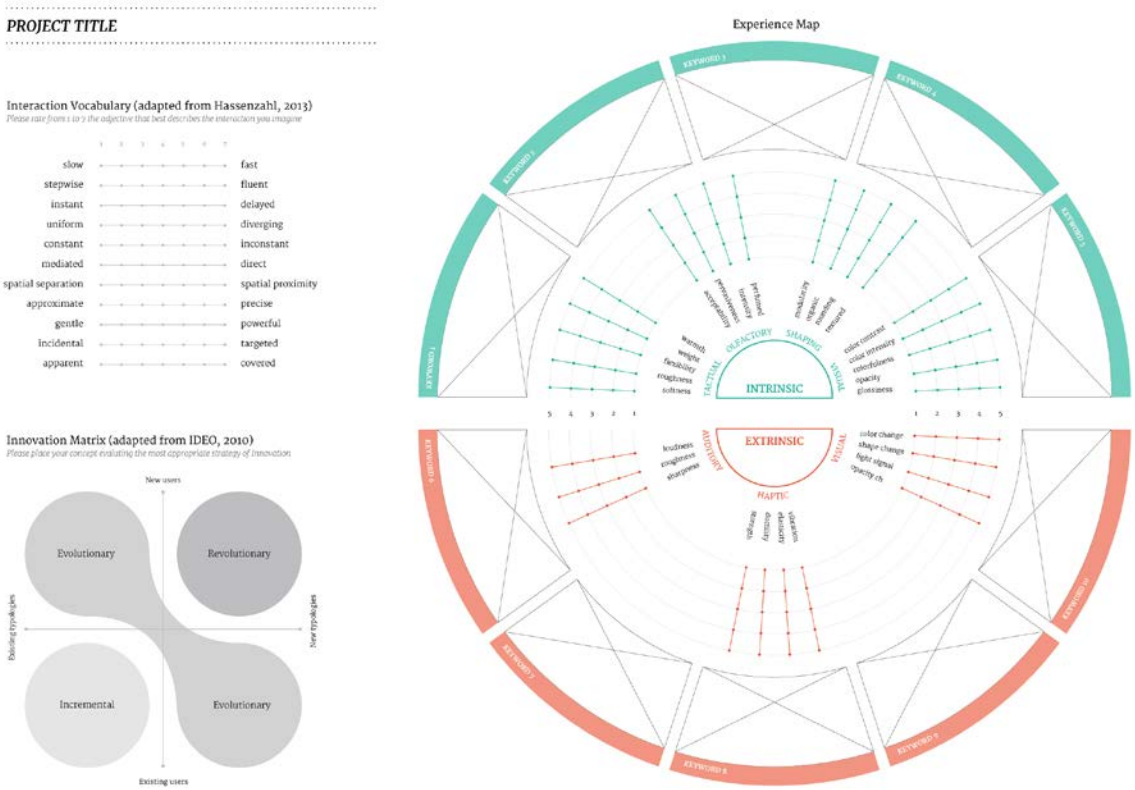

Figure 7. The Experience Map implemented for user tests.

DISCUSSION

While running the tests, some issues emerged immediately. Some of the terms describing the product features were not clearly understood. In particular, as mentioned above, we left some technical terms on purpose, while others were "translated" in common terms: the aim was to investigate which of the two semantics would make the Experience Map more usable. Almost all the participants did experience some troubles in understanding the features "ductility" (Extrinsic > Haptic), "roughness" (Extrinsic > Auditory), "opacity change" (Extrinsic > Visual), "warmth" (Intrinsic > Tactual). While the last two were not understood due to linguistic misleads (participants were all English-speaking but only 1 was English-native), the former two were instead harsh to be understood even when translated. Participants reported the map to be very clear, consistent, accurate and usable (although most of them specified that it was usable after receiving the general explanation of the methodology). All of them reported satisfaction in using it, and they stated the map would fit well into their average design process. Other meaningful insights were the following:

- Accuracy seemed to be satisfactory, even though some parameters were found to be missing. For example, participants felt the lack of smell attributes within extrinsic properties;
- Many of them stated they were not feeling comfortable at using the map for describing existing products, founding it more suitable for deconstructing a concept;
- The evaluation of features has been set from 1 to 5, as Likert scales. However, since the visual shape recalls radar graphs, participants reported the need of the "zero" value, in order to define the features that are not necessary;
- Some of them asked for a greater visual clarity in clustering the features through their attribute belonging.

These insights will be used in our future work to modify and improve the Experience Map.

FUTURE DEVELOPMENTS & CONCLUSIONS

In this paper we presented a research framework to undertake interactive Virtual Prototyping (iVP) methodology with an Affective Design approach. The paper presented a tool, the Experience Map, specifically aimed at facilitating the communication between designers and engineers in setting an iVPs User Experience test. The tool developed is the first of a series of tool currently under development. The preliminary qualitative test with a group of users demonstrated that designers appreciated the Experience Map and only few modifications are needed. However, in the next future we will include the tool in a more comprehensive case study. The case study will offer not only the possibility to adopt the Experience Map during idea generation, but also to share it with the other members of Design Team. Experience Map must be indeed understood by any of them. Further developments of this study will be the integration of a correlation between the ranking in the Experience Map and iVPs parameters. This delicate step will probably increase the chances of Experience Map to constitute a bridge between design thinking and technical reasoning.

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Measurement Magic to Deliver Hair Beauty

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ABSTRACT

We developed the method to evaluate hair beauty in terms of hair volume and hair alignment for development of hair care products. Optical Sectioning Method (OSM) based on laser triangulation was applied to measure 3D images of hair samples, and difference of volume control and ability of hair management was sensitively distinguished among hair care conditioners, which 2D imaging could not achieve. Here we introduce you to the OSM to measure hair volume and amount of frizzy hair. .

Keywords: hair beauty, hair care, OSM, laser triangulation, 3D imaging, hair volume, frizzy hair

INTRODUCTION

Shine (Wenninger and McEwen, 1992), smoothness, ease of combing, decrease of split ends ((Robbibs and Reich, 1986) are the benefits demanded to hair conditioners (Idson B, 1983). In addition, the benefits related to styling such as manageability, volume control and frizz control have become more important to the Consumer. In the process of development of hair conditioners which were expected to deliver volume and frizz control, measurement of hair volume and frizz was strongly needed by formulators to confirm the benefit. Available methods to measure hair volume and frizz were based on 2D imaging and they were not sensitive enough to differentiate the benefit by different formulations.

Here we introduce you to the breakthrough method to sensitively measure hair volume and frizz based on 3D imaging, which was achieved by laser triangulation, so called as Optical Sectioning Method (OSM) (Bickel et. al., 1985).

DEVELOPING OSM SYSTEM TO MEASURE HAIR VOLUME AND HAIR FRIZZ

Hair Sample

Hair samples were prepared by randomly selecting hair fibers from the hair source which was commercially available (See Figure 1).

Each hair sample was treated with a conditioner after pre-wash process. Then each treated hair sample was exposed to high humidity and high temperature, to accelerate fly away hair.

OSM

Optical sectioning method based on laser triangulation was applied to reproduction of 3D images of hair samples. Figure 2 shows the optical arrangement of measurement of hair state. The hair sample is placed in front of a center plane (x-z plane at y = 0) at a position which is within the focal area of the light, and the position of the surface of the hair sample is the distance y of the surface of the hair sample from the center plane.

The line laser is scanned from hair tip to root, the reflected light from hair surface is detected by CCD, then the received light is converted to the distance/displacement by triangulation. The 3D image reproduction is done with the displacement data.

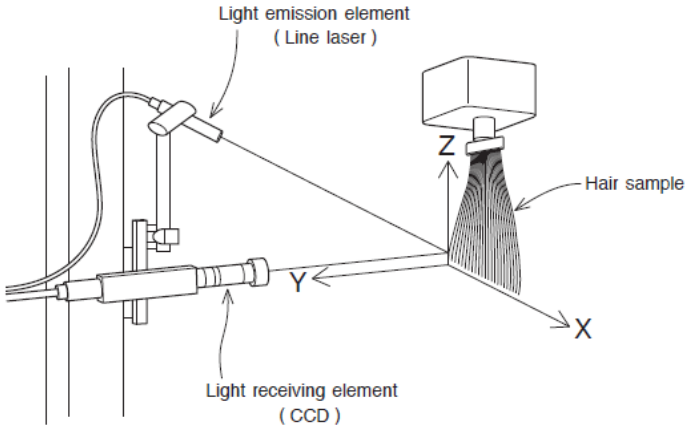
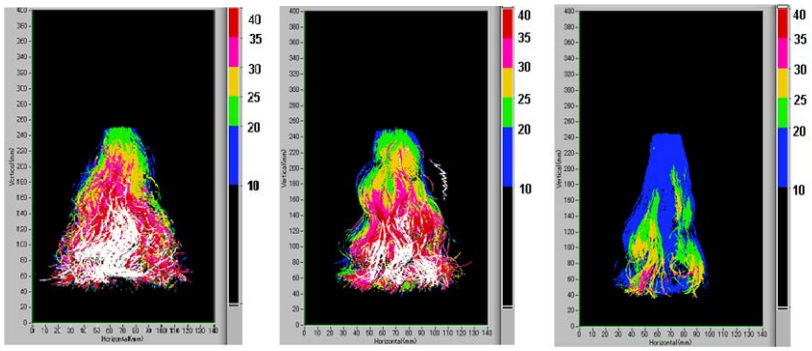


Figure 2 Optical Arrangement of the OSM system

COMPARISON OF PERFORMANCE OF HAIR CONDITIONER BY EVALUATION VOLUME CONTROL AND FRIZZ CONTROL

3D Images of Hair Samples

Figure 3 shows 3D images of hair samples treated with different conditioners. Hair fibers were color-coded by displacement from the center plane (x-z plane at y=0). In the images, hair fibers in white color are displaced from the center plane most largely, meaning most flying away.



A B C

Figure 3 3D Images of hair samples treated with different conditioners

Hair Volume

For the evaluation of the overall hair volume, the hair sample was scanned in whole, i.e., from root to tip and from right side to left side. The volume was calculated with reproduction of the structure of the hair sample in three dimensions.

Figure 4 shows the comparison of volume among three different treatments. Clearly the performance of volume control is differentiated.

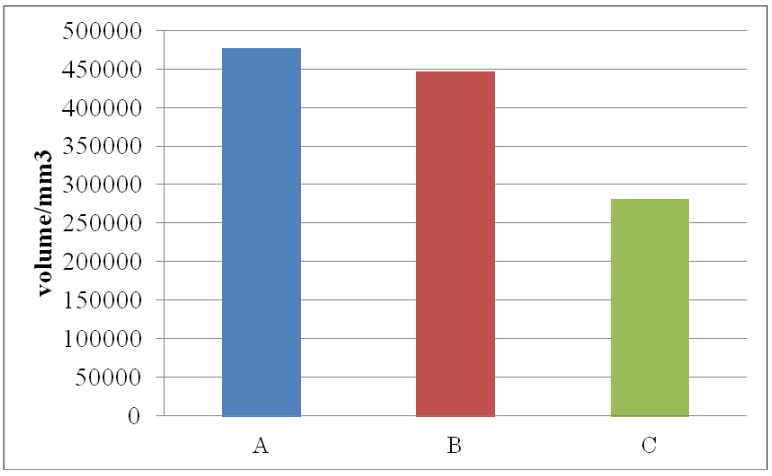


Figure 4 Comparison of hair volume among different treatments

Hair Frizz

Based on the same measurement with the volume evaluation, frizz amount was also obtained (see Figure 5). Here, the horizontal axis shows the distance y which is a distance of the surface of the hair sample from the center plane, and the vertical axis shows the percentage of hair volume compared to the hair volume at y=10. The ratio of the volume in % is taken as frizz amount. At y= 30 or more, Sample A shows a larger percentage, i.e., larger amount of hair volume compared to Samples B and C. Larger amount of hair volume at a certain distance such as y=30 or more means expanded hair and/or hair which is not aligned well, i.e., larger amount of frizz. Sample C which shows the smallest % at y=30 or more has the best frizz control performance.

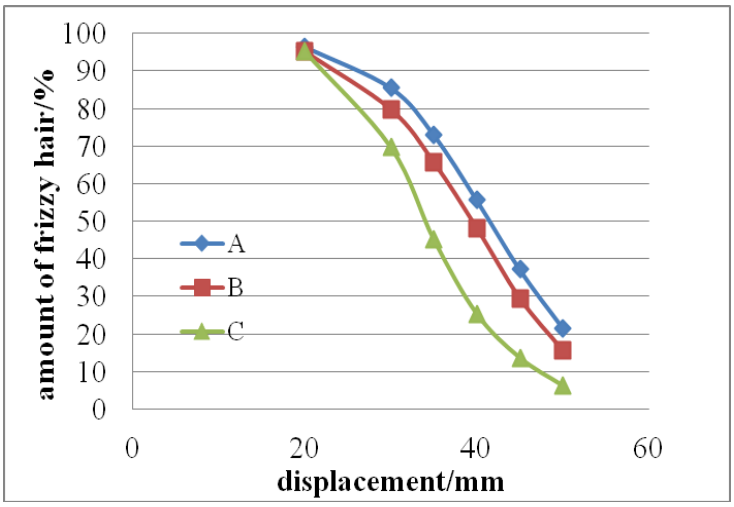


Figure 5 Amount of frizzy hair flying away from center plane

CONCLUSIONS

3D imaging based on optical sectioning method allowed us to measure hair volume and frizz amount. It was sensitive enough to differentiate the performance of conditioners, which had never been achieved by 2D imaging.

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Emotion and Interface Design

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ABSTRACT

Traditionally, human-computer interaction is conceived and assessed through the restrictive scope of usability. Although this approach has led to an overall improvement of the interfaces ease-of-use, it should now be overstepped. The question of the positive affect of users has become crucial for the interface project stakeholders. Our research is mostly turned towards applied perspectives. Our general hypothesis is that design strategies may affect positively the user, and influence a better attractiveness of the interface. Our objective is to define good design practices by assessing a set of emotional design patterns. In a first section, we will report an interview session with designers in order to identify any pattern of design for an emotional interface. Then, we will present and discuss a method to measure user's emotion during an interface interaction experience. The experimental setup gathers screen records, face recognition, galvanic skin response, and questionnaires. These complementary sources bring forward the behavioral, physiological, and subjective emotional responses of the user. We will discuss how these resources can be used in order to measure the emotional effect of a specific user interface.

Keywords: Emotional design, Emotion Assessment, Interface-Design, Cognitive Psychology

INTRODUCTION

In the area of user interface design, during numerous years, it was advocated to apply a user-centered approach, putting forward ergonomic recommendations, or "golden rules" (Norman, 2002; Shneiderman, 2005). These recommendations tended to focus on users' cognitive and perceptual-motor abilities, seeking for an ever-reduced cognitive load required by tasks and interactions. Thus, human-computer interaction is traditionally conceived and assessed through the restrictive scope of usability rather than based on what users felt when interacting with a system. (Bastien & Scapin, 1993, Hancock, Pepe & Murphy, 2005). Although this approach has led to an overall improvement of the interfaces ease-of-use, it should now be overstepped. Therefore, nowadays, humans and their interactions with systems are increasingly being studied. For instance, Don Norman suggests to analyze three different levels related to interface use: "knowing, doing and feeling" (Norman, 2005). Moreover, in recent years, the "feeling" level has become a popular research topic in cognitive science and the science of design. When developing new products or systems, designers have to come up with design solutions that are both novel and adapted to their future users (Shneiderman, 2004; Bonnardel, 2012). Towards this end, designers have to take into consideration other dimensions than the ones related to "usability". Especially, new systems must also inject a little fun and pleasure into people's lives (Norman, 2002). Thus, in addition to their functional characteristics, interactive systems must be regarded as conveying feelings through interfaces' design features. The question of the feelings of users – preferentially associated to positive emotions - has become crucial for the interface project stakeholders. This new field of research is related to two general objectives: understanding users' emotional processes; understanding how to arouse conscious or unconscious emotion through an interface.

Therefore, our objective in this paper is to present and discuss a method to measure user's emotions during an interface interaction experience. Towards this end, we first define this concept and point out its characteristics in the context of user interface design. Then, we turn towards interface designers to understand their views, and identify specific emotional design patterns to be evaluated. Finally, we present a method that we suggest for measuring emotions elicited by an interface design. Indeed, such a method is required to evaluate the effectiveness of specific design patterns.

Our study contributes to the definition of a reference-protocol pinpointing interaction and design features eliciting the user's emotions. These results will then be used in the context of a software called SKIPPI, which aims to favor designer's creativity. We participated to this research by analyzing end-users needs and representations, and by providing requirements for the SKIPPI application design. These studies questioned the emotional effect of the interface, in regards to the emotional value of the displayed content. A protocol of evaluation had to be drawn up in order to distinguish the emotional value of the interface design.

DEFINING EMOTION

To conceive an effective emotional assessment system, a first step is to understand the nature of emotion. In this section, we focus on the main models aiming at describing the emotional phenomena from the psychological domain.

A variety of approaches of emotional phenomena has been proposed in different fields of psychology: phenomenological, behaviorist, physiological, cognitive approaches (Strongman, 2003). Although no real consensus was established, recent models of emotions are based on the notion of appraisal, put in light by Arnold (1945), and Schachter (1959): a cognitive process is required to evaluate a stimulus in order to give rise to emotions. Following this view, the appraisal processes two components, internal and external (Mandler, 1982; Desmet, 2003; Scherer, 2005). This latter external component corresponds to the stimulus' features, whereas the internal component refers to the individual's past experiences and expectations. The sequence of fast but complex evaluations builds the relevancy of the stimulus (Frijda, 1986, Scherer & Tannenbaum, 1986), and prepares the user to react. This reaction may be expressed by cognitive, behavioral and physiological changes (Gil, 2009).

An example would make these notions clearer. At a railway entrance, escalators are located next to the traditional stairs, leading to the upper platforms. Usually, most public use the escalators, because they require less effort and less time. They are more efficient, therefore more usable, and this view is strengthen by our experiences. In 2009, a temporary art installation was setup in one of these stairs in a Stockholm subway (The fun theory, 2009). At night, the stairs steps had been covered in white and black, so that the overall stairway looked like a piano keyboard. The next morning, a first subway user noticed the change: a new cognitive evaluation was performed as the environment was unusually different. The user identified the external features of the painted stairs, and compared them to his internal passed experiences; he identified a stairway to go upstairs, and a keyboard to play piano. This incongruity generated an emotion: surprise, leading to a desire to know more, curiosity. His heart rate increased a little (physiological reaction), and, smiling, he walked towards the piano stairway (behavioral reaction). As he walked up the stairs, the user heard the sound of the piano notes matching his steps. The artist had developed the metaphor further, increasing the incongruity effect, and the pleasure for the users. Some of the users played with the piano stairs, running up and down. Finally, although it was less efficient and usable than the escalators, most of the users chose the piano-stairs that day.

Figure 1: The piano-stairs: how emotional design can influence users behaviors

This example demonstrates how a positive experience may influence the users behaviors, beyond the actual usability of the interface. Preferences and decisions being based on affect (Vakratsas & Allen, 1999; Sanabria, Cho, Sambai, & Yamanaka, 2012), we perceive the relevancy of the appraisal notion for our study as a way to better guide the users towards an objective.

Scherer (2005) defined the emotion as being a relatively intense affective experience, whose cause is clearly identified, and which does not last very long. If the emotion leads to an action tendency, then Scherer defines it more precisely as an 'utilitarian emotion' (anger, fear, joy, disgust), whereas an 'aesthetic emotion' (such as admiration, ecstasy, fascination), would not lead to action.

Two main streams can be drawn to define emotion: a dimensional perspective and a discrete perspective.

This latter discrete perspective views emotions as a sum of categories, which can possibly be intersected or intensity-faded to get finer sub-categories. Several models were proposed, where the number of basic and global emotions varied. For instance, Plutchick (1980) considers eight primary emotions (joy/sadness, trust/disgust, fear/anger, surprise/anticipation), based on their ability to trigger a fight-or-flight behavior. These discrete models are quite popular, especially in the design field, because they are easily linkable to the 'folk psychology': most common vocabulary terms standing for different emotions are localized into discrete model schemes, making them easy to handle. This may constitute an advantage in certain conditions.

However, certain drawbacks were pinned on these discrete models. Numerous studies show that an emotion may be difficult to categorize (Barrett & Wager, 2006). A term-based categorization would imply to share a same cultural and language background. In the same view, it would imply to skip any inter-individual variation in the interpretation of the meanings of the terms. By definition, a discrete model limits the potential number of emotions, disallowing any deeper and more accurate identification and inducing biases.

For these reasons, other models of emotions co-exist, based on a dimensional perspective. Among researchers, the number of dimensions varies. However, two dimensions emerge of most of the dimensional models: valence and arousal (Russell, 1980, Russell & Barrett, 1999). Valence corresponds to a pleasure/displeasure scale, whereas activation corresponds to a sleepiness/excitation scale. These scales define a circumplex space where it is possible to locate any 'folk-psychology' emotional term.

Other scales may be superposed on this basis, such as dominance/submissiveness (Mehrabian, 1996), which stands for the capacity of the participant to control the stimulus. In the same view, Scherer (2005) proposes two scales that are compatible with Russell's scheme: goal conduciveness, and coping potential. This allowed Scherer to locate more precisely eighty frequently used emotions categories (Figure 2).

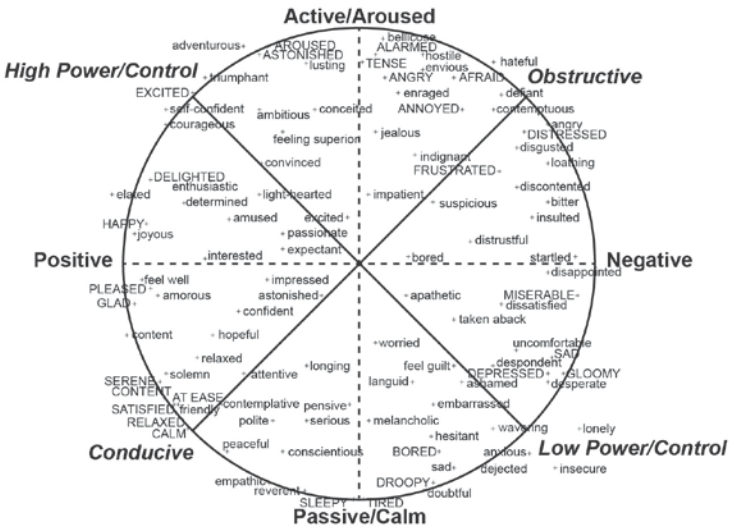

Figure 2: Alternative dimensional structures of the semantic space for emotions (Scherer, 2005)

A MODEL OF USER INTERFACE EMOTION

Russell ‘s analysis of the effects of emotions (Russell, 2003) allows us to point out relevant connections with the concern of interface user experience. Indeed, a positive valence improves attention and positive judgments (Sanna, 1998; Park & Banaji, 2000; Schwarz & Bless, 1991), whereas arousal influences cognitive performance (Humphreys & Revelle, 1984) and attention selectivity (Easterbrook, 1959; Eysenck, 1982). Combining a high arousal and valence gives a person a sense of optimism in choosing goals and plans. Other works also demonstrated how positive emotions could improve task efficiency and learning (Bonnardel, 2011, Bonnardel & Moscardini, 2012, D’Mello & Graesser, 2012, Davis, 2009).

Such conclusions lead to a justification of efforts towards a positive emotional interface design. Therefore, in order to favor positive emotions from the users, it appears first necessary to determine whether and how an interface design may influence activation and arousal of the users’ emotional response.

As stated above, the appraisal process resulting to the emotion is also fed by internal factors, such as user’s passed experience, cultural background, concern and involvement with the task. Thus, the interface design, resulting from designers’ work, is only one of the many variables eliciting end-users’ emotions.

Desmet (2003) proposed a four components “basic model of product emotions”: the emotion (1) results from an appraisal process (2), based on user’s concern (3), and product’s features (4). For Desmet (ibid.), user’s “concern” stands for the individually perceived utility, this perception being potentially affected by personality traits. Desmet adds that the product component is not always the direct stimulus of the emotion; the product may also elicit thoughts which are the actual stimuli. This view is in line with Norman’s proposal (2004), who distinguishes three emotional levels of the user affect with regard to a product: visceral, behavioral and reflective. The first visceral level is a direct gut feeling, whereas the two other levels are based upon the user’s consideration over the interaction (behavioral), or a more social/intellectual judgment (reflective).

Considering the specificities of interface design as a product, our study requires to sharpen the “product” component. Therefore, we propose another model that highlights some specificities of an interface as a product of design (Figure 3).

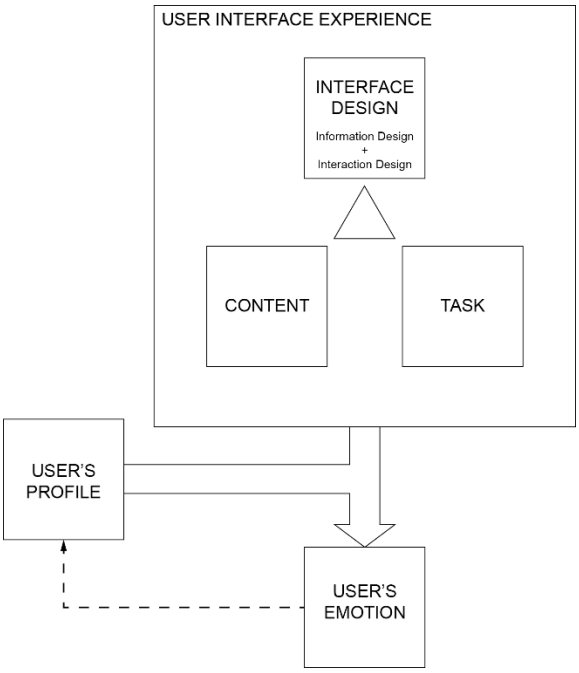

Figure 3: Model of user interface emotion

In this figure, the user's profile (internal) constitutes the baseline upon which the current interface (external) is appraised to give rise to emotions. In this view, this diagram matches the two internal/external components processed by the appraisal leading to emotions, as stated earlier. The diagram is also compatible with the "concern/product" dichotomy from Desmet's model.

Here, however, the "product" component is replaced by the label of "user interface experience". Two main considerations were taken into account for this change. First, the notion of "experience" refers to a continuous interaction with the product, implying ever-evolving changes of the system values. Second, our study focuses on "user interface". The specificities of a screen-based interactive product lead us to distinguish three specific components, each of them constituting stimuli eliciting user's emotions:

- The "content" stands for the information and data to be communicated to the users. It gathers textual elements (e.g. titles, articles), pictorial elements (e.g. photographs, illustrations, and diagrams), videos, music. Typically, content is created by redactors, whereas the interface is defined by designers.

- The "interface design" stands for the layout and presentation strategies of the content and the functionalities. We refer to "information design" for information display strategies, and to "interaction design" for ways users interact with the interface, including the embedded functions.

- The "task" refers to the purpose of the interface which has to be handled by any users (search, read, compare, calculate, organize…). Performing this task may induce an emotion.

These three items define the user interface experience, and are closely related.

- The "user's profile" refers to the specificities of the user, at the moment of the interaction. This item could potentially gather numerous inter-individual variables, such as cultural background, previous knowledge related to the content (brand, images, related articles…), to the interaction modes, user's personality, mood…

The user interface experience, considered as a global external stimulus is therefore assessed through the user's profile's internal scope, eliciting the emotion. This global process should be considered as continuous and iterative. The user's emotion contributes to the evaluation of the overall interface experience. It may affect the perceptions of the content, of the task, and slightly change the user's profile. Indeed, these changes constitute the designer's goals, aiming at influencing the users' actions and behaviors.

This model brings forward the relationships between the various components contributing to elicit the end-user's emotion. The interface design is a core component. Interwiews were performed with some interface designers in order to identify any interface design pattern to be assessed.

INTERFACE DESIGNERS' REPRESENTATIONS

Emotional design has become a crucial issue for interface designers. However, most of designers' practices are empirical. In contrast, our general objective is to find ways for analyzing and assessing end-users' emotions elicited by a specific interface design strategy. As a first step to identify those design strategies, a collective interview was performed with three product and interface designers of varied profiles (Table 1). The interview took place in a meeting room of the designers' studio, and lasted for two hours.

Table 1: Participants profiles for the interview.

Designer A	UX manager (3 years)	Product manager (8 years)	Education: engineering
Designer B	Mobile product designer (6 years)		Education: product design
Designer C	Graphic/Interface designer (4 years)		Education: graphic design

The interview was structured on an opened basis: a debate was set up between the designers about their strategies to pass trust, desire, and surprise through an interface. They were also asked to discuss any other emotion they considered relevant. The initial question to initiate the debate ways: "We are interested into the ways to pass an emotion through an interface. In your design methods, you may be aware of such an approach. These emotions would likely be positive. I selected three of them for instance: trust, desire -in the sense of teasing and attracting the user-, surprise. What would your strategies be?"

Several themes were expressed by the designers, from which the following synthesis is proposed:

Usability first

The ergonomic criteria (Bastien & Scapin, 1993), lead to the intuitiveness, the consistency and a good learnability. These qualities participate to the feeling of trust towards the application, and by extension, towards the brand. Ergonomic criteria are very important for the designers, various examples were evoked, involving consistency, compatibility, guidance, cognitive load, information structure and display, immediate feedback… Usability is also related to the notion of robustness (actual effectiveness and efficiency), completed by the notion of perceived robustness (related to the graphic design). Indeed, usability is not a strategy to convey emotion, it is rather a fundamental basis without which it is not possible to conceive any emotional interface.

Error handling

Following this view towards robustness, the specific context of error handling gives matter to illustrate the designers' considerations. The error message constitutes an occasion to initiate a dialog with the user, and consequently, to elicit user's emotions: "We try to explain to [the user] what is wrong, with 'human terms'. Then, we suggest a way to solve the problem. If we really can't, we apologize." This statement clearly emphasizes the designers' point of turning the human-machine interaction into a human-human interaction.

Identity

"The keyword is 'personalization' […]. We create a relationship because people do not completely trust machines yet". In order to build up such an interaction, replicating natural human behaviors, the visitor or customer should not be considered as an anonymous end-user, but as a real, identified, person. Various means are cited by the designers: personalized messages with user's name, behavioral habits, and geographical location. Used adequately, these strategies may improve trust towards the application.

As the end-user should be personalized, a strong identity should fit the application. The communication strategy

should match a strong and clear identity, based upon consistent choices of graphic design and editorial content: “Personally, I believe much more in a consistent and nice language style used on the whole application, something to be met again, like a ‘home spirit’ “. In certain circumstances, these choices lead to present the applications’ authors to the users, or to use a first-person formulation. The underlying option is to make the interface appear more human, less abstract: “They [the application authors] talk to you as a human being. They talk nicely, normally, with their gut.”

Targeted content

Following this view, some content, surprising at first sight, is sometimes used. The designers evoked Balsamiq, a wire-framing application. This application has a little function to display quick and easy cooking recipes. Of course, the user is surprised, but he is also considered as a human being, as a friend: the application author knows how tough is a work of wireframe for a designer, working late at night, without any time to eat. So he included a few simple video recipes from his wife in the application (figure 4).

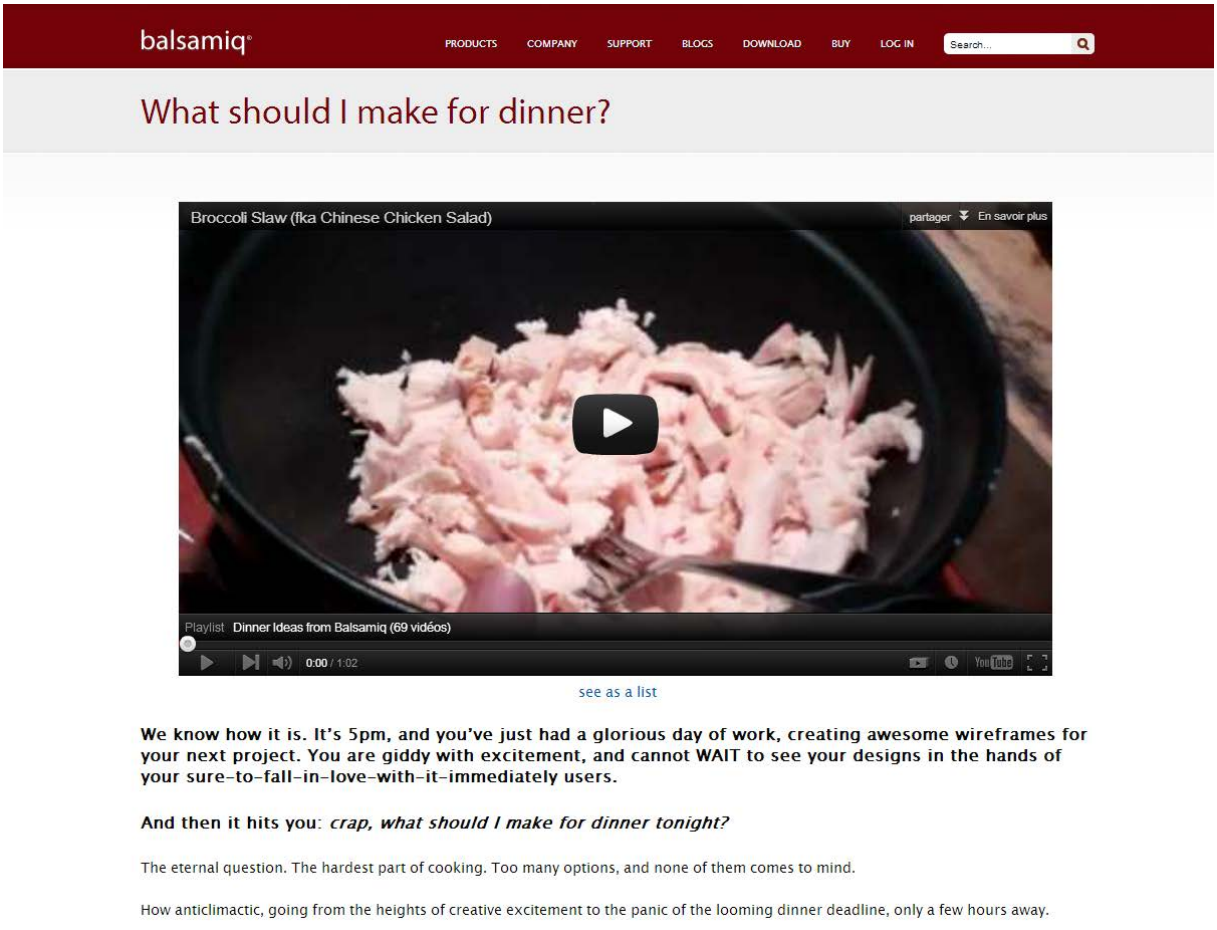

Figure 4: Balsamiq’s “What should I make for dinner” screen capture

Another example quoted by the designers is the short statement in the footer of the Vimeo’s website: “Made with love in New-York city.” (figure 5).

Figure 5: Vimeo footer capture

Vimeo is a website providing video streaming, turned towards artistic and high quality footage. This simple sentence conveys in fact rich values; the author of Vimeo become tangible humans, with feelings (love), and living in a specific city. They are passionate by their work, just like the targeted user is passionate by his/her video work. These

content-based strategies contribute to draw up a human identity to the interfaces, conveying inter-human social emotions, such as trust and sympathy.

Targeting the user

These last arguments evoked by the designers share a common background. In order to provide a strong identity of the application, and an according tone matching the end user's expectations, it is necessary to focus on a specific category of users. This point is consistent with our proposed model of user interface emotion (figure 3): the specific design features have to fit the specific users' traits. The designers therefore state that the more the interface is emotional, the more the audience has to be targeted: "the most important stage may be to understand who we are focusing on, to identify the triggers of this specific audience."

Gamification

The designers also evoke another way to elicit end-users' positive emotions based on playful interactions. One of these features is the notion of reward: the user may be congratulated after having accomplished certain actions, and therefore encouraged to keep on use (or discovery) the application. This trigger can also be strengthen using a dimension of "collection", e.g. the user will want to finish a 70% completion, or to win all the available badges. With this last example, the interaction comes closer to the "collect and reward" play style. It is also conceivable to introduce competition between users, by taking care to elude any counter-productive features. This constitutes a major emotional trigger for any user-content based applications, or any software in its appropriation phase.

Interface designers' representations: Conclusion

This collective interview brought forward several strategies of design. Beyond the essential usability quality of the interface, a global pattern seem to emerge: a machine designed as a human being to elicit end-users' positive emotions. Nevertheless, this approach might sound paradoxical, as the user is aware he/she uses a machine. A good balance should be weighted between a human/computer relationship on the one hand, and a human/human relationship on the other.

Following this view, we could formulate this hypothesis: the more the user feels the empathy of the author/designer, the more his/her experience is pleasant. According to this hypothesis, the following scheme present different thresholds which would likely influence the users'emotions (figure 6). This diagram was drawn on the basis of the hedonomic's pyramid (Hancock, Pepe & Murphy, 2005), derived from Maslow (1970).

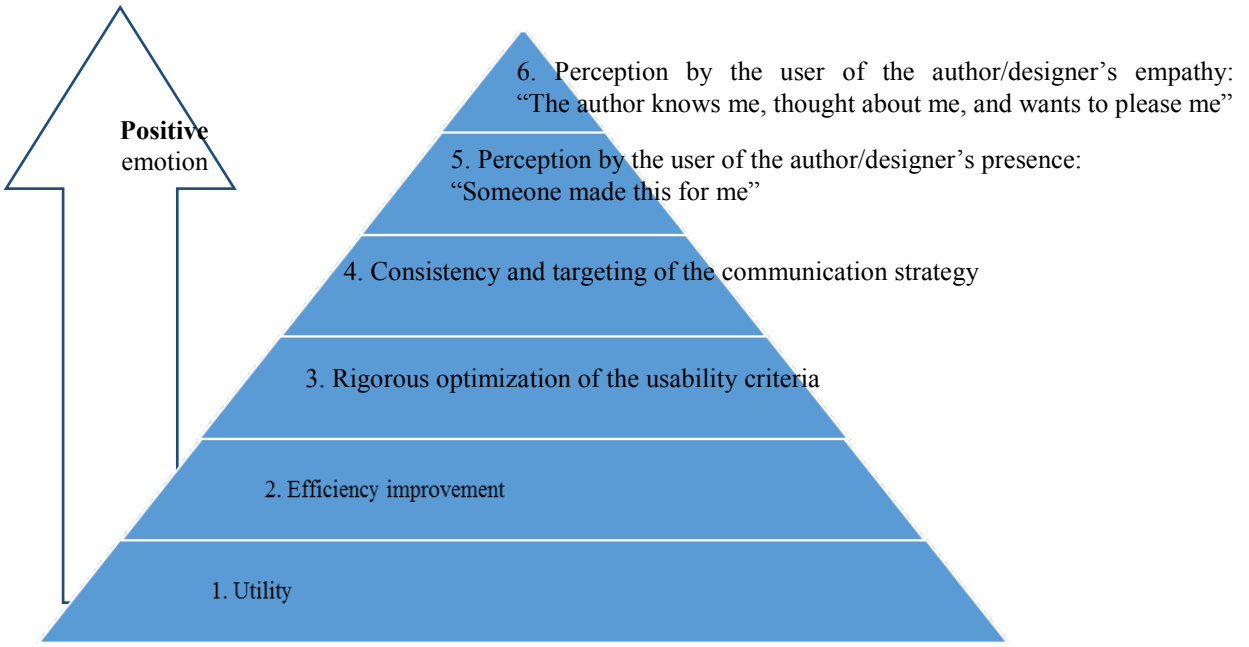

Figure 6: interface design's emotional thresholds

We notice that the highest the level of conception is, the more the underlying strategies need to focus a specific audience. Utility may answer most of the audience's needs, but the author's empathy might only fit a specific audience sensitivity. Therefore, emotional design would only be used for a limited audience, from the 4th level of the diagram.

At this stage, interviews with designers provided a set of features contributing to define some emotional design pattern. However, these design patterns are still empirical, and have not been assessed yet.

MEASURING INTERFACE USERS' EMOTIONS

In order to build an emotional interface assessment system, an experiment was set up in order to identify the best indicators of the users' feelings.

Objectives, participants and experimental conditions

Our first objective was to test the reliability of the chosen experimental setup to record the user's emotion during an interface usage episode. Then, our second objective was to test the sensitivity of this setup towards different interface design variations.

Eight participants, French native speakers, two males, six females, from 18 to 30 years old took part in the experiment. They were distributed randomly into two groups (see Figure 4). Three surveys were chosen in order to detect any exception or feature in the individual emotional baselines (Jolland, 2012). Brief Mood Introspection Scale (Mayer & Gaschke, 1983) has been widely used to assess participants' mood (Baumeister, Bratslavsky, Murayen & Tice, 1998, Halberstadt, Niedenthal, & Kushner, 1995, Kokkonen & Pulkkinen, 2001), and was therefore chosen for this study. The psychological well-being expression scale (Massé, Poulin, Dassa, Lamber, Bélair & Battaglini, 1998), is a four points Likert scale based on seventeen statements related to the user's emotional expressions during the last month. Stress was assessed by the Lafleur & Béliveau (1994) survey, composed of 109 items matching a large variety of psychic and physic stress symptoms. The users' results were successfully checked by a normal distribution analysis.

Objective #1: Testing the reliability of the emotional assessment system

To pursue this first objective, we provided users with twelve images with strong high/low or neutral valence. These images were issued from the GAPED (Geneva Affective PicturE Database, Dan-Glauser & Scherer, 2010), a set of 730 pictures, rated among valence and arousal and validated worldwide. We selected the four images with the highest, lowest, and closest to zero valence score were selected to constitute a set of twelve images for this experiment. User's emotions were recorded during and after each image.

We considered that measuring users' emotion requires to associate emotional states with at least cognitive and physical changes. These changes may be readable through three components: physiological, behavioral and cognitive (Gil, 2009).

Measuring the physiological component

Numerous studies have used physiological measurement and suggest that it constitutes a reliable method to assess users' emotional state. However, low arousal and long lasting stimuli such as user interaction are less present than stronger punctual stimuli. The galvanic skin response (GSR) is compatible with a continuous monitoring during the use experiment. It can also be considered as an objective measure over which the user has no control. The method that we proposed first relies on a monitoring of the variation of the skin conductance of the user, which indicates a change of activation. In the specific context of an interface usage, the stimuli are long lasting. Therefore, we considered all the falls (SCRs) detected during the stimulus exposure as being relevant. A rest period of 15 seconds was setup between each stimulus presentation. We recorded the mean skin resistance, the number of falls, and falls amplitude. There is no normative reference for GSR measurement, with very large inter-individual differences being reported. Therefore, we use the GSR score to compare the effect of different stimuli, at a different time on the same individuals.

Electrodermal activity was computed using Biopac AcqKnowledge 4.1. following the recommendations provided by

Braithwaite, Watson, Jones & Rowe (2013). However we decided not to reject any SCR of low amplitude considering the long lasting and low intensity stimuli.

Our results did not match our expectations, as nearly no skin conductance variation had been recorded during the exposure to the GEW pictures. We also observed this during the 'Objective #2' phase. In fact, we noticed that most of the detected SCRs were taking place outside of the stimuli periods. Most of these periods match a stronger activity of the participants: they work at answering questionnaires. Some other activity periods match waiting phases: these waiting screens were setup in order to obtain a baseline for the EDA recording of the following stimulus. Paradoxically, these periods were sometimes used by the participants to relax and stretch during the 40 minutes experiment.

These results mean that the provided task (watching a picture, reading a text, or both), generates much less activation than the task of answering questionnaires about emotions. This low activation impact of the provided pictures is consistent with the SAM questionnaire results (see cognitive component).

Therefore, we will not dismiss the GSR method for our next studies, as it may be relevant to measure the impact of the user experience generating activation, particularly the task component, and presumably the interaction design sub-component (figure 3).

Measuring the behavioral component

We also decided to analyze the behavioral component of users' emotions by analyzing changes on the user's face. This technic is inspired by the facial action coding system (FACS) (Ekman, 1970), analyzing 69 "action units" of face's muscles patterns, head orientation, and eyes gaze. Noldus' Facereader (Noldus, n.d) was developed in order to automate such analyses. The software performs a frame by frame analysis, and detects over 500 key points on the face. The resultant pattern is distributed among seven categories of emotion: neutral, happy, sad, angry, surprised, scared, and disgusted. The system was trained over 10000 manually annotated images. A valence score is calculated as the difference between the happiness score, and the highest negative emotion score. Face analysis provides a continuous monitoring. The measurement can be considered as objective with the limitation of the potential user's conscious control of his face.

FaceReader's results per image and participant (Figure 7) present a large dispersion. And more, no consistent pattern is distinguishable among participants, which could have explained a potential inter-individual difference. By calculating a mean per valence group (Figure 8), a slightly trend can be observed matching the expected results. However, the values are much less distinctive than the expected GAPED scores. Therefore, it seems difficult to use FaceReader in that context.

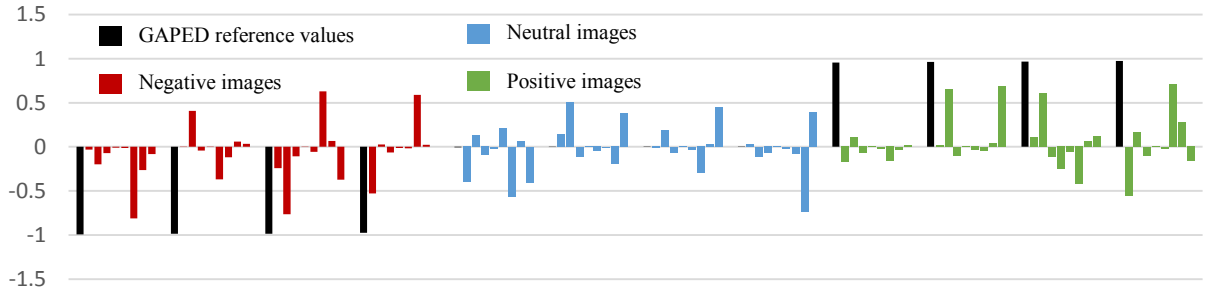

Figure 7: FaceReader's valence score per image and per participant

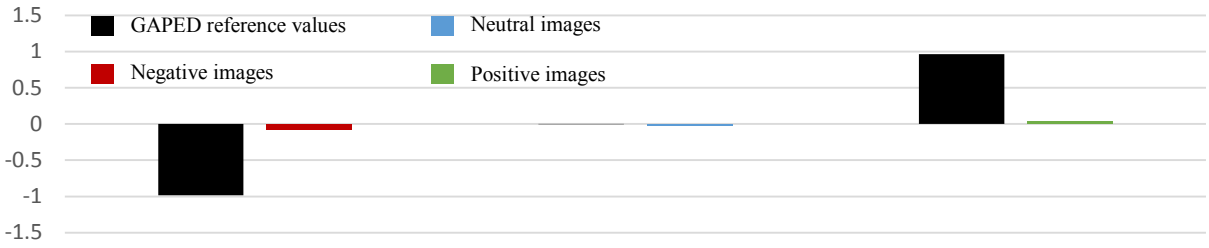

Figure 8: FaceReader's mean valence score per image group

The difficulties met with FaceReader should however be confirmed in further studies. A frame by frame manual monitoring in order to detect miss-leadings in the face identification should be added to the protocol, as it may happens with barbed users, and hands on face gestures. Otherwise, during later interviews, some users declared that they could have "laughed on the other side of their face", their reaction being more elicited by the succession of extreme images than by their actual content.

Measuring the cognitive component

Finally, in the method we proposed, we measured the cognitive component through two systems of questions. The first one is the Geneva emotion wheel (GEW), which was developed following Scherer's emotional model (figure.2). A set of twenty emotion labels are arranged in a circle. Each label can be rated according to its intensity using a five points scale, from the center of the circle to its periphery. A drawback of using a label-based system lies in the limitation of the provided set of terms. Moreover, Scherer added a free response area, where the user may choose a word which better fits his feeling. The user may also indicate that no emotion was felt.

Another drawback of label-based questionnaires lies in the necessary interpretation by the user of the label meaning. This may lead to different understandings of a same term among participants. Therefore, the second questionnaire we propose to use is the self-assessment manikin (SAM, Bradley & Lang, 1994). This questionnaire is composed of three scales, matching the three dimensions of the valence arousal dominance system. These scales make use of a pictures-based representation of emotional values. The questionnaire is therefore compatible with a wider range of population (children, participant of different languages or cultural background). Clickable screen versions of these two systems of questions were replicated for the purpose of the experiment.

The answers to the questionnaires are consistent with the emotional value of the GAPED images. The GEW clearly presents a split between negative emotions for negative images (in red), and positive emotions for positive images (in green) (figure 9). Moreover, neutral images are located at the center of the diagram. However, the neutral images slightly tends towards sadness and compassion. A consistent explanation would be that these images induce a low activation, as shown by the SAM questionnaire (figure 10), and in accordance with Scherer's model of emotion (Figure 2). All the activation levels are negative: the participants feel calm. The SAM is also clearly relevant for the valence level. However, the dominance measurements do not show any major distinctions. Although many studies dismiss this item from the SAM questionnaire, this result could be explained by the lack of interactions with the stimuli.

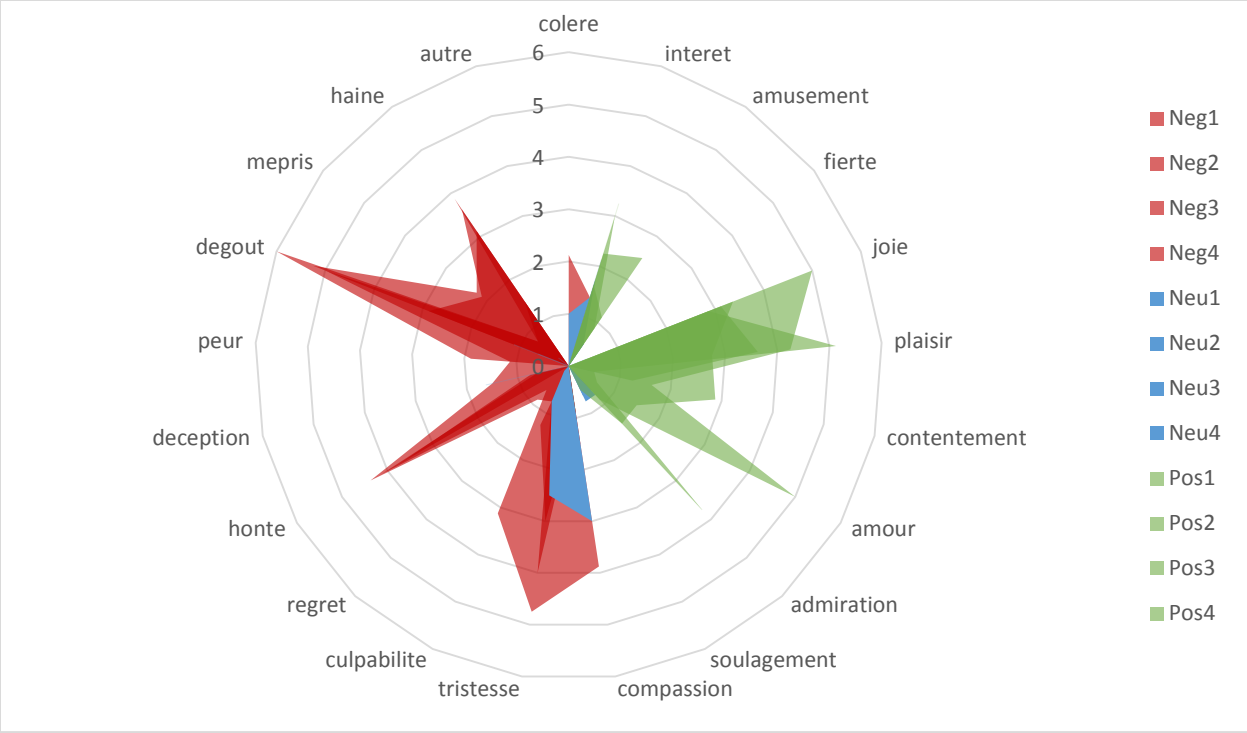

Figure 9: Participant's answers to the GEW questionnaire during the GAPED phase (means per image)

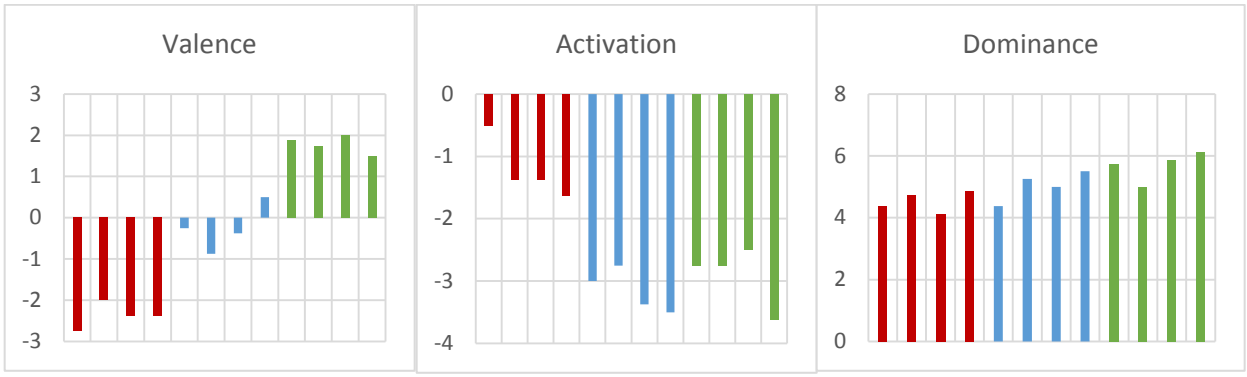

Figure 10: Participant's answers to the SAM questionnaire during the GAPED phase (means per image)

Therefore, these two questionnaires seem relevant and complementary to record subjective emotional feedbacks from users. However, the picture-based stimuli used in this section are presumably of higher arousal than an usual interface design, and these inferences should be handled carefully.

The 'Objective 1' phase of our experiment consisted of presenting GAPED pictures, whose valence score is known, to users in order to assess the efficiency of several emotional measurement methods. This phase presented the GEW and the SAM questionnaires as being relevant and complementary to express users' emotions. However, the Face Reader results were not satisfying. The GSR did not prove to be useful in the specific context of this experiment. Therefore, questionnaires only will be selected to pursue our second objective.

Objective #2: Testing the sensitivity of the emotional assessment system towards different interface design variations

To pursue the second objective, we wanted to measure the effect of the interface design alone, excluding the task's and content's effects (Figure 3). Content items alone were provided in a first stage, and gathered within an interface in a second stage. In the first stage, images and texts alone were therefore sequentially displayed. In the second stage, the users interacted with a four pages interface displaying the same content. During and after each item

display, user's emotions were recorded.

Thus, we assumed that the difference between the overall UX elicited emotion, and the content elicited emotion, stood for the interface design impact.

[UX emotion] x [User profile] = ([content emotion] + [interface design emotion] + [task emotion]) x [User profile]

[interface design emotion] = [UX emotion] - [content emotion]

We also considered that the task of watching and reading would similarly impact the results whether the content was provided individually or within an interface design.

However, it is not possible to successively provide a user with two different interface versions for a same content in order to compare the interface effect. The discovering impact of the first pass would necessarily bias the second pass' perception. Therefore, two different contents were provided and balanced among two groups : UX type A and UX type B. The content used for the interactive mockups was related to two movies: "Le Mépris" for the content type A, and "Mulholland Drive", for the content type B. Texts and images were retrieved over the Internet from royalty free sources. Movies were chosen as a support of emotional content to present consistent text and images on a multiple pages sequence. The content provided differs between the two movies. "Le Mépris" (1963) was less likely to be known by participants than "Mulholland Drive" (2001). The content structure also differs. The text chosen for "Le Mépris" present a more abstract thematic approach of the movie whereas the "Mulholland Drive" article is closer to a story. "Mulholland Drive" was also chosen because of the specific atmosphere of the content, and for the picture colors which could be associated to a vivid colors interface design. The type B interface differs from the type A by gathering the following features: a global layout composed in accordance with the golden section, a color background matching the colors of the picture, a picture with no margin, a centered title, with a larger font-size, an animated page transition, and a fading-color effect on the navigation bar buttons (figure 11).

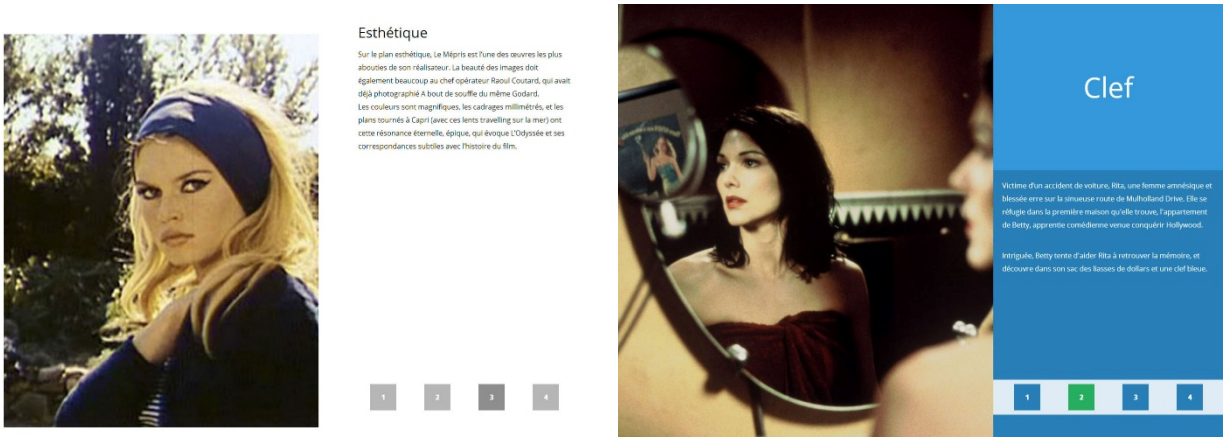

Figure 11: Screen captures of the pages (type A on the left, type B on the right)

Our objective is to determine whether the method we used is efficient enough to distinguish differences in the emotions possibly conveyed by two different interface designs. Following our earlier statement, the interface effect can be estimated as the difference between the overall experience effect, and the effect elicited by the content only.

The following diagrams present the effect produced by the content alone (blue and green), and the overall effect (red), for two different interfaces (type A and type B) (figure 12).

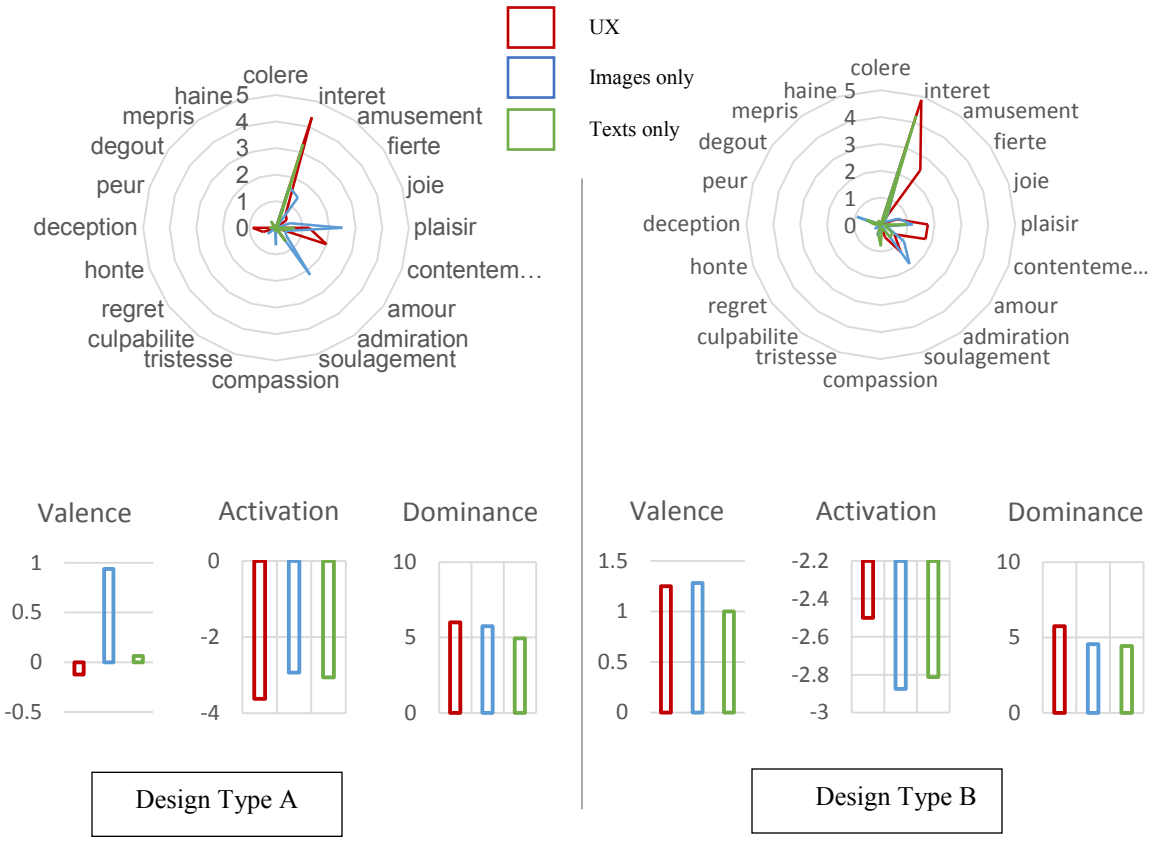

Figure 12: Participants' answers to the GEW & SAM questionnaires

In the following diagrams, we subtracted the content effect from the overall emotional effect, in order to distinguish the emotional effect of the user interface alone (figure 13). It is therefore possible to compare the emotional effect of the two types of design:

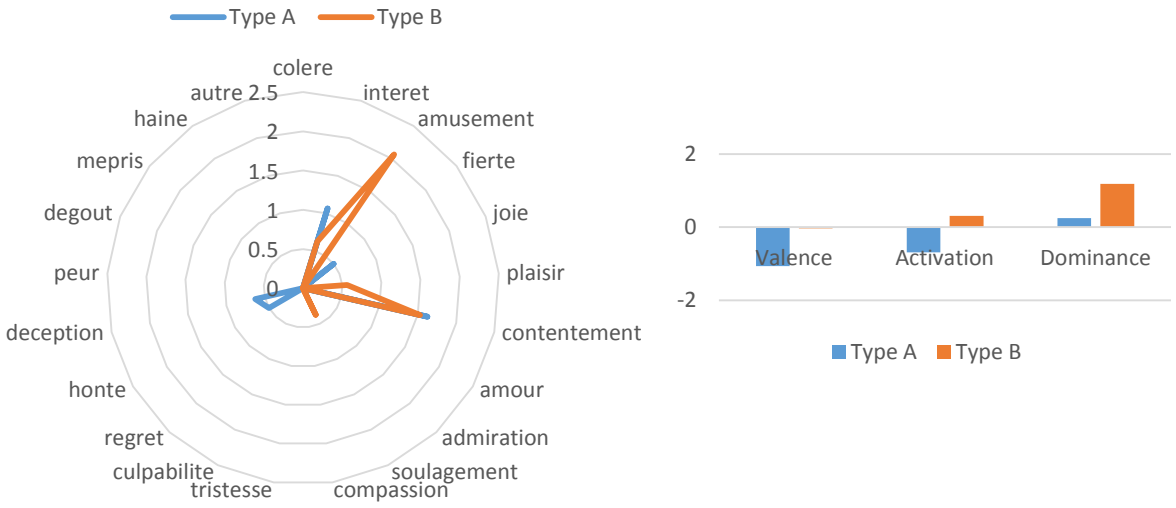

Figure 13: Comparison of emotions produced by two different interfaces

These results show that the type B interface is perceived as being more fun, and slightly more pleasurable than the type A interface. The two questionnaires lead to a similar interpretation on this point. Both interfaces elicit a similar level of contentment. The activation and dominance levels are higher with the type B interface.

These results are confirmed by the terms chosen by the users to describe their experience with the two interfaces during the short interview at the end of the experiment (table 2).

Table 2: Emotional terms used by the participants to describe the two interfaces

	User 1	**User 2**	**User 3**	**User 4**	**User 5**	**User 6**	**User 7**	**User 8**
Type A white		Neutral	Neutral	-		-		More tiring
Type B colorful golden section animation	More attractive, pleasant, friendly.	More friendly Too flashy Attacked	Nicer More positive	-	More implication, and interest. Motivating	-	Better Pleasurable	More attractive, much more pleasure

These results are consistent with previous studies. Interface color lead to a better attractiveness, and may influence cognitive performance (Bonnardel, Piolat & Le Bigot, 2011; Cyr, Head, & Larios, 2010). The higher activation and dominance levels of the type B interface could also be explained by its animation features.

Therefore, the GEW and SAM questionnaires seem to provide an accurate way of assessing the emotional impact of both the content and the overall experience. Moreover, the tested process of indirect measurement of the interface design effect lead to consistent results.

Measuring interface users' emotions: Conclusion

In this section, we tested several assessment methods considering the specificities of an interface design: a continuous and changing stimulus, eliciting low-intensity emotions. Moreover, we detailed a user interface emotion model, specifying the role of the design among other components. We proposed a method to measure the emotional effect of this specific component.

Our first results showed that some usual emotion assessment methods were not adapted to the specific context of an interface user experience. Face behavioral does not seem to be a reliable source. The analysis of the electrodermal activity did not provide any insights for our experimental mockups. However these results should be relativized as secondary results orientate its adequacy towards more developed interactions, and higher level tasks. On the other hand, SAM and GEW questionnaires, even if asynchronous and subjective, allowed us to distinguish the emotional effects of the two different interfaces.

These first results invite us to use an appropriate experimental setup, based on questionnaires and EDA, to evaluate specific strategies of interface design.

CONCLUSION

Emotional design has become a crucial issue for interface designers. However, most of designers' practices are empirical. Methods are required to better assess the emotional effect of an interface design. In a first section, this paper reported a collective interview of interface designers. A fundamental design baseline, the perception by the user of the author/designer's empathy, was identified as a global framework for interface emotional design.

In the second section, we tested several assessment methods considering the specificities of an interface design: a continuous and changing stimulus, eliciting low-intensity emotions. Moreover, we detailed a user interface emotion model, specifying the role of the design among other components. We proposed a method to measure the emotional effect of this specific component. Our first results showed that some usual emotion assessment methods were not adapted to the specific context of an interface user experience. On the other hand, SAM and GEW questionnaires, even if asynchronous and subjective, allowed us to distinguish the emotional effects of the two different interfaces.
These findings will supplement further works in order to specify an emotional assessment protocol fitting the interface design particularities. This method will then contribute to measure and compare the emotional effect of various interface design strategies.

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Description of Subjective Impression for the Service Experience

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ABSTRACT

The goal of the service activity is to give customers a positive impression on their experiences. Recently, the service quality is discussed in the context of the "user experience". But it should be noted that the quality of service experience is different from that of user experience for the product in terms of its intangibility, inseparability of production and consumption, heterogeneity and perishability as was proposed by Zeithaml et al. (1985). The important point of the discussions on the user experience that we can apply to the service experience is that the quality of experience should be analyzed and discussed not from the stance of the manufacturer (or the service-provider) but from that of the user (or the customer). In other words, designers and engineers cannot design the user experience per se but can only design "for" the user experience. Because of this fact, we should put more emphasis on the subjective aspects, i.e. affective and pleasurable aspects, of the service activity.

Keywords: user experience (UX), usability, experience engineering, service

INTRODUCTION

Since 1980s and especially in 1990s, the importance of usability has been recognized among stakeholders for the design of artifacts, especially ICT-related systems and products and such ISO Standards as ISO9241-11:1998 and ISO13407:1999 (now revised as ISO9241-210:2010) have been accepted by many industry people. Since then, the usability was regarded as one of the important quality characteristics of the systems and products.

But, in 1998, a new concept of UX (user experience) was proposed by Norman. He wrote "I invented the term because I thought human interface and usability were too narrow" (Merholz & Norman 2007). Since then, the concept of UX has gradually been used among industry people instead of the usability and now it replaced the position of usability as a holistic goal concept of the artifact design. A simple replacement of the concept of usability by that of UX is illogical considering the difference of connotations of both concepts.

Regarding the concept of the UX, Hassenzahl (2003) differentiated the pragmatic attributes and the hedonic attributes where the usability is regarded as a part of the former. The word "hedonic" was used because "functions and attributes it subsumes are strong potentials for pleasure – much stronger than pragmatic functions and attributes" and can be represented as "outstanding, impressive, exciting and interesting" (p.35). There are some others such as Jordan (esp. 2002), who put emphasis on the subjective aspect. Jordan proposed three-layered structure where the functionality is the base, then comes the usability and the pleasure at the top.

This article deals with the notion of experience in a wider scope than Hassenzahl and conducts the analysis of words that can be used to represent the experiencee and to evaluate its degree.

The Concept of Experience

The differentiation between the pragmatic attributes and the hedonic attributes are reasonable. But in this article, authors prefer to use the term "quality charcteristic". Hence the former is named as the objective quality characteristics and the latter as the subjective quality characteristics. One reason is that such characteristics as usability, reliability, and performance can be measured and can be represented as numeric values, thus can be regarded as objective. Anotherr reason is that the word hedonic is only referring positive aspects although subjective aspects will sometimes be positive but sometimes be negative. Hence authors adopted the term subjective quality characteristics as a generic term. These are drawn in Figure 1.

A fundamental question arises if these two characteristics are enough considering an artifact that has sufficient level of objective quality characteristics and subjective quality characteristics but has less or almost no meaning to the user. An extreme example could be the situation where iPhone was given to the blind people. iPhone itself has enough level of objective quality characteristics and subjective quality characteristics in general, but will be meaningless for blind people. Another example would be the iPhone given to a baby. Thus, we will have to consider about the match between the characteristics of the user and the context of use of the systems and products. Kurosu (2012) proposed the meaningfulness in addition to two attributes of Hassenzahl. Although the match to the user characteristics and the context of use will have to be considered to a certain degree with regard to the usability, the measure of usability is usually considered in terms of the “specified user” or the “intended user” (ISO13407). In other words, the system or the product is not necessarily usable to the whole variety of users in all kinds of situation.

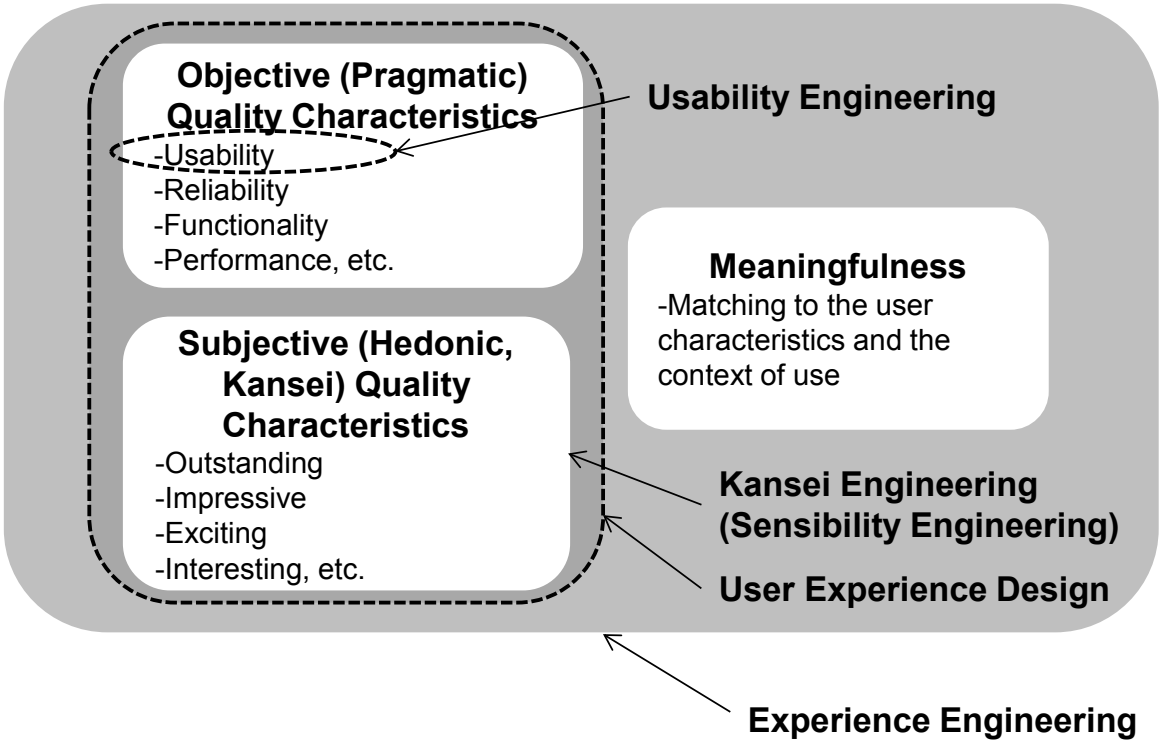

Figure 1 The meaningfulness as a third component of the experience in addition to the objective quality characteristics and the subjective quality characteristics

As can be seen in Figure 1, the traditional “usability engineering” has been dealing with the usability as one element of the objective quality characteristics. And the “user experience design” deals with both of the objective quality characteristics and the subjective quality characteristics. “Kansei engineering”, though not yet popular in Western

countries, is an academic domain that considers about the subjective quality characteristics (Nagamachi 1989). In addition to both groups of quality characteristics, there is the meaningfulness for the reason that was written in the previous paragraph.

The reason why there is the term “experience engineering” is that it is necessary to consider the service in addition to the system and the product and the recipients of service should not simply be called the user. For example, we don’t "use" the teacher at the school and don’t "use" doctors and nurses at the hospital but receive their service activities. Such services constitute other aspects of our experience in addition to the system and the product. Hence, the authors propose to use the simple word of “experience” instead of “user experience”.

Products/Systems and Services

Previous usability engineering has dealt with products/systems. The service was not considered because the usability was regarded much related to products/systems and not much related to services. But since the UX has been discussed as a target domain, the service was also included as the target domain because the experience that includes the expectation and the impression is quite important for the service. Zeithaml et al. (1985) argued that the service has such characteristics as intangibility, inseparability of production and consumption, heterogeneity and perishability.

This characteristics make the difference of the sequence of experience from that of products/systems. Figure 2 and 3 describes this difference in the course of processes in the industry and in the market. The process model in Figure 2 for products/systems includes the phases after the purchase (or obtaining). But the process model in Figure 3 does not include them because of the service characteristics of which Zeithaml et al. pointed out.

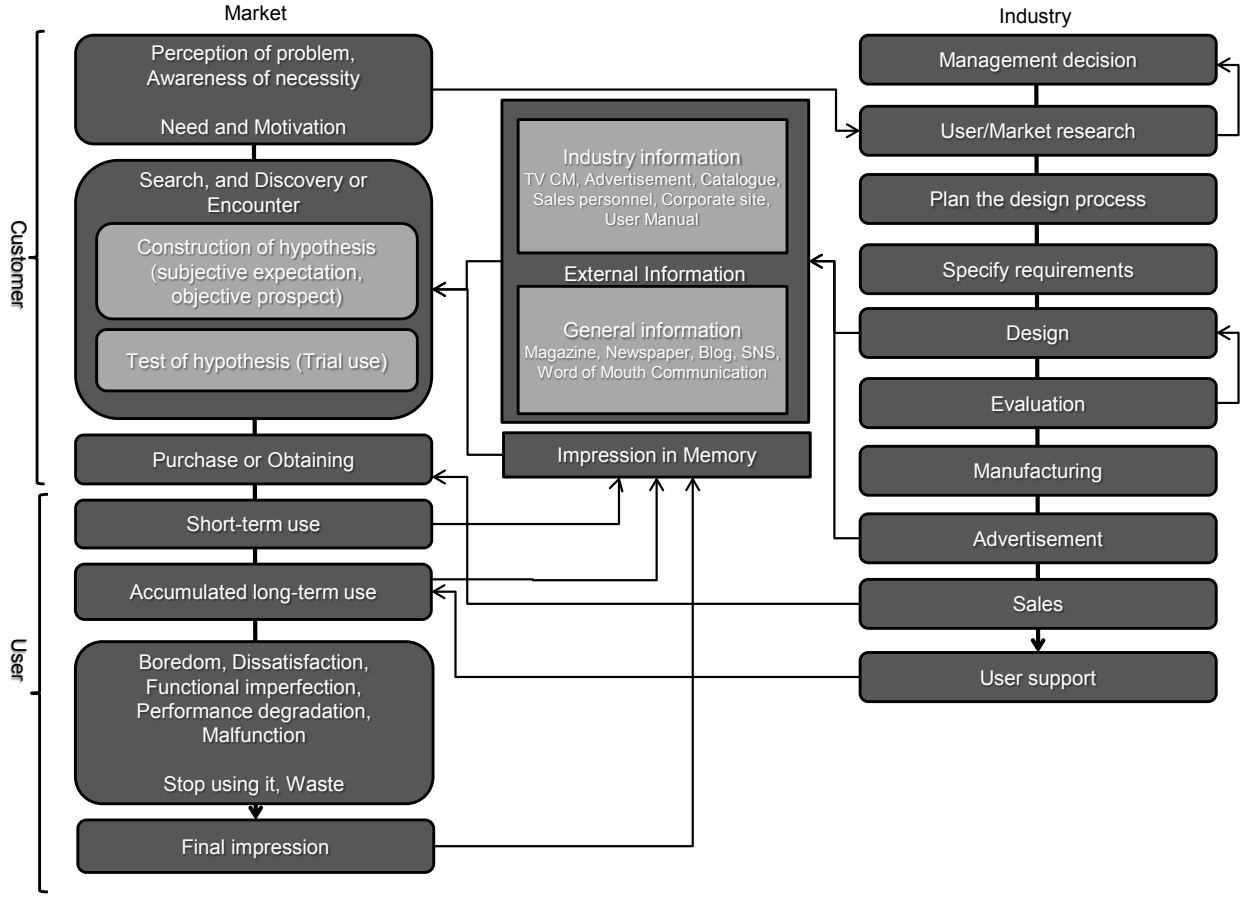

Figure 2. Process model on both of the industry side and the market side for products/systems

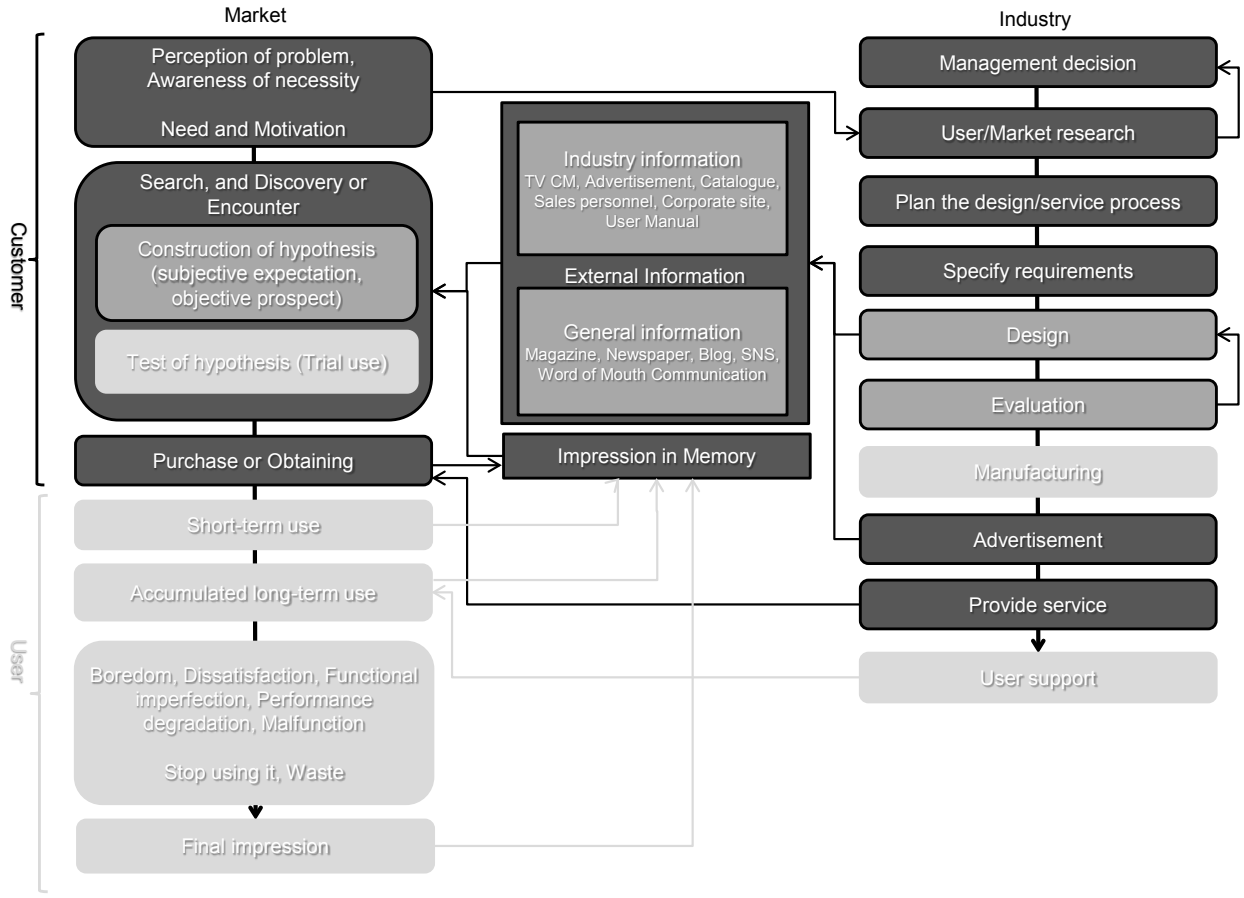

Figure 3. Process model on both of the industry side and the market side for services

The Classification of Experience and Its Description

The next question is how the experience can be described. Because the experience is quite subjective, it can not be objectively measured and represented as in the case of objective quality characteristics. The most popular approach to measure the subjective impression is to use the rating scale. And authors started to investigate the adequate words for the rating scale to measure the experience especially the adjectives and their noun forms. Kurosu & Hashizume (2011) analyzed various experiences and differentiated the goal-oriented behavior (GOB) where the achievement of the goal has the supreme importance and the process-oriented behavior (POB) where the process of approaching the goal is more important than the goal itself. They found that different words are used for describing different types of experience, i.e. GOB and POB. According to their findings, “satisfaction” and “delight” fit to the GOB and “joy” fits to the POB.

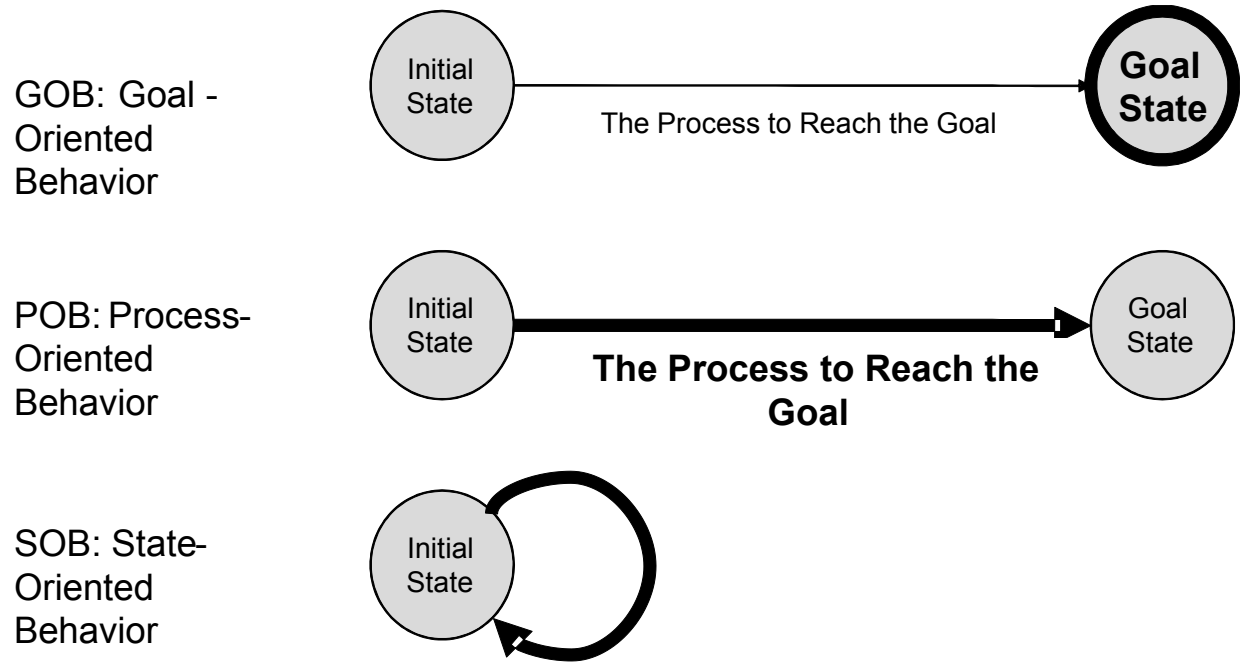

Figure 4. GOB, POB and SOB

The study of the descriptive words will have influences of language and culture. The language issue is the (slight) difference of the connotation of each word and the cultural issue is the difference among categorical structures of the words. But authors dared to translate the Japanese words that were used in their experiments into corresponding English words as much as possible.

Kansei that was used in Figure 1 is one example. “Aesthetics” used by Baumgarten and Kant was translated into Japanese about 150 years ago as “Bigaku (the science of beauty)” and “Kansei (nearly equal to the sensibility and ‘Sinnlichkeit’)” that are still used today in Japan.

Descriptive Words of Experience

Authors conducted a survey of which the goal was to differentiate and identify the Kansei or the subjective quality characteristics in Figure 1. It was because the objective quality characteristics can be described rather simply by one-to-one correspondence and the meaningfulness can also be described easily. The most difficult one among three attributes in Figure 1 is the description of subjective quality characteristics, or Kansei aspects.

Method

The survey was conducted by collecting descriptive words in the past references on Kansei. 604 words were collected that were used for the evaluation scale of Kansei from 9 references. Authors, as the specialists in Kansei engineering, adopted the KJ-method (Kawakita 1967) that is known as the affinity diagram method in English for classifying the words.

Result

The classification using the KJ-method brought 4 major categories of sensation, emotion, Kansei and behavior as Table 1. In this table, Kansei is interpreted as a projective process where the word “projective” is used in the same meaning of the projective methods of clinical psychology. Every descriptive word of Kansei seems to be the quality characteristics of the artifact, but actually they are the projected image or impression of the human being and are seemingly the quality characteristics of the artifact. A typical example is the dark cloud in the sky. Objectively, it is simply the dark cloud, but for those who have the anxiety it seems to predict some unhappy things to occur. That is the crucial point in terms of the mental process of Kansei.

Table 1. Classification of Descriptive Words of Kansei

Category	Notation	Definition	Examples
S:Sensation	S1	Simple sensory impresion	cold, sweet, warm, itchy
	S2	Complex sensory impression	well-balanced, harmonisch, peculiar, profound
	S3	Anticipation for the sensory impression	warm-looking, looks tasty, sounds like fun
E: Emotion	E	Emotion	sad, joyful, cheerful, foggy
C: Cognition (projection)	C1	Projective judgement	ambiguous, adult, brave, modern, exotic
	C2	Projective evaluation	pretty, lively, impressive, beautiful
B: Behavior	B	Anticipation of behavior	want to buy, want to own, want to try

Authors would like readers to consider about the issue of translation when viewing this table.

CONCLUSIONS

Now that the temporary set of descriptive words of Kansei was obtained, the next step is to check its validity of each words and the classification itself by conducting a large-scaled survey where participants will be asked to evaluate such experiences as follows containing both of the GOB and POB situations.

-I took a junk food at a dirty restaurant but it was unexpectedly tasty.
-I could succeed to draw a graph using MS Excel.
-The report could catch the deadline.
-I was playing a game with a bit higher difficulty.

The result will show how the subjective quality characteristics can and should be expressed verbally.

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Section 3

Pleasurable Design for Diverse Users in Asia

The Elderly's Text Entry on Smart Phones and Tablets: Challenges and Implications

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ABSTRACT

This study aimed to investigate the elderly's text entry experience on smart phones and tablets. An experiment was designed and conducted. During the experiment, 32 elders entered Chinese characters when using four applications (i.e., Contact, Microblog, Google Search, and Email) on four devices (i.e. Apple iPod Touch, Dell Streak, Samsung Galaxy Tab, and Apple iPad). They used two input methods (i.e. handwriting and typing) to enter text. The results indicated that although text entry on smart phones and tablets could avoid certain problems with feature phones (e.g. multi-tap), it also caused new problems for the elderly. They made 13 types of errors. The number and outcome of each error was recorded. This made it possible to check which error happen frequently but is easy to recover from, and which error seldom happen but is difficult to recover from. Based on the analysis of text entry errors, design suggestions were provided to improve the elderly's text entry experience.

Keywords: Text Entry, The Elderly, Smart Phones, Tablets, Errors

INTRODUCTION

In daily life, the elderly have many difficulties due to age-related decline in physical abilities and cognitive abilities, but limited social resources could not guarantee that all the elderly people are well supported. This problem could be alleviated by using technical devices, so using technology to support the elderly draws more and more attention. Recent years, many countries such as United States, United Kingdom, Germany, Spain, Italy, Switzerland and Canada provide sizable funding for research on using technical devices to support independent living of the elderly (GPII, 2011; OASIS, 2008).

Among various technical devices, smart phones and tablets have the prospect of wide application for two reasons. First, they serve as a platform that integrates abundant applications and services, which could be useful for the independent living of the elderly. Second, they are replacing feature phones and taking more market share. For example, in United States, smart phones already represent 56% of mobile phone use (Orlov, 2013). Although they are popular among young adults (66% of young adults ages 18-29 own smart phones), only 11% of the elderly (ages 65 and above) have smart phones (Lee, 2012).

Due to increased exposure, some elders begin to use applications on smart phones such as Photo Album under social influence, but most of them are still reluctant to use applications that need heavy text entry. Text entry used to be the

most challenging task on the limited display of feature phones, but it is not necessarily so difficult on smart phones and tablets. Due to new interaction technologies (e.g. direct gesture input on touch screens), smart phones and tablets could offer a brand new user experience.

However, smart phones and tablets might also cause new problems because they generally do not target the elderly and the interface is not tailored to the elderly's requirements. Therefore, this study aimed to investigate the elderly's text entry experience on smart phones and tablets, with the focus on difficulties that the elderly would have with this new user experience.

LITERATURE REVIEW

It is well documented that the elderly had great difficulties with text entry on feature phones. They usually failed to press the target key among compressed keys (Zhou et al., 2012). Besides, they could not understand the association between a key and its multiple labels. Therefore, they were confused about the changes of labels (Massimi et al 2007; Tuomainen and Haapanen, 2003), which resulted in their difficulty in using multi-tap to activate grouped letters on a key (Kurniawan, 2008). Furthermore, they had difficulty in distinguishing the short press and the long press (Kang and Yoon, 2008). These problems are applicable to feature phones with/without touch screens.

For feature phones equipped with touch screens, the elderly usually used a stylus to enter text. Since the stylus tip is smaller than the fingertip, the problems with compressed keys could be alleviated. However, the stylus-based interaction also caused a new problem: the elderly applied too much pressure using a stylus and resulted in redundant entry, or they applied too little pressure using a stylus and had to press a key again and again (Wright et al., 2000; Zhou et al., 2012).

Few studies investigated the elderly's text entry on smart phones and tablets. Our previous study (Zhou et al., in press) covered this topic, but we only gave brief introduction about the elderly's errors and did not dig into each error. Therefore, in this study, we will elaborate each error and discuss its implications for interface design.

METHODOLOGY

An experiment was conducted in the standard usability-testing laboratory in Tsinghua University. Recruiting flyers were distributed in Senior College of Tsinghua University. 32 elders (Mean age=67.2; SD=5.53; Range=60-79; 25 females, seven males) who were above 60 and used mobile phones participated in this experiment. Most of them did not own smart mobile phones but all of them were computer users. They were well educated (87.5% of them were at the college level and above).

Each participant used four devices: Apple iPod Touch (3.5″, 480×320 pixel resolution, iOS), Dell Streak (5″, 800×480 pixel resolution, Android), Samsung Galaxy Tab (7″, 1024×600 pixel resolution, Android), and Apple iPad (9.7″, 1024×768 pixel resolution, iOS). On each device, they used four applications: iOS's own and Android's own contact function and email function, Sina Microblog (China's version of Twitter), and Google Search widget/application (shown in Figure 1). Participants completed four tasks used in the experiment (listed as follows).

Each participant used either handwriting or typing to enter text. Each task had two trials and text in each trail contained Chinese characters, numbers, and punctuation marks. Task 1 contained three characters and 11 numbers, and the other three tasks contained nine characters and one punctuation mark. In order to make participants focus on the text input process and balance interaction steps in four applications, all the tasks only contained three steps: touch the new button (or enter text in the first input field), enter text in the only input field (or enter text in the second input field), and touch the save/send/search button. Other interaction steps were completed by the facilitator or participants, and the performance of other interaction steps was not counted.

The entire operation process was recorded through two cameras. The first camera was mounted with a tripod which was at the upper right side of participants, and the second camera was mounted with a lamp on the desk which was directly above the display. To avoid blocking the view, participants' hands were restricted in the area marked with a black mat and Scotch tapes (shown in Figure 2).

Task 1: Create a new entry in the contact function.

Task 2: Post a message in New-wave Micro blog

Task 3: Search keywords in Google Search

Task 4: Send an email to the predefined contacts

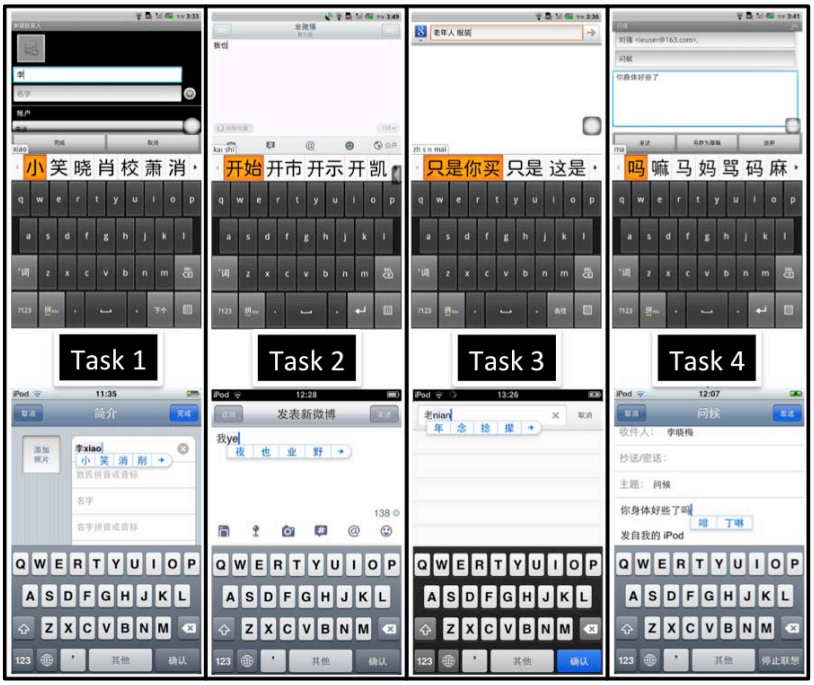

Figure 1. Screen shots of text entry in four tasks

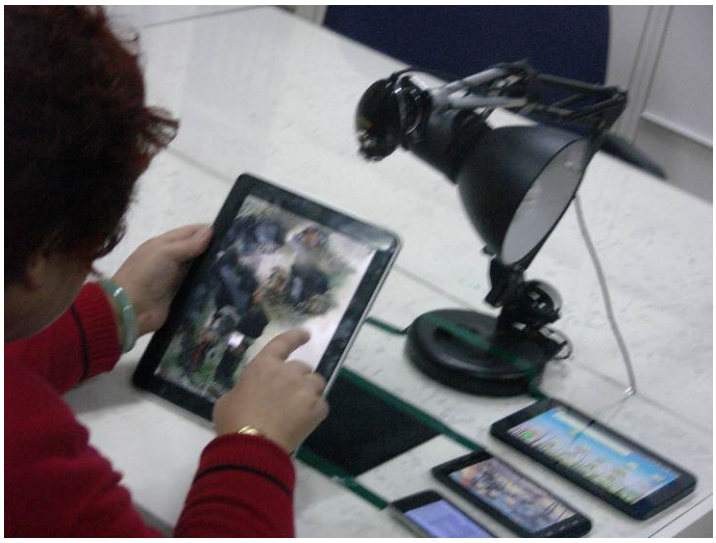

Figure 2. The experimental scene

In the practice phase, participants first watched a demonstration of each task, and then they practiced until they verbally indicated that they were ready to do tasks without the help from the facilitator. In the formal experiment, when difficulties happened, participants were encouraged to solve the problem independently. Some of them worked out the problem successfully; some failed to work it out and skipped to the next trail; others failed to work it out and asked for help. The facilitator will not help participants until they tried but failed to work out the problem.

RESULTS AND DISCUSSION

This paper analyzed errors during text entry by video playback. Each participant had two videos and the each video lasted about one hour. It took the researchers around 300 hours to analyze the videos. The analysis process had two stages:

Stage One: Developing a framework of errors. The researchers first wrote down all the types of errors mentioned in previous studies, and then went through all the videos to add or modify types of errors. The researchers watched video playback of 32 participants and recorded 26 kinds of errors, which were further grouped into 13 types of errors. This stage was only the qualitative analysis of errors, which meant that the numbers of errors were not counted.

Stage Two: Counting the number of errors and tracking the outcome of each error. The researcher first watched the videos shot from the upper right side of participants to count the number of errors, and then the researcher watched the videos shot directly above the display in order to double check the number of errors. The researcher slowed down videos to count the number of errors, and some clips were repeatedly played back if necessary. Apart from the number of errors, the outcome of each error was also recorded. As shown in Figure 3, each time an error happened, the researcher recorded three outcome through marks and abbreviations: the check mark (worked out the problem independently), help (asked for help), over (quitted this trial).

Two frequently happened errors were not recorded in this study: touching the adjacent keys of the target key during typing and wrong sequence of stokes during handwriting. The first error happened too frequently to count on small displays, and the second error was related to the recognition algorithm, which was beyond the topic of this study.

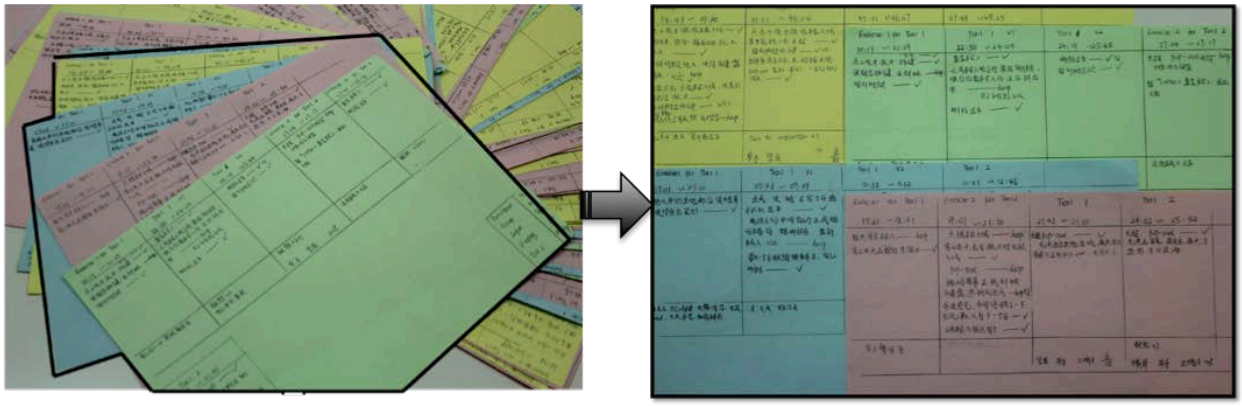

Figure 3. Error recording table

There were 13 types of errors identified. As shown in Figure 4, errors were categorized by two dimensions: the number of errors and the percentage of unsolved errors. Some errors happened frequently but were easy to work out (e.g. errors caused by wrong pressure), and some errors did not happen frequently but were difficult to work out (e.g. misuse of the complete button). The following section provides detailed description of typical errors and corresponding design suggestions.

Misuse of the Complete Button

86.7% of participants who used typing and 83.3% of participants who used handwriting could not work out this type of errors independently. When using the complete button, some participants pressed the complete button after each step (see Figure 5); Other participants perceived that pressing the complete button should be the last step, so they did not understand why they need to press other buttons (e.g. the send button) after pressing the complete button (see Figure 6).

The logical relations between pressing the complete button and other interaction steps should be clear. The location of the complete button, the distance between the complete button and the input field, and the flow of interaction steps might influence the elderly's anticipation of the logical relations.

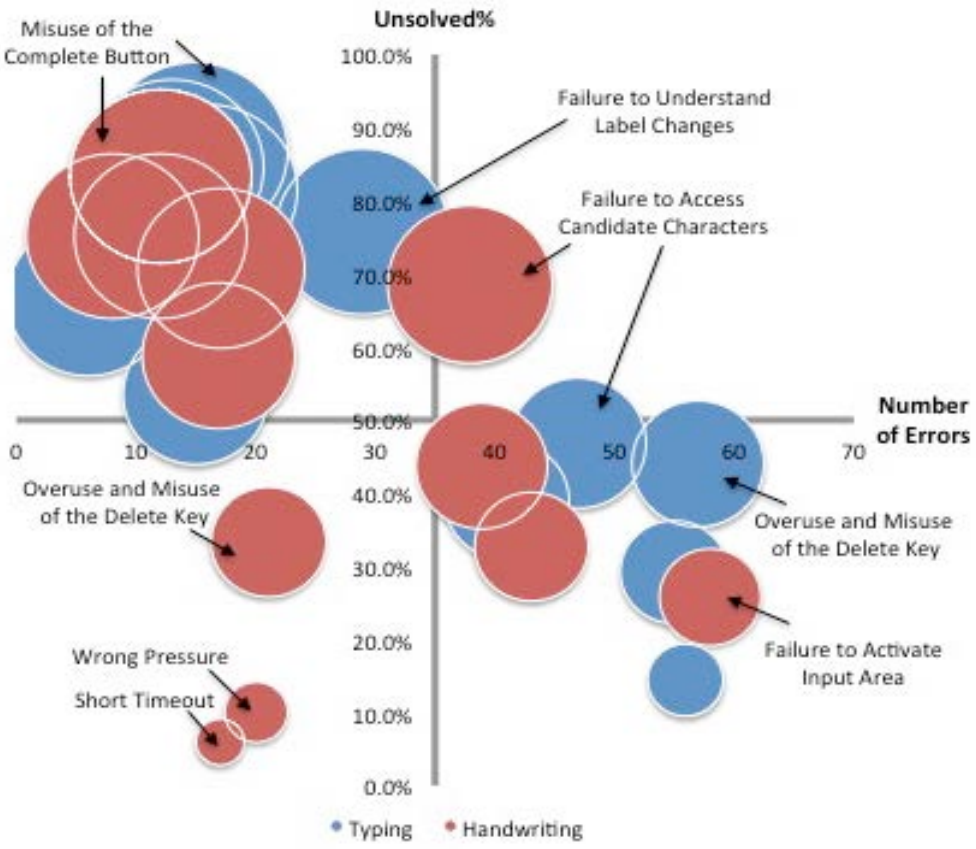

Figure 4. Bubble Chart of Errors

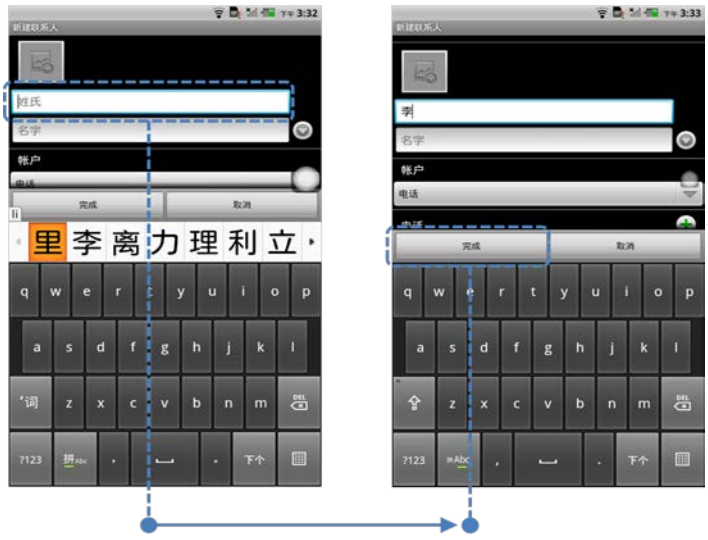

Figure 5. Pressing the complete button after each step

Figure 6. Pressing the complete button is not the last step

Failure to Understand Label Changes

75.9% of participants who used typing and 83.3% of participants who used handwriting could not work out this type of errors independently. They could not understand the changes in multiple labels associated with a button, which is consistent with previous studies (Massimi et al 2007; Tuomainen and Haapanen, 2003). Also, they did not know how to switch among letters, symbols, and digits, and to switch between English and Chinese, which is also consistent with previous studies (Li and Graf, 2007; Massimi et al 2007). In particular, for the elderly without computer experience, they do not know how many labels were there, and they did not know which would be next forthcoming label. For example, the elderly could not press the "Search" key until they pressed the "Stop Prediction" (shown in Figure 7). However, label changes of soft keys are common in handheld devices: the soft key to switch input methods, the soft key to switch between alphabet and symbols, and the soft key to switch keyboard layout (QWERTY keyboard, 12-key keyboard, digits keyboard). The consistency of labels should be noted.

Figure 7. Changing labels of a soft key

Overuse and Misuse of the Delete Key

43.9% of participants who used typing and 33.3% of participants who used handwriting could not work out this type of errors independently. Participants either pressed the return key to delete wrong letters, or they deleted more letters than needed. One possible reason is that they did not notice the small area of entered English letters (shown in Figure 8). Instead, they just used a trial-and-error strategy to press the delete key while they looked at the area of candidate characters.

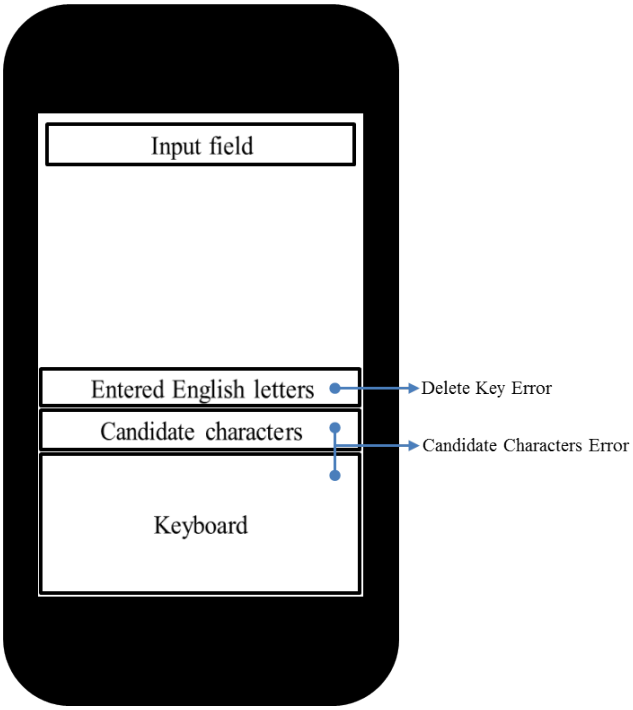

Figure 8. Typing errors associated with four input areas

Failure to Access Candidate Characters

46.8% of participants who used typing and 68.4% of participants who used handwriting could not work out this type of errors independently. They had problems with browsing, choosing, and confirming candidate characters. Participants made errors when they accessed more candidate characters and returned back. They accidently touch the keyboards and resulted in errors when they chose candidates characters near the keyboard (shown in Figure 8). They did not know how to make the candidate characters go to the input fields and they were not sure if they need to tap the candidate characters.

Accident Activation of Pop Outs

39.0% of participants who used typing and 43.6% of participants who used handwriting could not work out this type of errors independently. There are two kinds of pop outs. One kind of pop outs that won't disappear automatically, and participants usually touched the screen arbitrarily but usually did not know how to make it disappear. Another kind of pop outs disappears automatically (e.g. the magnifier, copy and paste in iOS), and most participants would just ignore them. During typing, participants usually had long press or used slide instead of tap, which resulted in pop-out options. One possible reason might be that the elderly had difficulty with distinguishing short press and long press (Kang and Yoon, 2008).

Failure to Activate Input Area

29.1% of participants who used typing and 25.9% of participants who used handwriting could not work out this type of errors independently. During typing, participants usually looked at the screen without keyboard and did not know where to start. They did not know the need to tap input fields to access on-screen keyboards. This is supported by Dickinson et al. (2005). After they knew the need of activation, they tapped many times to activate input fields, and they usually kept tapping without realizing that the input field was already active. Apparently, highlighting the input field is not enough, and more apparent feedback for input field activation is needed.

Misunderstanding of In-Field/Adjacent Labels and Separators

84.6% of participants who used typing and 75.0% of participants who used handwriting could not work out this type of errors independently. Participants did not understand in-field labels or in-field separators. They did not know that in-field labels or in-field separators would automatically disappear as soon as they started typing. They repeatedly pressed the delete key to get rid of in-field labels or in-field separators but failed. Then, they pressed buttons adjacent to the in-field labels or in-field separators by mistake (shown in Figure 9). Features that automatically appear or disappear should be carefully used.

Figure 9. In-field labels and in-field separators

Failure to Switch Input Fields

53.3% of participants who used typing and 70.6% of participants who used handwriting could not work out this type of errors independently. During handwriting, participants did not realize the need to switch input fields and entered text in one place. Even after they understood this need, they did not know how to switch to the next input field. One way of switching input filed is to scroll, but participants failed at the start point and the end point of scrolling. They usually started scrolling from the on-screen keyboard, which made the screen fail to move. Besides, they usually did not notice that the display was already at the end and kept scrolling. Another way of switching input field is to press the next step button. Participants confused scrolling with the next step button.

Wrong Handwriting Area and Short Timeout

The two types of errors are specific to handwriting. 32.6% of participants could not work out wrong handwriting errors independently. Participants seemed to not understand the need to write inside the handwriting area and wrote in the blank area outside the handwriting area (shown in Figure 10). Also, they often wrote multiple characters at a time. Beside, their hands or fingers sometimes accidentally touch the handwriting area and resulted in additional strokes. 5.9% of participants could not work out short timeout errors independently. Participants did not finish writing one character but the system recognized the input as the next character.

Accident Touch on Unrelated Area

81.3% of participants who used typing and 58.8% of participants who used handwriting could not work out this type of errors independently. Participants accidently touched areas (e.g. the home button) that are not needed by the tasks. They usually complained that touch screen were too sensitive.

Wrong Pressure

14.3% of participants who used typing and 10.0% of participants who used handwriting could not work out this type of errors independently. Participants applied insufficient or excessive pressure to press a button. Their problems with wrong pressure were consistent with findings of previous studies (Massimi et al 2007; Wright et al 2000).

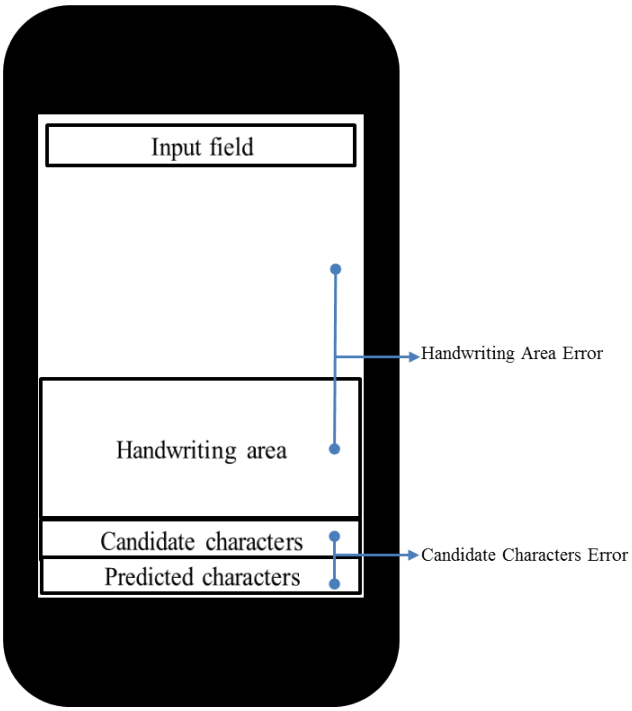

Figure 10. Handwriting errors associated with four input areas

CONCLUSIONS

This study investigated the elderly's text entry challenges on smart phones and tablets. Participants made 13 types of errors. One branch of errors happed frequently but was easy to work out. Typical examples include errors associated with wrong pressure and short timeout. Most of these errors were related to the elderly's declined motor skills.

Another branch of errors did not happened frequently, but once happened, few participants could work out independently. Typical examples include the errors associated with the complete button, overuse and misuse of the delete key. Most of these errors were caused by the mismatch between the elderly's mental model and the designers' mental model. The elderly tended to expect smart phones and tablets respond in the way that is consistent with their habits in the real world, or in the way that is consistent with their previous experience with feature phones and desktop computers.

Therefore, this study discussed deficits of current interface design and proposed possible solutions to match the elderly's mental model. Results of this study will help practitioners have a comprehensive understanding of the elderly's text entry difficulties with smart phones and tablets. Furthermore, this study discussed the cognitive process underlying these text entry errors, which may help practitioners have in-depth understanding of the elderly's mental models and come up with corresponding design modifications. To conclude, this study could help improve the elderly's text entry experience on touch screens, which might influence their intention to use smart phones and tablets in the future.

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Should Internet of Things Be Human-like? Exploring Social Media Users' Acceptance on Anthropomorphic Internet of Things

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ABSTRACT

This study examined how anthropomorphism of the Internet of Things (IoT) influences users' accepting IoT services. The objective was to explore uses' mental model of IoT, and develop an IoT mental model compatible with users'. A laboratory experiment was conducted with 36 college students. The independent variables were hierarchy of things (non-hierarchy, location-based hierarchy, function-based hierarchy) and level of anthropomorphism (no anthropomorphism, language anthropomorphism only, language and appearance anthropomorphism). Users' ratings on acceptance, trust, and satisfaction were measured after interacting with IoT systems with different characteristics of anthropomorphism. Results indicated that uses' mental model was more compatible with the one involving anthropomorphism of language than appearance. Compared with non-hierarchical structure, users' mental model was more compatible with structure with hierarchy, and no significant difference between functional and locational hierarchy was observed.

Keywords: The Internet of Things, Anthropomorphism, Hierarchy, Acceptance.

INTRODUCTION

The Internet of Things (IoT), first proposed in 1999 by MIT Auto-ID Labs, aims at connecting pervasive smart objects in an internet-like structure so as to interact with each other. More and more IoT services are becoming available for individual use, such as smart home service, healthcare for children and older adults, etc. Currently most IoT practitioners are utilizing the interaction paradigm of GUI (Graphical User Interface). The so-called WIMP (Windows, Icons, Menus and Pointer) metaphor has been the most dominant interaction model that users have been familiar with for long. In addition, as the trend towards computing into the real world, new interaction techniques (e.g., tangible user interface, ubiquitous computing) are becoming increasingly popular in technological products. For example, Siri on iPhone 4S is a noteworthy and successful product by enabling users "talk" to their cell phones and "issue" orders. Moreover, high intelligent social robots and agents interact with people in a natural way with the help of ubiquitous computing. These new techniques enable a new interaction paradigm: anthropomorphic interaction paradigm. By borrowing ideas of social media and human-like characteristics, anthropomorphic IoT can

augment and enrich the physical world with social network services. While at the same time, home devices within the anthropomorphic interaction paradigm tend to become "friends" that are more human-like, engaging, approachable, and understandable to the users.

Anthropomorphic interaction paradigm helps users understand the relationship with large amount of things in ubiquitous contexts, based on their general social experience. But it may also be balanced by its negatives. For example, anthropomorphic user interface are regarded by some researchers as less efficient and reliable than the traditional GUI paradigm. On one hand, current techniques such as speech recognition, natural language processing fall short of human assistant (Catrambone, Stasko, & Xiao, 2002). On the other hand, users might have not been ready to interact with their familiar environment through new ways like talking or sending messages. It is also questionable whether the users accept the way that home devices behave like human or not. Thus it is essential to carefully study the trade-offs between traditional and novel interaction paradigms when introducing anthropomorphism into IoT.

Another issue of the anthropomorphic interaction paradigm is re-understanding of human-thing relationship. Since user mental model towards things and their relationship with things decide their attitudes towards anthropomorphic IoT technologies, it is worth studying user perception of hierarchy of things, that is, how user treat different things and group things together.

This study addresses how IoT mental model could be designed to stay consistent with user mental model. Two factors influencing the IoT mental model are examined: hierarchy of things and level of anthropomorphism. We are interested in how the two factors would shape user mental model of IoT, and would affect user acceptance on anthropomorphic IoT. Although researchers have realized the influence of users' perception of things and how things present and perform in IoT smart systems, very few studies have been conducted to investigate these factors and no convincing explanations have been made. Only by recognizing and considering users' perception and mental model towards IoT and anthropomorphic features can all stakeholders of related areas fully benefit from IoT technologies. The additional value of this study lies in the insights it provided for practitioners of IoT services.

THEORETICAL BACKGROUND

HCI Interaction Paradigm on Internet of Things

GUI-based interaction paradigm is currently used in existing IoT system, through which users directly manipulate things with GUI elements. GUI-based paradigm corresponds to users' long-term formed mental model of interaction with things. GUI-based systems react towards operations immediately, and automatically normalize all actions. This kind of visible manipulation mode fits users' past experience very much, and supports users' more complex tasks and functions as well, especially in complex interfaces. However, when organization of things are getting complex, a group of discrete GUI interfaces require many rotations, various background knowledge and more physical workload when executing (Zhang, Rau, & Salvendy, 2009).

Another IoT interaction paradigm—social-based interaction paradigm comes from anthropomorphic IoT. In this paradigm, personalized things performed as human beings in a social-network-like system. Breslin et al. (Breslin & Decker, 2007) proposed that future social network on Internet will consist of both human and objects, and people will be connected via items of interest related to their jobs, workplaces, and hobbies. Kamilaris et al. (Kamilaris & Pitsillides, 2010) recently proposed interaction with smart home using Facebook and evaluated the technology feasibility. Guinard et al. (Guinard, Fischer, & Trifa, 2010) proposed a platform to share devices with other people in existing social network.

Problems come out as well when integrating social network and IoT technologies, since previous theory of human-human interaction could not be directly translated to human thing interaction. One approach is Natural Language Interface (NLI). EXACT and Yourway devote to enable basic control over household appliance by speech or simple sentences input with the help of NLI (Yates, Etzioni, & Weld, 2003; Zhou, 2007). NLI has obvious advantages in input/output space and interface layout; and the less natural the command, the heavier users' memory load. However, NLI also suffers from low perceived predictability, complexity, invalid commands and serious problems of safety control (Zhou, 2007). How to design natural language interface, what level of natural language should be are still among the critical issues. Comparison results of GUI-based and social-based paradigm in IoT are shown in Table 1.

Table 1: Sample human systems integration test parameters

	HCI Interactive paradigms in IoT	
	GUI-based interaction paradigm	Social-based interaction paradigm
User mental model	Users have to manipulate every device directly, and every device has its own interface	Users and things act as members in the relation network, and the relationship could be defined by the user himself
Interaction Style	Graphical user interface (GUI) and WIMP	Dialog-based natural language interface (NLI)
Requirement for knowledge of manipulation	High	Low
Direct manipulation	High	Low
Abstraction Level	Low	High

Perception of Human-object Interaction

In order to study perception of human-object interaction, studies on user mental model of Internet's appearing are reviewed, and then users' perspective of human-object interaction in household context is discussed, considering currently there're few studies on IoT from human cognitive aspects. A mental model is cognitive representation of something that defines a logical and believable estimation as to how a thing is constructed or how it functions (Heim, 2007), hypothesized to play a major role in cognition, reasoning, and decision-making. Advanced by the later birth of cognitive science, mental model was regarded as a way of describing the thought process when solving deductive problems (Johnson-Laird, 1986) and supplying people with a means of understanding the functioning of physical systems (Gentner & Stevens, 1983). When a person continues to modify his mental model in order to get to a workable result by interacting with the system, his mental models will be constrained by factors such as the user's technical background, previous experiences with similar system, and the structure of the human information processing system (Norman & Draper, 1986).

User Mental Model of the Internet

Internet brought new ways of gaining and processing information, as a result it changed user mental model towards human-machine interaction. Thatcher et al. (Thatcher & Greyling, 1998) found that people's mental models of Internet were arranged into categories hierarchically ordered according to respondents' experience with the Internet, and relatively high frequency of usage (with little conceptualization of the Internet's structure, such as e-mailing and searching) display somewhat simple mental models of the Internet. Levin et al. reported that more expert Internet users having more elaborate, detailed and flexible mental models than novices, and are more effective to diagnose and recover from problematic situations occurring during Web using. Studies by Papastergiou (Papastergiou, 2005) indicated that high school students form simplistic, utilitarian mental models from what they see, while adults' mental models from different ages follow roughly similar stages of evolution, from utilitarian to structural ones. All in all, most users mainly focus on their computers and activities, and do not perceive the Internet in terms of connections. For users holding the structural mental models, more frequent and sufficient use of the Internet leads to more elaborate mental models (Papastergiou, 2005).

Human-object Interaction in Household Environment

A way of understanding human-thing relationship is to studying human strategy of grouping things. There are many factors corresponding to grouping strategy: things' attributes, functions, location, task and household contexts. These factors will also influence the basic thoughts that things can only be used by people. The most common strategies are based on physical location and function. Users with location-based strategy group things according to their locations. They tend to have clear definitions for things with fixed locations and mono-functions. Location-based strategy comes from studies on smart home environments (Koskela & Väänänen-Vainio-Mattila, 2004) showing that in a familiar environment, human behaviour assumes certain regularities and thus certain action patterns (e.g. laundry in a particular time or particular place and way) are assumed.

Function-based strategy indicates that things are grouped, used and found according to their common functions, such

as things for cleaning, things for entertainment. This kind of strategy comes from "Activity Centre", the centre of certain activity and behaviours, around which a great many patterns of use revolve (Crabtree, Hemmings, & Rodden, 2002). For example, table plays as a coordination centre when adults may monitor the doing of schoolwork by children and as a site where young children may be occupied (doing drawing, crayoning, painting, etc.). Things with similar functions and same goals are easily grouped in certain "activity centres", which forms a fundamental perception of human-thing relationship.

Effects of Anthropomorphic Qualities in Accepting IoT

The tendency to ascribe human-like features to non-human entities is a natural disposition of human beings, known as anthropomorphism (Caporael & Heyes, 1997). People are likely to anthropomorphize objects that have human-like features, such as eyes (Haley & Fessler, 2005; Jipson & Gelman, 2007), hands (Woodward, 1999) or a human-like form (Aggarwal & Ann, 2007), or that behave in an apparently complex or intentional manner (N. Epley, Akalis, Waytz, & Cacioppo, 2008; Heider & Simmel, 1944).

In the era of information technology, computers, intelligent agents and social robots have always been favourite targets for anthropomorphic attributions. Reeves et al. (Reeves & Nass, 1996) claimed that anthropomorphism is modulated as a function of system features, that is the media equation paradigm (*media=real life*). Studies of Nass et al. (Nass, Steuer, & Tauber, 1994) indicated that people apply to computers politeness rules, gender stereo types, praise rules, human personalities, exactly as they do during interpersonal communication, since computers use natural language, interact in real time, and fill traditional social rules (e.g., bank teller and teacher), even experienced computer users tend to respond to them as social entities.

The study on the acceptance of anthropomorphic agents interface shows that the acceptance of agents strongly depend on traditional variables such as control, understanding, trust, and distraction (Schaumburg, 2001). Using humanoid embodiment and human voice-based communication significantly enhance user acceptance towards anthropomorphic agents (Qiu & Benbasat, 2009), and success of social agents highly depends on understanding the social dynamic underlying user-agent interaction (De Angeli, Johnson, & Coventry, 2001). Past studies about anthropomorphic features indicated that mind, body and personality are three most important factors affecting the success of personified agent (De Angeli et al., 2001). Thing's "face" in the smart system, referring to "body", was thought to help to increase users' familiarity as the increasing of human appearance similarity. Studies on language revealed that communication is enough to build an effective agent, even without any visual help. Moreover, the communication styles of the same agents could be different with different context (e.g., entertainment and serious) to improve the social presence and user preferences.

THEORETICAL FRAMEWORK

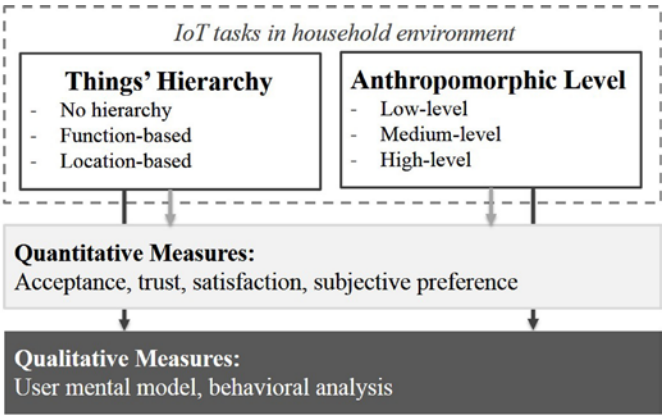

Figure 1. Research framework of user acceptance of anthropomorphic IoT

This paper focuses on the effects of things' human-like qualities on user acceptance of anthropomorphic IoT in a social networking service environment. The two factors are hierarchy of things (e.g., no hierarchy, function-based hierarchy, location-based hierarchy) and anthropomorphic level (e.g., low, medium, and high). This study was carried out in a household context. The dependent variables were user acceptance (including perceived usefulness,

perceived behaviour control, perceived behaviour control, attitudes towards using and perceived ease of use), satisfaction, trust, and subjective preference. Moreover, users' mental model of the network of household things is measured by drawing their mental models. The dependent variables are highly important for measuring social media users accepting anthropomorphic IoT systems. Figure 1 shows the research framework:

Hypothesis 1. Users are more likely to accept, trust, and satisfy when interacting with things organized in hierarchical rather than non-hierarchical structure, and the difference between hierarchical and non-hierarchical is larger than difference between location-based and function-based hierarchy.

In anthropomorphic IoT users "chat" with things through a natural language interface by typing in words. As the number of things and task complexity increase, the difficulty of manipulating and managing things increases heavily as well. Thus we raised the hypothesis: when users only interact with related agents, the amount of information decrease, thus workload decrease, as a result users' subjective preference increases. Moreover, things are treated as tools and subordinates to fulfil tasks, thus we have to make sure they are perceived to be credible and able to provide engagement. What's more, diversity of users' grouping strategy makes users' perceive little difference between different kinds of social hierarchies. That is to say, the two kinds of grouping strategies overlap in users' minds. In this paper we will verify this hypothesis by measuring users' subjective preference, perception and mental models.

Hypothesis 2. Users are more likely to accept, trust and satisfy when interacting with things with higher level of anthropomorphism than lower level, and the difference on acceptance, trust and satisfaction between low and medium levels are larger than those between medium and high levels.

Psychological researches aiming at user acceptance towards things' anthropomorphic characters indicated that users who tend to accept anthropomorphism are more likely to avoid uncertainty and increase familiarity (Nicholas Epley, Waytz, & Cacioppo, 2007). A research about the effects of task on human-robot interaction verified through experiment that when human-like characteristics of robot match task and context, users process higher preferences and acceptance (Powers, Kiesler, & Goetz, 2003). In this paper, alternatively, the natural language with different anthropomorphic levels is associated with corresponding levels of tasks and contexts. For example, things used more determined and serious tones in the gas-leaking case. What's more, human-like language helps to increase users' familiarity, and increases user cognition on analysing related context. Thus we came up with the former part of hypothesis based on above evidence. Previous studies on conversation agents (De Angeli et al., 2001) showed that language is enough to create a high-engaged interaction environment while appearance anthropomorphism could only improve engagement to a little extend. We came up with the later part of hypothesis 2 based on this point.

METHODOLOGY

Participants

Thirty-six participants were invited to take part in the experiment: 18 males and 18 females. In order to diminish the differences on education, computer literacy and network experience, all participants were students from Tsinghua University. All participants were among the age 18 to 25 ($Mean=21.36, SD=1.62$). All participants had basic social media experience on mobile devices, and they had primary understanding of IoT and never used IoT related or smart home applications.

Participants interacted with a set of smart things in an IoT platform and were asked to complete a series of tasks and finish the post-test questionnaire. Three kinds of tasks combining social media and IoT were chosen in household context: 1) Tracking of things' logistic information bought online; 2) Remote control of home appliances and communication among various things; 3) Monitoring the content of water, electricity and gas, carrying out emergency solution and suggestions automatically.

User Interface Prototypes

The experiment interface was developed with Macromedia Flash CS 4. Participants used keyboard and mouse to interact with the interfaces, which simulated social network sites on iPhone showing on a laptop. Moreover, since NLI are not supported by the prototype, a trained experimenter "acted" as things in the observation room, communicating with participants according to certain scripts.

The low-anthropomorphism user interface involved neither appearance nor language anthropomorphism. That is, things in this interface had no human-like appearances and "talked" in machine-like language (using simple nouns and adjectives, simple sentences without subject and unaffectionate to make a contextual status report). For example, an air conditioner reported its status as "Temperature: 30 centigrade, humidity: 80%-. Figure 2-[A] shows a screen shot of the low-anthropomorphism-level interface.

The medium-anthropomorphism user interface contained human-like language including subjects, emoticons and punctuation symbols, but no human-like portraits. For example, an air conditioner reported its status as "Dear master, I have turned off myself since the temperature now is 30 centigrade, and the humidity is 80 %. It is noteworthy that the same level of autonomy and intelligence were maintained at a medium level (e.g. things always act as subordinates and let users to make ultimate decision) for both machine-like and human-like language. Figure 2-[B] shows a screen shot of the "news feed" page of medium-anthropomorphism user interface.

The high-level anthropomorphism user interface contained both appearance and language anthropomorphism (e.g. cartoon appearances and human-like language). A screenshot of the high-anthropomorphism user interface are shown in Figure 2-[C].

Figure 2. Anthropomorphic IoT user interface prototype

Experimental Design

A *3×3* mixed design was conducted. The factor *things' hierarchy* was within-subject design while the factor *anthropomorphic level* was between-subject design. Different kinds of hierarchy corresponded to different mental models, which significantly affect users' attitudes and behaviour. In addition, it is natural for participants to interact with one specific level of anthropomorphic things during interaction. Thus the thirty-six participants were randomly assigned to three groups with certain anthropomorphic level. Each participant performed three groups of tasks: non-hierarchical, location-based hierarchy, and function-based hierarchy. The task group sequence was randomized as well.

Dependent variables

Acceptance. Users will form attitudes and intention when using a novel technological product before they making efforts (Davis, 1989). Attitudes and intention will directly influence user behaviour using new technology. The five factors used in measuring acceptance in this study were perceived usefulness (PU) (Chin, Diehl, & Norman, 1988; Davis, 1989; Moore & Benbasat, 1991) , perceived ease of use (PEOU) (Chin et al., 1988; Davis, 1989), attitudes

towards using or intrinsic motivation (C) (Davis, Bagozzi, & Warshaw, 1992, p. 1), perceived behaviour control (PBC) (Yi, Jackson, Park, & Probst, 2006), behaviour intention (BI) (Davis, 1989; Yi et al., 2006). We selected Intrinsic motivation (Davis et al., 1992) and perceived behaviour control (Yi et al., 2006) since these two factors were essential for users in unfamiliar situations such as the IoT system in this study. There were 15 questions in total in the acceptance questionnaire, measured by Likert 7-point scale.

Trust. Trust supplants contracts in providing the key sense of predictability in relationships. Previous studies proposed that people's trust towards automation and AI systems (e.g. anthropomorphic IoT) mainly relied on efficacy and characters of the system itself (Lee & Moray, 1992). Since users mainly relied on things' words to make decision in the IoT system, one of the factors contributing to trust was used: perceived reliability. We adopted the scales with five questions measuring trust towards computer systems in our study (Madsen & Gregor, 2000), and modulated "system" into "IoT" in our questionnaire. For example, "The IoT system always provides the advice I require to make my decision", "The IoT system performs reliably", "The IoT system responds the same way under the same conditions at different times", "I can rely on the IoT system to function properly", and "The IoT system analyses problems consistently". The Cronbach's α of perceived reliability is 0.85.

Satisfaction. Satisfaction is the level of satisfactory towards the interaction between human and system. We partially adopted QUIS 5.0 (Chin et al., 1988) in measuring user satisfaction, and made some modulations (e.g. replacing "software" with "IoT"). Items were consisted of "terrible/wonderful", "difficult/easy", "frustrating/satisfying", "inadequate power/adequate power", "dull/stimulating", and "rigid/flexible". We developed a 7-point Likert scale for users overall reactions to IoT systems.

Subjective preference. We asked users to rank different hierarchies after three groups of tasks, so as to measure their subjective attitudes and interaction effects. The type of things' hierarchy on the top of ranking was rated 3, and the one on the bottom was rated 1. This score, denoted as "subjective preference", was regarded as user attitudes towards things' hierarchy.

User mental model of human-object relationship. Although users are familiar with the social network mental model, the theory of human-human interaction could not be directly used into human-object interaction. We think it necessary to measure users' mental model when interacting with anthropomorphic IoT. Hence, users were asked to draw a picture of their perceived relationship with things in anthropomorphic IoT and explained their reasons orally (Thatcher & Greyling, 1998).

Procedures

This experiment was conducted in HCI Lab at Tsinghua University. An Acer laptop with a 2.67 GHz processor, 2.00 GB memory and 14.1'' screen was used for experimentation. Aside from the moderator, a backstage experimenter responded to participants' input in the observation room.

Each participant was given a brief verbal introduction to the experiment was given to each participant by the moderator. Then the participant was asked to fill out an informed consent form and a general information questionnaire concerning his biographical information. Before the tasks started, the moderator demonstrated to the participant how to use the system, a brief practice session with four small tasks were carried out to help the participant understand user interface and the tasks to be performed. Following the practice session each participant had to complete three sections of tasks and complete a questionnaire investigating his self-reported measurement (including acceptance, trust, satisfaction, subjective preference) after each section.

On finishing all three sections of tasks, each participant was asked to draw the relationship with all the things in the IoT system in his/her mind. After a 10-minute post-test interview on reasons of drawing, the whole experiment was completed.

An important component of the human systems integration plan should be a verification and validation process that provides a clear way to evaluate the success of human systems integration. The human systems integration team should develop a test plan that can easily be incorporated into the systems engineering test plan. The effectiveness and performance of the human in the system needs to be validated as part of the overall system. It may seem more attractive to have stand-alone testing for human systems integration to show how the user interacts with controls or displays, how the user performs on a specific task. This methodology can address the performance of the human operator or maintainer with respect to the overall system. The most important thing is to develop a close relationship

between human systems integration and systems engineering.

RESULTS

Participants

The hypotheses were tested by 36 participants in the experiment. The results of *t-test* on biographical information between different anthropomorphic level groups showed that there was no significant difference on age and previous experience with IoT. Two questions were asked in the post-test interview to determine the construct validity of thing's anthropomorphic level and hierarchy. The questions asked were as follows. (1) What were the main considerations when you decided the ranking of different organizations of things? (2) Do you think things were communicating with you in human-like language (only for participants from medium and high anthropomorphism group)? Did this difference influence your evaluation? The results showed that 80.56% participants noticed the differences in things' hierarchy; 100% participants noticed the differences in language, only 50% participants in the high-level anthropomorphism group discovered the human-like faces of things. The percentages of participants who were aware of independent variables during the experiment were high. The paper-based questionnaires were provided after the participants had finished each section. The Cronbach's Alpha of all questionnaires were 0.909 for perceived usefulness, 0.883 for perceived ease of use, 0.950 for attitudes to use, 0.870 for perceived behavior control, 0.921 for behavioral intention, 0.911 for trust questionnaire and 0.931 for satisfaction questionnaire, which were all above the generally acceptable level 0.7. The average scores of each questionnaire were used as the dependent variables, and represented users' acceptance, trust, and satisfaction towards the anthropomorphic IoT service.

Hypothesis Testing

MANOVA of acceptance (including perceived usefulness, perceived ease of use, attitude to using, perceived behaviour control and behavioural control), trust, and satisfaction were used to test the hypotheses. Since the subjective preference violated the MANOVA assumptions, the Kruskal-Wallis tests were performed on the tests of subjective preference on hierarchy.

Hypothesis 1. The intention of this hypothesis is to examine how thing's hierarchy might influence users' attitudes towards anthropomorphic IoT. The MANOVA test result indicates that hierarchy has no significant effects on users' attitudes. Because the data of subjective preference violates the assumption of MANOVA even after possible transformations, the Kruskal-Wallis test was used for comparison. The comparison *(chi-square=22.326, p=0.00001)* indicated significant difference at the significant level 0.05. That is to say, different hierarchies indicate different preferences in users' minds. In addition, the mean of function-based hierarchy *(M=2.1944)* is *31.64%* higher than nonhierarchy *(M=1.5000)*, whilst the mean location-based hierarchy *(M=2.3889)* is *37.2%* higher than nonhierarchy. Thus we know that preference of hierarchical organization of things is significantly higher than that of non-hierarchical organization. Thus hypothesis1 was partially supported.

Hypothesis 2. Hypothesis 2 suggested that the level of anthropomorphism would influence users' acceptance, trust and satisfaction, and the influence of language anthropomorphism would be larger than that of appearance anthropomorphism. According to MANOVA results in Table 2, significant differences in attitudes towards using *(F=3.347, p=0.039)* were maintained. The results of post-hoc multi-comparisons of the least square differences (LSD) using Tukey-Krammer adjustment showed that the significant differences existed between low-level and high-level *(p=0.012)*, whilst no significant differences were found between low-level and medium-level or between medium-level and high-level. In addition, users perceive things with high-level and medium-level anthropomorphism as more attractive than things with low-level anthropomorphism. 5.97% increase of attitudes towards use was found between high and low, and 3.15% was found between medium and low. Thus hypothesis 2 was partially supported.

The MANOVA test result of subject evaluation indicated no significant differences of dependent variables with the interaction between anthropomorphic level and thing's hierarchy, thus we regarded the two factors—things' hierarchy and anthropomorphic level—as variables without correlation, and the correlation of these two factors were not discussed further.

Table 2: MANOVA results of anthropomorphic level on user acceptance

Dependent Variables	Low-level		Medium-level		High-level		F	p
	M	SD	M	SD	M	SD		
Perceived usefulness	6.22	0.70	6.23	0.58	6.17	0.58	0.153	0.858
Perceived ease of use	6.19	0.69	6.37	0.59	6.52	0.53	2.264	0.109
Attitudes towards Using	6.14	0.79	6.34	0.72	6.53	0.54	3.347	0.039*
Perceived Behaviour Control	6.09	0.66	6.26	0.61	6.32	0.54	1.016	0.366
Behavioural Intention	5.98	0.75	6.06	0.73	6.02	0.69	0.053	0.948
Trust	5.28	0.81	5.62	0.74	5.55	0.62	1.911	0.153
Satisfaction	5.94	0.68	6.08	0.76	6.08	0.54	0.716	0.491

DISCUSSION

During the debrief section after the experiments, users reported their preference of function-based or location-based hierarchical things, even though they did not realize the differences in manipulation with hierarchical agents and non-hierarchical things. Users' mental model of relationship with things could explain this significant difference. That is, one-way communication with specific agents was thought as "time-saving", "easy to manage" and more "reliable" than directly communicating with things, especially when the number of things reaches a large scale. It is worth noticing that only when the hierarchical organization is relatively stable and compatible with users' mental model, can users accept certain organizations. For example, users rating function-based hierarchy higher thought that this extendable organization helps to improve efficiency of household tasks. In addition, users who prefer location-based hierarchy hold the opinion that this kind of organization made it easy to manage things and was more related to users' cognition of household appliances. Moreover, some users also mentioned their perceived difference on things' intelligent level and inequality with people. These users thought things were less reliable and less intelligent to be treated equally as people in the social media, whilst "agents" with higher "social hierarchy" were thought with higher reliability and equality with people.

Considering no significant differences in users' acceptance, trust and satisfaction in testing hypothesis 1, several plausible reasons may explain this phenomenon. A very likely reason may be the similarity in manipulation among three groups of tasks. In this experiment, the differences among different hierarchies were highlighted more from conceptual than from manipulation side. We guess that the interaction style would weigh more in influencing users' subjective evaluation. Second, similarity in manipulation may lead to learning effects, which made users perceiving no significant difference among different hierarchies. Even though Latin Square design was used, the effect of similar manipulation had larger influence on users' attitudes, thus no significant differences were found in the test.

Hypothesis 2 was supported by the significant differences in attitudes towards use. The results that language anthropomorphism played a more important role in effecting user acceptance than appearance anthropomorphism consistent with previous studies (De Angeli et al., 2001) on social agents. On the other hand, this results may to some extends not correspond to researches on human-robot "uncanny valley" effects (Rau, Li, & Li, 2009; Woods, Dautenhahn, & Schulz, 2004), in which users' evaluation would decrease as the increase of level of anthropomorphism after certain turning point. One possible explanation is that textual communication is different with speech communication. That is, users may be less sensitive in detecting smart agents' tones and intonation, and the chances for negative evaluation due to inconsistency between experience and tones decrease. In addition, results of conversation analysis indicated that users tend to reply less in simple, asking-for-confirmation tasks, while they are more likely to initiate conversation when doing more complex tasks (e.g. tracking or multitasking). One possible reason is that users' evaluation increases as the compatibility between context and language anthropomorphism increases. This finding needs further test because current data could not support influences of different compatibility between contexts and anthropomorphic level.

Even though attitudes towards use is the only one factor on acceptance showing significant effects in MANOVA, when making correlation analysis, the other three acceptance factors (perceived usefulness, perceived ease of use and perceived behavioural control) were highly positively correlated with using attitudes. One possible reason may be that current experiment tasks and conditions could not lead to users different evaluations on perceived ease of use, perceived usefulness and perceived behavioural control. Considering the positive correlation between attitudes and perceived ease of use, it is reasonable to believe that higher perceived ease of use may lead to higher attitudes towards using.

In order to figure out users' perception of their relationship with things, users were asked to draw their perceived relationship with things on a piece of paper. Four major types were obtained after sorting (seeing Figure 2): non-hierarchical organization with only discrete things (2), non-hierarchical organization with both things and agents (8), mixed hierarchical organization in which users could control both things and agents (8), hierarchical organization in which users could only control agents (18). Results indicated that 72% users have the mental model with hierarchical organization of things, and the grouping strategy of things existed in non-hierarchical organization with both agents and things. Moreover, in the two kinds of hierarchical organizations, different kinds of grouping strategies co-exist. Users were more likely to directly manipulate agents, and listen to things' or agents' status report. Thus it is clear that the analysis results of mental model was consistent with the explanation household behaviour (Crabtree et al., 2002), that is, users were more likely to accept things organized by similar location or function. Activity centre could also be considered in further design of IoT systems.

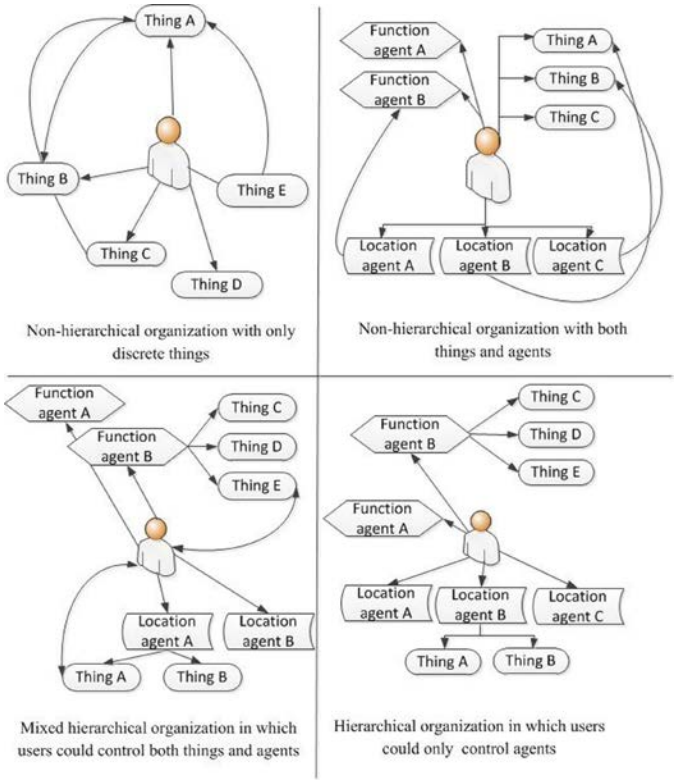

Figure 3. User mental model of relationship with things

A limitation of the study lies in control of experiment condition and design of tasks. One major reason for not obtaining significant difference in subjective evaluation is the similarity in manipulation among three groups of tasks during the test. In further studies, it is possible to design different tasks according to different hierarchies except for conversations. Increasing the complexity of tasks and number of things is another solution towards this limitation, in order to provide a higher-realism experiment environment for users. Another limitation of the study is sampling. Undergraduate and graduate students have been recruited for testing the hypotheses empirically. This non-probabilistic sampling method and the small sample size limit the generalizability of the result. In future study, target users of IoT should be identified and recruited in experiment. It is also interesting to investigate the individual differences (e.g. experience, technological background) in the perception and acceptance of anthropomorphic IoT.

CONCLUSIONS

This study explored the effects of things' hierarchy and anthropomorphic level on user acceptance, trust, satisfaction and subjective preference of anthropomorphic IoT. Anthropomorphic IoT is generally accepted by social media users. Considering users' mental model of relationship with things, users are more likely to accept things organized with hierarchy; grouping strategies based on both location and function could exist in the system. Moreover, using human-like language is capable to support social context and efficient interaction in anthropomorphic IoT. However, the design of anthropomorphic IoT interaction paradigm should consider requirements in different tasks and contexts. In addition, exploring the extent of combining GUI-based and social-based interaction paradigm might better serve the IoT technology.

Based on the findings of the current study, several design guidelines for anthropomorphic IoT are proposed. 1) It is essential to organize things mainly based on function and location in IoT system, especially when a large scale of things is involved; 2) Provide customized grouping strategy in IoT systems; 3) Appropriate human-like language in communication with things is essential in smart IoT systems, but to what extent should language anthropomorphism be requires careful consideration and design; 4) The ultimate decision should be made by the user all the time to maintain users' perceived control towards the novel, smart anthropomorphic IoT system; 5) IoT could consider both GUI and NLI model in system design.

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Cognitive Training Profile for Older People in China

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ABSTRACT

Nowadays China is facing a serious problem of aging population. Older people suffer losses in aspects, especially in cognitive function. It is necessary and worthwhile to design effective cognitive training programs, based on our knowledge of cognitive aging mechanisms, to help older people maintain and improve their cognitive abilities. The present paper aims to introduce the development of cognitive training program for older people from the following three aspects: a) the status quo of aging society in China, b) cognitive aging and its underlying mechanisms, and c) the approach and practice of cognitive training.

Keywords: Aging, China, Cognitive Aging, Cognitive Training

INTRODUCTION

Since 1999 China has become an aging society in light of the international standard (i.e. 10% of total population aged over 60 years). Currently, China remains its aging acceleration period (as can be seen in Figure 1). The Sixth Chinese National Population Census showed that by 2010 the number of people aged above 60 years had reached 178 million, accounting for 13.26% of the total population. Moreover, the latest data reveal that the population aged over 60 years has already exceeded 200 million (Woo, 2013). By 2050, nearly thirty percent of Chinese people would be older adults. The huge number of aged people brings serious challenge to China and thus calls for efforts from all aspects.

With regard to the psychological field, a significant mission is to help older adults effectively maintaining their mental health and cognitive function, as well as sustaining fair engagement in social life and productive activities. The concept of “active aging” could be very helpful to fight against the negative stereotypes towards aged people. An old age does not necessarily mean the end of participation in society. Older adults should still be viewed as active social participants and competent contributors of our society. "Participation" is a key concept of "active aging" which was put forth in the Second World Assembly on Aging (Stenner, McFarquhar, & Bowling, 2011). A lot of studies have demonstrated that social activity and social engagement contribute to better cognitive abilities, better health condition and higher level of well-being (e.g. Herzog et al., 1998; Pinquart et al., 2000). Thus, intervention on older adults’ social activities could be a valid way to help older adults’ achieving successful aging, and maintaining a good quality of life (QoL).

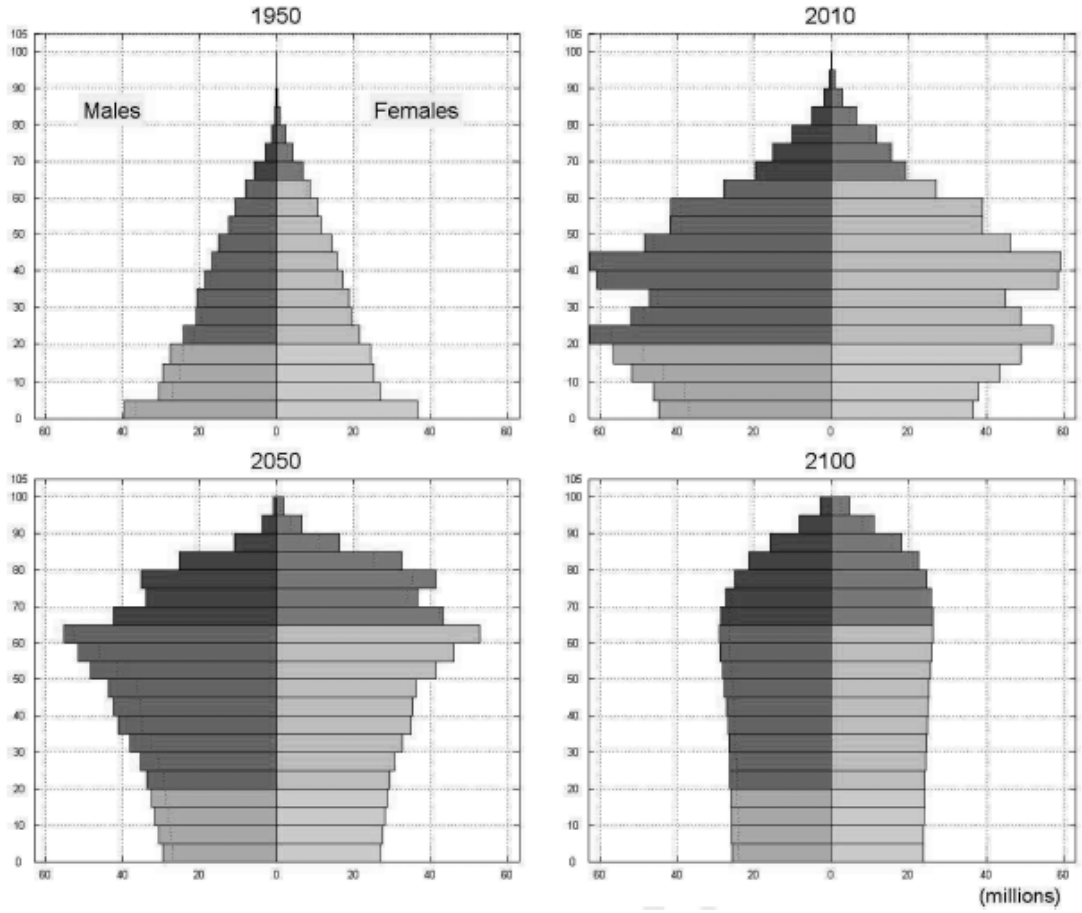

Figure 1. Age structure of China, 1950, 2010, 2050, and 2100. Source: UNDESA (2011).

COGNITIVE AGING AND UNDERLYING MECHANISMS

As people age, they usually experience physical, psychological and social loss. Decline of cognitive function is one of the most serious and common losses among the older adults. The decline exhibits typically as slower reaction, memory impairment, and deficiency in anti-interference. This degeneration directly impacts older adults' QoL. It's not uncommon to hear an older adult saying that "I have already forgotten the rest numbers after dialing just two digits" , "Please speak slowly, I can't catch you," "I'm not as sharp as I used to be," or "I'm much fresher in the morning but feel like rusted in the evening" and so on. All these complaints indicate that older people usually care very much about their cognitive function and they feel very worried when they experience decline in cognition. Take dementia as an example, it is a serious disease occurred increasingly with aging. People with dementia could suffer from impairment of memory, attention, language, and problem solving, which leads to a worsen QoL (Finkel, 2000).

In general, cognitive function could be grouped into to two sorts, namely crystallized intelligence and fluid intelligence (Cattell, 1971). Earlier in the field of cognitive aging, it was assumed that age-related changing patterns of these two intellectual abilities are different. As crystallized intelligence is the ability related to learned skills, knowledge, and experiences, it may not decrease but rather improve somewhat with aging. On the contrary, fluid intelligence is the capacity to think logically and solve problems in novel situations, and is independent of acquired knowledge, so it usually declines in old age. However, later evidence showed that both crystallized and fluid

abilities follow a decline pattern after around 70 years old (Schaie, 1996).

Much research has examined the mechanisms underlying cognitive aging in recent decades. By far, there are four major mechanisms that have been demonstrated to well account cognitive decline in the area of aging psychology (as can be seen in Figure 2): (a) working memory function theory, (b) processing speed theory, (c) defect of inhibition theory, and (d) sensory function theory. Working memory is the most sensitive to decrease with aging among all cognitive function (Hertzog, Dixon, Hultsch, & MacDonald, 2003). Craik and Byrd (1982) developed an important framework related with the construct of working memory to explain cognitive aging. They suggested that older adults are deficient in the ability to engage in what they called "self-initiated processing" determined by working memory, which makes older adults less competent in cognitive tasks. The processing speed theory of cognitive aging proposed by Salthouse (1985) argues that slower processing speed leaves more time for working-memory contents to decay, thus reduces effective capacity, and results in lower level of cognitive performance. Another explanation is the inhibition hypothesis advanced by Hasher and Zacks (1989). This theory assumes a general deficit in old age in the ability to inhibit irrelevant, or no-longer relevant, information. Therefore, working memory tends to be cluttered with irrelevant contents that reduce the effective capacity for relevant content. Finally, Baltes and Lindenberger (1994) argued that sensory function is a more fundamental index of cognitive aging. They proposed the "common cause" hypothesis, namely sensory function, as a general index of neurobiological architecture, is fundamental to cognitive function and thus is a powerful mediator of the influence of age on cognitive abilities.

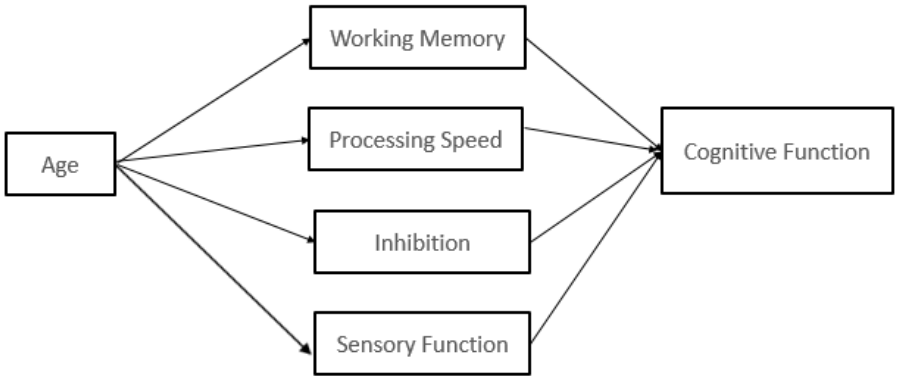

Figure 2. The mechanisms of cognitive aging

COGNITIVE TRAINING PROFILE: APPROACH AND PRACTICE

Cognitive plasticity of older adults

Although age-related decline in cognitive function is an indisputable fact, it does not mean that there is no way to cope with it. As a matter of fact, many empirical studies have revealed that not only young but also older brain presents cognitive plasticity despite that young people may get more benefits than their older counterparts. For instance, a study found that older subjects' performance on matrix test significantly increased after training (Jaeggi, Buschkuehl, Jonides, & Perrig, 2008). Another study conducted in China supports Jaeggi's results independently (Fei, Qin, Li, & Li, 2009). It's noteworthy that even more fundamental abilities could be improved in performance after training. Take our own research as an example, older adults' some primary mental abilities benefited from a 5-week speed training program (Wang, Huang, Peng, & Chen, 2012). There are also other studies suggesting that the cognitive aging among aged people is amenable to prevention and amelioration (Lytle, Vander Bilt, Pandav,

Dodge, & Ganguli, 2004; Fillit et al., 2002; Scarmeas & Stern, 2004). So it is effective and feasible to design practical activities that aim at maintaining and improving older adults' cognitive function.

Design principles of cognitive training profile

The principles of designing cognitive training program may include following considerations. First, the training program should involve some core components of cognition for older people, such as the primary mental abilities (i.e. five basic abilities according to Thurstone's theory), the four abilities serving as the underlying mechanisms of cognitive aging, and other abilities sensitive to aging process (e.g. prospective memory). Second, our cognitive training program should be designed in favor of older people's interests and motivation. So the training mode should be sort of entertaining style rather than dull and tedious research style in laboratory. Hence, the program is designed into a set of mini games that can be administered as intellectual sports game. We call this highly ecological training program practiced in communities as Senior Brain Game (SBG). Accordingly, the training program or the game should have diversity, fun and flexible degree of difficulty. Third, the program should be better designed and administered as group training rather than individual training. Piles of studies have found that older people benefit more from group training (Liang, Moreland, & Argote, 1995; Moreland & Myaskovsky, 2000; Helbostad, Sletvold & Moe-Nilssen, 2004), as the participants have chances to not only practice their cognition, but also engage in team cooperation, social activities and communication. And finally, the training program should be widely applicable into as many older people dwelling in communities or institutions as possible. Thus, it's better not to use expensive, specialized, or high technique materials or tools to serve the training. All materials shall be very handy in daily life.

Content of the training programs

According to the theories and principles mentioned above, we put forward eight components of cognitive function to be trained for the older adults, namely processing speed and sensory functioning, working memory, inhibition, mental arithmetic, prospective memory, spatial orientation, linguistic competence, and executive capacity. Accordingly, a training profile with eight modules are designed, and each module is composed of five activities or games. Take the module of processing speed and sensory functioning for example, the five games include (1) digit comparison (decide whether two strings of digits are identical), (2) pattern comparison (quickly identify which one of the 4-6 figure patterns is the same with the sample one), picture-match (find as many as possible pairs of pictures that are exactly the same in limited time), finger walking (use fingers alternatively as required to walk along the arrow on a geometric map), hitting ping-pong (hit a ping-pong repeatedly with a paddle as many times as possible in limited time). Although the games of the eight training modules address different aspects of cognitive function, we maintain that they are not independent from each other. Rather, we prefer the integration of the eight parts as a whole. Hence, our ultimate goal of the training profile concentrates onto the promotion of cognitive function integrally, rather than strengthening a certain single component.

With regard to one round of SBG, 3 or 4 activities would typically take 40 minutes if there are four groups (e.g. 5 persons per group) of older participants. The activities could be flexibly revised in length and difficulty according to the education background and cognitive impairment of the participants.

Organization and implementation of the training profile: a case of SBG

In order to concretely describe how to organize and carry out the cognitive training program, we would like to introduce a case of SBG conducted in one community of Beijing. The community committee, a distal official department of government in China, helped assemble older residents together to participate into the SBG. In this case, there were 40 older residents who attended the SBG. They were randomly divided into five groups, each with eight members. The SBG was composed of four games and one relaxing activity. One of our graduate played as the host who was responsible for clearly interpreting the rules of the games to the participants, and instructing and leading the whole process. For each group of participants, a volunteer was arranged to assist the host concerning clarifying the rules to the group members, and helping them play the games orderly and smoothly. The first game called "do to the opposite" demanded participants to respond in opposite to the host's instruction. For example, when the host commanded "turn left", the participants must turn their body to the right; when the host ordered "look up", they must bow their head down. Later on, the tasks gradually became more difficult. For instance, when the instruction was "There is a small water-melon on the top", the participants must gesticulate a big water-melon down

their chest. This game was mainly designed to train older adults' inhibition function. The second game was "digit comparison". The third was called "recite backwards" as participants must recite a digit string in backward order. The number of figures successively increased until it reached participants' maximum memory capacity. This game mainly aimed at promoting older people's working memory. The fourth game was "skip number seven". Starting from a random number, all participants successively one by one counted number loudly. But when meeting a number containing "7" as its one digit or a number that could be exactly divided by 7, the participants must report "pass" instead of the number per se. This game mainly aimed at promoting the competence of mental arithmetic. The volunteer assistants helped scoring for each group and ranking their total grades. The champion team who earned the highest grade was honored a special prize. The rest participants also gained consolation prize. At the end of the SBG, there was a relaxing session for all participants. The host taught and led the older people to play a finger gymnastic to exercise their finger flexibility.

The effects of the cognitive training profile

Given the ecological validity and the applicability we pursue, this profile could not be assessed strictly in light of lab-based experiment. Although data to do pre- and post-test comparison lack, we gathered comments of participants and organizers after the SBGs. From the feedbacks of the older players as well as the community committees, we are confident about the effects of the cognitive training profile. There are mainly three aspects of reasons to treat the implementation of the SBG valuable. First, it promotes the older people's enthusiasms of participating and cooperating in social activities. As we could see, the older adults actively participated and cooperated with each other so that they shared in a warm atmosphere. When asked about their feeling of the SBG, older adults often mentioned that "everyone was very happy to play the games together, and we had fun from exercising our minds. So it was very good", "I think community should carry out more such interesting activities for us", and so on. Second, it helps older participants maintain and improve cognitive function, which is the primary goal of the profile. Though there are no data so far to indicate the amplitude of promotion, the heightened cognitive efficacy and motivation could be obviously observed. "Some of we old people did have bad memory, so the memory activity was necessary,"" my performance in the game was ok, I had always thought that I was old and had a blocked head. Actually I can do much better than I think. It seems that I should not give up." And last, it brings older participants positive experiences and thus helps them improve their emotional well-being. As the SBG is designed as a contest between groups, the players feel excited and entertained during the whole process. When errors occur, they often laugh at themselves or each other with kindness. "The characteristics of the games were to make older people happy. I enjoy lots of fun here". Additionally, the training profile helps conveying the ideology of living an active life in old age. By experiencing the SBG, older people might stop accepting cognitive deterioration passively. For the elderly, actively exercising their brains is just as important as physical exercise because our brains follow the same rule of "use it or lose it".

CONCLUSIONS

To age without much recession is a desire for most people. How to keep a clear head when going into old age is a key question to be solved for researchers working in the area of cognitive aging. So far, the general conclusion for the possibility of maintaining or promoting older people's brain function via cognitive training is positive. However, there is still a long way to go concerning identifying the effective and efficient strategies for all kinds of older adults. Our training profile of the SBG is one of the attempts. And we need more robust and direct empirical evidences before we draw a conclusion that we have found a key. Moreover, there are huge inter-individual differences among aging people, so much more efforts are required to be invested into this matter.

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Constructing Interactive Virtual Scenarios for Investigating Human Behaviors in Pre-movement Time of High-building Fire

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ABSTRACT

Many fires in high-buildings have indicated that behaviors of occupants in period of pre-movement are important for survival. Pre-movement time and the behaviors in the pre-movement time are currently referred as most important factors that influence on the time of start to evacuate. The objective of this study is to identify occupants' behaviors in the pre-evacuation time and the period of the pre-evacuation in the event of high-building in the fire. This study proposes three kinds of factors based on the literature and characteristics of the domestic residential building and fire alarm, which are fire characteristics, building characteristics, human characteristics. Based on these factors, the earlier stage of the whole study constructs interaction scenarios of building interior in fire. Based on the interactive scenes, this study will investigate occupants' performance in the period of pre-movement time.

Keywords: Interaction virtual scenarios; human behaviors; high-building fire

INTRODUCTION

The research indicated that there are only 29% occupants leaving their houses while fire-alarm system giving signal firstly (Proulx and Reid 2006). Other persons continue to do their things, or respond it until their surroundings evacuate, or contact their family members or friends to identify their next activity (Fahy and Proulx 2001, Sandberg 1997). Some investigations showed that pre-movement time exhausted even more than 20 minutes in the reality (Proulx and Reid 2006, Fahy and Proulx1997, Averill, Mileti, Peacock, Kuligowski, Groner, Proulx, Reneke and Nelson2005). Therefore, the occupants' behaviors in the period of pre-movement are important for survival. Pre-movement time and pre-movement behavior are currently referred as most important factors during evacuation. Because the evacuation process is dynamic with chaos and memory bias in an emergency would appear, investigating the survivors after fire is very difficult. In the past twenty years, advancements in computer technology have given rise to high fidelity simulation, which make it possible to model the evacuation scenarios.

The aim of this project is to explore occupants' behaviors in the pre-evacuation time in the event of high-building in the fire. And the factors that influence pre-evacuation time of occupants during an actual fire evacuation also would be identified. This paper is part of the study, which is to construct interaction scenarios of building interior in fire.

METHODOLOGY

This study is to construct interaction scenarios of room interior in the event of high-building in the fire. So, at first, factors influencing human behaviors in the room while occupants hearing signals like fire would be studied in the base of literatures. Then, static scenes of the room would be constructed. After that, according to possible occupants' behaviors in the room while hearing the signals like fire, this study would set up interactive props. Consequently, participants under the interactive scenarios would perform many kinds of behaviors.

Virtual Scenes

The human decision-making process is not isolated, but subject to various internal and external factors. Based on related works (Kobes, Helsloot, De Vries and Post 2010, Kobes, Post, Helsloot and Vries2008, Deloitte 2006, O'Connor 2005, Proulx 2001), this study proposes three kinds of factors influencing the human behaviors during the pre-movement in the event of fire. The factors are: fire characteristics, building characteristics and human characteristics. The first factor related fire includes fire location in the building and ways of fire perceived. The second factor is physically environment which occupants' behaviors are carried out. Because the processes of occupants' behaviors are completed in the room, the floor position and layout of the floor are considered for the building characteristics. The third factor is human nature including physiological characters (age, gender and disability), psychological characters (fire experience, training, education and personality), family composition, and occupants' initial situation in the event of fire. Because the research focuses on residential building, the virtual environment is designed into two-bedroom apartment. The two-bedroom apartment includes a sitting room, two-bedroom, a kitchen, and a restroom. The apartment is located in the 20-story building. The layout of the apartment is shown in figure 1.

Fig. 1 Top view of the whole interior scenes and front view of living room

Note : The fire smoke can be observed from the sitting room after a fe

Interactivity of the scenarios for user performance

When the occupants perceive signals in case of fire, before evacuation a few kinds of possible behaviors in this period would happen. The behaviors includes searching information required for decision-making, collecting items of personal importance, rescuing relatives and friends and extinguishing fire and so on (Kuligowski and Hoskins 2010). In order to investigating these behaviors which could happen, this study constructs interactive interior scenarios through virtual software. The interior provides many related interactive props required in proceed of behaviors being conducted as shown in figure 2.

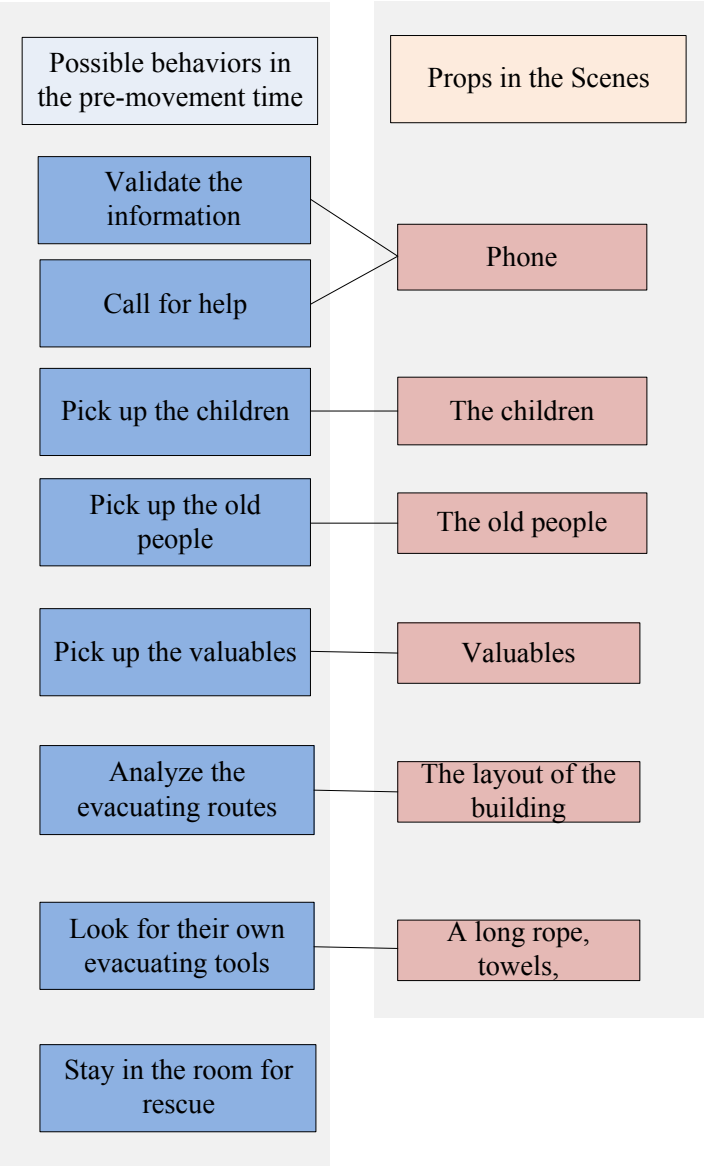

Fig. 2 Probable behaviors in the pre-movement and corresponding props

In addition, to achieve the behaviors in the pre-movement in the event of real fire through virtual scene, two aspects should be considered. One is normal situation designed for participants before the fire happens. Only in this way, the period of pre-movement could appear when the fire happens. The other one is to inspire participants in the virtual scenarios nervous, anxiety. In that way, the behaviors would be close to the real ones. The process of the experiment designed for a participant is shown in figure 3. This study only records the actions that the participants take before evacuating from the room while hearing the signals like fire.

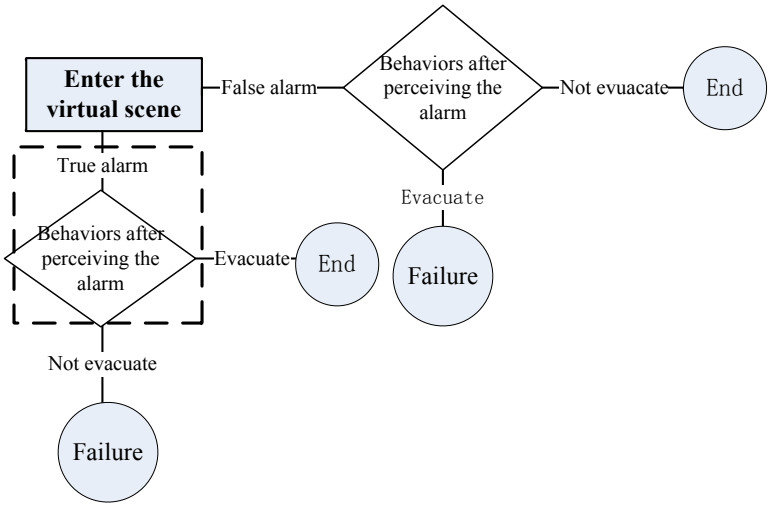

Fig. 3 Users' tasks in the virtual scenes

CONCLUSIONS

This paper is the part of earlier stage of the whole research project. In order to investigate human behaviors in pre-movement time in high-building fire, this study construct interactive virtual scenarios. According to the characteristics of the domestic residential building and fire alarm, this study proposes that three kinds of factors influence human behaviors in a fire. The factors including characteristics of the building, fire information, and characteristics of the people are considered in the course of constructing the interactive scenarios. Based on the interactive scenes, this study will investigate occupants' performance in the period of pre-movement time.

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Comparing Mystery Shopping with Smartphone and Traditional Mystery Shopping

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ABSTRACT

This study aims to investigate different methodologies in performing mystery shopping programs, i.e. new (call, SMS, and notes) and traditional methodologies in the aspect of shoppers' workload, satisfaction, consistency, accuracy and timing. For that purpose, a single factor experiment with four levels was designed in this research. A smartphone and computer-mediated experiment was conducted with 40 Chinese students. The results showed that the traditional method was the most consistent method and there was no significant difference among the other three mystery shopping methods. However, the results also demonstrated that traditional method was the least accurate and there was no significant difference among the other three methods. The researcher also found that when conducting a mystery shopping program, the SMS method took the longest time, followed by the calling method. Finally, this research discusses the implications of these findings for developing mystery shopping guidelines.

Keywords: Mystery Shopping, Convenience Store, Smartphone, Workload, Satisfaction, Consistency, Accuracy, Timing

INTRODUCTION

Roger Mayland, VP of Martiz's Quality Controlled Services Division, defined mystery shopping as a "process for measuring service quality, with feedback, that is understandable to the front-line employees" (Erstad, 1998). Mystery shopping uses trained researchers to act as customers or potential customers of an organization with the intention of monitoring and assessing the quality of the customer service level, and the processes and procedures used in the delivery of the service (Calvert, 2005).

Mystery shopping is a research technique that has frequently been used by many retailers to gather observational data about a store and to collect data about customer-employee interaction (McDaniel & Gates, 2010). It is estimated that 70% of America's national retailers use this technique. However, in measuring customer experience, this research method has not been really widely used in retailing sector in China such as convenience store.

In a typical mystery shopping experience, a key skill of mystery shoppers is the keen memory because no notes can be taken during the shopping experience (Lusch, Dunne, & Carver, 2010). This is then coherent with Wilson's (1998) statement which stated that retention and recording of information was particularly important, as the shoppers could not complete an assessment form during the service encounter.

Mystery shopping is a useful method only if it is conducted in a right manner. However, several issues may affect the reliability and validity of the results (Low, 2011). As mystery shopping relies on human judgment, the item of subjectivity must be reckoned and any bias must be reduced from the beginning. Moreover, many companies set a limit on frequency to conduct the program and number of audits due to high cost, which may affect the reliability of the results. Moreover, several factors such as timing, stores being studied, and mystery shoppers themselves might affect the validity of the results obtained. For example, shoppers might forget one or more things to be assessed, and stores condition is different during day and night.

A traditional mystery shopping involves visiting the business as a customer, then completing an evaluation form or narrative within 12 or 24 hours describing the customer service, cleanliness, quality, sales skills, and other aspects of the experience after the shopping is done (Stucker, 2004). For individuals who are not proficient at this method, there are difficulties they have to face in the process of mystery shopping. For example, they may leave out important details due to the big amount of information. These difficulties may influence the evaluation outcome of the method. However, the emergence of smartphone together with its multiple functions such as audio recording, note taking may assist mystery shoppers to maintain a high level of professionalism.

This study will compare two ways of mystery shopping: one with the assistance of smartphone and one with traditional methodology in terms of mystery shoppers' workload, satisfaction, accuracy, consistency and completion time. Afterwards, this study will try to provide guidelines for improving the evaluation outcome of mystery shopping.

CONCEPTUAL FRAMEWORK AND HYPOTHESES

Figure 1 shows the conceptual framework of this study. In traditional mystery shopping, shoppers' memory is the only tool which can be used to evaluate the service quality and customer experience. With the assistance of smartphones, new methods such as shorting messages, phone calls, taking notes and the function of audio recording can be used to improve mystery shopping. In summary, four methods of mystery shopping were compared in terms of shoppers' mental workload, satisfaction, consistency, accuracy and completion time.

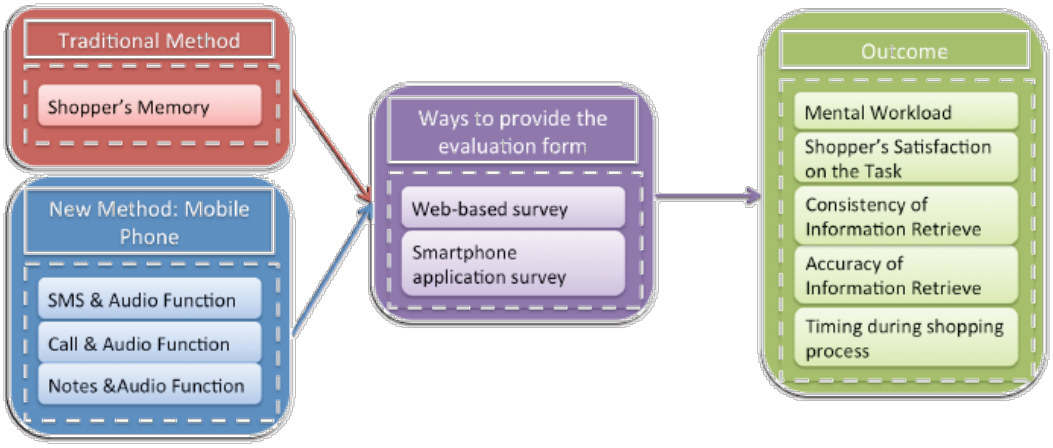

Figure 1. Conceptual framework

According to the framework, five hypotheses were come up with as follows.

By traditional method, mystery shoppers may forget some details during the process. By using smartphones especially the audio recorder on the smartphone, shoppers do not have to pay much attention to memorizing details. When shoppers use smartphone functions such as the audio recorder, they will have fewer items to remember and they are able to retrieve it again after the process; hence, it will reduce the amount of workload. Therefore, the first hypothesis is:

H1: When conducting mystery shopping, using smartphone application survey during the shopping process will reduce shoppers' workload compared with using traditional mystery shopping.

Since using mobile phone to conduct mystery shopping can reduce workload for shoppers, they can have a more relaxed status when they carry out the tasks. Besides, with the help of smartphone functions, shoppers can record more data and information, which facilitates further evaluation for the convenience stores. All these benefits can lead to higher satisfaction compared with traditional method. Hence, the second hypothesis is:

H2: When conducting mystery shopping, shoppers will have higher satisfaction by using new methods mystery shopping than by using the traditional mystery shopping.

In the traditional mystery shopping process, shoppers have to act as real customers and they cannot bring any tool to take notes. Thus, they have to read the evaluation guideline very carefully and try to remember every detail, otherwise they may have left out some aspects. Besides, every shopper has to complete a detailed form after the process. The details provided in the form should be as objective as possible. For a mystery shopper who is not proficient enough, it is difficult for them to observe and memorize every detail required by the guideline.

However, if the shoppers bring along smartphones, they are able to interact with the researcher who is outside the mystery shopping spot and directs the whole process in real time. They can keep contact via phone calls or short messages. Shoppers can write down important information in the smartphone before evaluation. Thus, the researcher does not need to give a tedious guideline to shoppers beforehand. Instead, the researcher just needs to give a brief guideline before the evaluation and interacts with shoppers during the evaluation. The interaction between the participant and the researcher can attempt to manage the retrospective problems of a complicated experience (Echeverri, 2005).

Traditional mystery shopping requires shoppers to fulfill the report within 12 to 24 hours after the evaluation. Since fresh mystery shoppers tend to forget more details than proficient shoppers, there might be bias or inconsistency in the report they submit. Calvert (2005) and Morrison et al. (2010) stated that mystery shopping could be coupled with other methods to improve reliability and validity.

Since traditional mystery shoppers have to memorize a lot of key points before the evaluation, the deep impression of those points may lead to a better consistency of those points they have memorized. However, it is easy for them to leave out details. Hence, the third and fourth hypotheses are:

H3: When conducting mystery shopping, using traditional method is better in terms of consistency of information retrieve than by using smartphone application survey.

H4: When conducting mystery shopping, using smartphone application survey during the shopping process is better in terms of accuracy of information retrieve than after the shopping process.

Although traditional mystery shopping has its weakness, there is one aspect that new methods may be inferior in: completion time. A study by Dawson and Hillier (1995) in the retail sector showed that the mystery shopping process should be at most half an hour and no longer. A mystery shopping that takes too much time may impact the business of the organization and risk the identification of the mystery shopper by the employee, thus jeopardizing the entire effort. The new method may consume more time than traditional method by which shoppers memorize every detail by their memory. They have to either ask the researcher about what to do next or wait for the answer via SMS or peek at their phone to see notes on smartphones. Therefore, the last hypothesis is:

H5: When conducting mystery shopping, using traditional mystery shopping will consume less time than using new methods to conduct mystery shopping.

METHODOLOGY

Independent Variable

The independent variable is different methods in mystery shopping, including calling and audio recording functions on smartphone, SMS and audio recording functions on smartphone, notes and audio recording functions on

smartphone, and participant's memory, i.e. no smartphone.

For calling and audio recording functions using smartphone, the mystery shoppers called the researcher once they arrived at a convenience store, thus real time interaction occurred during the whole process. The audio recorder functioned during the whole process. Mystery shoppers filled in the evaluation forms on the smartphone application during the process. During the interaction, the researcher guided and reminded shoppers and they were expected to ask questions secretly if there were points that they were unsure of.

For SMS and audio recording functions using smartphone, the mystery shoppers texted the researcher once they arrived, thus real time interaction occurred. The audio recorder functioned during the whole process. Mystery shoppers filled in the evaluation forms on the smartphone application during the process. During the interaction, the researcher guided and reminded shoppers via SMS and they were expected to text any questions for any points that they were unsure of. They then texted the researcher once they were done with the shopping.

For notes and audio recording functions using smartphone, the mystery shoppers were given a list of points written on the notes which showed on smartphone before the process. They were allowed to add or delete some points accordingly and they got the notes ready right before entering the store. No real time interaction occurred during the whole process. The audio recorder functioned during the whole process. During the process, they had to fill in the forms on the smartphone. They were expected to peek the key points on the notes to make sure they obtained the necessary data.

For the traditional method, without smartphones as tools, mystery shoppers were expected to memorize key points before the process and observe them during the process. After the evaluation, each shopper filled in an evaluation form right after the process.

All mystery shoppers had to fill in another evaluation form within 24 hours after the process.

Dependent Variables

There were five dependent variables measured in this study. First, in order to measure participants' mental workload, NASA-TLX was used. Second, to measure the participants' satisfaction about the tasks, a satisfaction questionnaire was used. It consisted of two sections. The first one had 8 questions measuring how participants felt and the second one had 6 questions measuring their opinions about the process. The third one is the consistency of information retrieving. It was measured by the comparison of two evaluation forms. The fourth one is the accuracy of information retrieving. It was measured by the number of key points which were listed in the guideline but forgotten to observe by mystery shoppers. The last one is the length of time from the moment when shoppers entered the spot to the moment when they stepped out of the spot.

Participants, Spot and Apparatus

In this study, 40 university students were recruited via social media as mystery shoppers. All of them were Chinese and were familiar with smartphone applications. They were divided into four groups. Each participant conducted one method of mystery shopping. A 7-Eleven convenience store was selected as the spot of mystery shopping.

During the process, each participant was equipped with two smartphones except those who conducted traditional mystery shopping. One was SAMSUNG smartphone which had Android OS and it was used to make a call or to send SMS as well as to fill in the evaluation form during the mystery shopping. The other smartphone was used to record the audio. They were both equipped with new SIM cards to prevent disturbance from others' call. Besides, for participants who were allocated to deploy the calling method, each one was equipped with an earphone. For participants who deployed the traditional method, each was provided with a laptop right after the mystery shopping in order to fill in the first evaluation form and each was equipped with a stopwatch to record the time.

Task and Procedure

Before conducting the evaluation, each participant was assigned individually to read a guideline of the key points and details that they needed to observe and ask in the store. Memorizing the detailed information was not required for participants who were involved in the three new methods. In addition, they had to fulfill a practice test on using the smartphone application prior to evaluation because they had to use the application during the process. Participants had to report every negative observation; for example, "the floor has debris all over the store". The result of the evaluation form would be sent directly to the researcher via text message once they clicked "submit".

During the whole process, the other smartphone was running to record conversation. For the traditional methodology, no smartphone was used. Thus, memorizing the detailed information was required.

The details in different groups were slightly different from one another. For the calling and audio recording method, each participant had to call the researcher once they arrived at the convenience store and the researcher would record the beginning time. During the shopping, real-time interaction via phone call was carried out to remind participant what to do. For SMS and audio recording method, all interaction between the participant and the researcher was via SMS. For notes and audio recording method, there was no direct interaction between the participant and the researcher. Each participant had to prepare the notes ready on the smartphone and recorded the beginning time all by himself. After the shopping process was done, he recorded the ending time again. For traditional method, each participant had to deploy the process all by his memory of the guideline and record the time by himself.

After the shopping process, they had to meet the researcher again in the nearest coffee shop to fill in post-evaluation questionnaires. Three questionnaires were given to them. The first was a web-based evaluation form, they were given a link with username and password, and they had to fill in the form anytime within 24 hours after the shopping. The result was submitted directly to the researcher's email immediately after they clicked the 'submit' button. Audio recording was uploaded together with the second evaluation form. For the traditional method, each participant also had to fill in the first evaluation form. Then the second and the third post-experiment questionnaires regarding participant's workload and satisfaction were provided and filled in.

RESULTS

Among the 40 participants, there were 15 male and 25 female. The participants' age ranged from 18 to 30 years old (Mean=23.1, SD=2.49). There was only 1 participant who had experienced mystery shopping before and there were 3 participants who had not used smartphone. Half of the participants majored in industrial engineering and the other half were from other departments. There was no significant difference among each group in the aspect of age, gender, education level, major and mystery shopping experience.

To test the hypotheses, this study compared the mean value of four methods in the aspect of workload, satisfaction, consistency, accuracy and timing.

K-S test was conducted to test if the sample was normally distributed. As a result, the accuracy was not normally distributed ($Z= 2.205$, $p<.001$) and the other four variables were normally distributed. Therefore, one-way ANOVA was conducted as the variance analysis on workload, satisfaction, consistency and timing while nonparametric test was conducted as the variance analysis on accuracy.

The result of variance analysis is revealed in Table 1. There was no significant difference on participants' workload ($F=.315$, $p=.814$) and satisfaction ($F=1.776$, $p=.169$). There were significant differences on participants' consistency, accuracy and completion time.

Pairwise test was conducted to confirm where the difference existed between groups in terms of consistency, accuracy and completion time. The result is in Table 2, Table 3 and Table 4.

Table 1: Variance analysis of dependent variables

Dependent variable	Calling		SMS		Notes		Traditional		$F(\chi^2)$	p
	Mean	SD	Mean	SD	Mean	SD	Mean	SD		
Workload	13.6	2.02	13.0	3.17	12.4	4.57	12.5	2.85	.315	.814
Satisfaction	5.3	.56	4.9	.44	5.0	.44	5.3	.59	1.776	.169
Consistency	.48	.22	.46	.10	.46	.19	.69	.08	4.955	.006
Timing	11.8	1.8	16.9	3.43	8.4	1.60	6.2	2.81	33.972	<.001

Accuracy*	1.00	.01	.98	.03	.99	.03	.89	.08	16.695	.001

Note: The variance analysis of accuracy was conducted via nonparametric test.

Table 2: Pairwise comparison of four methods on timing

Dependent variable		Mean difference	*p*
Calling	SMS	-5.1*	<.001
	Note	3.4*	.005
	Traditional	5.7*	<.001
SMS	Calling	5.1*	<.001
	Note	8.5*	<.001
	Traditional	10.7*	<.001
Note	Calling	-3.4*	.005
	SMS	-8.5*	<.001
	Traditional	2.3	.054
Traditional	Calling	-5.7*	<.001
	SMS	-10.7*	<.001
	Note	-2.3	.054

Note: The mean difference is significant at the level of *p*=.05

Table 3: Pairwise comparison of four methods on consistency

Dependent variable		Mean difference	*p*
Calling	SMS	.02	.777
	Note	.03	.724
	Traditional	-.21*	.006
SMS	Calling	-.02	.777
	Note	.01	.944
	Traditional	-.23*	.003
Note	Calling	-.03	.724
	SMS	-.01	.944
	Traditional	-.23*	.002
Traditional	Calling	.21*	.006
	SMS	.23*	.003
	Note	.23*	.002

Note: The mean difference is significant at the level of *p*=.05

Table 4: Pairwise comparison of four methods on accuracy

Dependent variable		Mann-Whitney U	p
Calling	SMS	34.500	.121
	Note	44.500	.503
	Traditional	11.000*	.001
SMS	Calling	34.500	.121
	Note	41.000	.399
	Traditional	16.000*	.007
Note	Calling	44.500	.503
	SMS	41.000	.399
	Traditional	14.000*	.003
Traditional	Calling	11.000*	.001
	SMS	16.000*	.007
	Note	14.000*	.003

Note: The mean difference is significant at the level of p=.05

It can be seen that SMS method took the longest time compared with other three methods and traditional method took the shortest time. As for pairwise comparison of timing, all methods showed significant difference with each other except for notes and traditional method.

As for consistency, it can be seen that traditional method had the highest consistency among the four methods while there was no significant difference among the other three new methods about consistency.

As for accuracy, it can be seen that traditional method was the least accurate method among the four and there was no significant difference among the other three new methods about accuracy.

Then a summary review of the five hypotheses is:

Hypothesis 1 was to examine the influence of four methods on participants' workload. The one-way ANOVA result showed that there was no significant difference. Hence, hypothesis 1 was not supported.

Hypothesis 2 was to examine the influence of four methods on participants' satisfaction. The result also showed that there was no significant difference. Hence, hypothesis 2 was not supported either.

Hypothesis 3 was to examine the influence of four methods on participants' consistency of information retrieving, i.e. the similarity between the results of the two evaluation forms which were filled in when participants finished mystery shopping just in time and afterwards within 24 hours respectively. The result showed that traditional method had significantly higher consistency than new methods and there was no significant difference among the other three methods. Therefore, hypothesis 3 was supported.

Hypothesis 4 was to examine the influence of four methods on participants' accuracy of information retrieve, i.e. how many key points the participants did evaluate during the mystery shopping process. The result showed that traditional method had significantly lower accuracy than new methods and there was no significant difference among the other three methods. Therefore hypothesis 4 was supported.

Hypothesis 5 was to examine the influence of four methods on the length of time. The statistical result showed that SMS method took the longest time and every two methods had significant difference of timing except for notes method and traditional method. Hence, hypothesis 5 was partially supported.

DISCUSSION

Within the aforementioned conceptual framework, some interesting results were found.

This study did not find significant difference among four methods on shoppers' workload or satisfaction, which indicates that when related organizations conduct mystery shopping programs, shoppers' workload and satisfaction would not be important factors influencing the adoption of different methods.

As for consistency of information retrieving, traditional method had significant advantage. This is due to the fact that for traditional method, participants have to memorize everything that is stated in the guideline in detailed manner before the evaluation and have to memorize everything that they observe in the store after the evaluation. Whereas for the new methods, shoppers are not required to memorize the guideline and things that they observe inside the stores as they are allowed to bring smartphone inside the store and interact with the researcher. Therefore, participants who undergo traditional method are able to memorize the information retrieved than those who undergo new methods.

Although traditional method beats the other three in the aspect of consistency, it shows low accuracy according to the result. This shows that having interaction with the researcher who appoints specific task to the shoppers and having additional tools to enhance the mystery shopping have higher accuracy in terms of information obtained. This is because shoppers can interact with the research in real time and the researcher can direct shoppers on information that needs to be observed. For notes method, shoppers can write as much information as they want in the smartphone application for it serves as a reminder. Therefore, organizations should trade off between consistency and accuracy of information retrieving or deploy mixed methods combing the advantages of human memory and enhanced assisting tools.

Finally, as for the length of shopping time, the result shows that SMS and calling methods take longer time than the other two. This is due to the fact that for SMS methods shoppers need to write an SMS once they arrive in the assigned store, and have to wait for the researcher's reply and direction for any information that needs to be observed. Likewise, calling method takes more time than notes and traditional methods because they have to do multitasking jobs, i.e. listening, observing, and filling-in the evaluation form on Android smartphone at the same time. As for notes and traditional methods, no interaction between the shopper and director occurs in this methodology so the shopping process takes less time than the former two.

In summary, depending on the type of company, budget, period of time, expected results, organizations interested in conducting mystery shopping programs can choose suitable method for them or mix them together to achieve comprehensively good results.

CONCLUSION

The objective of this study is to investigate different methods in performing mystery shopping programs, i.e. new and traditional methods, focusing on China's convenience stores. On one hand, the results should help the mystery shopping company to learn and to apply new approaches for its clients to enhance clients' satisfaction and experience. On the other hand, it should be seen as a guideline for any organization interested in conducting mystery shopping program in a way that ensures that their product and service quality can be improved after they implement the mystery shopping program. It should also help the mystery shopping company to evaluate which new method is the best.

An important finding is that traditional methodology is regarded as the best method in terms of consistency; whereas new methods are better in terms of accuracy. For timing, methods that are meant to interact in real-time situation with the project managers, i.e. call and SMS method, take more time than methods that are not meant to interact with the project managers. Although not all hypotheses formulated have significance differences among the methodologies, the results also indicate that those hypotheses have positive implications. For example, for workload and satisfaction, there is no significant influence among all methods. This means that organizations are allowed to choose any method depending on their budget, preference, and decision to conduct mystery shopping programs

without having to worry about the effect of shoppers' workload and satisfaction.

In addition, it is also possible to combine the new and traditional methodology so that the information obtained will be more accurate and consistent. The most important prerequisite is to provide the right and proper training to mystery shoppers prior to conducting the program.

However, the convenience store is limited to 7-Eleven in Beijing and participants' culture, education background is also limited, which may cause bias to the results. Besides, since most participants have no prior mystery shopping experience, whether or not the results will be the same on professional mystery shoppers is worthy of further validation.

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Research based on the iOS Platform on the Interface Design of Comprehensively Informationized Teaching System

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ABSTRACT

This paper introduces the UI interface design and its application based on the iOS platform of comprehensively informationized teaching system. On the basis of typical examples of interfaces, results of user's questionnaire and relevant theories, this paper attempts to present the UI interface in detail through the stages of discussion, design and implement. Meanwhile, in order to find balance between theoretical strictness and practical effectiveness, this paper will make every effort to point out the improvement methods and put forward solutions to the defect, according to the analysis of design under usability experience criterion.

Keywords: iOS, Teaching System, Interface Design

IOS PLATFORM AND TEACHING SYSTEM

Introduction to iOS platform

iOS is a mobile operating system developed and distributed by Apple Inc. Originally unveiled in 2007 for iPhone, it has been extended to support other Apple devices such as iPod Touch (September 2007), iPad (January 2010), iPad Mini (November 2012) and second-generation Apple TV (September 2010). Like with Mac OS X, it shares Darwin foundation, and therefore belongs to the same class of commercial UNIX operating system. Originally called iPone OS, iOS was renamed as iOS at WWDC conference in June7, 2010.

Interface Design based on the iOS Platform

There are two ways to design interface on the iOS platform. One way is using nib file or storyboard file. You can directly drag widgets to specified location in the corresponding graphical interface, such as UIView, UIKit (including UIButton, UILabel, UITextView etc.). Another way is using codes. You can also write codes to generate the appropriate widgets in the .m file by iOS class library.

It's worth mentioning that Apple Inc. introduced storyboard in iOS 5.0 to support and improve the UI interface design. Compared with the traditional nib file, storyboard breaks the form that a .xib must correspond to a ViewContoller. Instead, storyboard takes all the nib files and organizes them into MainStoryBoard.storyboard. Meanwhile, jumping among pages can also be done on the storyboard, which accords more with the idea of MVC. However, it also has certain requirements to developers. For example, view must be managed through ViewController which is not conducive to developments by more than one person at the same time.

UI Interface Design of Teaching Software on the iOS Platform

Apple Inc. announced that, by February 2012, App Store has the largest number of game applications, reaching 95,324 and accounting for 17.26%; book applications, amounting 60,604 and accounting for 10.97 %, came in second. Entertainment applications ranked third, accounting for 10.32% (Figure 1.1). It can be clearly seen from the number of book applications that teaching Apps on the iOS platform occupy an important position.

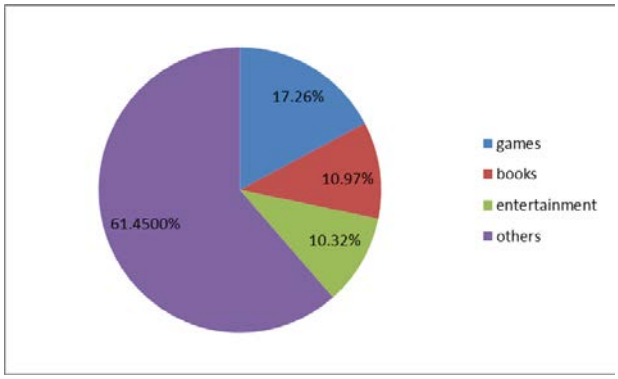

Figure1.1 pie chart of application amount and ratio in App Store

As a supplementary tool, teaching software plays a necessary role in the teaching and learning process, and friendly interface can make teaching software more efficient. Therefore, UI interface design of teaching system not only should the follow general requirements of software design, but also should meet some special needs:

1. Educational software mainly caters to teachers and students, and their physical and mental characteristics are the fundamental points. So the combination and structure of interface design should be reflected in the level;

2. The design need to closely connect “teaching” and “learning”, and its elements should fully reflect teaching strategies;

3. The “level” of design form is changeable. Interface’s framework should not only accords with aesthetic tendencies of teachers and students, but should also pay attention to knowledge.

THE INTERFACE DESIGN OF COMPREHENSIVELY INFORMATIONIZED TEACHING SYSTEM

Introduction to Comprehensively Informationized Teaching System

The iOS Client of comprehensively informationized teaching system mostly caters to the majority of students and employees who receive training. Further, its main function is cooperating with server based on .Net platform and finally implementing the auxiliary teaching between teachers and students. The system consists of training system, professional teaching system and other functions (Figure 2.1).

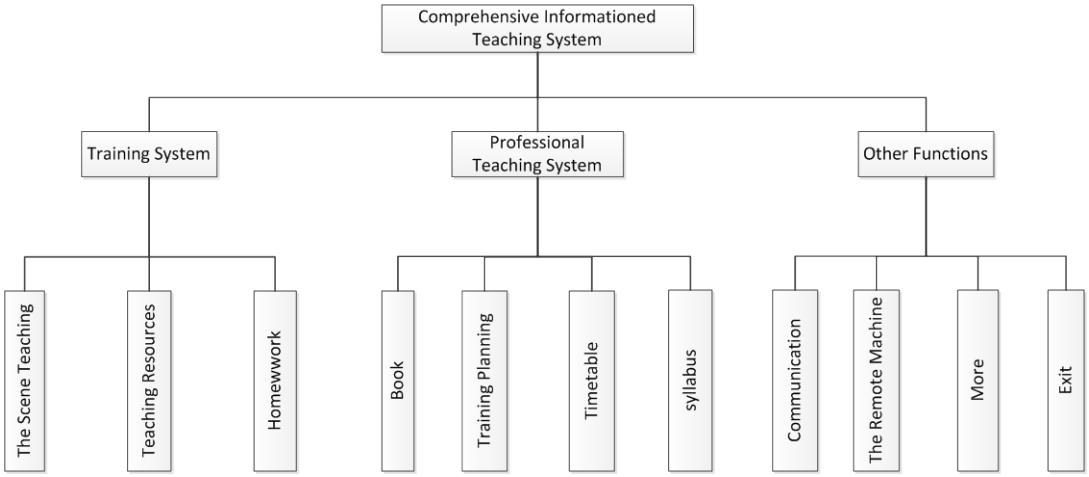

Figure2.1 Foundational Structure of System

The Ideas and Projects of UI interface Design

Nowadays, with the popularity of GUI and human-computer interaction concept, UI interface is not a simple visual design or presentation of information, but is the Apps' first impression for users. Therefore, friendly, beautiful and efficient interface can absolutely attract users' attention and thus becomes helpful to the application.

For the design of UI interface based on comprehensively informationized teaching system, this paper takes the functions and user groups into consideration. Combined common requirements with special needs of teaching software, this paper comes up with following requirements for the design of UI interface after researches among certain users (Figure 2.2).

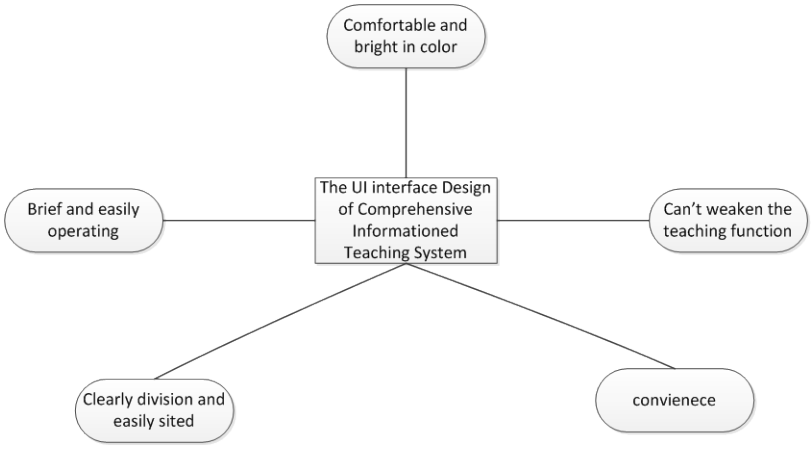

Figure2.2 the requirements of the interface design

Considering the users' requirements and the actual situation of the system, the initial idea of this paper was dividing UI interface into three parallel modules according to the Client's main functions. In order to realize the shift among sub-functions, specific contents are then added to their corresponding modules. Based on ideas above, this paper came up with some programs as alternatives:

1. In terms of the framework design, most of the existing mature frameworks use the tab bar to shift among

functions. Thus, this paper mainly proposed three plans:

Plan 1: Similar to web browsers, the framework puts the tab bar above the interface in order to shift among functions;

Plan 2: Similar to iOS, the framework puts the tab bar at the bottom of the interface;

Plan 3: Employing the vertical tab bar and making the shifts labels on the left side of the interface.

2. In terms of the color coding, on one hand, designers should attach more importance to the smartness of colors rather than the excessiveness, avoiding distracting users' attention. On the other hand, due to the color white, whose RGB value is (255,255,255), is used as the background color in the .Net platform, while the color gray, whose RGB value is (192,192,192), is employed in the Android platform, light color are thus chosen as the main color of the teaching system for keeping the uniformity between multiple platforms. Finally, two plans were proposed: ivory wood grain background and khaki wood grain background (Figure 2.3).

Figure2.3 Background color of the system

3. In terms of graphic design, square icons with round horn and round icons are the key of choice.

The implementation of the UI interface

After a detailed analysis of the alternatives above, the following plan was chosen on the basis of aesthetics and functions (Table 2.1):

Table 2.1 the choices of the UI interface design

Alternatives and Decision			
Framework	Plan 1:tab bar above the interface		Because horizontal screens are mostly used in operation interfaces of teaching systems, and iPad's screen size is 1024*768 with the ratio of 4:3, thus the third program was chosen. It can not only make the best use of the screen by making the widgets placed compatibly with the size of the screen, but can also be easier for users to operate. Meanwhile, the design resembles bookmark, which can better highlight the academic style of the teaching system.
	Plan 2: tab bar at the bottom of the interface		
	Plan 3:tab bar on the left of the interface	√	
Color Coding	ivory wood grain	√	As the background color, ivory looks brighter. With the help of dark words, it is clearer for the readers to read the text. Meanwhile, ivory goes with other background colors.
	gray wood grain		
Graphic Coding	square icon with round horn	√	Both of them are common on the iOS platform, so the combination of them were chosen. In order to distinguish, the former is used to express the main function modules while the latter stands for sub-functions.
	rounded icon	√	

In the actual implementation phase of design, the personalized interface directly drawn and set by Nib file (including three parallel functional modules and some sub-view) was chosen, according to the interface design approach offered by iOS platform. Meanwhile, generating the framework and universal interface by codes was chosen. Such design provides great convenience for further developments and maintenance.

The Main Design Plan of Teaching System

The design of UI interface of Comprehensively Informationized Teaching System (Figure 2.4) mainly takes user requirements into consideration and employed theories about user human-computer interaction and usability.

Firstly, its framework adopts vertical tab bar which is popular in many mainstream Apps. This design can not only provide enough space for illustrating functions, but can also make the interface more integral. Meanwhile, the division of interface modules is clearer: section A is used to shift functions, while section B is navigation bar corresponding to module, and section c is the area to operate sub-functions. Meanwhile, the area was divided by the complexity and frequency of operation, following the proportion parameter of 1:5:15.

Secondly, in terms of the color coding, the ivory was chosen as the background color and the dark or light color was chosen as text and pictures' foreground color. Such colors form a bright contrast.

Finally, the combination of square icon with round horn and round icon was chosen, which is in accordance with iOS in graphic coding. The square icon with round horn is used to express the main functions, and the rounded icon stands for sub-functions. Moreover, attentions were paid to the icons' metaphorical function. In other words, users can understand the functions of the icons without explanations. What's more, to avoid misunderstanding resulted from inappropriate illustrations of icons, simple title were employed to explain the function of the icons. Notably, the system development follows the idea of backward compatibility, thus the interface's style is still the "materialized" style before iOS 7.0.

Figure2.4 the UI interface of system

On the other hand, considering the problem of human-computer interaction, the system uses many information tips to communicate with users when interface shifts, waits and so on. Meanwhile, the highlight of this system is waking up the screen by pressing the suspended button (Figure 2.5) which was chosen to control video in training system module. This design makes it more interesting to operate. Moreover, clear explanations can also help users to find the corresponding operation easily.

Figure 2.5 suspended button

THE ANALYSIS OF THE UI INTERFACE

Analysis of Usability

Analysis of usability for UI interface design mainly refers to usability experience criteria in *Usability Engineering* (Table 3.1).

Table 3.1 Analysis of Usability of the system interface

Usability Analysis of the UI interface		
usability experience criteria	**mark**	**illustration**
Simple and natural dialog	√	in term of color coding, foreground color and background color contrast relatively distinct; and in graphic coding, it inherits the "materialized" style in the iOS
Using user language	√	
To minine the bunder on the user memory	√	
consistence	√	Using the unified interface layout, maximal reduce the burden of the user's memory
Feedback	√	Using many information tips to support waiting or confirmation
Clear mark for exiting	√	
Good error information	X	
Avoiding to mistakes	√	
Help and document	√	
Empirical assessment	X	

Improvement

The results of the usability analysis of system interface showed that the teaching system still has something to be improved. For example, in terms of color coding, since there is no professional coding design, there may be some errors that have an impact on aesthetics. Moreover, in terms of the whole design style, Apple Inc. introduced a new iOS 7.0 which successfully transformed from "materialized" to "flatten". Therefore, the UI interface design will be adjusted at the later stage. Finally, considering the influence of the human-computer interaction, it should be paid attention that the exit function of the function is quiet covert and there was no uniformed exit logo.

CONCLUSION

A growing number of European and American countries, especially America, the birthplace of Apple Inc., become trying to use handheld mobile devices to assist teaching, which is widely accepted by students. Taking the market into consideration, iOS technology with high proportion of 62.6%among equivalent products has its advantages; and in teaching field, applying mobile devices with the iOS platform has become one of the five teaching tasks. As a result, a friendly and efficient UI interface plays an important role.

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Section 4

Affective User Experience

Beyond Convenience: The Role of Emotions in the Adoption of Sustainable Technologies

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ABSTRACT

The slow adoption of sustainable technologies is cause for concern in an increasingly resource strained world. This study attempts to build on two main bodies of research: (1) a general technology adoption framework; i.e. the Unified Theory of Acceptance and Use of Technology (UTAUT) and (2) work on the psychological design for affect; i.e. affective design. The purpose of this study is to report on the development and psychometric properties of the scales that will be used to assess the adoption of the Interface® Urban Retreat™ carpets (a sustainable carpet using recycled materials and possessing biophilic characteristics) in a follow up study. The Semantic Differential Scale developed for these carpets produced a wide range of affective qualities. The scale did not, however, support the underlying structure of Evaluative, Potency, and Activity as proposed by Osgood et al. (1957). The UTAUT scales presented with reasonable to good internal reliability and with the exception of 'perceived effort', the subscales were correlated with intention to adopt. Based on these two preliminary studies, the scales will be revised and then administered to determine the complementary roles of the utilitarian factors (based on the UTAUT) and emotional factors (based on the semantic differential scale developed for this purpose).

Keywords: affective design, sustainable technology, Unified Theory of Acceptance and Use of Technology, biophilia

INTRODUCTION

Many market innovators and designers will be familiar with the experience that not every effectively engineered innovation is successful in the marketplace. There is little reason to suspect that sustainable technologies should be any different from other types of technologies. Despite the development of numerous sustainable technological innovations a number of authors have warned about the slow adoption of these technologies by States and individuals (Hekkert et al., 2008; Hensley et al, 2009; Kassie et al., 2009). There are many factors that determine whether a specific technology is a success or a failure. The most common reason for the success (or lack therefore) is often (sometimes incorrectly) attributed to the cost of a particular technology (Lenhart et al., 2003). While cost is obviously an important component, Green (2001) suggests that the adoption and use of technology is less about cost and the technical qualities of the technology and more about being socially bound; being determined by access to education and training, the perceived application within a society, and by individual ability. Douthwaite et al. (2001) noted that an overlooked component of why innovative technologies fail is because they neglect to take into account the role of the user in the adoption process.

There are a number of reasons why people would not adopt a technology or not continue to use a technology. First, people need to know about the technology. This is largely about marketing the technology, making sure that the potential user population gets to know about a particular technology (technology developers and governments have a role to play here). Second, people might know about the technology but they see little value in making a change. Change is associated with costs which include sourcing costs (e.g. getting access to technology often has costs associated with finding suppliers), monetary costs (of buying and installing new technology), lost opportunity costs (it takes time to learn to use a new technology), and risk-taking (not all new technologies perform as advertised). Again, this is primarily about marketing to ensure that appropriate and accurate information about the benefits (and problems) reach the potential user population to help them make informed decisions (again, technology developers and governments have a role to play here). Third, people access the technology but soon stop using it. This could be due to problems of non-intuitive design, training, operational support (e.g. a hydrogen car needs a hydrogen fuel support system), or maintenance amongst other reasons. Finally people could access technology but not use it properly (e.g. use a sustainable technology in a non-sustainable way). This paper focuses on how people adopt and accept sustainable technologies. How people use green technologies and whether they use them in a way that supports sustainable behaviour falls beyond the scope of this paper but are also important area to consider.

AFFECTIVE DESIGN

Jordan (2000) makes a distinction between functional elements (i.e. usability) and aesthetic components (including pleasure and other emotional experiences). Another branch of technology adoption has therefore also considered the emotional or aesthetic appeal of the innovation or technology. This is an area of study broadly referred to as "affective design". In general, affective design considers the full range of human emotional experience in a variety of contexts. Affective design (and design for emotion in general) considers a far greater range of connections for emotion and interactions with products and other systems, both pre- and post-adoption. This paper focuses on exploring affect up to the point where the decision to acquire/adopt a particular product or system is taken. Theories of affective design emphasise the relationships between the end user and the qualities of the technology. Affective design (Khalid, 2006) attempts to understand how a user's feelings and emotions towards a product or system influence their likelihood of adoption. Affective human factors design focuses on maximizing positive experiences with products and systems. This is supported by a number of studies that have found that positive affect leads to the greater acceptance of a design (Helander, 2003; Sonderegger & Sauer, 2010), greater perceive usability (Ben-Bassat et al., 2006; Sauer and Sonderegger, 2009), and objectively better user performance (Sonderegger & Sauer, 2010). Previous evidence also suggests that designs that produce positive affect also tend to be perceived as having greater utilitarian impact (Ben-Bassat et al., 2006).

The most common method of assessing the emotional factors related to the design of a product is through a semantic differential scale The semantic differential scale technique makes use of a questionnaire where participants are asked to rate signs, words, or objects on bipolar scales (Osgood, et al., 1957). These bipolar scales are defined as contradicting adjectives at each end of the emotional range where participants are required to check off the position which best represents how well each adjective suits the target technology (Karlsson et al., 2003). Osgood et al. (1957) argued that the dimensions underlying the scales were Evaluation, Potency, and Activity. The Evaluative factor can be explained by the adjective pair "good-bad" in that it captures the amount of goodness or badness a person associates with a concept. (White et al., 2008). The Potency factor captures the amount of powerfulness or weakness associated with a particular concept, while Activity captures the amount of liveliness or quietness of the concept.

UNIFIED THEORY OF ACCEPTANCE AND USE OF TECHNOLOGY (UTAUT)

Venkatesh et al. (2003) produced a theoretical framework that combined various technology adoption models (i.e. Technology Acceptance Model (Davis, 1989) and the Innovation Diffusion Theory (Rogers, 1962) together with the model of PC utilisation (Thompson et al, 1991), called the Unified Theory of Acceptance and Use of Technology (UTAUT). The central component of the UTAUT is the Technology Acceptance Model (TAM) which is one of the most widespread and empirically tested models of technology acceptance. The TAM is loosely based on Ajzen and Fishbein's (1980) psychological Theory of Reasoned Action. The TAM replaces many of the attitudinal components in the Theory of Reasoned Action with only two technology-related attitudes, perceived usefulness of the technology and perceived ease of use of the technology. Davis (1989) argued that high positive ratings of these two

attitudes would lead first to intentions to use a particular technology and then, if the intention levels were high, this would lead directly to the actual use (behaviour) of that technology. The TAM has been tested successfully on a wide variety of technologies including general information systems, computer applications, email, telemedicine technology, the World Wide Web, and mobile phone applications, amongst many other technological applications. In the original conceptualisation of the TAM, Davis (1989) used a "catch all" factor called external variables to incorporate unexplained influences on the relationships. Typical external variables used in previous studies included past experience, gender, age, and previous education. Venkatesh and Davis (2000) extended the original TAM (i.e. TAM2) to include social influences (i.e. social norms, voluntariness, and image), perceived instrumental factors (i.e. perceived relevance and perceived output quality), and the user's past experience.

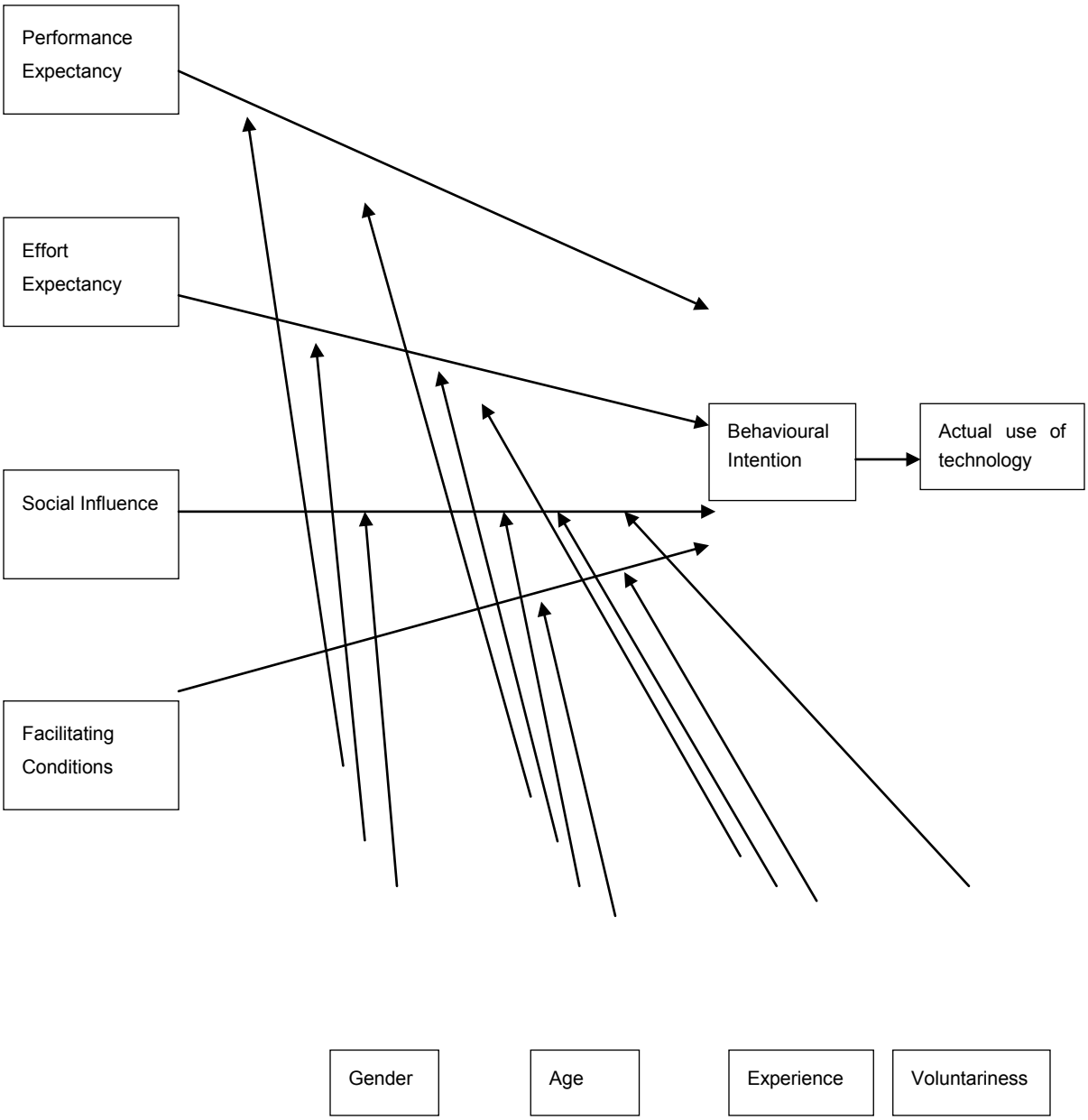

Figure 1. Unified Theory of Acceptance and Use of Technology – UTAUT (Adapted from Venkatesh et al, 2003; p. 447).

The Innovation Diffusion Theory is a decision-theoretic model with five predictors: relative advantage, compatibility, complexity, trialability and observability. According to Karahanna et al. (1999) relative advantage is an approximate for perceived usefulness and complexity is interchangeable with perceived ease of use as proposed by the TAM. Compatibility is also a close approximate of perceived relevance in TAM2 and observability is conceptually similar to perceived output quality in TAM2. It is argued that trialability is the only attribute within

Innovation Diffusion Theory that was not encompassed by the expanded TAM2 and is also not included in the UTAUT. Essentially, the model of PC utilisation included two aspects absent from the earlier models; job-fit and facilitating conditions (i.e. objective factors that make a specific technology easy to use). Venkatesh et al. (2003) argued that many of the concepts contained within these models were conceptually similar (see Table 1), but found moderate to poor empirical support for each of the theoretical models applied separately. The UTAUT (see Figure 1) is comprised of four determinants (i.e. performance expectancy, effort expectancy, social influence, and facilitating conditions) that predict intentional behaviour, which predicts actual behaviour. In addition, the model hypothesises that there are four moderating factors (i.e. gender, age, experience, and voluntariness) that influence the strength of the relationships between the determinants and behavioural intention. Venkatesh et al. (2003) found good empirical support for the UTAUT in two organisational settings.

Table 1: Comparison between UTAUT determinants and variables contained in other technology acceptance theories

Determinant/Variables	Theory	Empirical evidence
Performance Expectancy		
Perceived usefulness	TAM/TAM2	Davis (1989)
Relative advantage	IDT	Moore & Benbasat (1991)
Job-fit	MPCU	Thompson et al (1991)
Perceived relevance	TAM2	
Effort Expectancy		
Perceived ease of use	TAM/TAM2	Davis (1989)
Complexity	IDT/MPCU	Moore & Benbasat (1991)
Social Influence		
Subjective norms	TAM2	Thompson et al (1991)
Social factors	MPCU	
Image	TAM2	
Facilitating Conditions		
Compatibility	MPCU	
Facilitating conditions	IDT	
Perceived behavioural control	TPB	Taylor & Todd (1995)

TAM=Technology Acceptance Model; TAM2= Extended Technology Acceptance Model; MPCU= Model of PC Utilisation; IDT= Innovation Diffusion Theory

THE ADOPTION OF SUSTAINABLE TECHNOLOGIES

Applying affective design to sustainable technologies, Midden et al. (2007) considered four roles: 1) intermediary role (i.e. getting people to use sustainable technology); 2) amplifier role (i.e. technology amplifies the attainment of sustainability goals but also amplifies the use of resources); 3) determinant role (i.e. technology shapes behaviour by its presence/absence or affordances/constraints); and 4) promoter role (i.e. technology specifically influences behavioural choices). This paper is concerned with understanding products (i.e. technology) from an intermediary role perspective by understanding how affective properties might influence decisions to adopt sustainable technologies. Other than theoretical work (e.g. Thatcher, 2012) there are no studies that have looked at the impact of aesthetic and effective properties on the adoption of sustainable technologies. There is only a limited amount of published work that has applied UTAUT or its predecessor theories to sustainable technologies. Arkesteijn and Oerlemans (2005) looked at an extended version of the TAM by considering technological factors, individual factors, and economic factors associated with the adoption of green electricity. They found that ease of switching, knowledge of the energy sources, attitudes towards the environment, and willingness to pay were all important determinants of intention to adopt green energy. In other work on the adoption of green electricity, Gerpott and

Mahmudova (2010) found that a consumer's attitudes towards the environment were an important determinant of adoption, together with the influence of close social contacts, although they found there were differences among high power uses and moderate power users. Moons et al (2009) used a combination of the Innovation Diffusion Theory and the Theory of Planned Behaviour (a derivative of the Theory of Reasoned Action) to examine people's adoption of electric vehicles. The found that aspects such as perceived complexity, relative advantage, compatibility, social norms, and perceived behavioural control were all important determinants in the adoption of these cars. In addition, they found that past experiences and emotional reactions to these cars were also important determinants. Hong et al (2013) applied the same theoretical framework to understand the adoption of hybrid vehicles in Malaysia. They found that perceived behavioural control, relative advantage, and compatibility were the best predictors of adoption intentions.

Given the dearth of literature on the adoption of sustainable technologies, in this paper we describe two independent studies that were used to develop scales to assess the applicability of the UTAUT and affective design. The target sustainable technology in these studies was the Interface® Urban Retreat™ range of carpets (see Figures 2 and 3 for examples of the carpets in this range). These carpets were considered a sustainable technology because 81% of the yarn recycled, 35% of which is post-consumer (from used fishing nets), the backings are made from 50% recycled products (mostly backings from other carpets), and the adhesive method to attach the carpets to the underlying floor is 100% volatile organic compound free. The Urban Retreat™ range has been verified by several third parties on its reduced impact on the environment. The Urban Retreat™ range was also specifically chosen because these carpets were designed to look like products from nature (a concept known as biophilia – Wilson, 1984). The research questions in this paper were (1) to report on the development and psychometric properties of the Semantic Differential Scale used to assess affective qualities of the Urban Retreat™ range and (2) to report on the development and psychometric properties of the UTAUT dimensions used to assess the intention to adopt the Urban Retreat™ range.

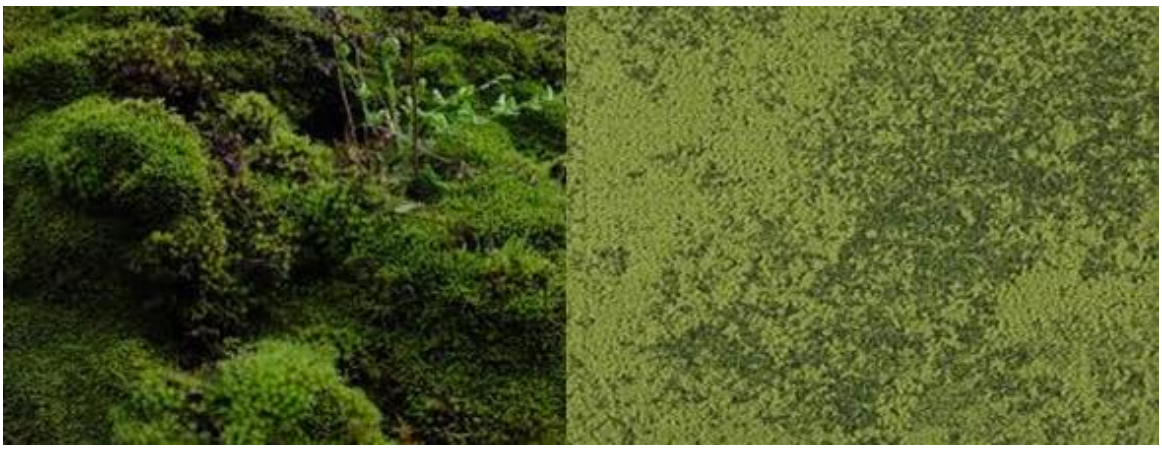

Figure 2. Interface® Urban Retreat™ carpet (pictured left) representing moss (pictured right).

Figure 3. Interface® Urban Retreat™ carpet installed in an office.

METHODS

Study 1: Semantic Differential Scale – affective factors

In Study 1, Auty and Elliot's (1998) generic semantic differential scale was adapted based on in-depth interviews with two carpet experts and a focus group with six employees (two interior designers and four architects) from an architecture firm that had already installed these carpets. The scale consisted of 25 word-pairs that required respondents to respond on a 7-point scale ranging from -3 to +3, with 0 indicating the neutral point The biographical questions and adapted scale (i.e. the questionnaire) were administered in paper-based form to a sample of employees from a range of industries (i.e. manufacturing, clothing, architecture, and education). Attached to the questionnaire was a short visual presentation of the Interface® Urban Retreat™ carpet range, provided by the South African distributors. A total of 219 completed questionnaires were returned from 236 that were distributed (giving a response rate of 93%). The sample consisted of 101 males and 118 females, with a mean age of 32.65 years (SD = 10.17), and 96 respondents having their first language as English (84 respondents used isiZulu as their first language, but all respondents worked in organisations where the medium of communication was English). The respondents came from a wide variety of job positions including students (N=41), operators (N=26), managers (N=25), team leaders (N=16), supervisors (N=12), and administrative staff (N=11).

Study 2: UTAUT factors

In Study 2, the UTAUT scales published by Venkatesh et al. (2003) and Marchewka et al. (2007) were adapted to relate to the sustainable carpet. These adapted scales were shown to two experts in the field who verified the consistency of the items with the underlying theory. A pilot study was conducted prior to data collection to evaluate the reliability and face validity of the adapted UTAUT scale. The questionnaire was administered to 15 employees in an organisation. This resulted in several changes to the precise wording of the items. The final scale consisted of 3 items each for the perceived performance, perceived effort, social influences, facilitating conditions, and intentions subscales. Attached to the questionnaire was information on the carpets that respondents were required to read. This information described the characteristics of the carpets as well as pictures representing the carpet range and was supplied by the South African distributors of the carpets. The adapted scales were administered electronically to a sample of 150 employees working in a law firm that was considering installing Interface® Urban Retreat™ carpets. A total of 114 responses were received (giving a response rate of 76%). The sample consisted of 31 males and 82 females, with a mean age of 43.15 years (SD = 12.63), and 71 respondents having their first language as English (all respondents worked in organisations where the medium of communication was English). The sample was well-educated with 44 respondents having completed a University education and a further 23 respondents having completed a post-matriculation diploma. The job positions included attorneys and candidate attorneys (N=27), directors and managers (N=22), and administrative staff (N=63).

Both studies captured biographical information for descriptive purposes. Nisbet et al's (2009) Nature-relatedness scale was also administered in both studies. This was a scale of 20 questions that asked each participant to rate how well each item described them using a 5-point scale ranging from 1 (disagree strongly) to 5 (agree strongly). Higher scores indicated a stronger cognitive, affective, and physical connection with nature. The newly developed scales and subscales were correlated with the Nature-relatedness scale to check that they were related to environmental sustainability. In Nisbet et al.'s (2009) original study, they found good internal reliability (a Cronbach's alpha of .87), good test-retest reliability (correlations between .66 and .85), and good face validity.

RESULTS

Study 1: Semantic Differential Scale – affective factors

In Study 1, only those items that scored one standard deviation above or below the mean (i.e. a score of 5 and above or a score of 3 and below). The dominant affective characteristics of the Urban Retreat™ range were expensive (M=2.76), high quality (M=5.96), exciting (M=2.83) and creative (M=2.58), where it elicits a high sense of visual stimulation, has unusual (M=2.64) and interesting or complex (M=5.30) patterns and colours adding to the carpets stimulating effects. The carpets were perceived as pleasant (M=5.38) and luxurious (M=5.11) in appearance, functional (M=5.22), durable (longevity) (M=5.36), and modern (M=5.66) in design, and organic (M=5.02) (see Figure 3). The internal reliabilities of the three dimensions' of Evaluative (α =.36), Potency (α=.14), and Activity (α=.47) proposed by Osgood et al (1957) were poor suggesting an alternative factor structure for this particular product. Further exploratory factor analytic analyses would be suggested to uncover any underlying factor structure

in the Semantic Differential Scale with respect to the Interface® Urban Retreat™ range.

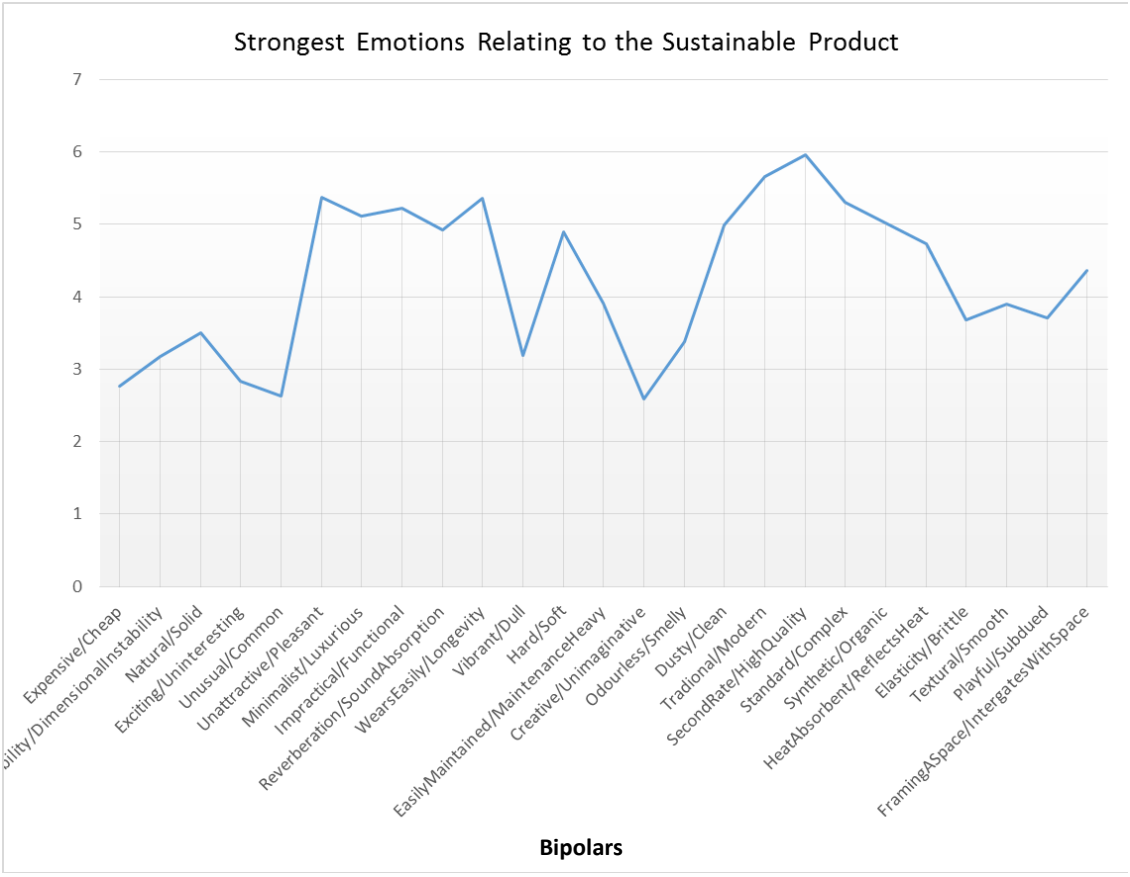

Figure 3. Semantic Differential Scale pattern of responses in relation to Interface® Urban Retreat™ carpet.

Study 2: UTAUT factors

In Study 2, means and standard deviations for the UTAUT items and subscales are presented in Table 2. The Cronbach alphas for the various UTAUT factors were α=0.43 for performance expectancy, α=0.52 for effort expectancy, α=0.57 for social influences, α=0.74 for facilitating conditions, and α=0.73 for intentions to adopt the sustainable technology. The facilitating conditions and intentions components of the UTAUT demonstrated acceptable internal reliability for social science research. Performance expectancy, effort expectancy, and social influences demonstrated questionable reliability. Performance expectancy ($r=0.43$; $p<0.01$), effort expectancy ($r=0.20$; $p<0.05$), facilitating conditions ($r=0.32$; $p<0.01$), and social influences ($r=0.40$; $p<0.01$) were, as expected, significantly correlated with intentions. Effort expectancy was significantly correlated with intentions, but the correlation was weak. Combined with the poor internal reliability, this would suggest that the perceived effort subscale requires further revision, and the performance expectancy and social influences subscales also require further investigation.

Table 2: Means and standard deviations for the UTAUT subscales

	Mean	STD
Perceived Performance	**10.89**	**1.53**
I think the Urban Retreat Carpet would create a work space that will result in me working harder.	3.14	0.75
I think the Urban Retreat carpet would create a work space where it feels good to work.	3.89	0.68

If the Urban Retreat carpet was durable it would mean that there will be less disruption over time for carpet installations.	3.89	0.78
Perceived Effort	**10.56**	**1.41**
I think it would be easy to install the Urban Retreat carpet.	3.42	0.68
I think the Urban Retreat would be easy to maintain.	3.59	0.57
I think the Urban Retreat carpet would be easy to keep clean.	3.57	0.65
Social Influences	**11.01**	**1.84**
I would be more likely to accept the Urban Retreat carpet if management endorsed it.	3.74	0.72
I would be more likely to accept the Urban Retreat carpet if my colleagues also accepted it.	3.37	0.86
I think the Urban Retreat carpet would give a positive impression to our customers/clients.	4.01	0.66
Facilitating Conditions	**11.34**	**1.65**
The Urban carpet is a good representation of the image of my organisation.	3.76	0.69
My organisation would clearly explain why it chose to install the Urban Retreat carpet.	3.69	0.70
My organisation would probably provide the necessary support for the maintenance of the carpet.	3.95	0.55
Intentions	**11.89**	**1.21**
Whether or not the company decides to install the Urban Retreat carpet I feel that it is a good product.	3.85	0.52
I would support my organisation in its choice to install the Urban Retreat carpet.	4.01	0.49
My feelings towards the installation of the Urban Retreat carpet are positive.	4.02	0.55

The internal reliability for the Nature-relatedness scale was 0.79 for Study 1 and 0.73 for Study 2. These compare favourably with Nisbet et al.'s (2009) original study. The correlations between the bi-polar pairs and the Nature-relatedness scale were generally small to moderate, ranging between 0.01 (the cheap/expensive bipolar) and 0.30 (the functional/impractical bipolar). The bipolar pairs that were significantly related to the Nature-relatedness scale were functional/impractical ($r=0.30$; $p<0.001$), playful/subdued ($r=-0.27$; $p<0.001$), odourless/smelly ($r=-0.24$; $p<0.001$), creative/unimaginative ($r=-0.22$; $p<0.001$), pleasant/unattractive ($r=0.20$; $p<0.01$), vibrant/dull ($r=-0.26$; $p<0.01$), exciting/uninteresting ($r=-.21$; $p<0.01$), dimensional stability/imbalance ($r=-19$; $p<0.01$), sound absorption/reverberation ($r=0.17$; $p<0.01$), textural/smooth ($r=-0.17$), natural multi-toned/solid tones ($r=-0.16$; $p<0.05$), longevity/wears easily ($r=0.16$; $p<0.05$), elasticity/brittle ($r=-0.15$; $p<0.05$), and easily maintained/heavy maintenance ($r=-0.15$; $p<0.05$). It is therefore expected that these are the qualities of the Interface® Urban Retreat™ carpet that respondents would have most closely associated with nature.

The Nature-related scale was significantly correlated with perceived effort ($r=0.20$; $p<0.05$), facilitating conditions ($r=0.24$; $p<0.05$), and intentions ($r=0.20$; $p<0.05$) although the correlations were fairly weak. The correlations with perceived performance ($r=0.01$; $p>0.05$) and social influences ($r=0.12$; $p>0.05$) were statistically non-significant. Given the wording of some of the UTAUT subscales and the fact that respondents have not yet physically encountered any Interface® Urban Retreat™ carpets, these results are not surprising.

DISCUSSION AND CONCLUSIONS

The analysis of the Semantic Differential Scale's bipolar descriptors, suggests that these cover a wide range of emotional and affective characteristics of the Interface® Urban Retreat™ range under investigation. The dominant affective characteristics that are considered when choosing an office carpet were expensive, high quality, exciting, creative, high visual stimulation, complex patterns, pleasant, luxurious, functional, longevity, modern, and organic. Based on the significant correlations with the Nature-relatedness scale it is tentatively suggested that the functional, playful, odourless, creative, pleasant, vibrant, exciting, dimensional stability, sound absorption, textural, natural multi-toned, longevity, elasticity, and easily maintained qualities are those most closely associated with biophilia in these carpets (at least in this sample of respondents). It is interesting that only the functional, exciting, creative, pleasant, and longevity qualities overlapped between qualities that respondents felt strongly about in a carpet and

those qualities that were related to nature. Nevertheless, these could be qualities that could be further developed to harness biophilic tendencies. The lack of support for Osgood et al.'s (1957) underlying dimensions of Evaluation, Potency, and Activity suggest that further exploratory factor analysis is required to determine the emergent factor structure of this Semantic Differential Scale.

The internal reliability measures for the UTAUT subscales was poor to good. The poorest measures of internal reliability were for the perceived performance, perceived effort subscales, and social influences subscales. Two of the items in the perceived performance subscale assess elements of personal workspace and one item assesses personal work performance, so it is unsurprising that the internal reliability is low. These items were developed to gain an understanding of the breadth of performance, but clearly these questions require rethinking. A careful reading of the items in the perceived effort subscale suggests that each item refers to the effort of another person rather than the individual effort of the person answering the items (e.g. perceived effort of the person installing the carpet, and perceived effort of the people responsible for maintaining and cleaning the carpet – there were no maintenance or cleaning staff in the sample). Therefore, it is unsurprising that this subscale demonstrated the lowest correlation with intentions. The items in these subscale will need to be carefully re-thought in order to relate to the effort that an individual employee would need to invest. For example, items could possibly refer specifically to the responsibility of each and every employee to avoid the carpet getting dirty, worn, or damaged. The items in the social influences subscale also demonstrated a poor internal reliability. These items assess the social influences from a wide range of people (i.e. superiors, peers, and clients) and it is quite likely that the individual influences of each of these groups would differ and so the poor internal reliability was understandable. The correlations of both perceived performance and social influences with intentions were both high and therefore there is an argument to be made for considering these subscales as they are currently worded.

The Semantic Differential Scale has demonstrated sound psychometric qualities and assesses a wide variety of emotional reactions to the Interface® Urban Retreat™ carpets. On the other hand, at least one of the subscales of the UTAUT (i.e. perceived effort) requires re-working and a further subscale (i.e. perceived performance) requires some reconsideration to improve coherence. One problem with the technology acceptance and diffusion theories is that they assume that the adoption of technology is based entirely on the perceived qualities of the technology. This is what Green (2001) refers to as "technological determinism"(p. 2). The future research will also explore whether the perceived qualities in the user are as important in determining the adoption of a sustainable product. After refinement, these measures will be administered to a new sample to assess the differential impact of utilitarian and affective qualities on the adoption of the Interface® Urban Retreat™ range. The next stage in the larger research project is to use the Semantic Differential Scale and the UTAUT scale to determine the relative contributions of affective and instrumental factors in the adoption (or intention to adopt) this sustainable product. Further investigations might also include concern for the environment and moral disengagement as possible moderator variables in these relationships.

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Personalizable Vehicle User Interfaces for Better User Experience

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ABSTRACT

In earlier research it has been shown that a personalizable product, one that is flexible and can be tailored to suit the users' needs, can offer a closer, more emotional and personal attachment to the product that affects the way the product is used and experienced. The possibility to personalize a product can increase both user experience of the product and usability, since unwanted functions and appearance related features can be removed and other features more usable and relevant to the user can be chosen. The objective of this paper is to show that the possibility to personalize a product is beneficial for users emotional responses towards the product. In this paper data from a study that used experience prototyping to study what happens if computerized interface personalization features are brought into the vehicle context. Twenty participants participated in a study, where a personalizable vehicle driver interface prototype was evaluated with a number of methods, for example interviews and Microsoft product reaction cards. The interface prototype was integrated in a high fidelity driving simulator and the participants interacted with the system both while driving the simulator and while standing still in order to be in the right context for increased ecological validity. All of the participants would, to some extent, like to use a system like this in their own cars. The possibility to make a product ones' own with a personal touch was important for many participants. This makes the users feel better and the product funnier and more entertaining to use. The usefulness and flexibility of the system was the most salient features and about 22% of the words best describing the users experience with the interface were related to their emotional experiences. It can be concluded that personalizable vehicle interfaces can increase both the usefulness and the user experience with the product.

Keywords: Personalization, User Experience, User interfaces, Automobile, HMI

INTRODUCTION

Lately, there has been a great focus on positive emotional experiences within human-product relations. This follows the increasing interest in positive affect and emotions in positive psychology (Seligman and Csikszentmihalyi, 2000). There are many frameworks for describing this relationship and many share one characteristics that differ them from traditional human factors design, namely the view on where pleasure come from: removing usability issues that causes the user some pain versus promoting positive aspects of the product that provide delight and enhancement. There are studies within affective human factors design that show that positive affect and emotion leads to, for example, more creative and flexible decision making (Isen, 2001), increased perceived usability when the product is regarded as aesthetically attractive (Ben-Bassat, Meyer, and Tractinsky, 2006; Sauer and Sonderegger, 2009) and also that the user performs better (Sonderegger and Sauer, 2010). Also Jordan (1998) has shown that aesthetics as well as usability and performance affect the user's pleasure with the product. The distinction between

removing pain and promoting pleasure translates to the difference between utility oriented perspectives (problem solving, useful and usable) and hedonically oriented perspectives (feeling, aesthetics, attractiveness). This distinction is present for example within the frameworks of Jordan (2000), Forlizzi (2008), and Hassenzahl (2003) who defines the views as pragmatic qualities and hedonic qualities. The emotional relationship is specifically important in personalized products. For example Blom and Monk (2003) state that personalized IT affects users in emotional, cognitive, and social ways.

Users motivation for using personalization

There are ways to bridge the gap between users' needs and the solutions that satisfy them, for example Gkouskos and Normark's (2014) need dimensions. A personalizable product can form the solution that satisfies many needs. In order to make a similar bridge over the gap between users' needs and the actions people take when they personalize their products Oulasvirta and Blom (2008) use the notion of motivation. The users' motivations for using personalization features are important for which type of emotional affect the product will convey. They make a distinction between extrinsic motivation (something outside of the user mandates what to be done) and intrinsic motivation, (the task itself motivates). According to Oulasvirta and Blom (2008) personalization features can support the users to align their motivation with their actions. Personalization features also help nurturing the users' intrinsic motivation. Utility aspects are often related to extrinsic motivation and hedonic aspects are often related to intrinsic motivation. Oulasvirta and Blom's (2008) motivations build upon Deci and Ryan's (1985) Self Determination Theory (SDT), which identifies three basic needs: autonomy, competence, and relatedness. Among the motivations for personalization identified by Oulasvirta and Blom (2008) that are related to SDT are: control and stabilization, differentiation, flow, emotional expression, ego-involvement, identity expression, and territory marking.

Motivational views in personalization are also present in other studies. For example, Fan and Poole (2006) have identified four different strategies for personalization each with different motivations for using personalization features: Architectural, Relational, Instrumental, and Commercial. The motivation for using personalization related to the architectural view is to express oneself through the design of one's environment. The relational view is motivated by socialization and a sense of belonging. The instrumental view caters to humans' efficiency and productivity sides. The motivation related to commercial personalization is to increase ones material and psychic welfare.

There are also many other motives for using a personalizable system to address hedonic and emotional factors. For example, people can express themselves through products that represent events, relations, or feelings important to the her or him (Hassenzahl, 2003), the user's personal and group identity can be represented (Blom and Monk, 2003), and the users identity can be represented by modifying and making an interface of her or his own (Kleine, Kleine, and Allen, 1995). Mugge, Schoormans, and Schifferstein (2009) and Normark and Mankila (2013) also showed that the attachment between user and product is important for the adoption and usage of personalized products.

AIM OF THE RESEARCH

Van Velsen (2011) points out that research regarding personalization is mostly within effectiveness and efficiency and that usability and user experience are underrepresented in personalization research. This gap in the research motivates the aim of this paper:

- What are the users' emotional experiences with a personalizable vehicle interface prototype?
- What motivates people to use hedonically oriented personalization features?

METHOD

Participants

This study consisted of 20 participants from Luleå University of Technology, four university academics within the same department as the researcher, six academics within other areas of the university, five university administrators, and five students. In total eight females and twelve males in the ages of 22-60 years, M = 36.1 years. When asked about their tendencies to personalize their products 19 participants responded that they personalize their products in some way.

Procedure

The participants were first given an overview of a vehicle interface prototype (Figure 1) that could be personalized similarly to a smartphone. The user could tailor the functions to be active in the system (e.g. activate different apps), where to place them, and the appearance of the interface in terms of color, size etc. The prototype also allowed for different home screens, where the user could place different sets of information. The participants were shown the display positions of the system and how to interact with the system on a touch screen. The participants were then encouraged to sit in the vehicle cab and personalize the system in a way that would suit their taste and preference. After a driving session to try out the newly personalized settings a post-session interview was conducted guided by Microsoft product reaction cards (Benedek & Miner, 2002), part of Microsoft Desirability Toolkit (Microsoft product reaction cards developed by and © 2002 Microsoft Corporation. All rights reserved.). The participants were asked to view a list of descriptive adjectives and tick the ones they thought best described their experience with the prototype. They were then asked to circle the five most descriptive words, which was used to guide the interview.

The study was conducted with a high fidelity driving simulator as a carrier for the prototype interface. The driving simulator consists of an actual vehicle cab with preserved factory standard automotive controls in order to maintain a realistic setting for studies regarding experiences of in-vehicle systems. The driving simulator is equipped with integrated programmable LCD displays, and a simulated HUD display in order to accommodate design and testing of various in-vehicle system prototypes.

Figure 1. The user interface prototype inside the driving simulator

RESULTS

The results were analyzed in order to uncover to which extent the participants' experiences with the prototype were emotionally laden. Also, to which extent the participants personalize their personal gadgets to reflect the hedonic view. Two views on motivations for personalization were merged into one framework, and finally, the participants' experiences with the prototype were compared and matched to these motivational views.

Figure 2. Word cloud visualising most frequently chosen words. (Created with wordle.net)

Experiences about personalization in general

The participants were asked whether they usually personalize their own phone or computer. Almost all, 19 participants, reported that they personalize either one of those. Fourteen participants personalized both functionality and appearance of the product. Nine participants personalized things related to structure and eight to make the device more personal, relevant, or to make it feel new. Four altered for better performance specifically.

After having had some experience with the prototype, the interviews revealed that most participants were positive towards the concept of personalizable vehicle interfaces. In general, 14 participants expressed a liking of the hedonic look-and-feel aspects of the interface personalization. Seven of these participants expressed that hedonic look-and-feel personalization was not only a bonus, but also an important feature of electronic consumer products in general.

User experiences of the prototype interface

The chosen word from the product reaction method where analyzed in order to study to which extent they reflected hedonically oriented experiences. The most frequent chosen words among the top five circled descriptive adjectives were mostly positive towards the prototype, except for the word 'distracting' (Figure 2). The same pattern was found, when taking all ticked words in the list into consideration. 82 (22%) of the total pool of chosen words were considered related to the users' emotional feeling or reaction to the interface. When considering the words marked as being the most important the same ratio was maintained, 22 out of 100 (22%) words were emotionally related. Only one percent among the emotional words were in a negative manner. The most frequently chosen emotionally laden descriptive words were: appealing, attractive, creative, desirable, entertaining, fun, and satisfying.

Mapping out the motivational views on personalization

The research by Oulasvirta and Blom (2008) and Fan and Poole (2006) show some similarities and the frameworks can be roughly mapped onto each other (Table 1).

- Motivations for control and stabilization, which satisfies the need of autonomy strongly relates to instrumental personalization (efficiency and productivity).
- Motivations for interest, mastery, differentiation, and flow, which satisfy the need of competence strongly relates to architectural personalization (expression through the built environment)
- Motivations for emotional expression, ego-involvement, identity, and territory marking, which satisfy the need of relatedness strongly relates to relational personalization (socialization and belonging).

Commercial personalization is disregarded since it is mostly out of the users influence.

Table 1: Two frameworks of motivations for personalization merged together

Personalization strategy	**Instrumental**	**Architectural**	**Relational**
Satisfied need	Autonomy	Competence	Relatedness
Example of motivations	Efficiency	Interest	Socialization
	Productivity	Mastery	Belonging
	Control	Differentiation	Emotional expression
	Stabilization	Flow	Ego-involvement
		Expression through environment	Identity
			Territory marking

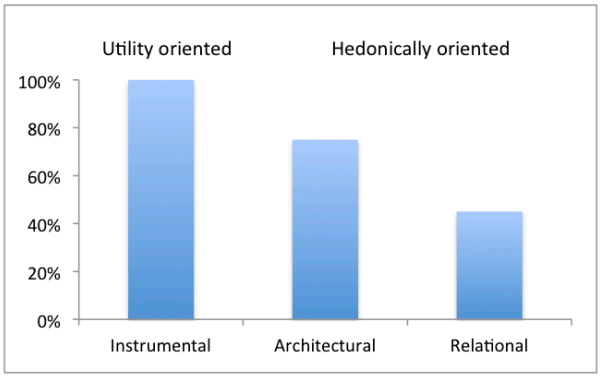

Figure 2. Percentage of the participants' motivations related to different personalization strategies.

The participants' motivations for using personalization in this study were analyzed and compared to the unified framework (Figure 3). The interviews with the participants revealed that, given that they had access to such a system, all of them would personalize the system to accommodate instrumental aspects. These aspects include selecting the suitable set of functions or improving the usability, as exemplified in the following quote: "It felt like I became a more efficient driver when I personalized as I want to have it. That what's relevant is in the right place. Both the type of info and the placement".

However, there was also a substantial interest for personalizing to accommodate more hedonically oriented aspects. Fifteen of the participants seem to be motivated by architectural related motivations. The visual appearance for example is important for many participants: "I change primarily the visual appearance. For me it's important to personalize the visual, not only on a functional basis". Some participants were even very explicit in that they wanted to personalize in a hedonic way: "I want to change background and such, mostly for the feeling of it, not the function". Some also mentioned intrinsically motivated views of competence and mastery: "You get very eager to personalize it and can't keep away from it. You want to keep on optimizing the system".

There were also nine of the participants that expressed some kind of view related to relational personalization. Both

that it will fit and reflect the individual: “I always want to change the interface, the aesthetics, to fit me. Make it a little more personal“ and also that there was a factor that may affect other peoples view: “It’s desirable both to me and to others. It can be something to brag about, that you have the latest apps or so”.

DISCUSSION

It is important to note that even if the emphasis is on the emotional side of human-product relations in this paper, the majority of the experiences with the prototype interface were still utility related. All 20 participants could see instrumental benefits and motivations with a personalizable interface, whereas six of these did not consider the hedonic side at all. Both the utility and hedonic aspects need to be considered at the same time in order to form a good user experience. Tractinsky, Abdu, Forlizzi, and Seder (2011) claim that both of these aspects matter, when humans make a choice, and Blom and Monk (2003) suggest that personalization features affect users cognitively and emotionally, but also socially.

Many participants emphasized that the biggest advantages with a personalizable product is that it can be “adapted to particularly suit me”. It can be argued that this construct can be related to the instrumental view (it conveys the right functionality), to a more architectural hedonic view (it makes the user feel good), or to a relational view (it reflects the user’s personality). However, this construct is most probably a composite of all three of these aspects and all three contribute to making the product appear to be tailored to just that particular user.

Affective design can be considered as consisting of a continuum of stages, where affect is considered to be the first initial reaction towards an object, while emotion is a more conscious longer lasting reaction developed over time (Aboulafia and Bannon, 2004). The relatively short time the participants in this study interacted with the prototype interface elicited some affective responses. However, the use of interviews in the study gives a broader view on how people function and can also give some insights in how the product is likely to affect the user emotionally in the future as well.

All the participants in the study emphasized instrumental aspects in personalization, such as changing functions. Many of the motivations for using personalizable features were also categorized as related to the hedonic look-and-feel aspects. The smallest category was regarding relational aspects. This outcome is not surprising since an interface was the object of study. The vehicle interface has a central role in the driving of the vehicle, which is a task that is laden with safety related issues. Thus, the functionality must be of uttermost importance. Nevertheless, the hedonic aspects were still apparent and many participants highlighted that look-and-feel aspects are important in the use of technological products.

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Eliciting User Experience through Rasch-Calibrated Metrics for Latent Variables

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ABSTRACT

Measurement of affective user experience is not straightforward as it is typically to measure the physical properties of the elements that aggregate a product For this purpose, it is necessary to develop metrics associating observed user experience in the real world with a relevant latent (i.e., unobserved) attribute of the product. However, metrics for latent variables can be undermined by misinterpretation, ambiguity, unfamiliarity, bias, redundancy and multidimensionality. For this reason, anomalies in data ought to be investigated through a robust measurement theory to determine to what extent they corrupt quantitative properties. This paper shows that Rasch measurement theory, which embraces a family of probabilistic models, provides procedures referred to as calibration to test the hypothesis that the metric fulfils measurement principles. As a result, linear scales of affective user experience can be aligned to physical properties of products, allowing generalization of comparisons beyond the particular sample under which a particular product experience was observed.

Keywords: User experience, affective engineering, Rasch model, measurement.

INTRODUCTION

In this paper it is introduced an approach to elicit affective user experience through measurement. Quantifiable properties of scales have been a bottleneck in the emerging area of affective engineering that seeks to integrate established engineering topics with affective user experience. The reason is that affective responses to products are frequently idiosyncratic, culturally located in the consumer's values and dependent on the influence of social groups. As a consequence, measurement of user's experience cannot be considered a trivial matter.

Eliciting users' experience to a product is not straightforward as it is typically to measure the physical properties of the elements that aggregate a product. The measurement of a physical property is associated with a magnitude, i.e., a relevant kind of quantity that can be expressed as a number and a reference or unit (VIM, 2012). Quantitative properties contrast with qualitative characteristics that cannot be represented through different degrees. A brick, for example, is not more brick than any other one. In this paper, affective experience to products is taken as a phenomenon that can reasonably be interpreted not only qualitatively but also quantitatively through users' responses to physical stimuli.

However, affective responses are related to an underlying property of the product, called an attribute, which exists solely as an element of a concept or premise. For example, one can conceptualise that posture while driving is associated with driver's comfort. Although it is possible to measure the driver's posture, a measure of the underlying attribute referred to as comfort cannot directly be obtained. The attribute can in this case be related to posture because users express some degree of positive or negative response to their experience associated with a particular

definition of comfort with certain consistency. Comfort is therefore interpreted as a latent variable; i.e., it is inferred from the manifested responses. The experience, which is expressed in degrees, can be used as measures only if it meets quantitative properties.

One of the benefits from a measurement approach is that its mathematical models reduce the dimensionality of data and consequently the complexity of the hypothetical construct representing the relevant underlying attribute of a product. In this paper some measurement assumptions and the application of the Rasch model (RM) in the domain of affective engineering are discussed. The purpose is to transform statistically discrete observations into a quantitative structure, which is called a metric. The paper shows that the applications of Rasch measurement theory (RMT), which embraces a family of probabilistic models, fulfil measurement principles (Andrich 1988; Bond and Fox 2007). As a result, linear scales of affective user experience can be aligned to physical properties of products (Camargo and Henson, 2012a).

PREPARING THE GROUND FOR MEASUREMENT

The concept of measurement is associated with the properties of metrics established for summarising the users' experience obtained from their affective responses to physical elements of products. The construction of metrics is a technique of relating users' experience in the real world (called manifest or observed) to the attribute of a product (called latent or unobserved).

One approach for establishing metrics of affective responses is to present to a number of respondents adjectives or statements as stimuli related to the underlying characteristic of the product that an analyst wants to know about. Those adjectives or statements will henceforth be called **items**, a term that suits in different domains of application. Additionally, physical stimuli using variations of one or more elements of a product are presented to respondents. After interacting with the product, users give their ratings on a five or seven-option scale embodied in self-report questionnaires. The scale contains the string of items that represent the underlying characteristic and will be replicated for each variation of the relevant physical element. Although the approach for quantitative measurement can be applied to alternative techniques of data collection, such as cognitive performance using a product, interviews and survey with free responses, they will not be discussed in this paper.

To elicit the user's experience it is expected that the string of items will depend to some extent on the degree of a person's inclination to endorse the underlying characteristic of the product. It is also expected that the degree of endorsement varies according to each individual although groups of similar degree of endorsement can arise for a particular physical stimulus. However, there is a degree of uncertainty in the observations. To deal with uncertainty, a response x to a variable X will be observed as a probability. Adapting the example by Andrich (1988), the probability can be represented as a function f of the attitude of a person n, characterised by the variable B_n, and the affective value of item i, characterised by the variable D_i, such that $\Pr\{X=x\}=f(B_n, D_i)$.

Setting Independent Items

Items are in many cases originated from observations of the users' interaction with a product, interviews, search in relevant literature and advice from experts (Nagamachi, 2011, Barnes and Lillford, 2009). However, items can be source of disturbances in data. Disturbances can generate unwanted variance, preventing the data from measurement conditions. Misinterpretation, ambiguity and unfamiliarity can, for example, result in inexpressive responses or simply guess. Another source of concern is the redundancy between items, which can artificially weight particular responses inflating or deflating reliability indices and item discrimination estimates in statistical analysis. To minimise disturbances in a data set Barnes et al. (2008) have suggested removing from a study items that require additional context to be understood by respondents, contain comparative adjectives, consist of non-gradable adjectives and require a prolonged experience. Although those procedures are undoubtedly useful, they are insufficient to ensure a measurement structure in a data set and, therefore, quantitative assumptions ought to be tested.

One of the assumptions when using a probabilistic approach is that responses are statistically independent. Dependence is identified when a person's response to any item in a scale interferes with his or her response to another item within the same scale. Response dependence can, for example, be found in satisfaction questionnaires where a positive rating of a respondent depends on the responses to the preceding items and where that rating will interfere in the way that the responses on the following items are rated (Marais and Andrich, 2008). Dependent items can mislead inferences or decision made on account of means and standard deviations (Smith, 2005).

Establishing a Frame of Reference

One method to elicit users' experience is simply to observe persons' manifestations in natural circumstances. However, this method can be time-consuming and subject to disturbances as a consequence of uncontrolled conditions. On the other hand, controlled conditions can undermine validity by removing the test from a naturally occurring circumstance. To minimise such an effect a metric has to be constructed to ensure consistency and replication. The items in the metric should carefully be designed to provide sufficient information in relation to a particular affective user experience for a given purpose. As a consequence, the items and the users' responses can be characterised as a function of one another.

The concept is similar to a regular thermometer. A measure of temperature can be taken on the basis of the expansion of mercury under some degree of heat. In that case, heat and expansion of the liquid are characterised as a function of one another. Thus, there are two classes of elements involved that define temperature even though many other factors could be included in the system. This simplification exists for practical purposes, establishing a two-way frame of reference, heat and expansion of a body.

In terms of users' experience, one of the entities that form the frame of reference is the sample of persons that interact with the relevant physical elements. Another entity is the string of items used to assess the underlying characteristic of the product (Table 1). In addition, an extension of the two-way frame of reference is necessary for the tests, in which includes the objects used as physical stimuli (Table 2).

Table 1 – Two-way frame of reference

	Items			
Person	Item I_1	Item I_2	…	Item I_i
P_1	x_{111}	x_{121}	…	x_{1i1}
P_2	x_{211}	x_{221}	…	x_{2i1}
⋮	⋮	⋮		⋮
P_n	x_{n11}	x_{n21}	…	x_{ni1}

Table 2 - Frame of reference for eliciting a relevant affective user experience

	Item I_1				***Item I_i***			
Person	Stimulus 1	Stimulus 2	…	Stimulus S	Stimulus 1	Stimulus 2	…	Stimulus S
P_1	x_{111}	x_{112}	…	x_{11S}	x_{1i1}	x_{1i2}	…	x_{1iS}
P_2	x_{211}	x_{212}	…	x_{21S}	x_{2i1}	x_{2i2}	…	x_{2iS}
⋮	⋮	⋮		⋮	⋮	⋮		⋮
P_n	x_{n11}	x_{n12}	…	x_{n1S}	x_{ni1}	x_{ni2}	…	x_{niS}

Functioning of a Metric

To meet quantitative conditions a metric that elicits just one single underlying characteristic of the product is assumed. This is similar to obtain an object's length using a measure tape. If one wants to know about the object's weight, then another measurement instrument would be necessary. However, it is not untypical in the domain the development of scales intended to measure multiple characteristics. The main concept of the approach in this paper is to meet conditions for reliable interpretations on numbers. For instance, a unidimensional scale can allow making comparisons using differences in degree (Andrich, 1988). Therefore, if an analyst wants to know about different underlying characteristics, then a number of metrics, each measuring one single attribute, will be necessary.

The functioning of a metric is subject to the conditions of the administration of the tests as well, which need to be understood and specified. This specification is also necessary in more classical statistical approaches to testing. In that case, persons are referred to in terms of populations. Based on theoretical grounds, classical approaches require

that a significant random sample be effectively taken from the population. It is noteworthy that if different groups are considered in a test, for example males and females, and a comparison of their means is expected, then the metric should show that the comparison is invariant with regard to any item. In other words, the persons' interpretation to an item ought to be the same for both groups to yield a solid basis for inference.

Although less familiar than the classical statistical approaches, Camargo and Henson (2011) have demonstrated that the RM can succeed in transforming observed data from affective user experience into consistent metrics that allow algebraic operations and consistent comparisons. Following the Rasch modelling approach, persons' responses are converted into objective measures by calibrating a scale with targeted items established as a yardstick.

A PROBABILISTIC APPROACH: THE RASCH MODEL

The Rasch model, named after the Danish mathematician Georg Rasch, is a probabilistic approach that obtains parameters of persons and items separately. This property allows the design of a range of items in different degrees of difficulty of endorsement on a scale and the distinction between individuals of a sample in different levels of attitude for each item.

The model's procedures test the hypothesis of that the observations meet the necessary assumptions for validating the quantitative structure of the data in hands (Andrich, 1988). Such procedures are denoted calibration, a term coined by Wright and Panchapakesan (1969), referring to measurement scales that are independent of the sample of persons used to estimate parameters of items and independent of the set of items used to obtain scale scores.

Another property of the model is that the raw scores are sufficient statistics to obtain independent measurement parameters. This property distinguishes the model from other probabilistic models and classical statistical approaches. In Rasch modelling, the observed responses are converted into frequencies. These frequencies are then transformed into locations of persons and items on the linear continuum of the metric. Person and item estimates are preliminarily obtained according to a rating scale (Andrich, 1978) or partial credit parameterization (Masters, 1982) and then compared with the observations. The estimates are then revised and new estimates are computed. This process of iteration is carried out until the changes of the estimates are smaller than a stopping rule controlled by a convergence criterion. After the estimates have been made, the data are evaluated to determine the extent to which they fit the model. Most of the estimation procedures are based on the method of maximum likelihood (Fisher, 1922). The estimates obtained from this method point to the values of parameters which maximize the likelihood that the observed data would have generated.

Thus, differently of the classical approach that tries to accommodate a model to the data, the procedures of the Rasch model examine how well the data fit together and cooperate to define the underlying characteristic of the experience being measured. Therefore, the assessment of dimensionality within the context of Rasch measurement theory uses discrepancies between the observed responses and the expected responses by the model. Although a variety of psychological processes are involved when responding to a set of items, it is understood that each item is affected by the same processes and in the same manner. That is, if data fit the model, items are said to be part of a unidimensional structure with quantitative properties (Smith, 2002).

Categories and Thresholds

One of the main factors to achieve a quantitative property in a scale is associated with the order of the response options. It is typical in self-report questionnaires for capturing affective user experience that the direction of responses options is established arbitrarily although an order is implied. For example, an analyst could determine that a mark would be given from 0, which represents the lowest level of endorsement of an item, to 7 the highest level, or from a mark of strongly disagree, representing the lowest level of endorsement of a statement, to strongly agree, representing the highest level. Some analysts also use scales with negative numbers, such as -3, -2, -1, 0, 1, 2, 3. In any case, an order is established to express the users' endorsement level in some way operationally. However, in many studies the scale does not hold the scoring function specifications established by an analyst as a consequence of people's inconsistent use of the response options. The Rasch model procedures examine the consistency of response options using the concept of thresholds.

Thresholds are the transitions between two response options. Conceptually, if the response patterns are consistent, each threshold specifies a point where the probability of a response is equally likely (Andrich, 1978). In a scale with

response options from 0 to 3, for example, there are three thresholds. The first threshold is the point between options 0 and 1 where the probability is 50%. The second threshold is the point where the likelihood of response either 1 or 2 is the same. The third threshold is similarly established between options 2 and 3. Each of the thresholds qualifies the average location, or difficulty, of the item on the linear continuum. Analysis of the transitions between categories can be interpreted as though there was an independent response for each of the thresholds. This allows identifying potential problems with the empirical order of categories.

Item Map for Scales with Multiple Response Options

Item map is a representation of persons and items locations on the linear continuum. Once an analysis output has been examined, a general overview of the location values of the items thresholds and persons' inclination of endorsement can be displayed through the item map.

Take Figure 1 as an example. It represents the item map from a study on specialness of wrapped confectionery (Camargo and Henson, 2011). In that study, more than 300 people gave their ratings based on Likert-style, five-point scales to 24 statements contained in a self-report questionnaire. After calibration, twelve items were removed from the preliminary pool as a consequence of anomalies in the data originating from misinterpretation, ambiguity, unfamiliarity or redundancy. The item map in Figure 1 refers to a scale of specialness for one piece of confectionery where the linear continuum has a range from -4 to +4 in logits (unit in Rasch-calibrated scales). The continuum range was produced from estimates calculated through the Rasch-dedicated software package RUMM2030® (Andrich et al., 2012). At the left side of the continuum person locations are, in this example, identified through groups of respondents with similar locations within a range in logits. Locations on the top indicate people more inclined to endorse the attribute specialness than locations at the bottom. At the right side of the continuum the threshold for specific items is indicated by the appropriate suffix appended to the item label, such as the indication 17.4 representing Threshold 4 of Item 17. Locations on the top of the continuum represent item thresholds that hold more difficulty for endorsement than item thresholds at the bottom, which are easier to endorse. The term difficulty of an item is associated with the number of people who used a particular threshold. That is, if relatively fewer people used a threshold of an item, then that threshold is said to hold more difficulty for being endorsed.

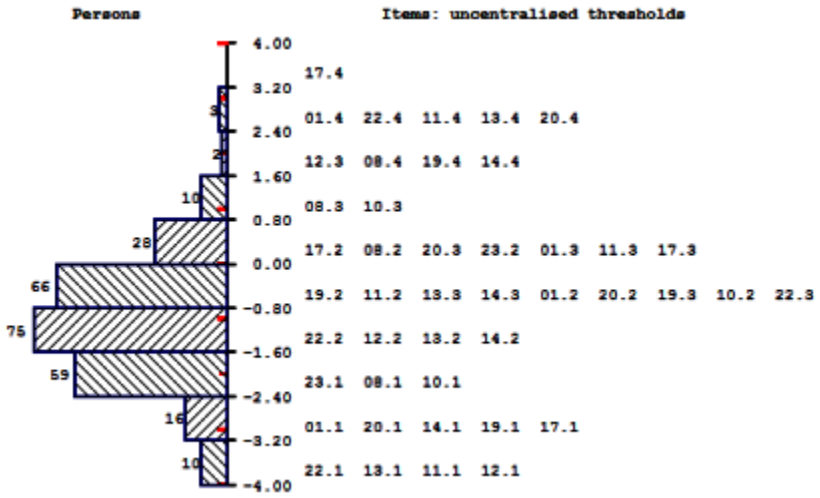

Figure 1 – Item map for eliciting the attribute specialness of one piece of wrapped confectionary (Camargo and Henson, 2011)

Interpretation of a Rasch-calibrated Metric for Affective User Experience

Applications of the RM for constructing metrics of affective user experience require a frame of reference with at least three elements; i.e., persons, items and physical stimuli. In this framework each observation is the result of an interaction among those elements, which are modeled to operate independently. Linacre (1989) conceptualized these interacting elements as facets, developing a derivation of the RM called the many-facet Rasch model (MFRM). The Linacre's model has been adapted by Camargo and Henson (2013) for applications in affective engineering. In the applications, Rasch-calibrated metrics attains interpretation when the difference between persons as well as between items is established by the distance between different locations.

An example of a Rasch-calibrated metric for affective user experience is taken from a study on squeezable packaging of five everyday products (Camargo and Henson, 2012b). The study aimed to establish a range of compliance for the products' containers that could give an impression of a moisturizer cream. In the study, 120 participants touched the containers without seeing the products. They gave their ratings of a preliminary pool of 16 items using Likert-style, five-point scales embodied in computer-based self-report questionnaires. Five items were removed after calibration. Afterwards, three more items were incorporated to metric through a re-calibration using 60 more participants (Camargo and Henson, 2013) (Figure 2).

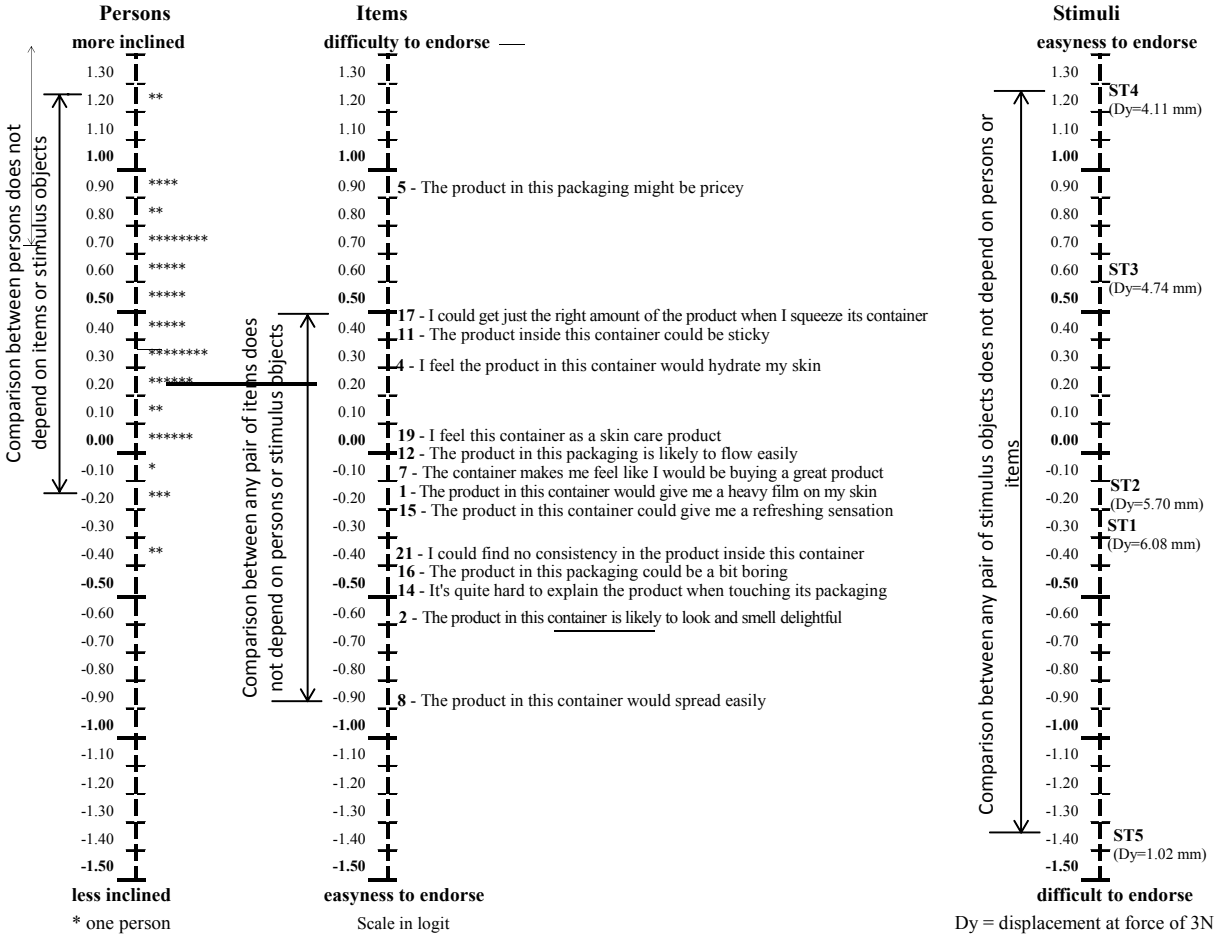

Figure 2 – Example of a metric for affective user experience from a study on packaging

In the metric all facets are on the same linear continuum. The person parameter indicated in Column Persons represents the inclination of endorsement to any item and any stimulus object. That is, the more the readiness, the higher the probability of affirming an item. The item parameter in Column Items indicates the difficulty of endorsement. An easier item is endorsed by relatively more respondents than a more difficult item. That is, the easier the item, the more likely it will be affirmed. The stimulus parameter in Column Stimuli indicates the easiness of endorsement for the relevant attribute of the product. The more the attribute is fulfilled by the stimulus, the more likely it will be endorsed. The interpretation of probability of a response is obtained through a function of the distance amongst a person, an item and a stimulus object. The distance is established by an interval property referred to as log-odds unit or logit. That is, the changes of level in the metric have a constant interval established by a factor of 2.718281…, which is the base of natural logarithm (Linacre and Wright, 1989).

One important characteristic of a Rasch-calibrated metric is the interpretation based on invariant comparisons. Note that the comparison between any two persons does not depend on any item in the metric and any stimulus object either. By a symmetric argument, the comparison of difficulty between any pair of items is independent from any person and any stimulus object. Similarly, the comparison of physical parameters between any pair of stimulus objects depends on neither the persons nor any item in the scale.

The metric allows also the observation of physical parameters associated with affective responses. In the example, the physical parameter compliance, which was obtained from measurement of the displacement of the containers' surfaces at force of 3N, is associated with the location of each stimulus, which was obtained from persons' responses. It is noteworthy that there is a particular range of containers' compliance around Stimulus 4 and Stimulus 3 where the persons' endorsement is higher for a moisturizer cream (Camargo and Henson, 2012b). The metric allow the quantification of the differences between Stimuli 1 and 2, and Stimuli 3 and 4. This kind of information is a valuable resource to establish physical parameters when accounting for affective user experience in product engineering.

IMPLICATIONS

Adding Value to Products

Improvement of existing features has been a common practice to add value to products. Values can be associated with the product experience of users and the interpretation of them. Product experience can fluctuate according to social and cultural oscillations, technological advancements and contextual conditions of each industrial application. Such fluctuations, therefore, produce data from affective responses that could not be statistically stable for time enough and with different groups of persons to be utilisable for generalisation of the outcomes. Nevertheless, some works in affective user experience seem to reside in a false sense of objective interpretation when using statistical reasoning, making hasty generalisations. On the other hand, in many situations a latent regression model based on RMT will make more intelligible the associations between variables (Christensen, 2006) allowing afterwards the application of scores transformed by the RM into a diversity of statistical tools.

The RM adds mechanisms in the process to elicit affective user experience that allow the validation of the structure of data from peoples's responses under certain empirical conditions. Such conditions can be seen through the works of Campbel (1920, 1928), Luce and Tukey (1964) and Krants et al. (1971), associated with the structure of numbers under corresponding algebraic operations. The most important perhaps, the RM can mathematically support the interpretation of the test scores and, as a consequence, to support the implications that the interpretation entails. On the contrary, if just the sum of scores was taken without any validation, the results would contain a high level of imprecision as an effect of systematic errors, and regression coefficients would likely be attenuated. Thus, in affective engineering the RM can find the best number of independent variables in an instrument, maintaining the quality of measurement and avoiding problems with regard to the adverse effects of short instruments and small samples when using classical methods.

Implementation of the RM

A practical value from metrics applied to elicit affective user experience is the potential integration and alignment with different stages of systematic or quasi-systematic product development processes. In most of the cases measurement of affective user experience has basically been a data-driven process based on a very general level under the assumption of a quantitative attribute, undergoing the influence of sampling and systematic biases. As a consequence, the measurement outcomes are difficult to validate empirically and exploit to the different stages of the product development process. However, if evidence of the existence of the affective attribute as a quantitative latent variable is obtained, then it is possible to implement metrics that can contribute to integrate different stakeholders' expectations, resources and decisions associated with consumers' responses to products throughout the process. Although Table 3 is not an exhaustive list of opportunities, it is possible to envisage many of the potential implementations of the RM in a product development process.

Table 3 - Potential opportunities of implementation of the Rasch model in product development processes

Opportunity during a product development process	Implementation options
Project scope	Definition of a theory-driven coverage assessment for human-centred design.
Physical requirements	Measurement of latent responses to physical characteristics.

Performance requirements	Measurement and adjustment of the relationship between affective responses and performance.
Usability requirements	Measurement of latent variables in human-factors design.
Interface definition	Measurement and improvement of different interfaces and derivatives with regard to affective responses.
Labelling	Measurement of perception of meaning and comprehension of information.
Inter-changeability	Measurement of attitude toward the integration with other products or accessories of the same family.
Packaging	Measurement of attractiveness and relationship with the product.
Quality management	Measurement of perceived quality.
Reuse and refurbishment	Measurement of attitude toward reusable products.
Affective attenuation	Measurement of the level of affective attachment to a product or components of the product throughout its life-cycle.
Reference documentation	Traceability of calibration of scales for affective responses and affective requirements based on objective measures.
Decommissioning	Measurement of affective responses to premature decommissioning or disposal.
Installation and set-up	Measurement of the level of users' expectation with regard to temporary interruption of services, downtime or difficulty of set-up.

CONCLUSIONS

In this paper a novel approach to elicit affective user experience based on Rasch measurement theory has been presented. It is assumed that in the process to interpret affective user experience, data ought to be evaluated not only by qualitative statistical approaches but also through measurement criteria. The approach's hypothesis is that people's affective responses are related to an underlying property of the product. If evidence of the existence of the affective user experience as a quantitative variable is obtained, then it is possible to construct metrics to associate manifested users' experience in the real world with a latent property of a product.

A metric of affective user experience, therefore, imposes particular requirements on data quality to achieve a constant unit of measurement and invariance across comparisons between the different elements that consolidate the scale. However, anomalies in data can prevent themselves from measurement conditions. The Rasch model provides procedures referred to as calibration to validate the quantitative structure of the data within a determined frame of reference. In the particular case of affective user experience the frame of reference embodies three elements; i.e., persons, independent variables referred to as items and stimulus objects. Within a relevant frame of reference, the Rasch model examines how well the data fit together and cooperate to define the underlying characteristic of the experience being measured, contrasting with typical statistical approaches that try to accommodate a model to the data. The Rasch model requires meeting the key assumptions of independence of the variables established as a yardstick for measurement and unidimensionality of metric with regard to the underlying attribute of interest. Therefore, if data fit the model, the measures will attain interpretation through the comparison between persons as well as between items established by the distance between different locations on a linear, interval continuum.

Based on previous research it is possible to envisage that in many situations a model based on Rasch measurement theory will make more intelligible the associations between variables, allowing afterwards the application of scores transformed by the Rasch model into a diversity of statistical tools. Furthermore, the approach introduced in this paper can overcome some difficulties from eliciting affective user experience through a data-driven process that undergoes the influence of sampling and systematic biases. The theory-based approach using the Rasch model can in many cases validate the data empirically and exploit the results to the different stages of the product development process.

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Specification of Affective User Experience in Product Design

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ABSTRACT

This contribution reviews approaches and methods for developing product design specifications that place emphasis and priority on affective user experience. Understanding customers' affective needs is difficult to grasp. For example, if a person wants an impression of luxuriousness, then it is necessary to investigate which product design attributes make the individual sense such an impression. To answer this question, the relationship between affective features and product design attributes should be analyzed, considering an interactive, evolving, and individual perspective. Pleasure with products, Kansei engineering, product emotion, Fuben-eki and product personalities are the approaches reviewed to illustrate the existing resources for specification of affective user experience in design. The notion of a product's ecosystem as part of the design of the user experience is related to experience prototyping. With the aim of providing guidance to designers, this contribution discusses whether the affective user experience specification methods translate directly into product design features, or if these are attained by trial and error, the latter being mostly the case, except for Fuben-eki. An expanding vision of futurism and evolution, based on projected future technological capabilities, may be associated to gradually enriching affective user experiences, increasingly demanding users and enlarging and more pervasive product ecosystems.

Keywords: Pleasure with Products, Fuben-eki, Kansei Engineering, Product Personalities, Product Ecosystem

INTRODUCTION

A fast paced changing world requires dynamic methods and robust theories to enable designers to deal with the new product development landscape successfully and make a difference in an increasingly interconnected world. Designers continue stretching the boundaries of their discipline, and trail new paths in interdisciplinary domains, constantly moving the frontiers of their practice farther (Coelho, 2013). Understanding customers' affective needs is difficult to grasp; product design practitioners often misunderstand what customers really want (Bahn et al., 2009). Customer needs or requirements depend directly upon product design attributes. For example, if a customer wants an impression of luxuriousness, then it is necessary to investigate which product design attributes make the customer sense such an impression. To answer this question, the relationship between affective features and product design attributes should be analyzed. In a practical manner, product design attributes should be selected based on the design practitioners' expert knowledge as well as design guidelines or golden rules.

The market of intangible products is growing and new types of products combining both tangible and intangible parts occur (Schütte, 2005). An example of these types of products are mobile communication devices. An artifact, the phone itself is needed, but this is just a smaller part. Its interface design is more cost intensive and more relevant to the customer. Rules for Interface design abound (e.g. Shneiderman, 2003: striving for consistency, enabling frequent users to use shortcuts, offering informative feedback, designing dialogs to yield closure, offering error

prevention and simple error handling, permitting easy reversal of actions, supporting internal locus of control and reducing short-term memory load). Cyr et al. (2009) proposed that perceived interactivity (modeled as a formative construct that includes user control, connectedness and responsiveness) influences cognitive perceptions (for efficiency and effectiveness), cognitive–affective perceptions (for trust), and affective perceptions (for enjoyment) in websites. However, De Angeli et al. (2006) showed that the use of interactive metaphors contributes to users' attitudes and rating of the interface aesthetics, even when the usability of the system is worse. This effect can be explained by affective interpretation of user judgement (Norman, 2004), in that an interactive metaphor can induce curiosity and pleasure despite being more difficult to use (this notion is aligned with the approach proposed in Fuben-eki, by Kawakami, 2002). Coelho (2006) took an activity theory approach aligned with Kankainen (2002), making the the distinction between motivational and action level needs, and presented methods that can be used to uncover user requirements at these two levels of the activity of the user with an artifact in context. The activity in each of these levels may involve a different kind of reward (either positive or negative), in line with Fuben-eki's assumption.

Effectively and efficiently satisfying individual needs in product use could be achieved by means of personalization (Tseng et al., 2010). Individuals' characteristics such as personal taste, traits, innate needs and experience are important integral parts of product design. This dimension for design enables offering personally unique products that may contribute to a positive user experience. The product ecosystem in personalization can be viewed as a core infrastructure, hard components, and soft characteristics. Hard components consisting of tangible physical elements can be customized and changed to meet physical functional requirements. The soft characteristics address the customer experience in human–product–ambience interactions. They include not only the software part of products, but also user interaction, service processes, aesthetics outlook, and feel of the products. Soft characteristics are often easier to modify and thus can enhance the value for personalization. Zhou, Xu and Jiao (2011) point to the fact that with the advent of the experience economy, strategic advantages depend more on the totality of the user experience than on the power of technology embedded in the product. There product ecosystem design framework consists of three stages: affective-cognitive needs acquisition, analysis and fulfillment.

There are many different approaches to interface design, especially considering the growing importance of artificial intelligence and connectivity (e.g. the internet of things). Intangible interfaces are increasing in products. Affective experiences, in terms of pure awe and affordances or signifiers (Norman, 2008) are very much tied to the technological capabilities available. An expanding vision of futurism and evolution, based on projected future technological capabilities, may be associated to gradually enriching affective user experiences, and increasingly demanding users.

EXISTING FRAMEWORKS THAT SUPPORT SPECIFYING THE AFFECTIVE USER EXPERIENCE

Pleasure with products and displeasure in product use

Pleasure in product use (Jordan, 1998) and displeasure in product use (Jordan, 1996) are two complementary concepts. Pleasure appears as a development from functionality and usability, hand in hand with a revised approach to ergonomic design that departs from minimizing loss towards maximizing gain (Jordan, 2000). Coelho and Dahlman (2002) drew attention to the exchange value of comfort and pleasure. The concept of pleasure is taken here from the viewpoint of product development and engineering design. In this regard, 'pleasure with products' is defined by Jordan (1996) as the emotional and hedonic benefits associated with product use. In practice, the field of pleasure with products was structured by Patrick W. Jordan, and his publications on this area date back to 1995. A number of studies by other authors also considered pleasure in the context of design (e.g. Fulton, 1993; MacDonald, 1998; Desmet &Hekkert, 2001; Hauge-Nielsen & Flyte, 2001). A difficulty of affective concepts such as pleasure or emotion is that they are probably as intangible as they are appealing (Desmet & Hekkert, 2001). Although some interesting and promising studies have been reported, the research field is still short of conceptual clarity and therefore lacks consensus on what the actual subject of study should be. Both the concepts of pleasure and emotion are somewhat undifferentiated, and are used as collective nouns for all kinds of affective phenomena. Design literature tends to refer to these when studying anything that is so-called intangible, non-functional, non-rational, or non-cognitive. Some of the reported studies involve 'experiential needs' (Holbrook, 1982), 'affective responses'

(Derbaix & Pham, 1991), 'emotional benefits' (Desmet et al., 2000), 'customer delight' (Burns et al., 2000) and 'pleasure' (Jordan & Servaes, 1995). Naturally it is inherent to any newly emerging research field that the emulsion has not even started to crystallize, but an adequate definition of the subject of study would facilitate fruitful discussions between researchers (Desmet & Hekkert, 2001).

Design research literature refers to pleasure as a product benefit that exceeds just proper functioning. Pleasure is thus seen as an emotional benefit that supplements product functionality and even usability. In this sense, pleasure covers all pleasant emotional reactions, but it is not an emotion in such (Desmet & Hekkert, 2001). Although people differ in their emotional responses to products, general rules may be identified in the underlying process of emotion eliciting (Desmet & Hekkert, 2001). In his book Designing Pleasurable Products, Jordan (2000) brings forward the concept of pleasure as an overriding goal in product design. Pleasure is seen to contain, but also to exceed, many instances of Human Factor goals in Product Development, such as usability, or comfort. Coelho and Dahlman (2002) developed this idea to some extent, using the example of automobile seats to show the overlapping character of these goals and concepts, including functionality, usability, comfort and pleasure.

The rationale Jordan devised to systematize building pleasure into products, considers the four-pleasure framework, which was originally devised by Tiger (1992). This framework is deeply covered in Coelho and Dahlman (2011) who contributed towards verification of people's need for pleasure in products. The four-pleasure framework is used to build product benefit specifications, using an array of methods that include focus groups, questionnaires, private camera conversation (Vries et al., 1996), co-discovery (Kemp & Gelderen, 1996), experience diaries, reaction checklists, field observations, etc. The transfer from product benefit specifications to product requirements is done through the means of the equivalence between experiential product properties to formal product properties (Jordan, 2000). This is however the area where less knowledge has been unveiled. Still there are some experiential properties which can be transferred to formal properties fairly easily, such as light weight, vivid color, etc., which draw on previously existing notions borrowed from industrial design, concerning product aesthetics, task analysis and culture. An overview of Jordan's design method for pleasurable products is depicted in Table 1.

Given the encompassing character of this concept of pleasure with products, some of the human factor goals included in the concept have come close to attaining predictability (e.g. usability guidelines). This means in practice that it is partially possible to use the four-pleasure framework to attain some product property specifications. But the sum of parts is not equal to the whole, and a lot of work remains to be done in the area, as well as in defining pleasure metrics. Jordan (2000) also considers the distinction between need pleasures and pleasures of appreciation (originally devised by Lewis, 1987) to aid the four-pleasure framework in the process of structuring thoughts about pleasure. The field resorts to human subjects to test the achievement of design methods in terms of pleasurability (e.g. product pleasurability questionnaire – Jordan, 2000) and there is yet no predictability attained in understanding the transfer of formal properties to experiential ones. Product development requirements derived from pleasure with products approaches are loosely tied to formal product properties and are very much still in the realm of experiential properties. As an example, consider the following requirement from a fully worked example of a product benefit specification for a photographic camera targeted for a particular sub-group of society: "the camera should confer the impression of high cultural status on the user" (Jordan, 2000).

Thatcher (2012), proposed a framework for affect in designing for sustainability. The three-point framework is derived loosely from a combination of Jordan's (2000) three levels of application for ergonomics and Khalid's (2006) consumer decision-making model. What is borrowed from Jordan (2000) is the separation between components that are functional, usable, or aspirational. Coelho and Dahlman (2002) also suggested that Jordan's (2000) hierarchy of needs could be adapted to incorporate sustainability as an end goal. The three elements of Thatcher's framework (design for functional balance, design for early engagement, and design for aspirational ideology) depict the three points at which affective design tools might be leveraged to encourage the choice for sustainable products and behaviors. Ultimately, the process of promoting sustainable development may benefit from an understanding of what motivates people to adopt and want to continue to use sustainable tools, artefacts, and systems. Increasing the likelihood of success in achieving sustainable development, could depend on assessing the affective resonance of proposed system development alternatives (Coelho, 2012). An alternative way to ensure the affective resonance was developed for toy design (Fernandes & Coelho, 2013), where the cognitive-affective stages of child development provide a road map for the relevant activities for each age and development stage.

Table 1 – Extract of Jordan's (2000) pleasure based approach to design.

People characteristics relevant for defining product benefit specifications	Methods for use in the creation and evaluation of pleasurable products (experiential properties)	Elements of product design (formal properties of product's elements)
Physiological Special advantages and disadvantages Musculoskeletal characteristics External body characteristics Body personalization Physical environment Physical dependencies **Sociological** Status Self-image Social relations Social labels Social personality traits Social lifestyles **Psychological** Special talents and difficulties Psychological arousal Personality traits Self-confidence Learned skills and knowledge **Ideological** Personal ideologies Religious beliefs Social ideology Aesthetic values Aspirations	**Empirical creation methods** Private camera conversation Co-discovery Focus Groups Think aloud protocols Experience diaries Reaction checklists Field observations Questionnaires Interviews Immersion Laddering Participative creation Controlled observation **Non-empirical creation methods** Expert appraisal Property checklists **Evaluation of design prototypes** Product benefits specification Product property specification Visual prototypes Models Screen-based interactive prototypes Fully working prototypes	Color Form Materials Sound Interaction design

Kansei engineering and Fuben-eki

Prior to the development of 'pleasure with products', Nagamachi (2000) developed the methods behind Kansei engineering / Kansei ergonomics. He founded Kansei Engineering 40 years ago at Hiroshima University, choosing the Japanese word 'kansei', as it means feeling. Kansei Engineering (Nagamachi, 1995, 2002) is hence one of the oldest and most enduring successful attempt to design the affective user experience. Nagamachi (2000) explains that 'kansei' means the customer's psychological feeling as well as physiological issues. The array of methods developed is quite wide, including: Category classification, Kansei Engineering System, Kansei Mathematical method, Virtual Kansei Engineering, Collaborative Kansei Design System and the combination of Kansei Engineering and Concurrent Engineering. The methods include ergonomic experiments and intelligent system inference, which relies on databases built up by peoples' kansei (people's reactions to products). The databases contain information about links that have been established between formal and experiential properties of particular products. Nagamachi (2000), states that Kansei Engineering / Ergonomics has been applied to the design of products from many different companies and domains, including automobiles, construction machinery, electric home appliances, office machines, construction tools for the home, clothes and garments and cosmetics.

Research in Kansei engineering has evolved into a body of non-parametric approaches to analyse information from affective responses focused on neural networks (Ishihara et al., 1995), fuzzy logic (Hotta and Hagiwara, 2005) and rough sets theory (Nagamachi et al., 2006; Nagamachi, 2008). These approaches are, however, absent of metrological rules such as traceability and variance control (Rossi, 2007) and therefore, they remain ones of analysis of a particular sample without allowing results to be compared against others' findings. Camargo and Henson (2012) presented some concepts of the Rasch model, which could allow constructing valid measurement structures targeted

at product features that are of interest for analysis.

Kansei Engineering can work in two ways – Nagamachi (1995) refers to these as the two directions of 'flow'. One direction of flow is termed from design to diagnosis. This involves manipulating individual aspects of a product's formal properties in order to test the effect of an alteration on the user's response to the product. The other direction of flow is from context to design. This involves looking at the scenarios and contexts in which the product is used and then drawing conclusions about the implications of this for design. This second direction of flow involves the gathering of qualitative data via field observations. The data is used to help establish the link between the formal properties of a design and the benefits associated with the product. The two directions of flow Mitsuo Nagamachi uses in Kansei Engineering have similarities with two approaches for design and research: research by design and design by research (Coelho, 2002; Coelho & Dahlman, 2006). The process resulting from the direction of flow from design to diagnosis is alike part of the process resulting from the theory breakdown approach, in compensating for lacunae in the theoretical structures. The process resulting from the direction of flow from context to design is alike the fielded experiment and observation methods described by Woods (2000) in approaching some of cognitive engineering design problems.

Fuben-eki stands for Further BENEfits of a Kind of Inconvenience. (Kawakami, 2011; Naito, Kawakami & Hiraoka, 2012). It opposes the assumption that the more convenient life is, the richer it is. Solely perceiving convenience may deprive users from the pleasure of intricately using the system. Inconvenient systems or methods provide users with such benefits as increased awareness, increased creative contributions and fostering affirmative feelings (Naito, Kawakami & Hiraoka, 2012). Fuben-eki touches the notion of displeasure, but only in the case of benefits accruing from that displeasure or inconvenience. The design principles of Fuben-eki as well as the benefits of inconvenience versus the convenience offered by the system are shown in Tables 2 and 3, respectively. The design principles are suggested to guide the designer in solving a problem, substituting for trial and error approaches. Initially two parameters are specified in the Fuben-eki matrix, the design principles suggested in the matrix are applied to the problem in question. According to the authors, this approach will guide the designer in solving the contradiction between the main convenience intended for the system and what would be lost as a result of the convenience. The principles of Fuben-eki and the matrix were developed based on the analysis of a set of examples (manual vs. automatic transmission, hand writing vs. word processor, etc.). A Fuben-eki design aims to rebuild systems to increase their subjective benefits, even though their apparent convenience may decrease. Given the limited scope of the examples the approach is based on, and the lack of validation, there is no guarantee that the purpose for using this approach will be achieved by the designer. However, this approach cannot be considered a pure trial and error approach, as it provides guidance to the designer.

Table 2 – Fuben-eki design principles (Naito, Kawakami & Hiraoka, 2012)

1. Degradation	5. Time consumption	9. Disorder
2. Enlargement	6. Continuity (analog)	10. Constraint
3. Increase the number of operations	7. Fatigue	11. Stimulation
4. Increase the amount of operations	8. Danger	12. Less information

Table 3 – Fuben-eki matrix (Naito, Kawakami & Hiraoka, 2012)

Benefits of inconvenience **Convenience of system**	**Enhance awareness**	**Devise ways**	**Improve**	**Under-stand the system**	**Prevent down-skilling**	**Be original**
Fast	5, 7					
Quick	1, 2, 6, 7, 9,10	3, 4, 6, 1, 2, 8	3, 4, 6, 8	3, 4, 6, 1, 10	3, 4, 1, 6, 8,10	3, 10, 1, 4, 6, 9

Small/Light	1, 5, 6	5, 6, 1, 3, 4	3, 4, 5, 6	3, 4, 5, 6		3, 4, 5, 6
Does not deteriorate	1, 2, 5, 6	1, 2, 5, 6		3, 5, 10	3, 5, 10	3, 5, 10
Few types of operation	5, 9, 10	4, 5, 6, 8, 9	4, 5, 6, 8, 9	4, 6, 5, 9	5, 6, 8	4, 5, 6, 9, 10
Low amount of operations	5, 9, 10	3, 5, 8	3, 5, 8	3	3, 5, 8	3, 5, 9, 10
Homogenization	5, 10	3, 4, 5, 6, 8	3, 4, 5, 6, 8	3, 4, 6, 5	3, 4, 5, 8	3, 4, 5, 6, 10

Positive and negative product emotions

Nagamachi's approach to designing products for kansei (feelings) comes very close to Jordan's approach to pleasure with products. Kansei Engineering can be seen as a method that fits nicely into being an operative of the theoretical structure adopted for pleasure (Coelho, 2002), and finds its justification in that structure. A similar approach has been developed by Desmet et al. (1999), working on product emotion measure, which was applied to exterior automobile aesthetics. It resorts to human subjects to categorize the emotions elicited by alternative product appearances, based on the comparison with 18 emotions. These emotions are represented by animations of a cartoon character presented on a computer interface. The emotion list is composed of: disgusted, indignant, contemptuous, aversive, disappointed, dissatisfied, bored, disillusioned, vulnerable, enthusiastic, inspired, desiring, appreciative, pleasant, attracted, satisfied, fascinated and softened.

Desmet (2012), identified 25 positive product emotions (when a car makes you smile) and 6 sources of emotion related to products. He also made a review of negative emotions, having found the following negative emotions: fear, anger, sadness, disgust, distress, contempt, shame, guilt. Surprise is considered by many of the reviewed studies as an ambivalent emotion, which may be either positive or negative, depending on the particular situation. Desmet's (2012) typology of 25 product emotions comprises two levels. The upper level concerns the emotional general category, and the lower level is populated by the emotion types, as follows: Empathy (sympathy, kindness, respect), affection (love, admiration, dreaminess), aspiration (lust, desire, worship), enjoyment (euphoria, joy, amusement), optimism (hope, anticipation), animation (surprise, energized), assurance (courage, pride, confidence), interest (inspiration, enchantment, fascination), and, gratification (relief, relaxation, satisfaction). After having identified this positive emotion set using fine-grain vocabulary, Desmet (2012) proceeded to empirically derive the sources of emotion in product-user interaction: object, meaning, interaction, activity, self and other people.

Product personalities

Product personalities (Jordan, 2002) were used by Versos and Coelho (2011, 2013) to assist in verifying if signifiers intended for an object at the onset of the design process had been achieved in the designed concept. Moreover, da Cunha e Silva and Coelho (2011) used product personality attributes to transfer cultural traits to product specifications. Semiotics also plays an important role as we consider Norman's (2008) signifiers, particularly in intangible products, and affordances (Norman, 1988) for industrial design products (Figueiredo & Coelho, 2010). Coelho, Versos and Silva (2012) present the underlying rationale for the use of the product personality assignment approach (Jordan, 2000) in two design processes, albeit in different phases of the design process (in the specification stage and in the design validation stage). Table 4 provides an overview of the 17 product personality dimensions and each semantic ordinal categorical scale associated.

Table 4 – Product Personality Dimensions (adapted from Jordan, 2000).

Scale for product personality pairs
kind – somewhat kind – neither kind or unkind – somewhat unkind – unkind

honest – somewhat honest – neither honest or dishonest – somewhat dishonest – dishonest
serious minded - somewhat serious minded - neither serious minded or light hearted - somewhat light hearted - light hearted
bright – somewhat bright – neither bright or dim – somewhat dim – dim
stable – somewhat stable – neither stable or unstable – somewhat unstable – unstable
narcissist – somewhat narcissist – neither narcissist or humble – somewhat humble – humble
flexible – somewhat flexible – neither flexible or inflexible– somewhat inflexible – inflexible
authoritarian – somewhat authoritarian – neither authoritarian or liberal – somewhat liberal – liberal
driven by values – somewhat driven by values – neutral – somewhat not driven by values – not driven by values
extrovert – somewhat extrovert – neither extrovert or introvert – somewhat introvert – introvert
naïve – somewhat naïve – neither naïve or cynical – somewhat cynical – cynical
excessive – somewhat excessive – neither excessive or moderate – somewhat moderate – moderate
conforming – somewhat conforming – neither conforming or rebellious – somewhat rebellious – rebellious
energetic – somewhat energetic – neither energetic or non energetic – somewhat non energetic – non energetic
violent – somewhat violent – neither violent or gentle – somewhat gentle – gentle
complex – somewhat complex – neither complex or simple – somewhat simple – simple
optimist – somewhat optimist – neither optimist or pessimist – somewhat pessimist – pessimist

Each one of the product personality dimension scales inherently includes to opposing personality traits. Each one of these may however be deemed as either positive or negative, depending on the individual, the product or system in question, and even the context and time of use. The author has used these dimensions in several studies involving industrial design students. When introducing the instrument to students they tend to ask themselves if they prefer products that reflect their own personality or if they would rather have products quite different from their personalities, even opposite. Unveiling the 'wants' and 'unwants' in terms of product personality dimensions is bound to be very specific to each individual and to the context of use of the product and the product function itself.

DISCUSSION

While defining an affective user specification is bound to be a difficult task, whether existing or intended potential or future users are involved in the creation of the specification or it is entirely designer and, or, expert created. This task is especially difficult for new intended products and systems, for which there is no applicable earlier version, or, in alternative, no applicable benchmark, attaining the specified affective user experience properties (and verifying the attainment thereof) depends to a great extent on the design practitioners' expert knowledge. This is bound to be an iterative and extended process. For the most part, the approaches to specification described in this contribution require for effective usage that the designer puts her or his creativity to use in order to generate product and system concepts that might meet the requirements set forth. Experience prototyping (Suri, 2003) and envisaged user or user proxy evaluation is the indirect manner by means of which the evaluation cycle can be closed earlier on the design process before an actual physical and or fully functional prototype is available. Experience prototyping is a form of prototyping that enables design team members, users and clients to gain first-hand appreciation of existing or future conditions through active engagement with prototypes (Buchenau & Suri, 2000). The notion of a product's ecosystem as part of the design of the user experience is related to experience prototyping, as this approach provides the freedom to expand system limits as product ecosystems enlarge. It is expected that the ongoing research efforts in various design domains shall gradually provide well accepted guidelines to complement designer's expertise in

attaining a more straightforward design process to fulfill affective user experience specifications, considering enlarging and more pervasive product ecosystems.

Positive, neutral and negative emotions, product personalities, pleasure with products, Kansei engineering and Fuben-eki, and their respective scales and instruments may provide an interesting and varied set of approaches, that designers may consider in preparing for drafting an affective user experience specification for a newly designed or a redesigned technical product or system. With the aim of providing guidance to designers, this contribution discussed whether the affective user experience specification methods translate directly into product design features, or if these are attained by trial and error, which is mostly the case, except for Fuben-eki. An expanding vision of futurism and evolution, based on projected future technological capabilities, may be associated to gradually enriching affective user experiences, as well as increasingly demanding users, which is bound to expand the importance of the affective user experience in product and systems design, as well as an increasing imbalance towards intangible interfaces, rife of signifiers, supported by increasingly powerful and versatile technology.

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A Study of Passengers' Real-Time Emotional Responses and Comfort Experience During the Flight Using an Experience Sampling Method

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ABSTRACT

The majority of research on passengers' subjective and holistic comfort relies on the retrospective recall of their experiences. Moreover, studies on the emotional responses of passengers to the aircraft interior are infrequent. This paper addresses the above issues by investigating the real-time comfort and emotional responses of passengers during the flight using an Experience Sampling Method (ESM). The results showed that the real time comfort remains constant during the flight, suggesting that passengers' first impressions of the cabin could potentially determine their overall comfort. The results of emotional assessment highlighted two emotion groups as significant to passengers' overall comfort in long haul flights. Those are wellbeing (e.g. joy/feeling good) and prospect-based (e.g. frustration/disappointment) emotions, evoked by passengers' evaluation of several cabin features based on their concerns for a sense of security, peace and relaxation, and accomplishment. Enhancing passenger comfort should involve improving their experience with those features though fulfilling their concerns, offering higher degrees of joy and lowering frustration.

Keywords: Comfort, Emotion, Aircraft, Experience Sampling Method

INTRODUCTION

In recent years, a number of studies investigated passengers' subjective experience of comfort in the aircraft interior environment using passengers' trip reports (Vink et al., 2012; Ahmadpour et al., 2014a). Among those, passengers' affective and emotional responses are rarely examined. Vink et al. (2005) emphasized on the role of emotion in defining one's comfort experience and suggested that designing comfortable products should incorporate knowledge about emotional responses. The relationship between seat comfort and emotions was previously highlighted by De Looze et al. (2003) and Ahmadpour et al. (2014b). This is of interest particularly because the seat plays a central part in passenger's experience during the flight. These studies provide enough evidence to motivate a study on the relationship between passenger comfort and emotions. This issue is addressed in this paper.

Most empirical studies on passenger comfort rely on reports of the flight experience after the trip. Vink et al. (2012) examined the trip reports of more than 10,000 travelers and prioritized the elements of the journey that influenced

their overall comfort. Using passengers' rating of overall comfort and descriptions of their experiences, legroom, hygiene, crew and seat were found to correlate significantly with their comfort and willingness to fly again with the same airline. Ahmadpour et al. (2014a) also used open descriptions of passengers' experiences in the aircraft cabin after their summer vacation and suggested that their comfort experience could be described in relation to eight types of perceptions including peace of mind, physical wellbeing, and proxemics (e.g., perception of personal space). Each of those perceptions was linked to the specific concerns of passengers and the contextual features. For instance the perception of peace of mind was linked to passengers' concerns for security, tranquility and relief and to cabin features such as the seat and temperature.

The above studies provided invaluable information about passengers' recall of the trip impressions after the journey. However, less research is performed on passengers' in-flight experiences whilst they take place in commercial flights. This paper reports an examination of passengers' real-time comfort, emotional responses and their eliciting conditions in the aircraft cabin interior during the flight. Comfort, in this study, is defined as a person's state of physical, physiological and psychological harmony (Slater, 1985). Some researchers have previously shown that comfort and discomfort could co-exist as independent concepts and that they are underlined by different sets of variables (Helander, 2003). An earlier study by Ahmadpour et al. (2014c), however, showed that passenger comfort and discomfort in the cabin interior are underpinned by the same types of variables and characterized by the same set of features. Consequently, comfort and discomfort are viewed as two extreme points of a bipolar phenomenon rather than being independent.

The Model of Aircraft Passengers' Emotions

A pilot study (Ahmadpour et al., 2014b) provided evidence on the salience of passengers' emotional reactions for to their comfort experience. The emotion words were elicited from trip reports of 155 passengers and then sorted into groups using the OCC model (Ortony, Clore, Collins, 1988), proposing unique appraisal patterns for each group. The model is shown in Figure 1.

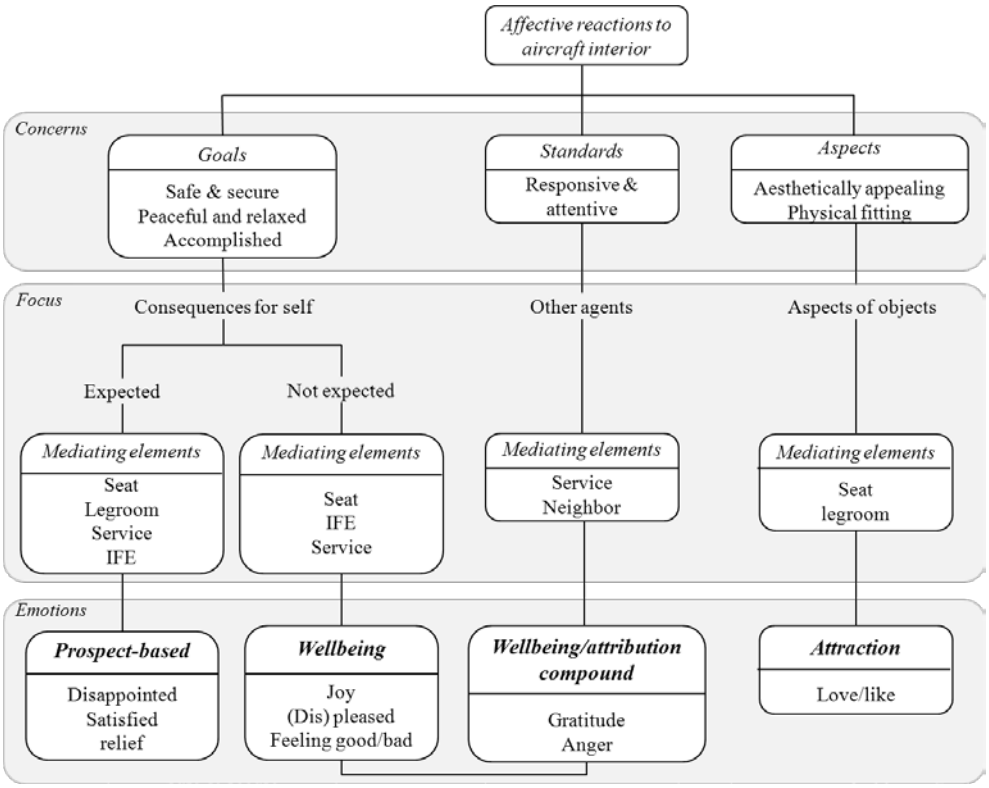

Figure 1. The cognitive structure of passengers' emotions in relation to comfort in reaction to the aircraft cabin interior during the flight (Ahmadpour et al., 2014b)

The model suggests that the passenger comfort experience is linked to four groups of emotions. Those are prospect-based (e.g., disappointed, satisfaction, relief), wellbeing (e.g., joy, feeling good), wellbeing/attribution compound

(e.g., gratitude, anger), and attraction (e.g., love/like). The appraisal patterns leading to each of those emotion groups included passengers' focus (on events, agents or objects) and concerns (goals, standards, and aspects) at the time. Certain mediating elements (i.e., context features) were identified in relation to each group as well. For instance attraction emotions, such as liking, were shown to result from passengers' evaluation of the aesthetics appeal and the physical fit (i.e., their concerns) of the seat and legroom (i.e., mediating elements). The seat was the feature most frequently mentioned overall, suggesting that different qualities of this feature can elicit different emotions. The service, *In-Flight Entertainment* (IFE), and legroom were also influential on generating various emotions in the cabin environment.

This paper reports a follow-up study conducted to validate those emotions groups in the model, their appraisal patterns and relationship to passenger comfort. An Experience Sampling Method (ESM) was used for collecting real-time data about the above. A short description of the method follows next.

Experience Sampling Method (ESM)

In psychology, a method called *Experience Sampling Method* (ESM) was developed to study real time subjective experiences (Csikszentmihalyi et al., 1977; Larson and Csikszentmihalyi, 1983). In this data collection method, the respondent is required to stop at certain times during the course of their experience to report "a high resolution description of their mental state right as they are happening" (Csikszentmihalyi and Csikszentmihalyi, 1988, p.253) in their natural environment. Usually, a beeping electronic device or cell-phone text message presents at random times during their experience indicates they should now stop and answer a series of questions (Anderson, 2002). If interruptions are impractical at that time, an event-contingent protocol is used in which participants report immediately after a particular, pre-determined event (Christensen et al., 2003).

Using EMS is advantageous for studying experiences as it eliminates memory biases in respondents' answers and thus increases the validity of the results (Scollon et al., 2003). Depending on the signaling intervals, various changes in the experience dynamic become accessible. In this study, we employed ESM with an event-contingent protocol to access passengers' real-time experiences and in particular their emotional reactions and comfort.

METHOD

Participants

A convenience sample of 17 participants (14 male) of personal contacts was recruited. All participants had more than five flight experiences. Their age ranged from 20 to 70 (N=8 were 20-39 and N=8 were 40-59) years old. Their average height was 179.6 (160-190, SD=8.5) cm. Ten respondents reported long haul flights (>4hrs), mainly trans-Atlantic from north America to Europe or Asia, and 7 reported short haul flights (<4hrs) in Canada. Only two participants traveled on business class on long haul flights to Asia, and the rest traveled on economy class. None of the participants had any disability.

Questionnaire

The first page of the questionnaire gave instructions about how it should be completed. The questionnaire began by seeking demographic information, flight information, seating location (window, middle, and aisle) and an assessment of their mood using a 5-point scales version of the Self-Assessment Manikin (SAM)(Lang, 1980). Next, three identical sections addressed the beginning, the half-way mark, and the end of the flight. Each section asked them to evaluate their overall comfort at the time on a 9-point rating scale (1=not very comfortable and 9=very comfortable) and to give an emotional assessment containing 22 emotion types of the OCC model, each accompanied by a 5-point scale (1= slightly feeling the emotions and 5=intensely feeling the emotion). The respondents were encouraged to provide justifications for their emotion ratings in a section provided for comments. Another question concerned the level of comfort with regard to certain interior cabin features. Those features were seat, legroom, temperature, noise, air quality, lighting, In-Flight Entertainment (IFE), service, hygiene, luggage room, and neighbors, all of which had been identified as generally influential on passengers' comfort in a previous study (Ahmadpour et al., 2014). A 5-point scale (1=slightly comfortable, 5=very comfortable) followed by a comment section was provided for the rating of those features. Next, four open questions prompted the respondents to describe their experience at the time of reporting including their thoughts about the flight, their activity and

reasons for taking it, as well as noting what made the flight memorable thus far.

Procedure

The participants were contacted individually and were briefed on the structure of the questionnaire as well as on how it should be completed. They were instructed to enter the demographic information and mood assessment before boarding the aircraft. It was explained that passengers of long flights should complete all three sections at the beginning (when it was announced that they could unfasten their seat belts), halfway through the flight and at the end of the flight (10-15min before landing). Passengers on short flights were advised to complete the questionnaire only at the beginning and end of the flight. Each participant was also given a brief introduction to the emotion types used in the questionnaire. It was explained that each emotion represents a family of similar emotions, some examples of which, based on Ortony, Close and Collins (1988), were provided. Then the questionnaires and consent forms were emailed to respondents to print and take with them on their flight.

RESULTS

This section reports only a part of the data analysis. It includes the inter-relationship between participants' overall comfort evaluation, emotional types, and cabin features as the impacting factors on the former. A full analysis and report is in preparation.

On average, the duration of short flights was 77.0 (60-95) min and long flights were 479.3 (300-665) min. The mean value (and standard deviation - SD) for overall comfort ratings and time of reporting for long and short flights are given in Table 1. The average of overall comfort appears to remain nearly constant throughout both short and long flights. The average comfort ratings on long flights were slightly higher than that of short flights.

Table 1. The average rate of overall comfort (1-9) at different time intervals on short and long flights

	short flight		long flight		
	beginning	end	beginning	halfway	end
mean comfort (SD) (1-9)	4.9 (2.2)	4.8 (2.1)	5.6 (2.6)	6.1 (2.4)	6.1 (2.1)
average time (SD) of reporting (min)	10.5 (2.7)	60.5 (10.6)	26.0 (11.3)	228.3 (48.7)	430.0 (120.2)

Next, a t-test was performed on the comfort ratings taken at the beginning and at the end of short flights; it was not significant. For long flights, a one-way ANOVA was performed on the comfort ratings at the beginning, halfway through and at the end of the flight. It was not significant either.

Next, a series of Pearson Product Moment correlation analyses were performed to uncover the relationship between overall comfort, emotional responses and ratings on cabin features. The correlation coefficients between ratings on overall comfort (long flights, short flights) and cabin features are shown in Table 2 and those that are significant for $P<0.05$ are marked. As the Table shows, overall comfort for short flights correlated strongly with legroom, followed by the seat, temperature, and noise. It must be noted that most of the reported short flights did not provide any entertainment unit in form of a personal screen (usually placed in front of the passenger). The results of the correlation analyses for long flights indicate a significant correlation ($P<0.05$) between overall comfort and temperature, seat, air quality and luggage room.

Table 2. The correlation coefficients between overall comfort and ratings on comfort of cabin features for short and long haul flights.

	cabin feature										
overall comfort	seat	legroom	temperature	noise	air quality	lighting	IFE	service	hygiene	luggage room	neighbor
short flight	0.51*	0.64*	0.50*	0.49*	-0.06	0.24	-	-0.13	0.02	0.04	0.28
long flight	0.70*	0.52*	0.79*	0.52*	0.57*	0.41	0.50*	0.46*	0.52*	0.56*	0.43*

* Correlation is significant at 0.05 level (P<0.05)

Significant correlations (P<0.05) were found between overall comfort of long flights and three emotions types frustration/disappointment, joy/feeling good, and hope. These emotions also correlated with some cabin features. There were no significant correlation between emotion types and any comfort ratings of short haul flights. The correlation coefficients between emotions types and comfort ratings of long flights are listed in Table 3 and those that are significant (P<0.05) are marked. As shown in the Table, frustration had a negative correlation with overall comfort meaning that elevated levels of frustration could deteriorate the passengers' level of comfort experience. Hope also correlated negatively with overall comfort. The respondents' comments explained this emotion as hope for the flight to be over or hope for the flight to be over, indicating low levels of comfort. On the contrary, the positive correlation of joy with comfort indicated enhanced comfort when higher degrees of that emotion were experienced during the flight. Each of above emotion types are influenced by a number of cabin features as discussed below.

Table 3. Correlation coefficients between emotions types and ratings on overall comfort and cabin features comfort for long haul flights.

emotion type	overall comfort	seat	legroom	temperature	noise	airquality	light	IFE	service	hygiene	neighbor	luggage
love	-	-	-	-	-	-	-	-	-	-	-	-
anger	-0.34	-0.17	-0.25	0.03	-0.16	-0.34	-0.50	-0.40	-0.29	-0.15	-0.41	0.25
gratitude	0.01	0.25	0.24	-0.18	-0.41	-0.43	0.23	0.23	0.21	-0.49	0.21	0.25
remorse	-	-	-	-	-	-	-	-	-	-	-	-
gratification	0.35	0.09	0.12	0.06	0.10	0.16	0.24	0.24	-0.07	0.25	0.10	0.05
reproach	-0.34	-0.17	-0.26	0.03	-0.18	-0.36	-0.40	-0.39	-0.23	-0.19	-0.38	0.22
shame	-	-	-	-	-	-	-	-	-	-	-	-
admiration	-	-	-	-	-	-	-	-	-	-	-	-
pride	-	-	-	-	-	-	-	-	-	-	-	-
frustration	**-0.73***	**-0.61***	-0.16	**-0.58***	-0.21	-0.34	-0.40	-0.42	-0.38	-0.35	**-0.56***	-0.50
joy	**0.71***	**0.47***	0.36	**0.42***	0.52	0.58	0.43	**0.55***	0.72	0.53	0.68	0.49
distress	-	-	-	-	-	-	-	-	-	-	-	-
relief	0.04	0.18	-0.31	0.37	0.21	0.24	0.21	0.21	-0.01	0.23	0.04	-0.04
fear-confirmed	-	-	-	-	-	-	-	-	-	-	-	-
satisfaction	0.38	0.13	0.47	0.25	0.47	0.39	0.06	0.06	0.17	0.36	0.12	0.01
hope	**-0.53***	-0.33	-0.50	-0.24	**-0.57***	-0.43	-0.40	**-0.77***	**-0.51***	-35	**-0.72***	0.10
fear	-	-	-	-	-	-	-	-	-	-	-	-
pity	-	-	-	-	-	-	-	-	-	-	-	-
resentment	-0.46	-0.38	0.04	-0.58	0.03	-0.07	-	-0.03	0.01	-0.02	-0.03	-0.29
gloating	-	-	-	-	-	-	-	-	-	-	-	-
happy for	-	-	-	-	-	-	-	-	-	-	-	-
hate	-	-	-	-	-	-	-	-	-	-	-	-

* Correlation is significant at 0.05 level (P<0.05)

The emotion joy correlated strongly with the IFE, followed by the seat and temperature. The respondent's comments with regard to the seat were focused on having more space than expected, ability to obtain a relaxing posture to sleep and not worry about being tired at the time of arrival. A good feeling was also elicited due to the cool but not too

cold temperature or due to cool air being blown from the vents as refreshing. These provided a relaxing and peaceful experience. Descriptions of good feelings mediated by the IFE system were related to finding the content of the entertainment unit interesting and helpful to pass time and relax.

The emotion frustration correlated negatively with the temperature, seat and neighbors respectively suggesting that undesirable temperatures could exacerbate. The seat frustrated participants when the physical fit was not perceived desirable and their fidgeting attempts at finding more comfortable positions frustrated them. Another common complaint was about a lack of personal space, having no space designated for personal belongings or a general feeling of confinement. Participants' frustration with the temperature resulted from its instability (going from hot to cold or vise versa), mal-functioning of the overhead vents and the felt temperature extremes, e.g. feeling too hot or too cold. Finally the frustration with neighbors was commonly described in terms of unwanted interaction with the seat-mates, undesirable physical proximity to them, or in reaction to the reduced space when the passengers in front of them reclined their seats.

The emotion hope correlated most strongly with IFE, neighbor, noise, and service. The negative correlations demonstrated a low level of comfort experienced by those respondents and their wish for arriving at the destination and the flight to be over. The comments with regard to IFE were related to the constant interruption of the programs on the entertainment unit due to flight announcements and passengers' hope that those type of communications would not continue. One passenger described his diminished hope to get any rest or sleep when his front neighbor reclined her seat to the maximum, shrinking his personal space. The correlation of hope and noise was related to instances where the noise level became uncomfortable and the respondents hoped to arrive at the destination, not having to endure the noise any longer. The service comments were related to respondents' hope for a better service and the flight crew to circulate in their section, attending to their request.

DISCUSSION

The ESM method has been used before to study the interaction between people and systems. In product design, Demir et al. (2009) employed ESM combined with interview techniques to investigate the appraisal patterns of emotions in human-product interaction. The method proved successful and gave indications about the underling process and eliciting conditions of four emotions namely joy, satisfaction, anger and disappointment. This paper similarly benefited from repeated reports of passengers during the flight in order to gain an understanding of the dynamics of their comfort experiences and to verify the features that commonly elicit comfort and emotional responses.

The overall comfort did not significantly ($P<0.05$) vary when assessed at different times during the flight. This could imply that passengers' early impressions of the flight context (design features and the service) might predict their impending experiences. That suggests that positive or negative aspects perceived in the first 8 to 14 minutes of a flight could overshadow the forthcoming experience and that the average comfort of the flight is close to that of the first impression. The mean value of comfort on long flights was slightly higher than on short flights. One reason for this could be that the service in long (trans-Atlantic) flights were reported to be better than short flights. There was also a significant correlation between the service and overall comfort of long flights (see Table 2). Another reason could be the offered In-Flight Entertainment (IFE) on long haul flights which also correlated significantly with overall comfort of those flights. Moreover, the aircrafts used on longer flights are usually larger in size, offering more personal space and lower noise level. Noise level was shown to have a significant correlation with overall comfort as well.

It was showed that four features namely seat, legroom, noise and temperature significantly influenced comfort regardless of the flight length. Thus identifying passengers' preferences with regard to these features is of crucial importance as they are likely to predict the comfort of the whole flight if they provide favorable first impression. The temperature and the seat particularly had strong correlations with comfort in long flights.

The significance of features IFE, service, hygiene, luggage room and neighbor were specific to long flights. The impact of luggage room is likely to be related to that passengers on long flights carry more luggage and find it challenging to fit them in the shared luggage bins. Sometimes, they are forced to store some pieces under the seat in front of them, which impedes on their free personal space. The significance of the social aspects of passengers'

experiences (i.e., their interaction with their neighbors) for comfort of long flights necessitates particular attention to the design details. In their study, Ahmadpour et al. (2014a) suggested that the arm rest design is influential on these interactions. A removable arm rest improves the interaction of passengers who are travelling together while wider arm rests that are properly separated underneath would reduce the chances of conflicts between strangers.

The only significant relationship between emotional responses and passenger comfort was found for the long flights. It could be argued that short flights do not last enough to engage passengers' emotions in a significant way. However, our study was limited in resources and it would be beneficial to repeat the study by recruiting a larger sample of participants.

Ortony and colleagues categorized the emotion type joy/feeling good in a group of emotions they called wellbeing. The appraisal process of these emotions involves evaluating the outcomes of an event for oneself without any prior expectations associated with them. In the flight context, if they are desirable, various degrees of joy and subsequently comfort are elicited; otherwise one experiences distress and discomfort. The results in this paper suggested seat, temperature, and IFE as the eliciting features of joy, meaning that once these features provide pleasant experiences or even surprises despite the passengers' prospect, they generate a general good feeling. A common theme among comments related to the emotion joy was feeling peaceful and relaxed which is also confirmed by the model of passengers' emotions (see Figure 1) as a concern for wellbeing emotions. Moreover, the appraisal patterns proposed by Ahmadpour et al. (2014b) for this group of emotions also confirm the seat and IFE as two mediating features of those emotions. However, the correlation of cabin temperature and passengers' experience of joy was not calculated in that study.

The emotion types frustration/disappointment and hope belong to the prospect-based group. These emotions are elicited when the consequences of events are evaluated against one's expectations and goals. If those consequences meet one's expectations, they result in relief whereas violation of those expectations leads to disappointment and frustration. The results of the present study highlighted the temperature, seat, and neighbors as the mediating elements for the appraisal process of frustration. When passengers' expectations for those features are not met, they feel frustrated and that negatively impacts their comfort. Among the features mentioned, the model of passengers' emotions confirmed the importance of the seat but not that of the temperature and neighbors. However, once analysis method employed by Ahamdpour et al. (2014b) for developing the model is examined more closely, it became clear that the comments relating to feelings of confinement and proximity to neighbors had been classified as belonging to the 'seat' category. The reason for that classification, as they argued, was that this problem was caused by the seat design (e.g., seat dimensions, improper separation from neighbors) rather than by the actual neighbors. Interestingly, the feature neighbor was mentioned in prospect-based group in relation to emotion hope. This emotion type was not previously mentioned in the emotion model by Ahmadpour and colleagues but it was noticed that respondents' ratings in relation to this emotion type was similar to that of frustration, i.e., they signified a level of disappointment in goals that were not met with respect to IFE program interruption, noise level, service quality or neighbors invading their personal space. Thus the ratings did not portray the respondents' level of being hopeful as a positive state but rather they depicted respondents' disappointment in the system and hope for either improvement during the rest of flight or wish for the flight to be over. Thus it is safe now to conclude that temperature is the only feature that was not mentioned in relation to prospect-based emotions in the model.

Passengers' concern in relation to frustration is reflected in a common theme in their comments, namely the lack of personal space and a feeling of confinement. Those fall into the category of concern for security, i.e., not feeling any worry, on the model of passengers' emotion. One concern relative to the hope emotion was feeling discomfort and agitation due to the noise level. This concern falls into the peaceful and relaxed category on the emotion model. Finally, passengers' concern for entertaining themselves with no interruption or obstruction on the IFE unit is similar to the concern for accomplishment on the model of passengers' emotion. It is therefore concluded that the results of this study verify the three concern categories for prospect-based emotions on the model proposed by Ahmadpour and colleagues.

The results of this study have some implications for the cabin interior design. It was shown that passengers' comfort experience is highly influenced by their first impressions of the flight. These impressions should be addressed with more detail in future research. The cabin features that contributed strongly to passengers' overall comfort and emotional reactions were prioritized (based on their correlation coefficient) for short and long haul flights separately and this could be used as a design reference. Such information is a valuable resource for the airlines and aircraft manufacturers' decision making during product development and the cabin interior improvement process. The

results point to specific features that could enhance comfort more effectively. In particular, the features that generate strong emotional reactions on long flights should receive more attention, given that emotions inform human behavior, i.e., they generate appropriate responses in people to cope with their environment (Frijda, 1986). Strong feelings of frustration, for instance, could alter a passenger's interaction with other people during the flight and be potentially troublesome. They also impact comfort negatively and potentially passengers' future choices of an airline. Brauer (2004) claimed that 35% of passengers base their selection of airline on comfort. The felt temperature, in particular, should be considered an important design criterion for passenger comfort of long haul flights. The reason is that we found it to have a correlation with comfort and also increase an emotion of frustration when not desirable. Finally, the seat was shown to impact those emotion groups in different ways; mediating joy through providing relaxing postures and facilitating sleep and preventing frustration by eliminating worries about personal space and privacy and fulfilling passengers' concern for security.

Real time versus retrospective recall of comfort experience

The ESM proved to be a good choice for this study of the real-time passenger experience during a flight. The above results confirmed two of the emotion groups (i.e., wellbeing and prospect-based) initially proposed by Ahmadpour et al.'s (2014b) passenger emotion model. More research is required to validate the remainder of the model and to replicate the above results. It is also essential to investigate the relationship between what passengers actually experience onboard commercial flights and their memory of the experience after the trip, i.e., what makes a trip memorable. These are examined in a follow up study by the authors of this paper in which regular travelers are recruited for reporting their in-flight experience both during and after the trip, using ESM questionnaire.

CONCLUSION

This paper studied the real time experience of passengers during the flight using ESM. It was shown that the real time comfort remains constant during the flight, suggesting that the first impressions of the passengers in the cabin could potentially determine their overall comfort. Furthermore, a number of cabin features (seat, legroom, temperature and noise) were identified as highly correlating with the comfort experience on both short and long haul flights. The results of emotional assessment highlighted the importance of fulfilling three important groups of passengers' concerns in an effort to provide them with the feeling of joy, avoiding frustration and ultimately delivering comfort. Those are concern for peace and relaxation and concern for security (i.e. not having any worry or anxiety) and accomplishment. Some cabin features were attributed to each of those groups. The model of passengers' motions in the aircraft cabin was partly validated in relation to prospect-based and wellbeing emotions.

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Reconciling Affective and Ergonomic Objectives of Product Design

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ABSTRACT

This paper describes a methodology for optimizing the pleasurable affects of a product's design without mitigating ergonomic imperatives. Drawn from well-established principles of psychology and information science, it has been developed and applied in both educational and professional settings. A designer employs it by manipulating just four of a product's visual properties: *contrast* (objective information); *novelty* (subjective information); and two properties called *objective concinnity* and *subjective concinnity* that facilitate a viewer's ability to process the design's inherent information quickly enough to derive affective pleasure and/or ergonomic benefit from it.

Keywords: Aesthetic Valence, Affective-Cognitive Lag, Arousal, Collateral Information, Contrast, Discretionary Information, Empathic Communication, Essential Information, Novelty, Objective Concinnity, Semantic Profile, Stereotype, Subjective Concinnity

INTRODUCTION

Reconciling the affective and ergonomic objectives of product design is a topic best considered in the context of information theory—even though that word *information* has acquired many meanings while passing back and forth between common usage and technical or scientific usage: "knowledge," for example, or "news" are popular everyday meanings. But it also refers to "a collection of data" (statistics); "bits" and "bytes" (computer science), "uncertainty" (physics and communication theory); and "reduction of uncertainty" (psychology and ergonomics).

All those notions regard information as a commodity to be sought, gathered, processed, stored and regurgitated by nervous systems, computers and other information processors. But digging down to the word's Latin roots it also pertains to a process; *informare* means "to fashion," "to shape," or "to give form to" something.

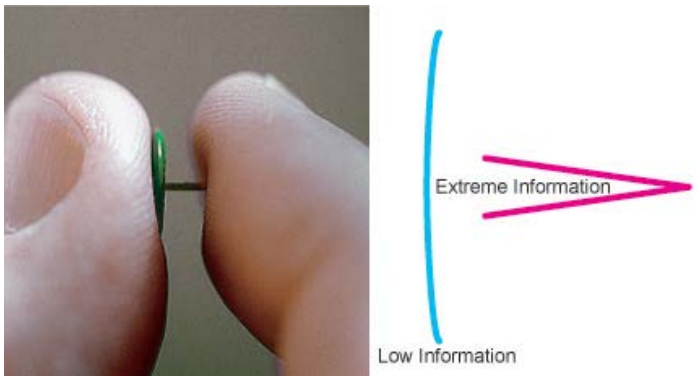


Figure 1. Squeezing a tack informs the finger with affective and ergonomic consequences.

An ordinary tack (Figure 1) *informs* the person squeezing it as surely as a speaker informs a listener. Its point embodies more information than its cap because the curvature of its surface changes in a more pronounced and abrupt fashion than the cap's. The point thus informs the flesh more as it is squeezed and evokes more sensations than the cap—even though Newton's Third Law assures that both ends of the tack exert the same reactive force on each finger. The point increasingly preoccupies the attention and thoughts of the person doing the squeezing as the sensations go from uncomfortable to painful. Squeezing even more tightly would lead to the aesthetic and ergonomic calamity of injury if the mounting urge to back off were not heeded soon enough.

Note: "Aesthetic" replaces "affective" here, but not merely as a synonym for "beautiful." One of the ergonomic objectives guiding design of a tack is to make the cap as *anesthetic* (devoid of feeling or sensation) as possible by minimizing its curvature and, thus, its inherent information.

PRODUCTS AS MASS MEDIA

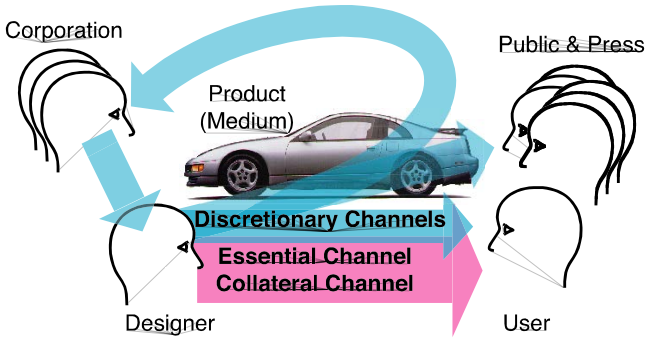
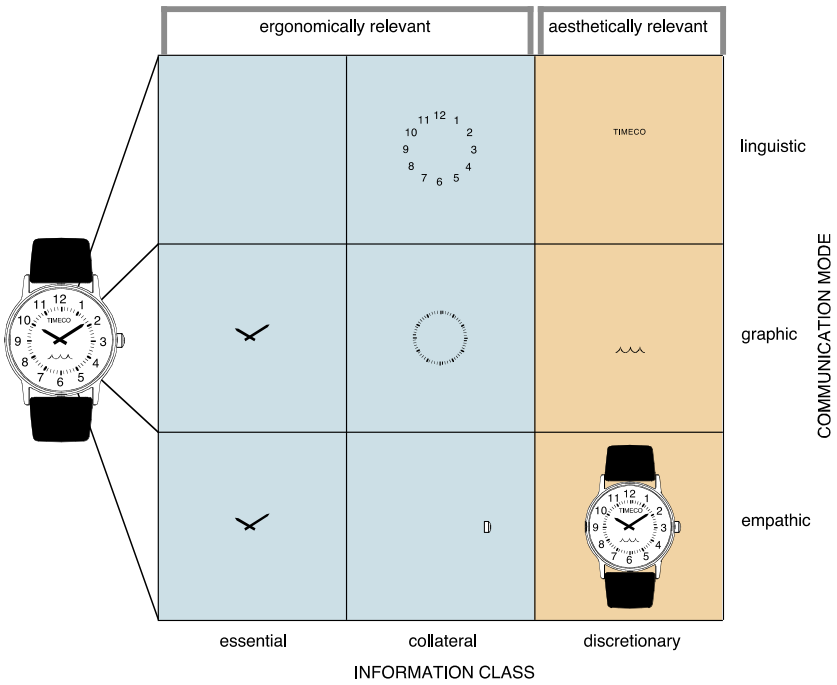


Figure 2. A product considered as a mass medium.

Table 1. Information Classes and Communication Modes employed by designers.



Information in a designer's head (knowledge, concepts, ideals, managerial directives, etc.) informs a product's design with three kinds of information: essential; collateral; and discretionary (Figure 2). The product then serves as a communication medium—literally *in between* the designer and several audiences: users; the public (including

potential consumers and users); the press and other media who shape public impressions of the product; and corporate decision makers and designers who are influenced in their shaping of future products. Designers employ linguistic, graphic and empathic (body language) modes of communication to convey three classes of information (Table 1):

Essential information, determined by ergonomic objectives, is most critical to users. The hands of an ordinary analog watch provide sufficient essential information to tell time by. They are graphic in nature but also empathic by "pointing out" the time.

Collateral information provided by numbers and minute marks reduce uncertainty further. So they are useful ergonomically, but not essential. They would be essential if the watch were used to time sporting events. The visible knob informs the user where to reset the time. It communicates empathically by tapping cultural stereotypes to "invite" the user to take hold of it and turn it clockwise to advance the time.

Discretionary information satisfies aesthetic and any other non-essential communication objectives. A watch's brand name is not essential to the watch's purposes. So it is discretionary and could be omitted (although the CEO and marketing manager might argue otherwise). The wave-like symbol suggesting water resistance is also discretionary and expendable. The case's shape is discretionary information. So are its color and the band's material and color. All these visual elements empathically express a watch's semantic profile (Figure 3): whether it is expensive or cheap, accurate or inaccurate, heavy or light. Discretionary information answers all these questions and any others that come to a viewer's mind.

Figure 3. Each watch empathically expresses a different semantic profile via discretionary information

Information Budgets

The nervous system can process only so much information at any given moment. So it is important to budget the information load imposed by a product on its user to ensure that non-essential information does not overwhelm essential information. The watch on the lower left of Figure 3 is easy to use because it is dominated by essential and collateral information. The one to its right is dominated by discretionary information. It serves best as jewelry, which can be devoid of essential information. The low contrast between essential elements and their background make it more difficult to use under low ambient lighting conditions. Its rectangular face violates analog principles by forcing reference marks to be unevenly spaced.

Car designers have almost as much latitude in the use of discretionary information as jewelry designers. The exterior form of a Chrysler concept car (Figure 4) consists almost entirely of discretionary information. Its designers were virtually as free as fine artists to make it empathically express any set of emotions and meanings they saw fit. The turn signals and brake lights were the only sources of essential information that had to be shaped, sized and placed according to legal and ergonomic requirements. Practical requirements dictated things like wheel size and placement of the windshield. But those didn't involve information issues.

Designers achieved a degree of visual harmony inside the 1996 Ford Taurus by setting some displays and controls within an ellipse that harmonized with the discretionary elliptical theme of the car's exterior design. They also exercised the reasonable discretion by including elliptical buttons. But the elliptical arrangement of the buttons

introduced considerable uncertainty that made them difficult to use and caused excess driver distraction.

Figure 4. Use and misuse of discretionary information.

INFORMATION AND AROUSAL

In a sense, whatever rouses the nervous system, draws attention, and evokes the affective, cognitive and physiological reactions known collectively as *arousal* is de facto information. The following properties have hardwired or learned arousal potential (Berlyne, 1971):

- biological importance (food, sex, noxious elements).
- intensity (bright light, loud sound, strong smell, etc.).
- certain spectral regions (red light has more arousal potential than blue light; sounds in the 500-800 Hz region have less arousal potential than those on either side).
- acquired importance (a person's name, a recognized threat, symbols or signs associated with important matters).

A bright red car is more arousing than a blue one. And a Ford might interest and excite someone named Ford more than a Chevrolet. A bright light and loud horn make effective warning signals. But there is none of the uncertainty normally associated with information. A driver already knows what a red traffic signal means.

They also lack the *variance* cited as the hallmark of all information in the seminal publication on information theory (Shannon, 1948). The flashing of a car's turn signal is more compelling and informative than its red color.

There are two general categories of information characterized by variance:

- *Novelty* (subjective information) (see Figure 5) arises from comparison of a product's design with its stereotype, a mental model stemming from all similar products seen in the past, especially most recently. The design's novelty is a measure of how much it varies from its stereotype.
- *Contrast* (objective information) (see Figure 6) arises from comparison of simultaneously perceived properties of a product's design. Contrasts can be objectively measured by standard instruments and mathematical means.

Novelty: Subjective Information

A novel counterclockwise watch (Figure 5) is loaded with the additional uncertainty because it differs from the typical. Like a joke, it's affectively amusing but a burden ergonomically. It requires more time and effort to tell time with it—until its novelty dissipates with practice and the user can tell time with it as easily as with a standard watch. Note that the user has been informed as his watch stereotype has been re-formed; the user has learned something and the watch is no longer novel.

Figure 5. Examples of novelty: a counterclockwise watch and a cup with an unusual handle.

Corning's Corelle cup (Figure 5) seems quite normal except for its novel handle, which grabs attention and compels the viewer to ponder the uncertainty associated with it: "Why is it shaped like that?" and "Can the cup be held securely?"

Contrast: Objective Information

The tack's point (Figure 1) provides an example of contrast. It is objective information because the curvature of its surface and its change of curvature can be measured. The tack's cap embodies less information because its surface has less curvature.

Except for its novel handle, the Corelle cup (middle profile in Figure 6) is quite ordinary. The more complex curve with three changes of direction, which defines the profile to its right, has much more information as contrast. As a result it holds a viewer's attention more surely than the other, less informed profiles. Its body language empathically expresses a more active, emotional, baroque personality. The less informed profile on the left, with its unvarying, straight sides, projects a cooler, more rational personality typical of the German Bauhaus' Modern design.

Figure 6. the variance (contrast) of a cup's profile increases its objective information.

Aesthetic Valence and the Affective-Cognitive Lag

Information ignites arousal with its attendant emotions, urges, thoughts and the host of other psychophysical reactions that characterize aesthetic experience. The brain's very rapid affective system, largely responsible for feelings and emotions, is mediated largely by the amygdala, which has been called the seat of fear. Indeed, some studies of brain function suggest that fear is the prototype of all emotions (LeDoux, 1996).

Even the most beautiful design, it seems, frightens if only for milliseconds before it pleases. This is especially so if the emotional kick is due to novelty. The brain makes an instantaneous, “quick and dirty” appraisal of a novel stimulus, usually defaulting to a negative one—unless and until the cognitive system uncovers reason enough to do otherwise. The initial, instantaneous urge is to flee the offending thing by turning away or to fight it by hurling invectives at it like “Ugly!” This is good, of course, because it has implicaitons for survival. Most threats come in the form of something unexpected. Best to shun the unknown until there's time to figure it out. Better safe than sorry.

Arousal persists and increases as long as uncertainty lasts. Brief "arousal jags" associated with a joke quickly gotten and "arousal boosts" associated with beautiful things feel good (Berlyne, 1971). But not the prolonged arousal associated with a joke not gotten while everyone else in the room is laughing.

Unfortunately, the cognitive system, with the cortical means for figuring out the answer to the questions "What is it?" and "Why?" is ponderously slow. Affective and cognitive processes begin simultaneously but cognition always lags behind racy affect. A short affective-cognitive lag associated with a product's design feels good; the viewer likes the design and is drawn toward the product. A long lag feels bad and repels the viewer.

Skilled designers instinctively incorporate a property called concinnity to accelerate cognition and shorten the lag enough to ensure a positive aesthetic result. Basically, the more inherent information a design has, the more concinnity it must have to make sense of it and ensure positive aestehtic valence.

CONCINNITY

Most dictionaries define concinnity simply as “harmony,” “symmetry,” or “elegance." Ancient Romans who coined the word had in mind "skillfully arranged parts." Nineteenth century rhetoricians referred to concinnity as a “a close harmony of *tone* as well as *logic* among the elements of a discourse.” A concinnous poem about a babbling brook, for example, might phonetically remind the listener of the sounds (tone) emanating from the brook being (logically) described. So it is useful to consider two kinds of concinnity, subjective and objective:

- *Objective concinnity* speeds cognition by facilitating pattern finding (compare with Gestalt psychology’s Principle of Prägnanz).
- *Subjective concinnity* speeds cognition by means of logical and emotional appropriateness.

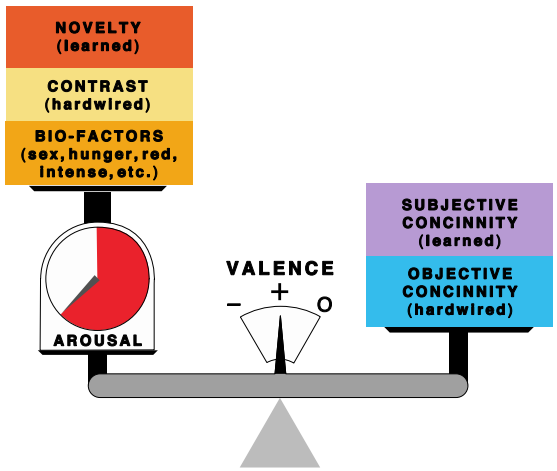


Figure 8: A design's positive aesthetic valence results from an appropriate balance of information and concinnity.

A design with positive aesthetic valence (Figure 8) is attractive or, in the extreme, beautiful. Some combination of contrast, novelty and suggestions of biological importance in a design triggers arousal. Some combination of objective and subjective concinnity help the viewer to cognitively "make sense" of the design quickly enough to keep the associated affective-cognitive lag short enough. Things change over time, of course. Contrast and biological factors remain constant. But, since nothing can remain new forever, novelty begins to dissipate immediately. Arousal, indicated by the "arousal meter" on the left decreases and the design becomes less exciting. Valence swings toward neutral, indicated by the zero. Objective concinnity also remains constant, but subjective concinnity can increase or decrease as the viewer's mindset is changed by the design or changes in such things as trends of cultural values.

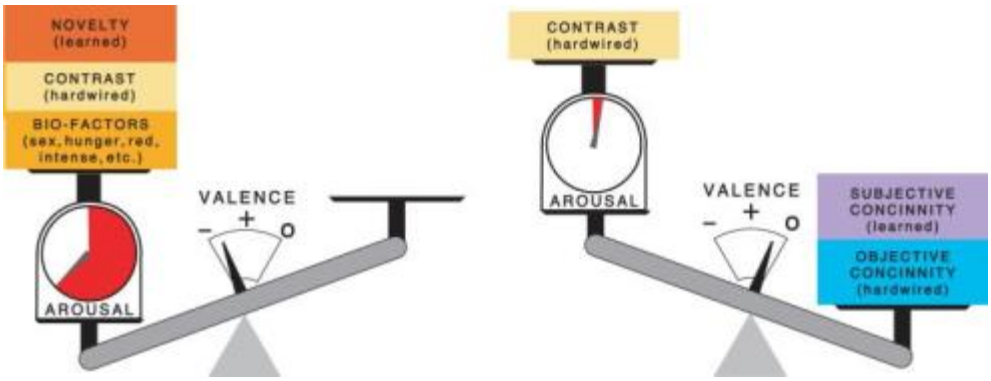


Figure 9: Negative valence (left) and neutral valence (right).

Negative valence results from insufficient concinnity (Figure 9). The design continues to be exciting due to lots of information and resulting arousal, but in the wrong way. It is repulsive or, in the extreme, ugly. Since novelty does dissipate, the negative reaction can soften over time. A designer might also fix such a design by reducing contrast (making it simpler) or reducing any arousing biological factors (by changing its color from red to blue, for instance).

A design with neutral valence (Figure 9), which is neither attractive nor repulsive, is the third extreme possibility. While it is dominated by concinnity, it can never be entirely devoid of information. It will always embody some contrast; otherwise it would be invisible. While it might be unexciting aesthetically, a relative excess of concinnity guarantees that it will not be ugly. Indeed, it might find its way ultimately into museaums as a classic. Neutral Valance, might be thought as an "anesthetic" base for outstanding ergonomic quality.Assuming that whatever information does exist serves only essential or collateral needs, neutral valence can be ideal for ergonomic purposes.

Increasing Objective Concinnity

- symmetry
- horizontal, vertical, orthogonal and parallel relationships
- simplicity (minimal number of elements)
- mathematically definable by continuous functions of the lowest possible degree (a straight line is more objectively concinnous than a circular, elliptical, or parabolic curve, which are in turn more concinnous than third degree curves)
- minimal number of intersections of elements (done by extending lines beyond their end points, and by passing lines through such landmarks as centers of circles)
- aligned and flush elements
- redundancy (minimal number of unique, one-of-a-kind elements that do not resemble other elements)
- minimal variety of elements (shapes, lines, surfaces, colors, proportions, etc.)
- repeated attributes (color, finish, texture, etc.)
- proportional relationships limited to integers 1 through 5 (1:1, 2:1, 2:3, etc.) and 1.618:1 (the so-called "Golden Ratio")

Figure 10: Objective concinnity achieved with symmetry and repetition.

The Corelle cup's handle is part of a virtual combination of two *identical circles* whose *aligned* diameters are *symmetrical* about a *vertical* axis with the nominal side of the cup.

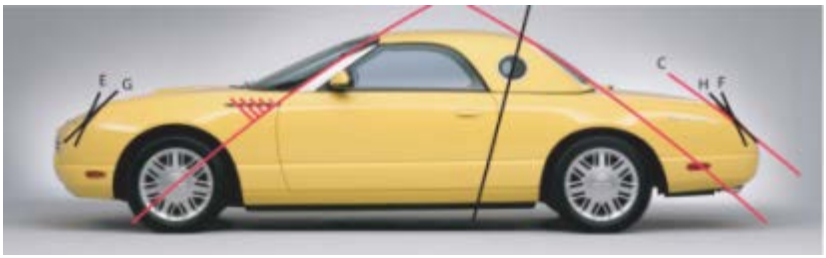


Figure 11: Objective Concinnity achieved with symmetry and repetition.

Several examples of objective concinnity are obvious in the side view of the 2002 Ford Thunderbird (Figure 11). The windshield pillar lines up with one of the front wheel's spokes and passes through the wheel's center. It is also symmetrical with the rear profile of the top, which is, in turn, parallel with the tail (C). The rear edge of the door is aligned with the center of the porthole and the break in the top. The plane of the headlights (E) is symmetrical with that of the taillights (F). The openings for the lights (G & H) are also symmetrical.

While it is impossible to imbue a design with too much subjective concinnity, it can have too much objective concinnity (Figure 12). A symmetrical car, front to rear, slows empathically to a stop, which is out of character with the whole notion of a car.

Figure 12: Excessive objective concinnity can diminish subjective concinnity.

Figure 13: Objective concinnity of left ring increased by aligning notch vertically with center or by adding a symmetrical notch.

It is tempting to think of objective concinnity as negative information. But, in fact, the objective concinnity of a design can be increased by adding information (Figure 13). The objective concinnity of

the ring on the left is increased by rotating the notch to alight with the vertical diameter of the circle as in the center design. Or, it can be increased by adding a second notch (more information) as in the design on the right.

Subjective Concinnity

Essentially any thing in the product's form that brings to mind thoughts or feelings consistent with the beliefs, values and other aspects of the viewer mindset constitutes subjective concinnity. Subjective factors include:

- *Clichés*. Once a cliché is established it can become so commonplace that it seems essential. So designers consider nothing else for a modern car's design but cast aluminum wheels with an odd number of spokes, which seem more active and sportier than an even number. Consumers are likewise reluctant to consider anything else. Skirts that cover the rear wheels could reduce aerodynamic drag and increase fuel economy but are even less acceptable to designers and consumers than old-fashioned disk wheels (Figure 14). But a cliché can be displaced by a new one overnight and embraced just as fervently. When aerodynamic efficiency becomes truly important again, watch for a return of skirts and wheels with fewer and smaller openings.

Figure 14. Timely cliché (cast, spoked wheels) and untimely cliché (rear-wheel skirts).

Figure 15. 1963 Ford Thunderbird with timely cliché (rear-wheel skirts).

- *Nostalgia*. Much of the appeal of Ford's 2002 Thurderbird stemmed from its nostalgic recall of earlier Thunderbirds like the 1963 T-Bird (Figure 15). Note the simpler wheels, whitewall tires and skirts, which were dominant clichés of the period. It would have seemed declasse without them.

- *Zeitgeist.* An era's zeitgeist (time's ghost) is the stuff of styles, fashions and fads of the day. It changes as a culture's values, concerns and preoccupations change, but usually at a slower rate than the popularity of clichés wax and wane. You can sense that the 2002 T-Bird belonged to a different era than the 1963 version. Neither would have as much appeal today as in their own times.

- *Stereotypes*. As part of the study of the Corelle cup's design, a class of 20 first-year industrial design students were asked produce actual size sketches of "the typical coffee cup." It was stressed they should not design a cup but merely depict the typical cup. Best approximations of vertical centerlines were added to each of the 20 sketches. The heights of the sketches were resized as necessary to align the rims and bases of the cups. The one handle oriented to the left (probably drawn by a left-hander) was flipped to the right. Otherwise, the sketches were remarkably similar in size (Figure 16) and needed very little adjustment to normalize them. The ghost of a visual stereotype is quite obvious in the resulting compilation of the 20 sketches (Figure 17). A comparison of a profile drawing of the Corelle cup and a computer-derived mean of the sketches reveals that the actual cup is quite close to the stereotypef. Except for the Corelle cup's novel handle, it is quite normal in appearance. It has a lot of subjective concinnity in this regard.

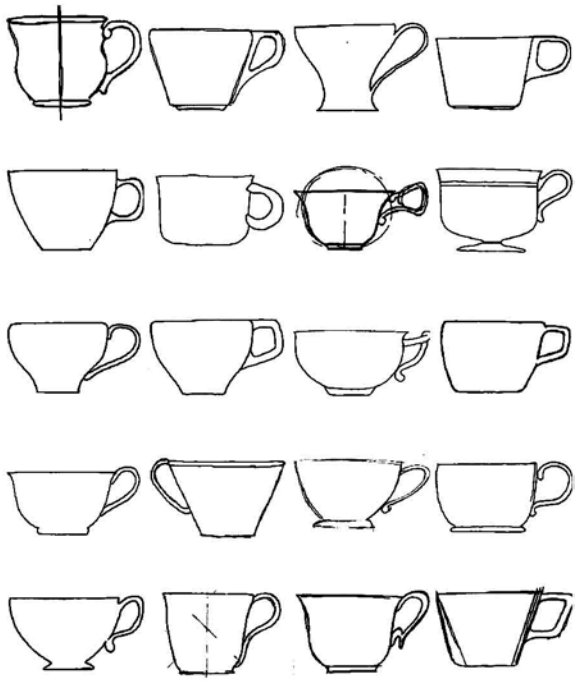


Figure 16: Sketches of "typical" cups drawn from memory.

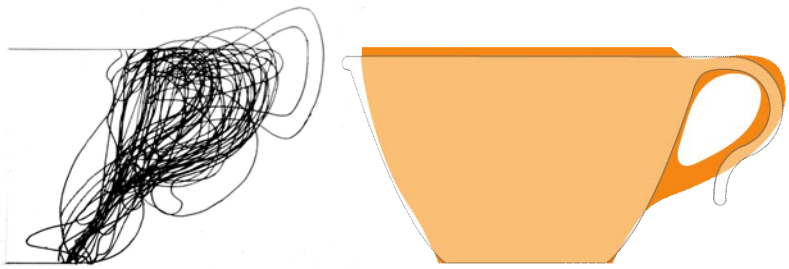


Figure 17. Visual Stereotypes derived from combined students' sketches (left) and computer-generated average of sketches compared with Corelle cup profile.

- *Ideals*. A measure of empathic expression of the Corelle cup was obtained by analyzing its design using the semantic differential survey tool developed by Charles Osgood (Osgood et. al., 1955). A different group of students did this several years after the visual stereotype was devised. The resulting semantic profile of the actual cup was compared with a profile of an imaginary "ideal cup" derived by yet another group of students using the same semantic differential survey sheet. The adjective pairs of the survey were randomized left to right and top to bottom. Results were rearranged to place the most significant judgments at the top (Figure 18). They were also rearranged to place adjectives most highly correlated with increased information on the right. An ugly-beautiful scale, added to the Corelle cup's survey, shows that most subjects judged it beautiful, which is consistent with the fact that subjects judged its semantic profile to lie quite close to that of the ideal cup.

  The Corelle cup hardly seems in need of more subjective concinnity. It could be tweaked, however, by judiciously changing the mix of information and concinnity enough to bring its semantic profile more in line with that of ideal cup. For example, it would seem heavier, more interesting and more complex with additional contrast. Its profile might be made more baroque, as the example in Figure 6. But this might make it dirtier, which could be counter-productive. A cup should surely seem as clean as possible.

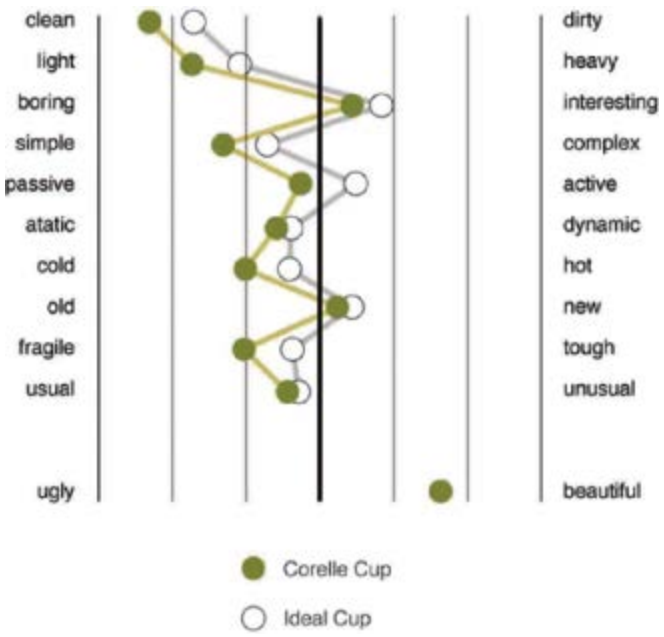


Figure 10. Semantic Differential surveys of Corelle cup and Ideal Cup compared.

Figure 16: Sources of Subjective Concinnity in the novel shape of the handle.

- *Agency*. We never lose a basic regard for what can best be called *agency*, from a Latin word meaning, "to do." The maxim that "form follows function" is as venerable as any other guiding principle of design. A product's form should express what it does—or at least not contradict its purpose. The Corelle cup's novel handle makes sense and thereby contributes subjective concinnity to the overall design in three ways (Figure 16): (1) the handle holds the user's fingers away from the hot body of the cup; (2) the handle mimics the Coanda effect, a physical phenomenon that causes a fluid to hook back onto the container it flows from (as in the case of a dribbling teapot); and (3) because it permits cups to be nested, many more of them can be stored in a given space.

CONCLUSIONS

With just four powerful and readily quantifiable factors to juggle (contrast, novelty, objective concinnity and subjective concinnity), virtually any product design can be optimized with respect to both affective and ergonomic objectives. Because these factors are definable and quantifiable in terms of information theory, they lend themselves to incorporation into computer-aided design (CAD) technology.

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Section 5

Kansei and Emotions in Design

About the Nature of Kansei Information

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ABSTRACT

Kansei studies refer to the more and more holistic consideration of the cognitive and affective processes which occur during user experience. In addition, few studies deal with the experience of the designers during the design process, and its influence on the final design outputs. Historically kansei engineering has been firstly focused on the semantic differential approach. Afterwards emotions were integrated into kansei approaches. The semantic differential approach enabled to evaluate products and then to generate automatically design solutions with semantic input data. Thereafter, evaluations have been completed by physiological measurements in order to reduce the subjectivity involved in those evaluations and also to capture some unconscious reactions. This implementation is still in process. Today kansei studies have been much enriched from the three disciplines of design science, psychology and artificial intelligence. The cross influence between these disciplines brought new dimensions into kansei approaches (multisensory design information, personality, values, and culture, new formalisms and algorithms) which lead progressively towards the consideration of a whole enriched kansei experience. We propose in this paper a description of the nature of kansei information. Then we present some major orientations for kansei evaluation. Finally we propose an overall table gathering information about kansei dimensions and formats.

Keywords: Kansei information, Measure of emotions, Kansei formats

INTRODUCTION

During this last decade, user centred design has been much developed at a worldwide scale. More recently, new methods and tools have been established in the discipline of design science, which put emphasis on the emotional impact of product experience. Related dimensions such as semantics, sensory dimensions or brand values are often associated to emotions in the framework of these methods because they are the most impacting. In the light of this, the fields of emotional design and of emotional engineering are intensively spreading out in the communities of design science, psychology and artificial intelligence.

Nowadays, product design turns to be more considered as experience design. While product design was very much focused on the product, experience design considers the whole experience and the temporal sequence of the human-product interaction in real time. As emotions are considered as a main dimension of this experience, emotion-driven creativity, and at the same time emotional measurements, are more and more used in design methods. Behind usability, the analysis of the emotional reactions helps in the understanding of product experience. Even if the designers are themselves conscious of the importance of the emotional dimension in their work, this dimension is however still not well integrated in standard design methods. Kansei Engineering and Emotional Design, are such approaches which enable to integrate these dimensions.

In this paper, we will first describe the early design process, and the related design information, and then we will present some methods for measuring emotions in early design, with in a second time the description of some methods we elaborated for the designers in a wide sense, including designers, engineers, and ergonomists. Some experiments will be taken as examples, which enabled to validate the relevance of these methods in an industrial context.

THEORETICAL BACKGROUND

Emotional Design

The concept of Emotional Design was initially and principally disseminated worldwide in the community of design science by Donald Norman (Norman, 2004), Green and Jordan (Green & Jordan, 2002), and through the conference Design and emotion (Overbeeke & al, 1999). This research orientation is currently developing currently in several disciplines. It develops the topic of the integration of emotions not only in the field of design science but also in those of psychology, marketing, ergonomics and artificial intelligence. Lately, this current has been consolidated through establishing the Designing Pleasurable Products and Interaction two year conference (DPPI). Related research focus broadly on the theme of emotional evaluation in design and design science, in order to constitute input data for the generation of new design solutions. On the base of the semantic differential, many studies have been led in Europe (Osgood, 1969, Smets & al, 1995, Overbeeke & al, 1999, 2000, Van Dijk, 2004, Battarbee & al, 2002, Schütte, 2002, Desmet, 1999, 2000). These studies implement semantic analysis in order to measure the semantics of design stimuli by using the meaning of words. The semantic differential is a method which proved to be very useful in the field of design. This method involves Lickert scales which enable to position perception stimuli between two opposite or antonym adjectives. Nowadays, semantic and emotional evaluations tend to integrate explicitely the cognitive and physiological analysis of emotions in addition to des semantic analysis.

Kansei Engineering

The technology of kansei Engineering is born at the University of Hiroshima in the seventies. They were initially developed in an experimental way by Mitsuo Nagamachi (Nagamashi, 2002, Schütte, 2002, Bouchard, 2005), after which they have been disseminated and applied in industry. Kansei engineering is used in order to determine which emotions are elicited by particular subjective responses by the products' end users. This methodology enables to develop some products by means of attributes which will provoke the expected emotions. Evaluation results are then integrated in the kansei engineering process in a pro-active way. As many approaches have already been formalised according to the semantic analysis in the framework of Kansei Engineering systems, (Jindo, 1995, Ishihara, 1997, Tanoue, 1997, Yang, 1999, Hsu, 200, Chuang, 2001, Suh, 2001) some authors ont par la suite suggéré de compléter ces mesures cognitives par des mesures physiologiques et comportementales des émotions (Lee, Harada, Yamanaka). Kansei engineering follows three main steps: data gathering, rules elaboration and rules implementation. Data gathering establishes first the main groups of data which are necessary for the system to work. Those can be keywords including semantic descriptors, product descriptors or representations. The elaboration of rules will be then achieved by applying semantic or emotional measurements, mainly through Lickert scales. The statistical data processing enables then to go towards some algorithms which make it possible to automate partially these rules. Kansei engineering has been disseminated lately through the conference Kansei Engineering and Emotion Research (KEER) which has been enlarged since 2010 out of Asia in Europe.

Kansei Information

Design information is very specific in the way that its integration and transformation involves affective processes. Kansei is a complex informational process carried out by a designer or a consumer who perceives a design stimulus. Kansei is a Japanese word which covers multi-dimensional meanings such as feeling, emotion, semantics, affectivity, feelings (Nagamashi, 2002). It can be seen as a function which processes information which is by nature analogical and fuzzy, Kansei also refers to the nature of the relations that the designers are used to establish between various levels of abstraction of information. It involves both cognitive and affective processes which are already involved when designers integrate information. Its content can be classified into information called high-level information, middle-level information and low-level information, according to a terminology on loan from artificial

intelligence which defines the levels of abstraction of the information (Black, 2003). We retained this definition which is relevant in our case because it reveals well the skills of the designers and it covers the whole information levels the designers deal with. Indeed the levels here go from very abstract values such as purity to concrete attributes such as the white color. Low-level information encompasses characteristics of shape, color and texture. Middle-level information includes concepts and artifact names. High-level information is translated at the same time by semantic descriptors, sociological values and affective and emotional dimensions, which leads us to the definition of kansei. This emotional dimension is a major one in those which are perceived and processed by the designers. They cover 46% of the whole information integrated and processed by the designers, the other dimensions being style, technology, user and aesthetics. We emphasized the variety of types of information which are behind the term of kansei. This information is non-homogeneous and this is a difficulty when trying to formalize the process. Kansei refers as well as the content of information as the expert relations that can be built by the designers between these various corpus of data involved into the design process. Designers' skills mainly lie in mastering the whole set of data categories working, and above all in the ability to link them together in an intuitive way. The core expertise of designers comes from their ability to link high-level information with low-level attributes and vice-versa. In particular, a main part of the expert rules involved of association, categorization, or generation carried-out y the designers, consists in linking low-level information with low-level information and to use various levels of abstraction at the same time. Kansei rules are brought into play in a quasi-continuous way in order to mentally or explicitly categorize design information. They are subtly crossed with other rules applying to the contribution of harmonies intra- or inter-levels which provoke positive emotional reactions. They are conjointly supported by analogical reasoning which will also contribute to provoke some feelings in the presence of more or less evident metaphors.

Kansei information refers to a complex system between human and artifact. Kansei information calls for heterogeneous forms of data. Indeed, if we step back from the methods and concentrate on the nature of information, we can recognize this information may encompass various dimensions under a variety of formats. Qualitative data are naturally involved in the design process by the designers from generative tasks. Quantitative data are mainly involved in design research or sometimes in design contexts in the evaluative part of design. In the context of early design, the kansei information system may include a set of dimensions such as color, shape, texture, sound, smell, which can be expressed or conveyed in the generative phase of design through different formats such as sample pallets, multi-sensory compositions, keyword's sets, mood boards, sketches and prototypes. In addition, kansei information may be conveyed in the evaluation phase through quantitative data, coming from physiological measures or from differential scales with keywords or labels used in order to grasp the user state in front when experiencing specific static or dynamic design stimuli. To summarize, the main formats through which kansei data are potentially expressed are threefold (see table 3):

- Qualitative data (categories of words from various categories: brand or human values, semantics, sensory characteristics, emotions, styles, design elements, product sectors, multisensory design elements such as shape, color, texture, sounds, smells, and behavior).

- Quantitative data from differential scales associated to keywords (emotions, semantics, sensory, values, familiarity, numbers or icons, or from design elements digitization and description (global and local descriptors of shape and color),

- Quantitative data used in direct quantitative user measures (galvanic skin response, brainwaves…).

MEASURING EMOTIONS IN EARLY DESIGN

The measure of emotions in design provides a way of interpreting the effect of style, of sensory dimensions, and of semantics. More subtle dimensions such as the adequacy of a style or semantics or sensory properties to human values can also be extracted from emotional measures. On the Japanese side emotional measurements, which were initially based on questionnaires and the semantic differential of Osgood, tended progressively to integrate physiological measurements in order to bring more objectivity and real time information for the interpretation of the emotional measurements. This trend is now developing in Europe where, historically, the measure of emotions in design started also on the base of the semantic differential. In our research group, we progressively developed some methods and tools which enable some physiological measurements through an integrated platform. Today we are

still implementing this platform and developing methods including physiological and behavioral measurements. Both physiological and behavioral measures will still be massively incorporated in the future in the field of design science. It is only through a cross approach between cognitive, physiological and behavioral measurements that we can extract robust and relevant information. In the context of design, we experienced most of the time secondary emotions instead of primary emotions which are very intensive ones and do not necessarily occur in experiencing design, both as designer or as user.

Cognitive Measure of Emotions

The cognitive measure of emotions relies on carrying out and using questionnaires. The cognitive measure based on the semantic differential was largely used in design and emotional engineering. Lately, it has been proved to be relevant to add the sensory and emotional dimensions, while using the same Lickert scales. The only difference is, it is more appropriate to use mono-dimensional scales in the case of the emotional dimension, and antonyms for the sensory and semantic ones. This way, design representations can be assessed by using scales for evaluating some design elements with keywords, or/and fix or dynamic icons representing emotions. The keywords used are coming from more or less relevant and complete lists of emotion words which must be systematically reduced depending on the specific context of the experience. Some icons representing emotions can also be used but they turn to be more or less valid, depending on the way they are represented ans also on the cultural differences of the assessers. A good compromise is the use of the list of Geneva University (Sherer, 1986) which includes about 100 emotions words translated in 5 languages. We used this list initially in the framework of the elaboration of an evaluation tool for early design. To get precise results, these emotion words must be completed by the Lang scales. The SAM (Self Assessment Manikin), created by Lang (Lang, 1993, 1997) is an illustrated questionnaire to measure intensity, valence, and dominance. The intensity corresponds to the amplitude of the emotional response. The valence is more related to a positive or negative polarity. The dominance for its part concerns the persistence in the time of the emotional reaction. Lang scales have been validated for a long time ago in the field of psychology, mainly first in medical contexts. A combination of emotion words and Lang's icons gives efficient results. Those are then analyzed through statistical approaches. We validated this method in various contexts and through several different industrial case studies.

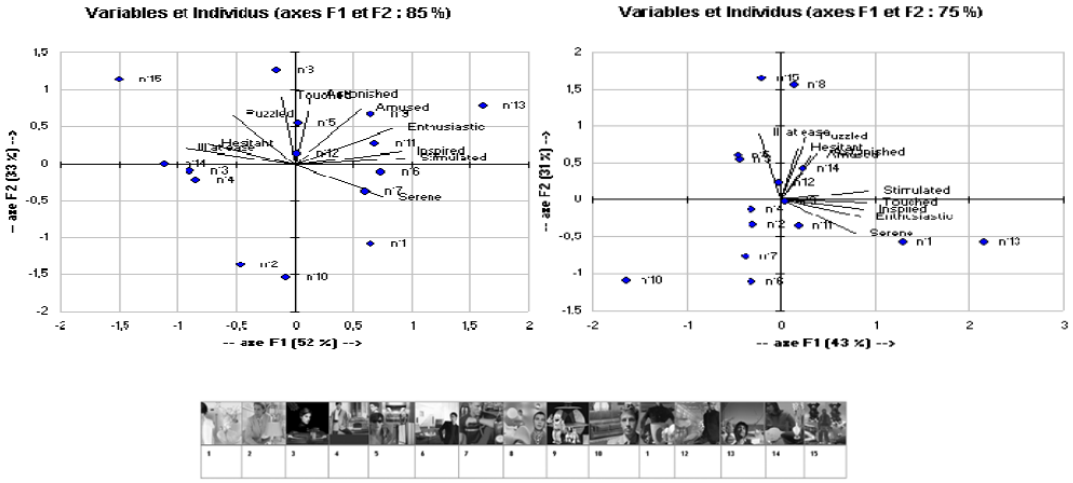

Figure 1. Semantic and emotional evaluation of moodboards (Bouchard & al, 2009)

We obtained efficient results so that this method can be considered as generic (Mantelet, 2006, Bouchard & al, 2009) (see figure 1). Some recent studies introduced in addition the notion of familiarity through which an artefact might be characterized (Sanabria & al, 2012). Indeed, in particular cases such as for the emotion of surprise, the emotional dimension alone does not necessarily provide enough information for further interpretation and exploitation. Even if the cognitive approach is simple, quick and ecological enough in terms of resources and means, some questions have been raised. The limit of the cognitive evaluation of emotions comes from the subjectivity which occurs during the evaluation and the interpretation of the assessor. Moreover, this measurement is not continuous and does not provide a real time feedback. Furthermore the use of emotional scales with a long list of

emotion words can cause a certain fatigue by the respondents. Besides, some of them have difficulty for expressing their feelings because they are not always conscious of those (Poels, Dewitte, 2006). In order to overcome the limits linked to the cognitive measure of emotional reactions, some recent studies were initiated in the field of Kansei Engineering in order to complete these measures with other physiological ones such as electromyography (EMG), skin conductance (GSR), heart frequency, electroencephalography (EEG), etc, as explained in the following paragraph.

Physiological Measure of Emotions

The measure of emotions can also be done by using devices which enable to record physiological changes by the human beings and provide quantitative feed-back information. Most of these devices were initially used in the medical field. Now they tend to be progressively transferred into the field of design science. This democratization is accompanied by less intrusive devices and the increasing introduction of low cost materials. The advantage of physiological measurements is that, oppositely to the case of cognitive measurements, recording is done in real time and quantitative objective data can be extracted automatically. This enables to get very emerging information about cognitive and affective processes in design. Indeed the measures based on physiological devices and which are manipulated carefully enable a deeper understanding of unconscious emotional processes (Tran & al., 2003, Kim 2011). Consequently, we suggest that physiological measurements are essential to detect emotional reactions of design stimuli and to identify a correlation between cognitive measures and physiological ones. Criteria to determine physiological detectors may be the non-obstruction, the ability to interpret signals and above all a big reliability. As it is difficult to catch objectively an emotional state which involves secondary emotions, we use most of the time these devices in combination with the questionnaires which have been described in the previous paragraph. In order to do this, it is necessary to record the time for the automatic entry and filling-up of the questionnaire, in order to be able to apply some correlations between physiological data and those of the questionnaire. Even if it is possible to get robust cross results, there still exist some drawbacks by using these technologies. Indeed physiological measures can be intrusive, uncomfortable, obstructive and heavy with the risk to reduce the mobility, so to interfere against the natural activity process of the test takers and finally to influence results (Gaglbauer & al. 2009; Tran & al, 2007). Some potential drawbacks are also the costs for some of these devices and the lack of portability and of consistency due to the environment variations. Comfort and natural activity are potentially altered, and sweating problems can occur. Because all of these reasons, the results of any evaluation must be taken carefully in order to avoid the eventuality of biased interpretation. There is a wide range of ways of measuring the physiological changes in relation with emotions. We can notice some every devices focused on skin conductance, temperature (of skin, of body), electric activity of hearth (ECG), brain activity (EEG), muscles moves (EMG), blood pressure, heart rate and finally the magnetic resonance (FMRI).

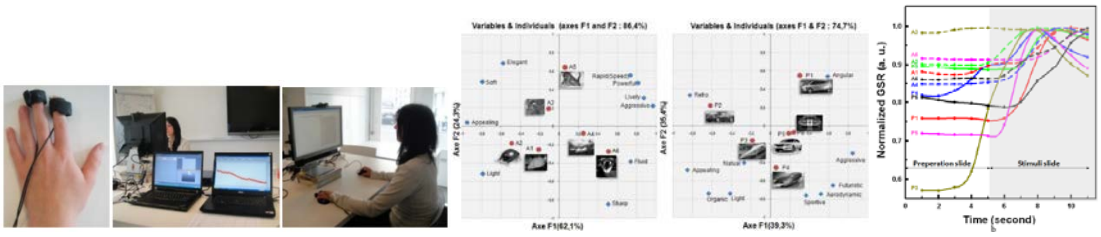

Figure 2: Physiological measuring system instruments and results ACP + GSR (Kim & al, 2010)

According to our experience, one of the most appropriate physiological measurements in design is the analysis of the electro-dermal activity (GSR) (see figures 2 and 3). We experimented this kind of measures in various contexts, such as evaluating the experience of visualizing inspirational images, evaluation of the early design activity of the designers when visualizing traditional or immersive mood-boards (Rieuf, 2013), or when producing traditional (Kim, 2011) or immersive sketches (Rieuf, 2013), evaluating the experience of users when manipulating a software with gesture controls (Blanchy, 2013). In all of these contexts, we noticed some congruence with the results coming from the questionnaires. This indicates that GSR is a good means to evaluate the experience in all of these contexts. To complete this, it is likely that an optimal measure of emotions should also integrate behavioral measures such as the tracking of eyes movement, gaze, body movement, postures, gesture, and facial expressions, as explained in the

next part.

Behavioral Measure of Emotions

The measure of emotions can finally be done by using observation, recording and indexing behavioral changes. These measurements can be achieved by audio-video recording and information coding, or by the direct tracking of movement, posture, gesture with a more or less automatic information processing. The main types of behavioral markers are facial expressions, postures, pupil size, gaze direction and saccades. Prosody and verbal expression can also be considered in this part. Broadly, depending on the context, it is necessary to explore which type of markers will be the most appropriate. For instance, eyes movements and face expression can be combined with physiological measurements. This way, it is possible to depict precisely which visual stimulus will provoke which emotional effect. Facial expressions are involved when eliciting intensive emotion. We did observations during the early design activity of designers and more precisely during the creative phase of sketching. This phase is by essence hedonic and emotional. Facial expressions were not clearly a marker of the emotional activity in this context where the emotions, even if they exist, are not intense enough to get a clear effect on face expression. However, we stated the usefulness of onomatopoeia to complete the interpretation of video information in this specific context. In another study, we observed the relation between emotions and postures when using gesture commanded interfaces. The tracking of eye movements, when analyzing results such as the number and the length of fixations, the size of pupils, the frequency and the length of eyes blinking, is very rich, providing at the same time physiological and behavioral information. But as in the case of facial expressions, the intensity of emotions must be high in order to be able to apply the pupil size measure and to extract relevant results. For instance, we did some experiments with people visualizing and/or touching some textural 3D information, and we did not notice any exploitable result in terms of emotions felt. Brainwaves have already been applied with satisfying results in the context of people visualizing art paintings in museums. High frequency brainwaves tactile experience increases neural reactions.

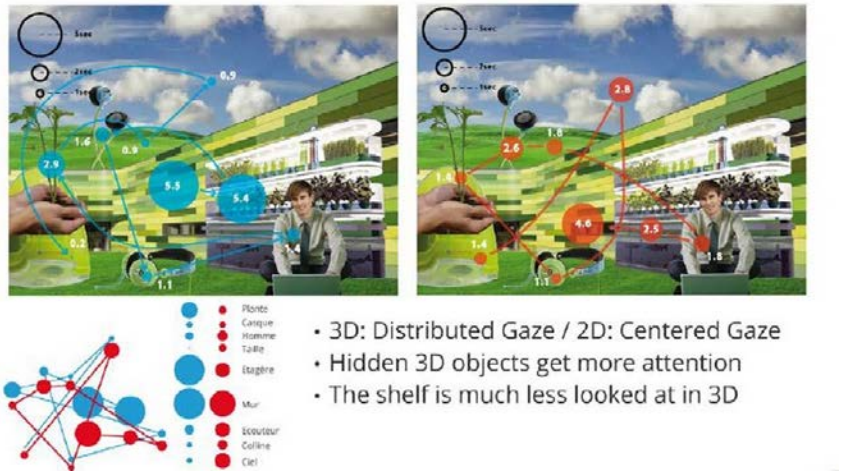

Figure 3: Distributed gaze in front of immersive moodboards (Rieuf, 2013)

KANSEI DIMENSIONS AND FORMATS

Kansei vocabulary provides valuable formats because it makes possible to communicate every kansei dimensions, which are very heterogeneous when considering the various formats they are composed of. Moreover, kansei vocabulary it is such a language which is daily used by the designers. It is also well adapted to the early design phases, the generative and the evaluative ones. But even if kansei vocabulary is a format which helps to precise every dimensions of kansei, the limits of this format lie in the subjectivity they involve, and also the dependency to the context, and the necessary consciousness of the users to express it. Kansei formalisms, on the other side, must involve formats that are possible to implement with algorithms. Consequently, two formalisms which enable to

formalize kansei design information into a lexical format are explored: ontologies and bag-of-words. Finally we propose a format which may be implemented by a hybrid technology.

Kansei information	*Dimensions*	*Formats*
Qualitative data related to product design	Color	*Keywords* *Sample Pallets* *Multi-sensory compositions* *Mood boards* *Sketches* *Prototypes*
	Shape	
	Texture	
	Sound	
	Smell	
Discrete quantitative measures related to user cognitive appreciation through product perception	Emotions	*Keywords* *Icons* *Numerical values from Lickert scales*
	Semantics	
	Sensory	
	Values	
	Familiarity	
	Shape descriptors	*Numerical values from region, contour, 3D descriptors*
	Color descriptors	*Numerical values from dominant color, color histograms*
	Texture descriptors	*Numerical values from edge histograms, Fourier descriptors*
Continuous quantitative measures related to user emotional response	Galvanic skin conductance	*Numerical values from electro-dermal activity*
	Brainwaves	*Numerical values from cerebral activity frequency*
	Posture	*Numerical values from momentum*
	Gesture	
	Facial expression	
Relations	Inter-dimensions rules	*PCA, FA, ANOVA, MDS* *Algorithms (GA, NN, FS, RS, …)*

Table 1: Kansei dimensions and formats

In this table we gathered all information related to kansei possibly found in early design. This goes from the design dimensions under the shape of keywords, pallets, moodboards, multi-sensory compositions, sketches and prototypes, which are linked to abstract dimensions such as semantics, values. This abstract information may be used in the generative phase not necessarily into visible formats, and they also are used for cognitive measurements. Finally, some other dimensions such as physiological changes observed by human beings may be measured through digital devices.

CONCLUSIONS

Kansei information is naturally involved into design process. It may take various forms depending on the different phases of design activity. Recently there is a high interest in all of these dimensions become the have become crucial for innovation and differentiation. These dimensions can be used in a reciprocal way, for generation and for evaluation. Even if they are still used by the researchers mire in evaluation methods, they tend now to be explicitly used by the designers in a more formalized way. Both approaches are important for design optimization.

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Emotional Engineering and PLM

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ABSTRACT

Quickly increasing diversification and frequent and extensive changes in our environments and situations call for new frameworks for Product Lifecycle Management (PLM) and Mass Customization and Personalization (MCP) and their effective integration.\This paper points out that if we introduce modular design and manufacturing and if we divide modules into functional ones and emotionally appealing ones, we can reduce time, cost and energy considerably, because we can substantially minimize modular diversifications and at the same time can increase emotional satisfaction of our customers.

Keywords: Emotional Engineering, PLM, Modular Design and Manufacturing, Emotional Modules

INTRODUCTION

This paper points out that if we divide products into functional modules and emotionally appealing modules, we can reduce time, cost and energy considerably and at the same time, we can increase the emotional satisfaction of our customers. And we can integrate PLM (Product Lifecycle Management) and MCP (Mass Customization and Personalization) and can accommodate the preference and the needs of our customers in a much better way.

PLM (PRODUCT LIFECYCLE MANAGEMENT)

PLM (Product Lifecycle Management) (PLM-Conference.Org, 2014 and Product_lifecycle_management, Wikipedia, 2014) is well known today, although it is not yet clearly defined. But to the author's knowledge, all arguments relating to PLM are focused on product functions. And there are very few, if ever, which discuss PLM in connection with emotional satisfaction. This is because the current framework of PLM is developed mainly from the standpoint of the producer.

But if we consider that diversification comes from the diversifying requirements from the customer to customize and personalize their products, we should focus more on the customer. Indeed, why PLM is getting more and more attention these days is because the product lifecycles are getting shorter and shorter with diversification. The producer is developing products in increasingly wider variations to respond to the diversification of customers' requirements. But the increasing number of variations does not truly satisfy our customers, because it is very difficult for producers to develop products which are very much unique and are different from the current ones. So although the product variations are increasing, their differences are getting smaller and smaller and customers feel more disappointed than satisfied because what they would like to have is a very much new and unique product. This is very much natural because for the producer, it is very difficult to develop a completely different product from their current products because they have to re-innovate their design and production and they need sometimes larger or completely new resources (human, money, time, etc) .

MASS CUSTOMIZATION AND PERSONALIZATION (MCP)

Mass customization and personalization (MCP) (Pillar and Tseng, 2009) is one of the solutions to this issue. It is proposed because if producers attempt to develop products in smaller numbers to increase variability, the cost, time and energy for production will become exceeding large and in fact they cannot introduce such a system. So its main idea is to produce products in mass but still maintains variability. This idea is very good and many proposals are made to realize it. But they do not discuss the problem in connection with PLM and most of them focus their attention to daily goods and not to industrial products.

MCP OF INDUSTRIAL PRODUCTS - LEARNING FROM TRUCK INDUSTRY

On the other hand, PLM researchers are focusing their primary attention on industrial products. It is dubious, however, if current discussion of MCP can be applied in a straightforward manner to such industrial products. But if we recall how trucks have been designed and produced in order to respond to the diverse requirements of their customers, we can mass customize and personalize our industrial products much easier. In fact, this practice has been developed in truck industry far earlier than the time the concept of MCP was proposed.

As trucks are used for a very wide variety of purposes, they divided design and manufacturing of a truck into a chassis and a body. As a chassis does not change appreciably from truck to truck, they introduced a common chassis. But what cargo body a user needs differs extensively from user to user. So they introduced another group who specialized in design and manufacturing of cargo bodies. See Figure 1.

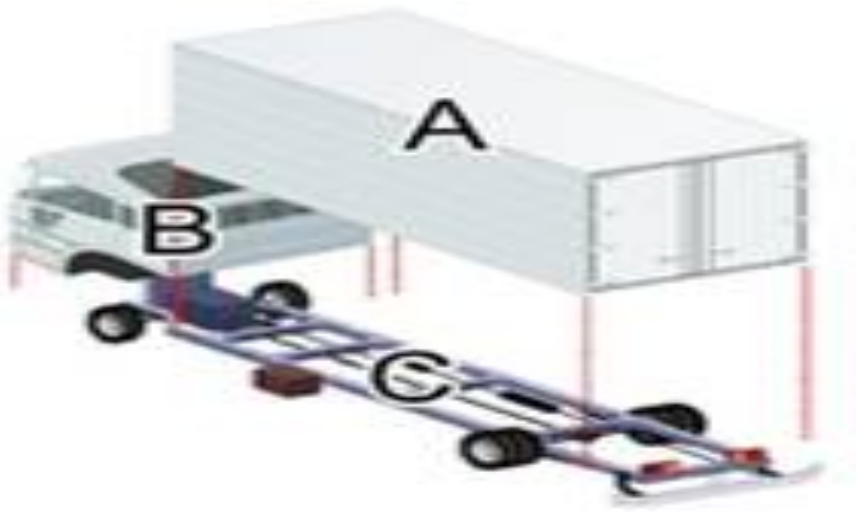

Figure 1. Truck Design

Thus truck companies were divided into two groups; one specializing in chassis and the other in cargo bodies, brought a great reduction of energy, time, cost and human resources. The chassis companies can produce their products truly in mass. Cargo body companies cannot produce their products in such mass, but they still can produce their products with great efficiency by clustering the users needs, because although cargo bodies are very much diversified, there are not small number of customers who need the same or similar bodies. Thus, they can secure their profits if they can classify them properly. The design and production for chassis and cargo bodies are very different, but if we can modularize a whole truck into such fit-for-mass production modules and fit-for-customization modules, then we can resolve the challenging conflict between mass production and customization.

MCP IN AUTOMOTIVE INDUSTRY - PASSENGER CARS

The same idea is being introduced today in other areas of automotive industry as well. Passenger cars are now introducing the same idea. They are now sharing common platforms across different models of passenger cars to reduce cost, time and energy. Their focus is still limited on the chassis and they do not discuss much about the other parts. Trucks are easier than passenger cars because they are used for industry applications so truck cargo body makers can have a clear idea about what groups need what type of cargo bodies. Thus they can discriminate a whole truck into proper modules easily. But in the case of passenger cars, such division or categorization is not straightforward. Each customer has his o her preference and the operating conditions differ from driver to driver or from user to user. Thus the degree of variability or diversification is much far greater in passenger cars than in trucks.

BIG DATA

Big Data is getting wide attention these days. What Big Data brought us is a paradigm shift. Change of views from producer-centric to customer-centric.

Open Loop System

The traditional producer-centric view is one way from the producer to the customer. This system was an open loop system as shown in Figure 2.

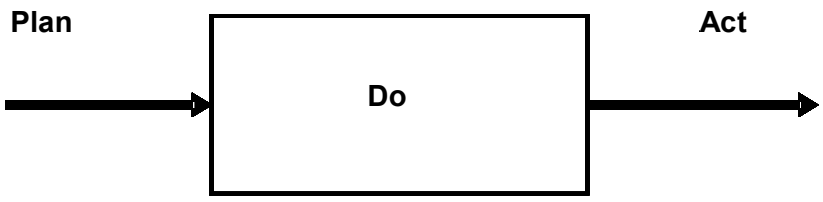

Figure 2. Open Loop System

Closed Loop System with Feedback

But the remarkable progress of Information Technology has made it possible to process enormous amount of user data. Thus the system now emerging is a closed loop system with feedback loop from the customer as shown in Figure 3.

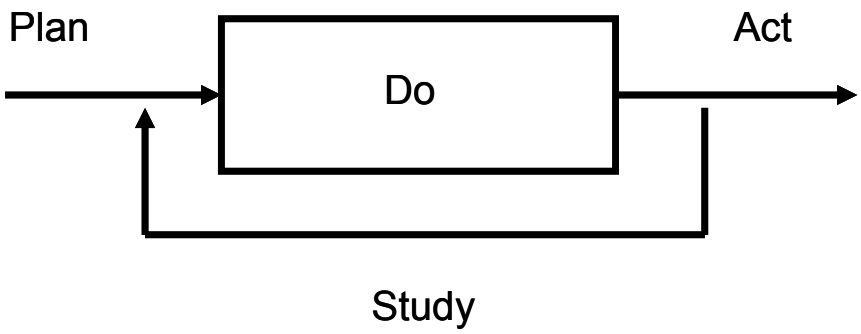

Figure 3. Closed Loop System with Feedback

But no matter how much progress IT has made, it is a great waste of time, energy and cost to observe how each customer is using their products and to extract their preferences or their needs for feeding back their information for updating design and production. Thus, in the case of automotive industry, especially in the case of passenger cars, further modularization beyond functional requirements still remains an open problem.

WHAT WEDDING DRESS MAKERS TEACH US

This is why most MCP research works discuss only daily goods and do not discuss much about industry applications. But interestingly enough, wedding dress design provides a hint to solve this issue.

Every lady would like to wear a wedding dress just for her alone. But not every lady can afford to order a wedding dress. So most of them rent one. But wedding dress companies which produce rental dresses cannot afford to develop and produce one-of-a-kind dresses.

To solve this problem, they observed where ladies pay their attention to during shows, etc using such technologies as eye cameras, etc. They found out that there are feature parts which attract their attentions and if these feature parts are well taken care of and differ from dress to dress, ladies think that it is unique. Thus, if these feature parts appeal emotionally to them, they think that the dress is just made for her, although the other majority parts are same. Such feature based design and modularization brings emotionally satisfaction to ladies.

This is another example of modularization which separates characterizing modules from common modules. The example described here is a wedding dress, but many designers told me that other clothing designs as a whole have developed along the same line. Therefore, if we separate the emotionally appealing modules from modules that are not relevant to emotion, we could develop a truly MCP design and development for passenger cars. This idea is not restricted to automotive industries, but we can extend it across many different products and across many different industries.

MCP AND PLM

Coming back to PLM, we not only can divide products into common functional modules and emotionally appealing ones, but we can further divide functional modules into several groups. those which can be used for much longer time and those which need shorter term replacements. Emotionally appealing modules can be used interchangeably from product to product and can be designed for shorter lifecycles because the cost, time and energy are in most cases far less than the functional modules.

Such division and combination of long life and short life modules is very important to respond not only to increasing diversification but also to adapt to the quick and extensive changes which often take place in these days. The current PLM certainly discusses how we can combine long life and short life modules, but their focus is limited to functions. We have to remember what brought forth diversification.

EMOTIONAL DESIGN STRUCTURE MATRIX

Then, we can apply a design structure matrix (Eppinger and Browning, 2012) for such a modular emotional design and manufacturing. We can develop an emotional design structure matrix by placing emotional features in a row and component life in a column as shown in Figure 4. This allows us to combine them in an optimum way to respond to the needs and preferences of customers. Such a MCP oriented design structure matrix will reduce a great reduction of energy, time and cost, and we can minimize human resources. But it also should be stressed that it will provide a great amount of emotional satisfaction to customers.

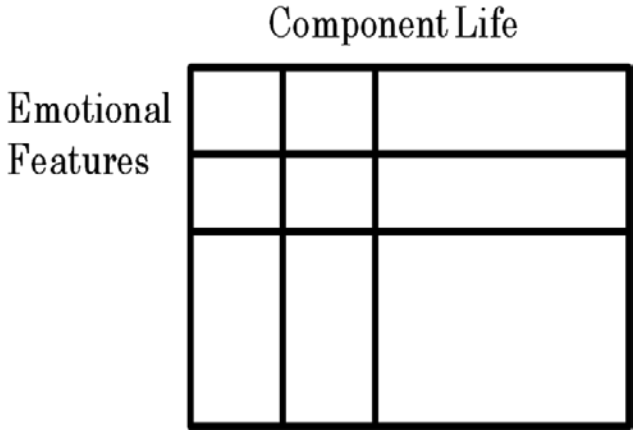

Figure 4. Emotional Design Structure Matrix

SUMMARY

Modular design and production is getting wide attention these days as a very effective approach to reduce time, cost and energy and to cope with the increasing diversification. But most of them are carried out on the basis of functions. Products are divided into modules based on functional or manufacturing such as assembly requirements. Thus the

current modularization is being carried out primarily from the standpoint of the producer.

But if we look back why products are getting more and more diversified, we immediately realize that the needs and preferences of our customers are quickly diversifying and in addition they change very frequently and extensively. Therefore, if we can modularize our products based upon the needs and preferences of our customers, we will be able to develop a better and more effective modularization and we can reduce time, cost and energy. The needs are primarily associated with functions so the current modularization based on functions will be effective. But the problem of responding to the preferences of our customers is not well answered yet.

If we divide products into functional modules and emotionally appealing modules, we can solve this problem. And further we can adapt to the frequent and extensive changes of our customers' preferences because we only have to replace the modules with other ones that best respond to the preferences of our customers when needed.

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Experience-Driven New Concept Development Projects: Differences in Context, Design Activities, and Design Information Conveyed

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ABSTRACT

In this paper, twenty-seven experience-centred industrial design projects were analysed. Information was gathered from interviews with former project team members and from an analysis of the projects' final reports. All of the projects involved at least the Toyota Motor Europe – Kansei Design (TME-KD) division. Three types of projects were identified: "exploratory concept," "product lining strategy," and "pre-development direction." For each project groups, the analysis detailed specificities in terms of context (purpose, design team members), design activities (information, generation, evaluation & decision, communication), and regarding the nature of their outputs and the type of design information they conveyed. This led to a comparison of the different types of projects and a discussion about the kansei-related design information exchange in early design stages. A model of kansei-related design information based on these discussions is finally presented.

Keywords: Kansei Design, Design Information, Early Design Stage, Industrial Context

INTRODUCTION

In the consumer goods industry, design teams include members with diverse profiles, such as marketing product planners, engineers, and styling designers. Initially, the design team usually identifies problems and defines challenges in a document often designated as the "brief." Before any concrete aspects (e.g., shape, technology specification) of the product to be designed are fixed, other representations appear in the process. These representations (e.g., mood-boards, target customer description, technology demonstrators, etc.) convey intentions and possible directions. They can be seen as communication tools to increase mutual understanding of the concept and facilitate discussions about specific topics between the diversely skilled members of a design team.
These representations all touch on aspects of user experience, but they never communicate any clear intention related to it. Nevertheless, user experience is at the boundary between the three main functions involved in design teams (marketing, engineering, styling) as it relies on an affective link between a user (i.e., market) and the environment (including the product, the interaction, the context). Users' experience with products recently became a major differentiation factor between competitors and can greatly influence the success of a product. Karapanos and Martens (2009) stated that decisions made at the conceptual design stage have the highest impact on the final user experience (UX) and eventually on UX failures. From this statement, we postulate that taking experience into

account and discussing it early in the design process increases the chances that the final product will have a positive impact on the qualities perceived by its users.
In this paper, different uses of kansei representations in the industrial process will be investigated. In order to do so, 27 early-design projects leading to the creation of kansei representations were analysed. These projects, which took place between 2008 and 2013 and were coordinated by the TME-KD division, can be characterised as experience design-driven NCD projects.

LITERATURE REVIEW

The first section of the literature review will create a link between the complementary notions of user experience and kansei process. The second section will detail the early phase of the industrial design process. The third section will discuss design activities and the final section will investigate the literature related to the design information exchanged within a design team during this phase.

User experience and the kansei process

Ortíz Nicólas and Aurisicchio (2011) analysed 11 user experience frameworks from the literature in an attempt to bring together in a consistent overview the rapidly growing and disjointed literature on the subject. The conclusion of this research suggested that even if the perspectives and focus points of the 11 researchers were different, common constituent elements (user, interaction, artefact, context) and aggregates (subjective, conscious, emotional, interconnected, dynamic) of user experience were acknowledged by the majority of the perspectives reviewed.

The situation described with the term *user experience* can be understood in relation to the definition of the *kansei process*. Lévy, Lee, and Yamanaka (2007) described the latter as the function of the brain related to "emotions, sensitivity, feelings, experience and intuition, including interactions between them" (p. 9). It is further described as originating in one's sensory perception and personal characteristics (*kansei means*) and providing as output a qualitative meaning and value of the environment (*kansei result*). Notably, Lévy et al. indicated that the flow between kansei *means*, *process*, and *results* is not strictly linear and that these different aspects influence each other.

Figure 1 represents a framework that combines the notions of user experience and kansei process. It represents the main entities of an experience during the interaction between a user and a product. The *personal characteristics* and *attributes of the environment (product, interaction, context)* cover what has been previously defined as *kansei means*, whereas the *perceived kansei qualities* are direct consequences of *kansei results*. Notably, the framework also retains the four constituent elements of an experience identified by Ortíz Nicólas and Aurisicchio (2011). More details about the creation of this framework can be found in another publication (Gentner, 2014).

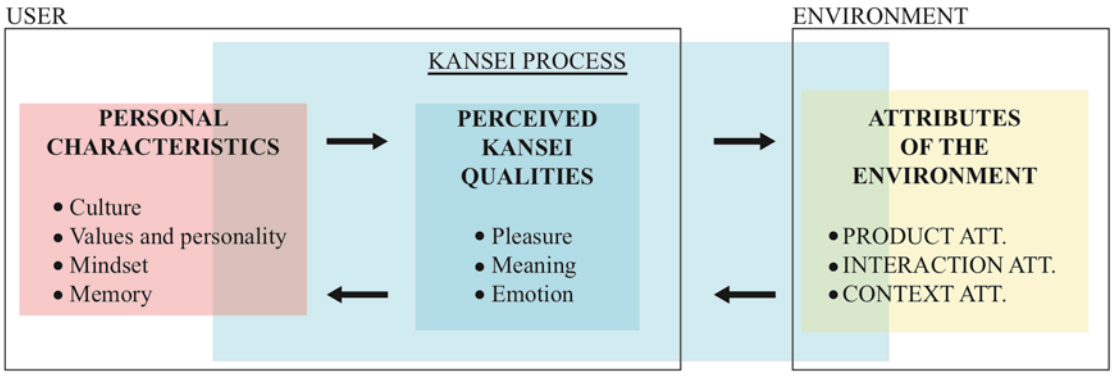

Figure 1. Kansei-Experience framework

The new concept development phase of the industrial design process

Scholars usually divide the industrial design process into two major phases: the new concept development (NCD) phase and the following new product development (NPD) phase (Buijs, 2012). The NPD phase then leads to the commercialisation of the new product. Gero (2010) described an *innovation* as the introduction or uptake of

intellectual property (created during the NCD phase) into NPD projects (during which the consumable artefacts are designed). This means that both phases (NCD and NPD) are necessary for the innovation process. This definition of innovation also corresponds to that of Van de Ven (1986): "new ideas that have been developed and implemented" (p. 590). Depending on the changes they involve, innovations can be range from incremental innovation to radical innovation. Their nature also impacts the typology of products to which they are related (Wheelwright & Clark, 1992). In that sense, the nature of the intellectual property created determines the product development strategy that will be adopted by the project managers (Verworn & Herstatt, 1999).

Wheelwright and Clark (1992) distinguished between three main types of new products: *breakthrough products*, *platform products*, and *incremental products*. These project-types characterise products based on the extent of product and process change induced by their development.

- *Breakthrough products* involve the most product and process changes. In the automotive industry, the introduction of the first hybrid vehicle in the 1990s and electrical vehicle in the 2000s are good examples of *breakthrough products* (in these cases, the breakthrough innovation came from the engine).
- At the other extreme, *incremental product* developments involve only few process and product changes. In the automotive industry, such developments correspond to small vehicle updates that occur usually three years after the launch of a new vehicle. They involve minor styling and performance changes (but not deep architecture changes).
- In between these two extreme types are *platform product* developments. These developments establish a basic architecture for a next generation of product or process and are substantially larger in scope than *incremental products* (Meyer & Lehnerd, 1997). The introduction of a new vehicle and the addition of new body styles (e.g., coupe, convertible, station wagon) are the result of *platform product* developments.

Verganti (2009) described three types of context for innovations: market pull, technology push, and design driven innovations. Market pull innovations correspond mostly to *incremental products* and are based on needs expressed by customers. Criticisms from scholars regarding this type of innovation are that customers (the market) have a short-term view and that their requirements are neither fully explicit nor stable (Norman, 2010). This is why market pull innovations alone cannot induce the changes and intellectual property necessary for the development of new *platform products* and *breakthrough products*. In recent years, new *platform* as well as *breakthrough products* (and services) providing new and well-achieved experiences gained in importance (e.g., Nintendo Wii, Apple music and app ecosystems) (Verganti, 2009). When dealing with NCD activities, organisations are shifting from a technology-only focus (the two examples given previously do not necessarily have the most advanced technical specifications) to a combination of technology- and design-driven approaches. The latter approach enables organisations to better deal with user experience and concepts that radically influence the meaning of the product. Scholars indeed highlighted both the nonsense of NCD processes focused only on users and their needs, and the importance of considering the UX at the conceptual stage (Norman, 2010; Karapanos & Martens, 2009).

Design activities

The basic model of design activity often used in the contemporary literature transcribes (Bouchard & Aoussat, 2003; Cross, 2008). It is represented in Figure 2. It is composed of four symbiotic design activities: *information*, *generation*, *evaluation and decision*, and *communication*. Notably it is also referred to as the *design informational cycle* as it describes the way design team members process design information (collect, transform and generate, communicate).

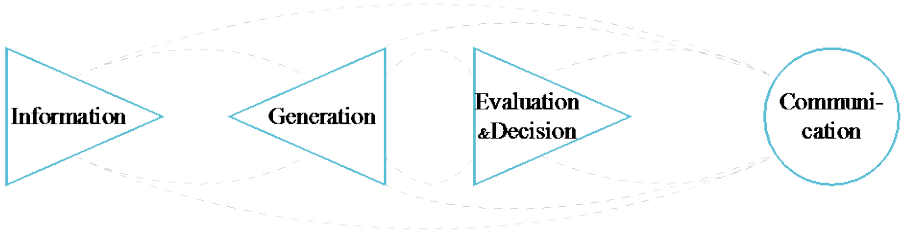

Figure 2. Design activities (adapted from Bouchard and Aoussat [2003], and Cross [2008])

Experience-centred tools and methodologies have been created to support the different design activities (Abras et al., 2004). They have as common characteristics the fact that they contribute to improving the user experience (through

information, *generation*, or *evaluation and decision* activities). They differ in the different ways described below.
One of these characteristics is the way they treat potential future users. Depending on the tool or methodology, he/she can either be treated as a subject (observed and questioned) or as a partner (participatory design). When treated as a subject, "users" are either directly (e.g., interviews) or indirectly (e.g., field observations, desk research) involved in the design activities (Sanders & Stappers, 2008).
The tools and methodologies can be based on scientific (based on quantitative data analysis, based on induction and deduction) or abductive reasoning (based on qualitative data, able to deal with ambiguity, one of the characteristics of "design thinking" [Tomiyama et al., 2003]). Some of them also combine both and can be referred to as originating from integrative thinking approaches (Martin, 2009).
A wide variety of tools exist. Some authors have published reviews and classifications (e.g. Byttebier & Vullings, 2009). When used in the early stage of the design process, these tools lead to the creation of early representations. These representations can either be visual (persona, mood boards, visual theme board [Baxter, 1995]), multi-sensory (MSD approach [Schifferstein & Desmet, 2008], Mood boxes [Gentner et al., 2013]), narrative (Sanders, 2006), or interaction (Koskinen & Lee, 2009).

Design information

Bouchard, Kim, and Aoussat (2009) studied the design information expressed by design team members when discussing and brainstorming about design intentions during early NCD design-driven activities. The authors gathered design information from empirical studies. They organised it into different design information categories, which were structured into three different groups depending on their abstraction level. The three groups identified corresponded to low, middle, and high levels of abstraction. Each category of design information has originally been defined and exemplified. Additional categories were later identified by Gentner (2014). An description of the categories used in this experiment can be found in Table 1. Notably, the categories all relate to the different entities of the intended experience (user's personal characteristics, perceived kansei qualities, product attributes, context attributes).

Table 1: Categories of design information (Gentner, 2014)

Category name	Description	Example	Related UX entity
Value [O] (H)	These words represent final or behavioural values.	Ambitious, open-minded	User's personal characteristics
Semantic descriptor [C] (H)	Adjectives related to the meaning and characteristics.	Playful, romantic, traditional	User's perceived kansei quality
Emotion [N] (H)	Targeted emotion to be felt by the user	Joy, surprise, interest	User's perceived kansei quality
Style [O] (H)	Characterization of all levels together through a specific style.	Edge design	Product attributes
Lifestyle [N] (M)	Combination of values of the user	Work hard and play hard	User's personal characteristics
Interface characteristic [E] (M)	Underlying logics, engagement required	Mental engagement, physical and direct interface	Interaction attributes
Action enabled [E] (M)	Function, usage	Create, relax, communicate	Interaction attributes
Product characteristic [E] (M)	Components, ways of functioning, spatial organisation	Mechanical handle, roominess	Product attributes
Sector/object [O] (M)	Object or sector being representative for expressing a particular trend	Tennis, wearable computing	Product attributes
Physical context [X] (M)	Physical elements surrounding the product	In a modern living room	Context attributes
Temporal context [X] (M)	Notion of time in the interaction	Narrative description on an interaction	Context attributes
Culture [N] (L)	The culture of a user covers his/her age, gender, nationality, function, and organisational affiliation.	Young (20-29) Europeans	User's personal characteristics
Morphology [N] (L)	Related to the outward appearance of the user	Body shape, structure, handicap	User's personal characteristics
Gesture [E] (L)	Movement of a part of the user's body used as input	Hand and body movements	Interaction attributes
Feedback [E] (L)	Communication to the users that is influenced by prior inputs	Blinking light and sound	Interaction attributes
Visual attribute [C] (L)	Overall shape or component, shape size, and chromatic properties	Square, long and thin, Light blue, Pantone 17-	Product attributes

		5641 Emerald	
Tactile attribute [X] (L)	Material, temperature, texture	Plastic, stripped surface, rough	Product attributes
Auditory attribute [N] (L)	Rhythm, timber, etc.	Irregular, high pitch	Product attributes
Olfactory attribute [N] (L)	Scent families and facets	Citrus, woody, floral	Product attributes

(H): High level of abstraction
(M): Middle level of abstraction
(L): Low level of abstraction
[O]: Category originally presented by Kim et al. (2009)
[E]: Extracted from an original category
[C]: Combination of original categories
[X]: Extension of an original category
[N]: New category

RESEARCH QUESTION AND HYPOTHESIS

The research question is related to the notion of experience-driven NCD project introduced in the literature review. It can be formulated as follows: *How can experience-driven new concept development projects be characterised and compared?*

One hypothesis was identified in order to discuss the research question. It combines the notions of "experience," "new concept development," "design activity," and "design information" described in the state of the art:

> H - The nature of design activities undertaken and the design information exchanged during experience-driven new concept development projects depends on the context and purpose of these projects.

PRESENTATION OF THE EXPERIMENT

The projects were selected because their outputs described a user experience intention. For each of them, the projects' material (including a description of the design process and final reports) was analysed and used as an input. Interviews related to each project were also conducted with at least one member of the original project team. The interviews were semi-directed. Approximately 30 minutes were spent for each project. Similar questions were asked each time to clarify the context of the projects. Discussions focusing on the output material (early representation) were then initiated. This part of the interview permitted the gathering of additional information related to the category of design information on which the resulting early representations were focusing.

The projects were structured according to their position on the overall operation procedure of the company. Three types were identified from the 27 design-driven NCD projects analysed. These types are related to the creation of "exploratory concept", "product lining strategy", and "pre-development direction." During the interviews, the context of the project (in regards to one of the three below types) was discussed and specific attention was paid to the project's purpose, the composition of the design team (culture and affiliation of the members), and the audience addressed by the project.

- The "exploratory concept" group is composed of design-driven NCD projects that intend to explore innovative possibilities able to provide new pleasurable experiences, including new meanings (Verganti, 2009). These projects intend to influence the development of *breakthrough products* as defined by Wheelwright and Clark (1992).
- "Product lining strategy" projects are NCD projects meant to impact upcoming *platform product* development projects (e.g., hybrid vehicle NPD projects). Their outputs highlight kansei directions and related design strategies. They provide material related to user experience that enriches downstream NPD information activities.
- The purpose of "pre-development direction" projects is to prepare an upcoming *incremental product* NPD projects. Similar to "product lining strategy" projects, they intend to communicate kansei directions and related design strategies. As the focus here is on user experience and not on style, these strategies are centred on the kansei qualities that can be expressed by different variations (or grades) of a vehicle update.

The information gathered about the projects also covered the different design activities that were undertaken. The reasoning approach of the *information*, *generation*, and *evaluation & decision* activities will be discussed. Regarding

the *communication* activity, the analysis focused on the nature of kansei representations used for intermediate and final outputs. Four different types of representation were identified: visual, multi-sensory, narrative, and interactive. The audience to which to projects were presented corresponded to the other type of data collected regarding the communication activity.

In order to classify the design information conveyed by the kansei representations created in the projects, the 19 categories presented in the literature review will be used (Table 1).

ANALYSIS

In this section, the results of the analysis of each typology of design-driven NCD projects will be presented one by one. The results focus on the context of the projects (purpose, design team, audience), and on the design information conveyed by their output representations. The results will then be discussed together in section 6.

"Exploratory concept" (EC) projects

Eleven of the 27 projects analysed were described as "exploratory concept" projects. These include, for instance, the "Window to the world" project, which proposed to tackle the interaction between car occupants and their environment in a poetic and seamless way. An output of this project (storyboard, video, and prototype pictures) can be found on the Internet (http://bit.ly/15sb6A3 and http://bit.ly/114Gwhq).

The outputs of EC projects were concepts offering new experiences of mobility. Their focus was on mobility itself or on the interactions between a human and the environment (including other humans) supported by a mobility device. They can be regarded as NCD projects providing experience design-driven outputs for future *breakthrough products*. For all of these projects, the design team involved were rather small (around 5 persons) and varied a lot from one project to another. They were always multi-cultural (multi-nationality, multi-gender, multi-function). The functions covered included design, business, and engineering, as well as complementary functions such as social sciences and computing. Most of the projects (73%) involved design team members external to TME. These external members were affiliated with organisation such as consultancy firms or universities.

The *information*, *generation* and *evolution & decision* activities of these experience design-driven NCD projects were dominantly based on abductive approaches. They were mostly based on qualitative data and relied in some part on intuition and experience. The potential users were treated as subjects (directly or indirectly) except for information activities, which could also involve participatory design sessions.

- *Information:* The most used tools and methodologies were desk research, field observation, discussions with "users," longitudinal studies, brainstorming, and bodystorming. The latter two tools included in some cases participatory design sessions. In some other cases, they used the "kansei card" tool. Generally speaking, these tools and methodologies were mostly used to gather insights and inspire the design teams.
- *Generation:* Using the information and insights gathered various creativity tools were used to generate concepts.
- *Evaluation & Decision:* In order to evaluate concepts the design teams mainly relied on expert panels (discussions, voting sessions). For this type of projects, many iterative cycles occurred between generation and evaluation & decision activities.
- *Communication:* For every project analysed, part of the final audience was unknown at the start. The audience finally reached was nevertheless much wider than that of the other types of projects. The audience reached depended on the topic tackled but also on the advice and recommendations received during the communication process. It was generally high up in the organisational scale. The educational dimension of the communication material was therefore reinforced. Narration was used 82% of the time. It was done with the help of storyboards, digital animations or videos. Interactive representations were also used 27% of the time. They are meant to provide "explicit innovative new experiences and give a more tangible context for an audience that is often focused on short term concerns" (extracted from the interview of project #4).

The main design information categories conveyed by final outputs of "exploratory concept" projects are presented in Table 2. The table organises categories according to their abstraction level (vertically) and the experience entity to which they refer (horizontally). As shown in this table, it appears that the kansei representations created mostly cover abstract design information. Most of the categories corresponding to high and middle levels of abstraction are covered (all except *style* and *product characteristics*). Notably, no concrete design information categories related to the product to be designed are covered. The narrative and interactive outputs relied on concrete elements in order to

communicate the experience intention, but these characteristics did not belong to the main design information that were intended to be communicated.

Table 2: Categories of design information conveyed by EC project outputs

Abstraction level	User's personal characteristics	User's perceived kansei qualities	Interaction attributes	Product and context attributes
High	- Value	- Semantic word - Emotion		
Middle	- Lifestyle		- Interface characteristic - Action enabled	- Sector/object - Physical context - Temporal context
Low	- Culture		- Gesture [EM] - Feedback [EM]	

[EM]: Emerging category

"Product lining strategy" (PLS) projects

Ten of the 27 projects analysed fit in the "product lining strategy" project type. These projects include, for instance, the methodologies and outputs such as those presented by the authors in other publications (Gentner, Bouchard, Esquivel, & Favart, 2013).

"Product lining strategy" projects are meant to impact specific upcoming *platform product* development projects (e.g., hybrid vehicle NPD projects). Their outputs were meant to be used by upcoming NPD teams (internal or supplier R&D teams). Compared to EC projects, the profiles of the multi-cultural design teams were much more structured. Only product planners, designers, and engineers were involved in PLS projects. They also involved fewer members affiliated with external organisations (30% and only as support).

In the case of PLS projects, the balance between scientific and abductive reasoning was more even than for EC projects. Most of the time, users were treated as subjects (directly involved or not) but they could also be involved as partners. This happened mostly for generation activities and sometimes for information activities.

- *Information:* For PLS projects, this activity combined quantitative and qualitative research. The ones presented in EXP 2 (respectively, results from EXP 1 and image search) were for instance used in two projects. The most used tools and methodologies were desk research, interviews, and exploration activities (including participatory design sessions).
- *Generation:* Four projects out of ten (40%) involved participatory design sessions with potential future users. In this case, "users" were guided in their generation activity with sensory stimuli (low abstraction level) and keywords related to kansei qualities (high abstraction level). The other tools and methodologies used were abductive creativity tools.
- *Evaluation & Decision:* The concepts were either evaluated by a panel of potential users or by decision makers from the organisation (expert panel). In cases where potential users were involved, quantitative evaluations were used. Additionally to psychological measurements (self reported questionnaires), behavioural measurements were done in some cases (eye-tracking).
- *Communication:* The kansei representations created were meant to be used by upcoming NPD teams (internal or supplier R&D teams). The audience was composed of both managerial (as for EC projects) and working-level Toyota employees. The interviewees expressed therefore the importance of having the experience directions and strategies conveying information that could be used directly by engineering, business, and design departments. In 80% of the cases, multi-sensory representations were used. They made it possible to convey concrete UX-related design information. Narration started to be used for some projects dealing with interactions (20%). For all the projects, visual-only versions of the output representations also existed and were used for distant communications (e.g., video conference). The visual material typically included keywords, pictures and/or figures.

The main design information categories conveyed by the kansei representations resulting from PLS projects are presented in Table 3. The scope of information covered is wide. All experience entities except the context are covered with low to high abstraction categories (when a category exists). The kansei representations contained information to guide and inspire styling (e.g., *semantic word, emotion, style, visual attribute, tactile attribute,* and *other sensory attributes*) and interaction design activities (e.g., *semantic word, emotion, gesture, feedback*). They could also be used by product planners interested in information about markets (e.g., *value, culture*) and product package (e.g., *sector/objec*t), as well as by engineers working on topics such as material developments (e.g.,

emotion, semantic, style, visual, and *tactile*). Notably, many categories of design information are currently emerging in PLS projects (noted as EM in Table 3).

Table 3: Categories of design information conveyed by PLS project outputs

Abstraction level	User's personal characteristics	User's perceived kansei qualities	Interaction attributes	Product and context attributes
High	- Value [EM]	- Semantic word - Emotion		- Style
Middle			- Action enabled [EM]	- Sector/object - Product characteristic [EM]
Low	- Culture - Morphology [EM]		- Gesture [EM] - Feedback [EM]	- Visual attribute - Tactile attribute - Auditory attribute - Olfactory attribute [EM]

[EM]: Emerging category

"Pre-development direction" (PDD) projects

Six projects could be described as PDD projects. They will be described in terms of context and design information conveyed.

The UX-related design information that these projects provide was preparing upcoming NPD projects (short-term). These representations expressed directions and strategies focused on the kansei qualities that could be expressed by different grade variations of a future vehicle updates. The particularity of "pre-development direction" projects is that they were directly related to a new *incremental product* development project (NPD). The design teams involved were multi-cultural. In the teams' composition, a stronger accent was usually put on the function that would later be the most involved in the NPD projects (e.g., more styling designers were involved when preparing styling oriented projects). Notably, this typology of projects only involved members working at TME.

In the case of PDD projects, the balance between scientific and abductive reasoning approaches was almost even. Users were treated as subjects (directly involved or not) rather than as partners.

- *Information:* Quantitative data from market research (user involved as subject) appeared to be crucial at this stage. Information related to potential customers (i.e. target users) was studied and could lead to further *analytical reasoning* activities in order to translate it into high-level design information (Boisseau, 2013). Previous style-related NCD concepts could be used as starting points (e.g., concept cars). Finally, inspirational desk research was also used in order to put together design information from the different abstraction levels.
- *Generation:* The creation of *character* directions followed an iterative process. Refinement occurred cycle after cycle. The generation activity was in most of the cases led by styling designers sensitive to UX. Co-creation tools involving the entire design team could also be used.
- *Evaluation & Decision:* Team members evaluated initial ideas and concepts using their expertise. Questionnaires and votes could also be used to assist the evaluation activity. Final decisions concerning directions and strategies occurred at specific milestones and involved the project's top management.
- *Communication:* As mentioned in the context, the audience of "pre-development direction" projects was very specific. It covered managerial and working-level Toyota employees. The kansei representations always took the form of visual mood boards. They included multi-sensory samples when they were related to upcoming parts or material development projects (33% of the time). Narrative and interaction types of representations were never used. Their audiences were composed of specific function-oriented (styling, product planning, engineering) NPD project teams, as well as development teams from part or material suppliers.

The main design information categories conveyed by the kansei representations resulting from PDD projects are presented in Table 4. It can be observed that whereas all product attributes are covered, no design information categories related to interaction attributes are tackled. This can be put in perspective with the fact that the original role of TME-KD was related to sensory quality perception. The experience resulting from static perception appears to remain the domain of activity of the division the most established for the projects that are the closest to the NPD phase.

Table 4: Categories of design information conveyed by PDD project outputs

Abstraction level	User's personal characteristics	User's perceived kansei qualities	Interaction attributes	Product and context attributes
High	- Value	- Semantic word - Emotion		- Style
Middle	- Lifestyle [EM]			- Sector/object - Product characteristic
Low	- Culture			- Visual - Tactile attribute

[EM]: Emerging category

DISCUSSION

The three types of projects will now be discussed together. Table 5 summarises this discussion.

By construction, the purposes of the three types of projects are different (this is the definition of EC, PLS, and PDD projects). Similarities could nevertheless be observed regarding the nature of the design teams involved. It appeared that they were all composed of a similar number of members. Five seemed to be the average number, regardless of the project type. The different design teams also had in common the fact that they were multi-cultural. Functions traditionally less related to the industrial context (e.g., human sciences, computing) could only be found in EC projects. The involvement of people outside the company in the design team was the highest for projects related to long-term innovations (EC projects). Their involvement decreased progressively for PLS and PDD projects (when the commercialisation date becomes more and more clear).

In there design activities, all projects combined *abductive reasoning* and *scientific reasoning*. EC projects used the most *abductive reasoning* approaches in comparison with *scientific reasoning* approaches. It is justified by the ambiguity of their context: for this type of project there were no clear and definitive context *("you don't know what you don't know")*. The fuzziness of the context also led to very different types of representations. For EC projects, narrative and interactive representations were mostly used for final outputs. They seemed to better communicate concepts conveying a radical change in experience. These types of representation were very rarely used in PLS projects and never used in PDD projects. For these projects, the design teams relied mostly on visual and multi-sensory representations. These types of representations conveyed design information using material more established in the organisation (e.g., keywords, pictures, figures, material samples). They also communicated more information of direct use to the working-level employees involved in other NCD or NPD projects. Indeed, whereas EC projects mainly targeted managers dealing with vision and strategies, PLS and PDD projects' audience covered both managerial and working level employees. The clearer link between PLS or PDD projects and new industrial development projects (i.e. upcoming platforms and incremental development processes) is also reflected in the approach taken. Scientific reasoning is more used during the design activities. These approaches are meant to create knowledge about UX that is more explicit and that is proven with quantitative data *("you know what you know")*. This type of output appeared necessary in order to convince an audience to take decisions related to the implementation of new concepts in NPD projects. In table 5 the summary figures located in the design activities section graphically present the different uses of abductive and scientific reasoning for the information, generation, and evaluation activities of the three types of projects. The size and fuzziness of the audience reached by the communication activity are also represented.

The kansei representations resulting from the different types of projects had in common the fact that they effectively covered abstract design information categories and that they related these categories to design information categories with a lower level of abstraction. All the types of projects expressed an intention regarding kansei qualities (*emotion*, *semantic descriptor*). They also referred the abstract design information related to the potential user (*value*) and to the product to be designed (*style*). Outputs from EC projects were nevertheless the only ones to convey design information related to all five UX entities and sub-entities. PLS and PDD projects lacked information about intentional contexts of use (temporal, physical), and PLS projects did not covey any intention related to interaction attributes.
For EC projects, the design information related to the product to be designed remained abstract. On the contrary, this type of design information was very present for PLS and PDD projects. This is indeed the experience entity that appeared to be most directly impacted by the NPD projects that followed. This might be because it is where new

meanings and experiences are traditionally created in the automotive industry (e.g., interior layout, materials, features).

EC projects and, increasingly, PLS projects conveyed design information related to interaction attributes. They covered categories such as *gesture*, *feedback, interface characteristic,* and *action enabled* (*action enabled* only for EC). The reasons for this were nevertheless different. On the one hand, EC projects proposed concepts with radically new UX (in the sense of Verganti, 2009) that included new interaction propositions, and on the other hand PLS projects increasingly sought to investigate the influence that different interfaces (e.g., button vs. touchscreen) have on the perceived kansei qualities in conventional vehicle environments. In the latter case, the interaction-related design information enriched the recommendations provided by the resulting kansei representations.

As highlighted previously, the outputs of PLS and PDD projects did not express any specific intentions related to the contexts of the intended experiences. One reason for this is that the temporal and physical contexts of new *platform* and *incremental products* resemble that of current vehicles. This aspect is therefore not the centre of attention of these project types.

Table 5: Summary of the experiment

		Exploratory concept	**Product lining strategy**	**Pre-development direction**
Context of the projects	Purpose	Propose new experience concepts for future *breakthrough products*	Identify user experience logics and directions for future *platform products*	Prepare grade and character strategies of future *incremental products*
	Design team	- Multi-cultural - Members from inside and outside the company	- Multi-cultural - Mostly members from inside the company	- Multi-cultural - Only members from inside the company
Design activity	Type of representation	*Visual*: For intermediate output (co-creation session) *Multi-sensory:* No use *Narrative*: For intermediate and final output *Interactive:* For final output	*Visual*: For intermediate and final output *Multi-sensory:* For intermediate and final output *Narrative*: Limited use *Interactive*: No use	*Visual*: For intermediate and final output *Multi-sensory:* For final output *Narrative*: No use *Interactive*: No use
	Audience	- Wide but fuzzy - Mostly management level	- Specific - Management and working levels	- Very specific (development team) - Management and working levels
	Summary			
Design information conveyed	High level	PC: Value KQ: Semantic descriptor, emotion	PC: Value KQ: Semantic descriptor, emotion PA: Style	PC: Value KQ: Semantic descriptor, emotion PA: Style
	Middle level	PC: Lifestyle IA: Interface characteristic, action enabled PA: Sector/object CA: Physical context, temporal context	IA: Action enabled PA: Sector/object, product characteristic	PC: Lifestyle PA: Sector/object, product characteristic
	Low level	PC: Culture IA: Gesture, feedback	PC: Culture, morphology IA: Gesture, feedback PA: Visual, tactile, auditory, olfactory att.	PC: Culture PA: Visual, tactile att.

PC: Personal characteristics
KQ: Kansei qualities
IA: Interaction attributes
PA: Product attributes
CA: Context attributes

CONCLUSIONS

It this experiment, 27 industrial NCD projects conveying an intention in terms of user experience were analysed. Their outputs can be referred to as kansei representations as they link intended kansei qualities with personal characteristics of targeted users and attributes of the environment of design. The three types of projects identified ("exploratory concept," "product lining strategy," "pre-development direction") were described and compared in terms of context, design activities, and design information categories conveyed by their outputs.
This experiment enabled us to validate our hypothesis (H - The nature of design activities undertaken and the design information exchanged during experience-driven new concept development projects depends on the context and purpose of these projects.). Indeed, it appeared that the three types of experience-driven NCD projects (different in terms of purpose and context) could be characterised with specific *information*, *generation*, *evaluation & decision* activities (tools, methodologies, reasoning), communication activities (audience, type of early representation used) and design information conveyed. Although this experiment covered 27 industrial design projects, one limitation that can be identified is that these projects were all related to the same organisation (TME-KD).

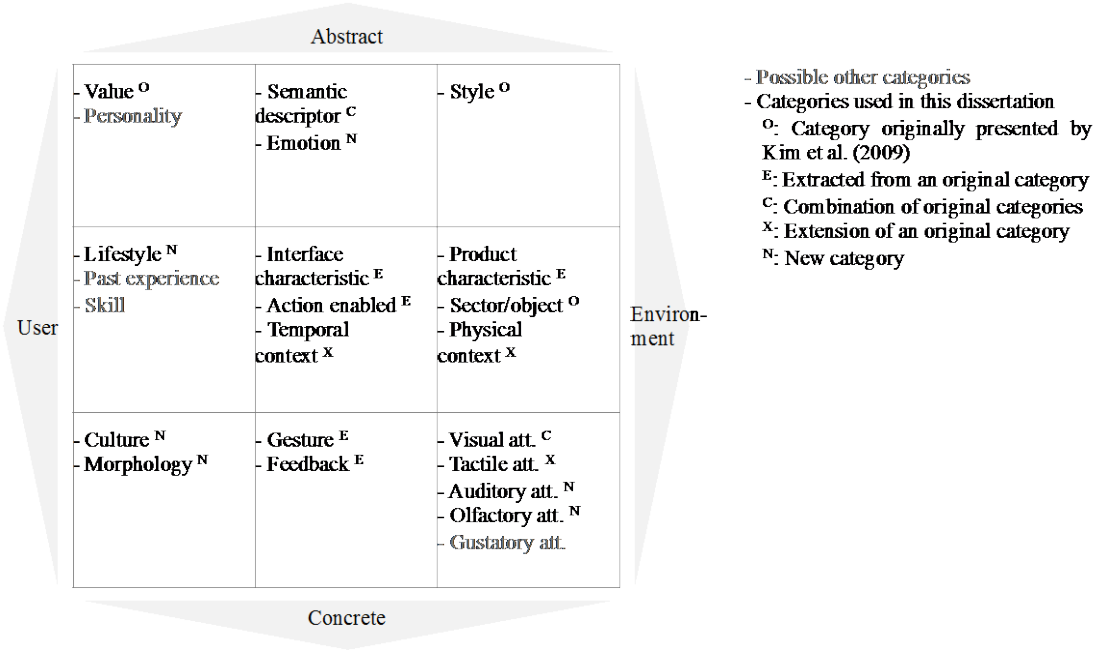

Figure 3. Model of kansei-related design information

A model of kansei-related design information has been created in order to better picture the contributions of this experiment and to facilitate future researches of the subject. The design information categories in Table 1 are presented according to two dimensions (two axes). The vertical axis corresponds to the abstraction level (low, middle, high). The anchors of the horizontal axis are labelled "user" and "environment." The left column corresponds therefore to design information describing the targeted user (i.e., personal characteristics) and the right column to design information describing static aspects of the environment (i.e., intentional product attributes, physical context). Finally, the centre column corresponds to the information related to the intended user-product interaction (i.e., kansei qualities, interaction attributes, temporal context). The related categories neither describe to the targeted user, nor the intended product and environment of use. The model shows a representation of the experience originating from a human-product interaction (see "Kansei-Experience framework" in Figure 1) from the perspective of the design information exchanged during concept creation activities.

Besides describing the design information exchanged within a design team, the model also facilitates comparisons and discussions related to our research question (*What are the design information categories that kansei-focused activities can cover in the early concept creation phase?*).

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Emergence of Self Awareness Using Shared Knowledge

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ABSTRACT

Because of the progress of Internet and search engine represented by Google, the value of idea is increasing instead of the value of knowledge. Mind Maps are the famous and useful method to support imagination and association. However, to make the Mind Maps by oneself causes the partial knowledge and idea. From this viewpoint, we have proposed the idea generation support system by using the shared knowledge made by the colleagues who have same background and Google Suggest. To investigate the effectiveness of shared knowledge and Google Suggest on the idea generation, we performed a couple of experiments. As a result, the performance by using the proposed system with shared knowledge was superior to others, and also the subjects tend to prefer the proposed system with shared knowledge.

Keywords: Mind Maps, Shared Knowledge, Idea Generation, Google Suggest

INTRODUCTION

As a recent trend of university learning, Learning Commons and Active Learning have appeared in the education institutes (OECD report, 2008, Holmgren,2010 and Roy, 2008). Learning Commons is a new service of the university library and has been suggested. Learning Commons is defined as "A service to provide a space enabling the learning style that some students collaborate and have a discussion with the information, which is obtained from various information resources including digital information and printed media. The service provides not only the computer facilities and printed matters, but also a support by the library staff to the self-leaning of students who use these information." in Ministry of Education, Culture, Sports, Science and Technology (Ministry of Education, 2014). This can be regarded as a new function for libraries having a sense of stagnation due to the digitization of documentations and development of Internet, and also as a change to the style of learning in common according to the social requirements arising from the limitation to categorize and interrelate an enormous volume of information by oneself in the information society.

The view of Learning Commons has rapidly developed around the department of humanities, and the discussion about its effectiveness has just begun in the department of science and technology. Meanwhile, Project Based Learning (PBL) has been already adapted to both departments. PBL is intended to make the students, who have different background, collaborate and understand each position and the meaning to take a role through the project. In fact, PBL is used in various ways to play an important role in the university education.

The learning method described above requires the (project) team participants to have the imagination and

association skills. This study focuses on "idea" and describes the experimental results about the effectiveness of using a group idea generation on the idea by oneself. The idea method such as Mind Maps are used to create a new idea and find a meaning to the undefined thing, and are proposed as an effective method to find the cause and solution of the problem (Buzan,1995 and Wright, 2011). However, using Mind Maps for the idea generation and thought by oneself may cause the limited and partial idea. For this reason, the shared knowledge, the synthesis of Mind Maps made by the colleagues who have same background, gives self-awareness and supports a new idea generation. However, the shared knowledge becomes less as the idea generation is expanded. To make up for this problem, we have proposed the utilization of prediction candidate function used on search engines.

IDEA GENERATING SUPPORT BY USING SHARED KNOWLEDGE

The Mind Maps, advocated by Tony Buzan, is one of the thinking and idea methods (Buzan and Buzan,2010). This is a visible indication of thoughts in the human brain with the same method of thinking. The Mind Maps are used to find a solution because it improves the memory, organization (understanding), and idea. The step is, to place a target topic at the center of sheet, expand the linked words in the radial direction, and repeat this action. The sample of Mind Maps is shown in Figure 1.

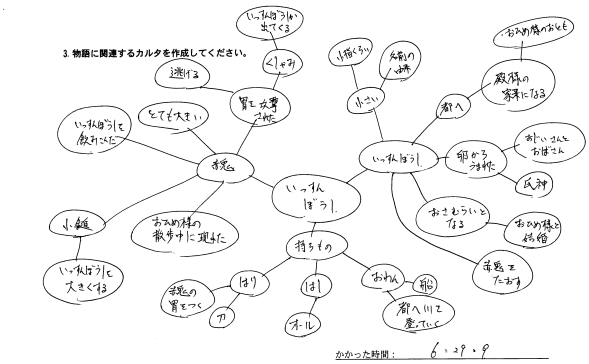

Figure 1. Example of Mind Maps.

Making the Mind Maps by oneself tends to the partial field or direction of idea generation according to his/her background and thought. We think that integrating Mind Maps, made with a same topic by multiple people into the knowledge shared among the participants (hereinafter called "shared knowledge") and presenting this knowledge enable to find a direction of new idea. We therefore propose the idea generation support system, using the shared knowledge. (See Figure 2) .

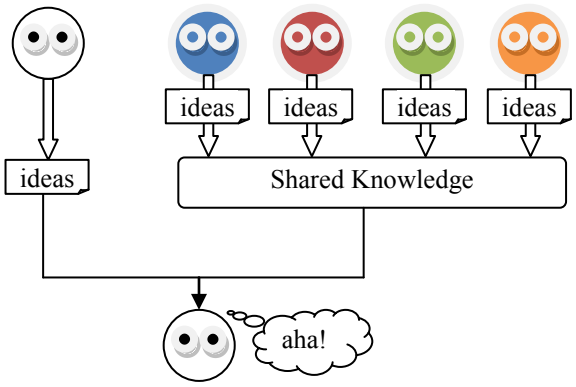

Figure 2. Idea generation support using shared knowledge

We performed a couple of evaluation experiments to verify that the presence of shared knowledge can help the self-idea generation. To prevent a large difference of information amount obtained from the shared knowledge between the topics, 100 keywords are registered as the shared knowledge for each topic. In consideration of the effect of order, 6 patterns of experiments, combining 3 topics with the self-idea or using the shared knowledge, were performed for 18 graduate students consisted of 17 males and one female. The average and standard deviation of number of idea by self-idea and those by using the shared knowledge are shown in Figure 3. The number of idea generation in Figure 3 shows that even if the self-idea is stopped, a new idea generation is increased by using the shared knowledge. This result proves that the shared knowledge can support a self-idea. Also, the average and standard deviation of thinking time for one idea by self-idea and those by using the shared knowledge are shown in Figure 4. The thinking time for one idea by self-idea at the second is shorter than the first. Especially, the time for idea by self-idea has 5% of significant difference between the first and second. From these results, it is found that the shared knowledge can support a new self-idea generation, and the repeated use of shared knowledge enables the improvement of self-imagination.

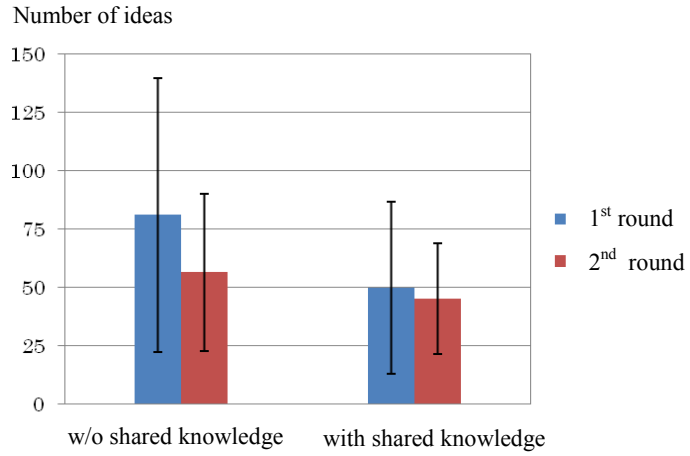

Figure 3. Number of ideas without shared knowledge (left) and with it (right).

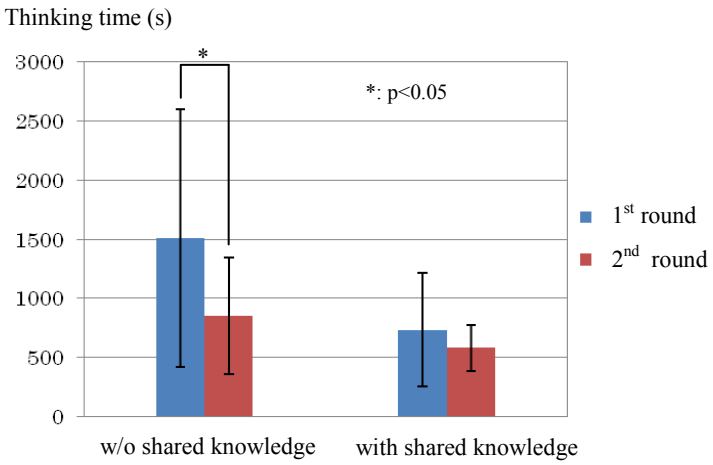

Figure 4. Thinking time for each idea without shared knowledge (left) and with it (right).

COMPARISON OF IDEA GENERATION SUPPORT BETWEEN SHARED KNOWLEDGE AND GOOGLE SUGGEST

The shared knowledge has a high possibility of effectiveness on self-idea generation. When the group in the class makes the Mind Maps with a given topic, it isn't so difficult to create the shared knowledge, however when using a personal topic, it may become difficult to create the shared knowledge. Also, the larger Mind Maps is created, the smaller information can be obtained from the shared knowledge. For this reason, instead of the shared knowledge, we propose the idea generation support using Google Suggest, the keyword prediction function of Google (Notess, 2009). Google Suggest is the way to predict what a user wants to search for from a character string input in Google search box and display the candidate list of keywords (see Figure 5). In this function, the frequently-searched words and phrases and the frequently-clicked those are selected as the candidate of keywords. These keywords are extracted from the usage history by unspecified users, not from the partial knowledge of a person or community. In other words, Google Suggest has a high possibility of being the well-balanced shared knowledge. The outline of proposed system is shown in Figure 6.

Figure 5. Example of Google Suggest

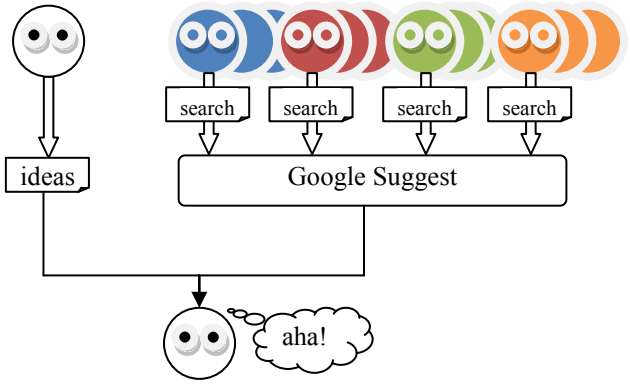

Figure 6. Outline of idea generation support system using Google Suggest

The proposed system is developed for the application on iPad (Apple inc.). The example of graphical user interface is shown in Figure 7. The left side of the screen shows a currently-prepared Mind Maps by a user. The user can refer to the keyword information in the right side of the screen, and create, edit, and delete the listed keywords. The candidate list of keywords, obtained from Google Suggest proposed in this research, is also displayed in the right side menu.

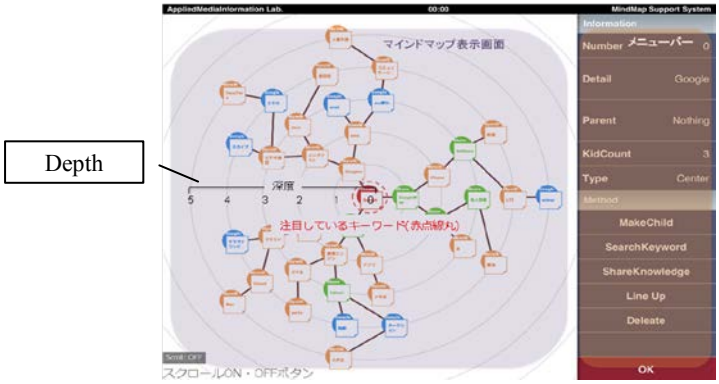

Figure 7. Graphical user interface of proposed system.

We verify the usability of the proposed idea generation support system. First of all, to investigate the influence of the effectiveness of the reference keywords obtained from Google Suggest, we compared between the general Mind Maps and the Mind Maps using the support system. Next, focusing on the reference keywords used in the creation, the difference in the effectiveness of the candidate reference keywords was compared between Google Suggest and the shared knowledge. The experiment was performed three times for 36 students in their 20's (See Figure 8). In consideration of the effect of learning order, 36 patterns of learning, made through combination of 6 topics and 6 learning methods, were given to 36 participants. The average and standard deviation of number of idea generation for each learning is shown in Figure 9. There were no significant difference between Google Suggest and the shared knowledge.

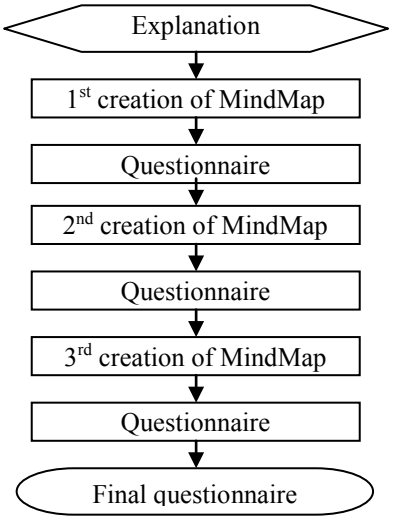

Figure 8. Experimental procedures.

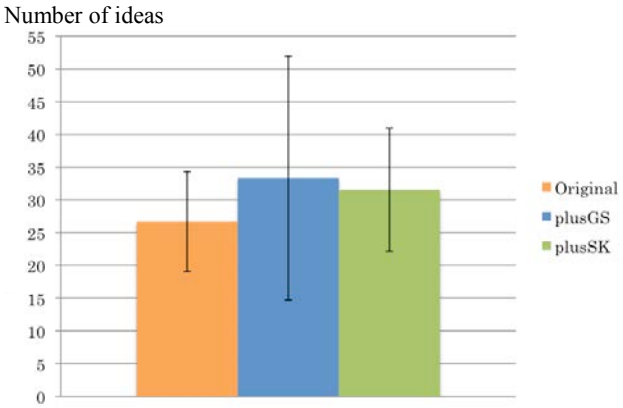

Figure 9. Average and standard deviation of number of ideas

After the experiments, the participants answered questionnaires about “Smoothness”, “Usability”, “Satisfaction” and the ranking of satisfaction among the created Mind Maps. The result of questionnaire is shown in Figure 10 and 11. According to the questionnaire, the performance with the shared knowledge was superior to others. Google Suggest was second.

We classified the reference keywords for each depth of idea. The average is shown in Figure 12. A line chart in the Figure 12 is the average ratio of the reference keywords out of keywords for each depth of idea. In the case of depth 1 and 2, the candidate reference keywords obtained from the shared knowledge is more than that from Google Suggest, with 5% of significant differences. On the other hand, in depth 3 to 5, the candidate reference keywords obtained from Google Suggest is more than that from the shared knowledge, with 5% of significant difference. This is because the number of reference keywords from the shared knowledge is smaller as the depth becomes deeper, however the number of that from Google Suggest does not change.

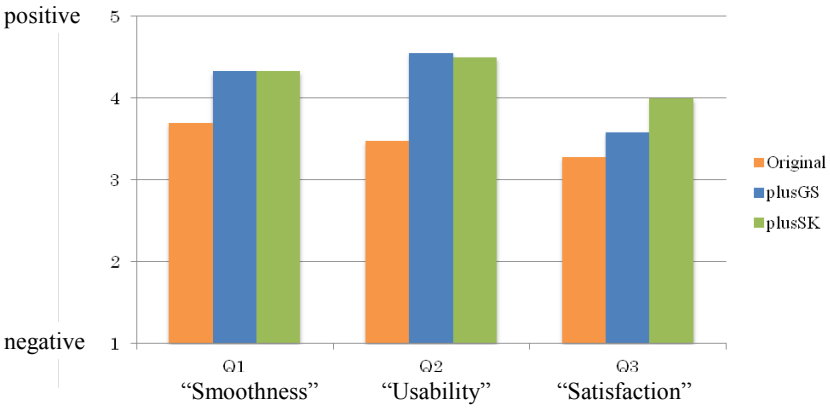

Figure 10. Results of questionnaires.

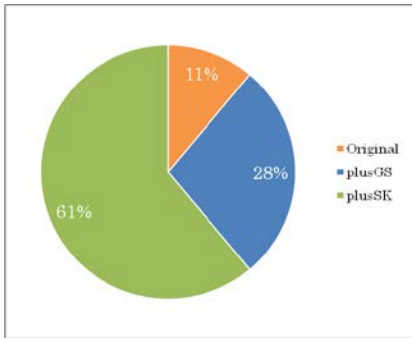

Figure 11. Results of questionnaire about usage.

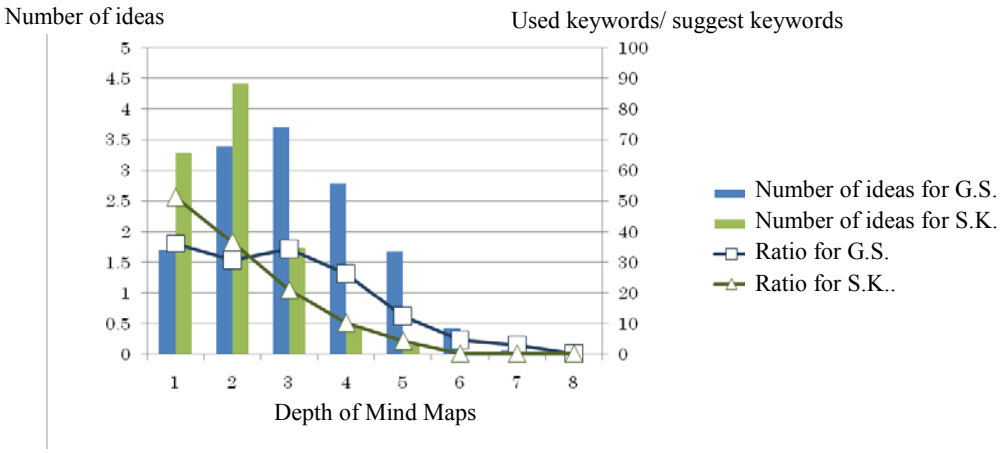

Figure 12. Number of ideas and referred keywords for each depth of idea.

CONCLUSIONS

In the information society, the various types of information can be accessed through the internet anytime, anywhere, and by anyone who wants to know. This leads that the ability to expand the idea based on the information becomes more important than to have a lot of information. In this research, using the proposed system, we verified effectiveness of the shared knowledge made by the colleagues who have same background and the idea by unspecified users on the self-idea. As a result, it is found that there is a possibility that the shared knowledge is effective for the idea generation and its learning. It is also found that the idea by other people who have the same background is preferred than that using the candidate referred keywords of Goggle Suggest. However, the shared knowledge needs the advance preparation and tends to be less by depth of idea. We think it desirable to use the idea with the prediction candidate function of Google Suggest as the second best. Further clarification of the process to get the idea realized from various information, and further development of the support system are excepted in the future.

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Gender-Sensitive Product Design by Kansei Engineering: An Application Example Using Kano-Questionnaire

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ABSTRACT

The paper presents a quantitative study based on the Kano-model to gender-sensitive product design by adapting the Japanese user-centered approach of Kansei Engineering. Underlying assumption of the approach is that products are not only perceived by functionality, but essentially by emotions such as joy of use and satisfaction for the fulfilment of user-centered product requirements. Thereby, the customers' satisfaction is investigated by applying the Kano-method, a procedure to structure product requirements and to determine their influence on customers' satisfaction. In this study, product designers overtake the role of the customer in order to bridge perspective gaps between customers and designers of products. Thereby it is analyzed, how designers perceive and evaluate products, which requirements they claim as relevant and satisfying, and to what extent the gender plays a role. The results of the study indicate that for the creation of designers' (as customers') satisfaction, the same product requirements are – more or less – relevant for both genders. However, there are slight differences in the perception and evaluation of product requirements observable. While women place great importance on hedonic characteristics such as attractiveness, the men are rather indifferent regarding product requirements.

Keywords: Kansei Engineering, Kano-method, product design, emotional user experience, customers' satisfaction, product requirement, designer perspective

INTRODUCTION

Consumers expect from a product that it is not only a useful object, but also that the product meets his needs and desires. This includes, in particular, an attractive design that motivates the consumer for use and, thereby, evokes a feeling of pleasure. If these product requirements are met, the customer is satisfied with his choice. Anyway, often products are not customer-centered designed. Reasons for this are, among others, divergent perspectives of customers (users) and product designers *(perspective gap)*. For instance, the customer product impression relies on personal expectations (Lindgaard and Dudek, 2002) whereas the designer creates products according to his professional (design guidelines) and personal view (mental concept of the object). To get closer to a user-centered design, it has to be investigated how designers perceive and evaluate products and which requirements they claim as relevant and satisfying. Thereby, the assumption is that the emotional perception of products not only varies role-

related but also by gender.

User-centered approaches such as Kansei Engineering (Nagamachi, 1995) offer one way to close this perspective gap. Kansei Engineering describes a methodology to collect and transfer customer's product feelings, impressions (in Japanese *Kansei*), and demands during the development process of a product into product properties. A main assumption of this approach is that products are not only perceived via their functionality, but also by properties that can be felt and experienced.

In the interdisciplinary project "Gender-Specific Kansei Engineering (Design Lab)" (runtime: 2009–2010), funded by the German Excellence Initiative, the Kansei Engineering approach was adapted. Experts from communication science and mechanical engineering investigated, which methods are appropriate for supporting designers in the process of user-centered product design. The aim was to define methods that allow designers to identify user requirements and to help transform these into product properties. Thereby, the influence of gender on the process of product perception *(user perspective)* and product design *(designer perspective)* is investigated.

The present paper reports the application of the Kano-method (Kano, 1984) for the investigation of gender sensitivity in product design. The Kano-method is a procedure to structure customer requirements and to determine their influence on customers' satisfaction. These requirements are divided into basic, performance, and excitement requirements according to the Kano-model. The Kano-method is conducted in two steps. In a pre-study, relevant product requirements are identified. In the main study, the product requirements are quantified regarding the categories of the Kano-model. As stimuli, blood pressure monitors of varying quality, maturity, and type are given. The study is lead by the assumption that female designers are more sensitive to product requirements that relate to the attractiveness and hedonic quality of a product while male designers stress more pragmatic product aspects (Jakobs et al., 2008).

The paper is structured as follows. First, approaches for affective and pleasurable design are presented such as Kansei Engineering and Kano-method. In this context, the objectives of the associated project, where the present study is conducted, are described. Second, the study design is depicted and results presented. Third, the results are discussed regarding gender perspectives and methodical aspects. Finally, a conclusion and an outlook are given.

APPROACHES FOR AFFECTIVE AND PLEASURABLE DESIGN

Kansei Engineering

Kansei Engineering describes a three-step methodology by which customer impressions, feelings, and demands concerning a product can be collected and transferred into product properties during the development process (Nagamachi, 1995) (see Figure 1).

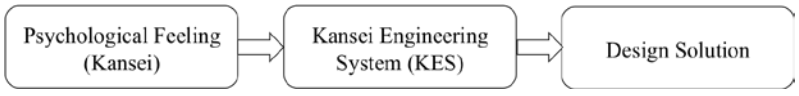

Figure 1. Steps of the Kansei Engineering process (Nagamachi, 1995)

The assumption is that products – according to the Japanese expression *Kansei*, which means "total emotions" – are not only perceived via their functionality. Moreover, they are perceived by properties that can be felt and experienced. Thus, the *psychological feeling* must be identified for the product development process. Therefore, in Kansei Engineering, product concepts are collected by methods such as participating observation, semi-structured interview, or questionnaire *(Kansei Engineering System)*. The collected product-related impressions, feelings, and demands are objectified and result in the final (product) *design solution*.

In the past, the approach was used for the design of different products such as welding helmets or industrial handling equipment (e.g. electrical driven warehouse reach truck) (Schütte, 2002, 2005). Thereby, the most successful examples of product development using Kansei Engineering is Mazda's sports car Miyata. Recent case studies use Kansei Engineering for user-centered optimization of brassieres, word sound image, and housing (Nagamachi and Lokman, 2011). In the present paper and in the reported project, the approach is used for the enhancement of medical products, concerning the influence of gender and role on the product development process.

Kano-method

The Kano-method is an approach to structure customer requirements and to determine their influence on customers' satisfaction. Thereby, customers' satisfaction can be fulfilled in different gradations (very satisfied, fully, very dissatisfied, not at all) (see Figure 2).

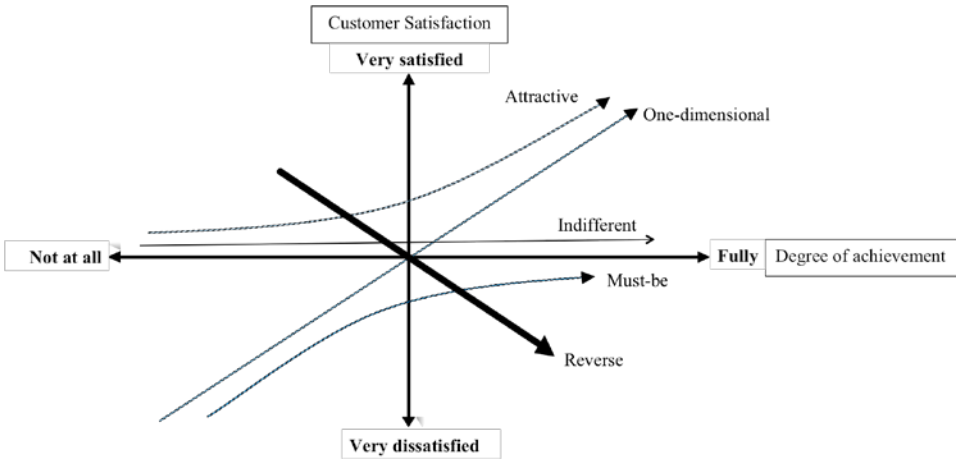

Figure 2. Kano-model of customers' satisfaction (According to Gustaffson, 1996)

In the Kano-questionnaire, requirements are – according to the Kano-model – segmented into five categories: attractive, one-dimensional, must-be, indifferent, and reverse (Kano, 1984). They can be defined as follows:

Must-be requirement: Basic features, which are so fundamental, that the customer only become aware of non-compliance (implicit expectations). If the basic requirements are not fulfilled, dissatisfaction arises; in contrast, if they are fulfilled, no satisfaction arises. The benefits increase is very low. Example: protection against rust for cars.

One-dimensional requirement: The customer is aware of the performance characteristics: they eliminate dissatisfaction or create customer satisfaction, depending on the degree of fulfilment. Example: fuel consumption of a car.

Attractive requirement: Benefit-creating characteristics which the customer does not expect, necessarily. They characterize the product against the competitors and raise enthusiasm. A small increase in performance can lead to a disproportionate benefit. Differentiations against the competitors may be low, but the benefits enormous. Example: special equipment such as the Concierge service.

Indifferent requirement: Features, which are both in the presence as well as in the absence of no importance for the customer. Therefore, they cannot donate satisfaction, but also do not lead to dissatisfaction. Example: sunroof.

Reverse requirement: If they exist, they lead to dissatisfaction; if they are missing, they do not lead to satisfaction. Example: rust stains.

In the questionnaire, each category is represented by two questions: a functional and a dysfunctional question. The *functional question* refers to existing (conscious) properties, the *dysfunctional question* relates to non-existing (subconscious) product properties. Thus, questions are raised regarding the opposite (non) existence of the different quality properties of an object. The maximum number of opposite questions per data collection is about 8-10.

Usually, the method is used in product profile planning for structuring customer needs. Especially for complex products with many different customer requirements the use of the questionnaire is recommended. Areas of application are, for example, the hotel industry (Giesbert, 2008), websites of financial service providers (Buhl et al., 2007), or the food retail sector (Heinlein et al., 2013).

Design Lab: projects objectives

The aim of the project is to test appropriate methods for the collection of gender- and role-specific concepts, needs, and quality requirements of products with the intention of improving the process of product design. The basic assumption of the project is that people – depending on role and gender – evaluate and perceive products differently, which was also suggested in previous studies (Xue and Yen, 2007; Trevisan et al., 2014/in press). Users have divergent demands concerning a product in comparison to product designers. Thus, the project combines both: the user perspective *and* the designer perspective. Here, studies for the investigation of the *user perspective* serve to determine gender-related needs, wishes, and sticky or hidden requirements linked to products. In contrast, studies for the investigation of the *designer perspective* serve to analyze what they assume as user-centered requirements for medical devices, what they consider to be a pleasant and affective design, and how they act when designing products.

To achieve a more user-centered product design, the Kansei Engineering-approach is adapted and modified according to the project's objectives and completed by the perspective of gender- and role-sensitivity. For this purpose, five selected methods are examined (Trevisan et al., 2012): the Kano-questionnaire (Kano, 1984) and AttrakDiff2-questionnaire (Hassenzahl et al., 2003), couple interview (Przyborski and Wohlrab-Sahr, 2008), focus group (Morgan, 1997), and prototype mapping (Mangasser-Wahl, 2000). The methods are evaluated with respect to the following criteria: *data quality* and *application effort*. Data quality is a complex rating scale including the sub-criteria *gender aspects, role aspects, hedonic quality, pragmatic quality, domain applicability, result quantity,* and *result quality*. The criteria application effort subsumes the sub-criteria *handling complexity (o=operator, p=participant), adjustment effort, planning effort, data collection effort, data analysis effort* and *fix to variable effort*. Three evaluators rated each method concerning data quality and application effort by Harvey Balls (Tullis and Albert, 2008). The evaluation is summarized in an evaluation portfolio (see Table 1).

Table 1. Evaluation portfolio for the appropriation of methods for user-centered design (excellent 4 90-100%, very good 5 80-89%, good 8 70-79%, fair 1 60-69%, poor 0 <60%) (Trevisan et al., 2012).

	Data quality							*Application effort*							
Criteria	*Gender aspects*	*Role aspects*	*Hedonic quality*	*Pragmatic quality*	*Domain applicability*	*Result quantity*	*Result quality*	*Handling complexity (o)*	*Handling complexity (p)*	*Adjustment effort*	*Planning effort*	*Data collection effort*	*Data analysis effort*	*Fix to variable effort*	***Overall evaluation***
AttrakDiff2	5	8	4	4	1	4	1	5	8	0	4	4	4	5	1
Couple interview	5	4	4	4	5	4	8	8	4	8	8	8	1	1	5
Focus group	5	5	4	4	4	5	8	8	5	4	8	8	0	8	5
Kano-questionnaire	8	8	1	1	4	5	8	4	8	4	4	4	5	4	1
Prototype mapping	4	4	8	8	5	5	5	4	4	4	4	4	4	5	8

The paper focuses on one method of the projects' research portfolio: the Kano-questionnaire.

STUDY DESIGN

Pre-Study

The Kano-study was carried out in a two-step-procedure: a pre-study (focus groups) and a main study (Kano-questionnaire). In the *pre-study*, relevant product features or user requirements are identified in focus group-studies (Trevisan et al., 2014/in press). In *focus groups*, the interviewer leads the participants and gives them gradually tasks to be solved (Morgan, 1997), for example, *"Mention typical components of the blood pressure monitor"*. Thereby, the participants are triggered by an interview guideline.

In this study, the focus groups were organized homogeneous by gender; highly advanced design students represent the professional guild of designers (f=13, m=14). Parallel to the study, the students designed in class medical

devices. Thus, the students had insights and knowledge about patients' quality requirements on medical devices. All students were aged between 20 and 30 years. The focus groups took about 60 minutes per group; they were recorded by audio recorder and camera. All participants consented to the recording of video data and the use of the anonymized data for research purposes. In this study, the evaluation object was a medical device (a blood pressure monitor) represented by four different stimuli (products) (see Table 2).

Table 2. Study stimuli of the focus groups: blood pressure monitors.

A	B	C	D

Device A is awarded with a quality seal by the German consumer protection organization (Stiftung Warentest) and is in the price range between 20 and 25 Euros. Device B did not receive a quality seal. It can be purchased in discount shops for 10 to 15 Euros. Product C is also tested by German consumer protection organization. The device received a rather poor rating (adequate). Product D is a rarity among the blood-pressure monitors: blood pressure is measured on patients finger. It was produced in the 90ties and is not more sold anymore. The focus groups started with the exploration of the evaluation objects; in this phase, the designers got the chance to try out the four product models. None of the products has already been used or known by them prior to the study.

The data analysis and evaluation was conducted in three steps. First, the focus group discussions were transcribed. Second, the transcripts were coded bottom-up using the content analysis software MaxQDa. Third, product components or requirements are selected from the interview data that were used in the Kano-questionnaire. The selection was led by two criteria: Named in the focus groups and relevant component of blood pressure monitors. The selection includes the following components: left/right handed, button, cuff, display, surface, guidance, feedback, switch, pump, clearance, and edge.

Main Study

In the main study, the Kano-method is conducted. The questionnaire is applied in the designer group.

Initially, the Kano-questionnaire is designed, which took approximately 2-3 hours. For each identified product feature of the pre-study opposite questions (functional vs. dysfunctional) are developed. Thereby, the questions are formulated as if the user would respond; in our study, the designers overtake the role of the user. As a best-practice example, the questionnaire design described in Sauerwein et al. (1996) served. Figure 3 shows an extract of the Kano-questionnaire.

What would you say if the blood pressure monitor has a comfortable cuff?	☐ That would make me very happy. ☐ I expect that. ☐ That does not matter to me. ☐ I accept that barely. ☐ That would bother me very much.
What would you say if the blood pressure monitor has <u>not</u> a comfortable cuff?	☐ That would make me very happy. ☐ I expect that. ☐ That does not matter to me. ☐ I accept that barely. ☐ That would bother me very much.

Figure 3. Example of a contrasting question pair with answering opportunities from the Kano-questionnaire (Adapted from Sauerwein et al., 1996)

To each question, five possible answers are given. Responses of the type *That would make me very happy.* state that the respondent rate the requirement with *like*. The response "*I expect that."* sets a requirement as *must-be*. If the respondent replies with "*That does not matter to me."* he has a *neutral* opinion towards the requirement. The response "*I accept that barely."* sets a requirement as *acceptable*. Responses of the type "*That would bother me very much."* show that a participant *does not like* a feature. The response possibilities and the method are explained to the participating design students prior to the study; as evaluation object, the medical device blood pressure monitor served. For the completion of the questionnaire, the designers had 10 minutes. Discussions between the respondents were not permitted during the questioning period.

After data collection, the answers of the participants are coded (e.g. A) according to the evaluation table of Sauerwein et al. (1996), in which for each response pair (e.g. Functional=1.like + Dysfunctional=3.neutral) a category of the Kano-model (e.g. attractive) is assigned. The evaluation table including all categorized response pairs is shown in Table 3.

Table 3. Kano evaluation table (A=attractive, M=must-be, R=reverse, O=one-dimensional, I=indifferent, Q=questionable) (Adapted from Sauerwein et al., 1996)

Product requirements		Dysfunctional (negative) question				
		1. like	2. must-be	3. neutral	4. acceptable	5. don't like
Functional (positive) question	1. like	Q	A	A	A	O
	2. must-be	R	I	I	I	M
	3. neutral	R	I	I	I	M
	4. acceptable	R	I	I	I	M
	5. do not like	R	R	R	R	Q

The codes A (attractive), M (must-be), R (reverse), O (one-dimensional), and I (indifferent) correspond to the categories of the Kano-model as described before. The code Q (questionable) indicates a vague result, i.e., it is assumed that the respondent has ticked the wrong answer or the question was not understood. Normally, answers do not fall into this category.

Finally, the results of the frequency analysis for each product requirement are transmitted in a result table. Thereby, each assigned combination is counted as 1, i.e., if for a product requirement three times in total the combination functional=1.like and dysfunctional=3.neutral occurs, for the category O a 3 is entered. The counting of entries is done for each gender separately as shown in Table 4.

Table 4. Table of results (f=female, m=male, A=attractive, M=must-be, R=reverse, O=one-dimensional, I=indifferent, Q=questionable) (Adapted from Sauerwein et al., 1996)

		f	m	∑
Product requirement	A			
	O	1		
	M			
	R			
	I			
Final category				

Hence, the whole evaluation process includes three components: (1) the questionnaire, (2) the evaluation table, and (3) the table of result. The process is exemplarily depicted in Figure 4.

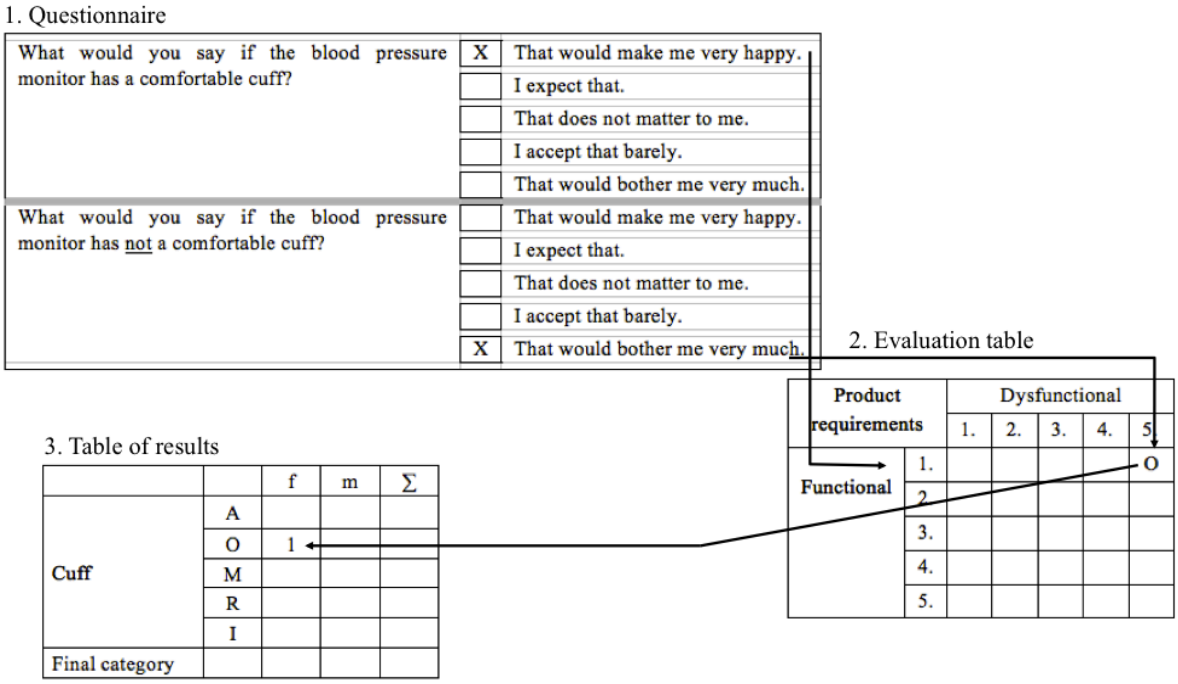

Figure 4: Evaluation process (f=female, m=male, A=attractive, M=must-be, R=reverse, O=one-dimensional, I=indifferent, Q=questionable) (Adapted from Sauerwein et al., 1996)

RESULTS

A first result indicates that none of the product requirement is assigned finally to the categories one-dimensional (O) or reverse (R) (see Table 6). Mainly, product requirements reached as final category attractive (A, n=5). These are *display, surface, feedback, switch,* and *edge*. The remaining product requirements are distributed evenly (n_M=3, n_I=3) across the categories *must-be (M: button, cuff, guidance)* and *indifferent (I: left-/right-handed, clearance, pump)*. Anyway, the results are not based on clear decisions of the participants: In the female group, the product requirements *cuff*, *display, clearance,* and *guidance* achieved multiple final categories; in the male group, the product requirements *guidance, feedback,* and *switch* are assigned to multiple final categories. Matching categories between the genders exist only for the product requirements *left-/right-handed, button, edge,* and *pump*. Thereby, only one product requirement is categorized multiply by both genders: *guidance*. The overview of evaluation results per product requirement and gender is given in Table 5.

Table 5. Overview of evaluation results per product requirement and gender

	f	m	Final category
left-/right-handed	I	I	I
button	M	M	M
cuff	A/O/M	M	M
display	A/M	A	A
surface	I	A	A
clearance	A/I	I	I
guidance	A/M	M/I	M
feedback	A	A/O	A
switch	A	A/I	A
edge	A	A	A
pump	I	I	I

Taking a closer look at the results it turns out that the answer numbers of both genders are relatively low considered separately (see Table 6). High entries per category are rarely reached, i.e., only for the categories attractive (A) and

indifferent (I) (*left-/right-handed* (I): nm=5, *edge* (A): nm=5, *surface* (A): nm=5, *pump* (I): nm=5, *clearance* (I): nm=6). The category one-dimensional is found primarily among the female responds.

Table 6. Detailed view of evaluation results per product requirement and gender

		f	m	∑			f	m	∑
left-/right-handed	A	3	2	5	guidance	A	3	2	5
	O	0	0	0		O	0	0	0
	M	0	1	1		M	3	3	6
	R	0	0	0		R	0	0	0
	I	4	5	9		I	1	3	4
Final category		I	I	I	Final category		A/M	M/I	M
button	A	2	0	2	feedback	A	4	3	7
	O	1	3	4		O	2	3	5
	M	4	4	8		M	0	1	1
	R	0	0	0		R	0	0	0
	I	0	1	1		I	1	1	2
Final category		M	M	M	Final category		A	A/O	A
cuff	A	2	1	3	switch	A	4	4	8
	O	2	0	2		O	0	0	0
	M	2	4	6		M	0	0	0
	R	0	0	0		R	0	0	0
	I	1	3	4		I	3	4	7
Final category		A/O/M	M	M	Final category		A	A/I	A
display	A	2	4	6	edge	A	4	5	9
	O	1	1	2		O	0	0	0
	M	2	1	3		M	0	0	0
	R	0	0	0		R	0	1	1
	I	2	2	4		I	3	2	5
Final category		A/M	A	A	Final category		A	A	A
surface	A	1	5	6	pump	A	2	3	5
	O	1	0	1		O	1	0	1
	M	2	2	4		M	0	0	0
	R	0	0	0		R	0	0	0
	I	3	1	4		I	4	5	9
Final category		I	A	A	Final category		I	I	I
clearance	A	3	2	5					
	O	0	0	0					
	M	1	0	1					
	R	0	0	0					
	I	3	6	9					
Final category		A/I	I	I					

DISCUSSION

Gender perspectives on designers' satisfaction

The results of the study indicate that for the creation of designers' satisfaction, the same product requirements are – more or less – relevant for both genders. However, there are slight differences in the perception and evaluation of product requirements observable.

Looking at the results obtained by the female respondents, it is clearly visible that – including the multiply categorized product requirements – the category attractive (A, n=7*)* outweighs. According to Hassenzahl et al. (2003), the *attractiveness* refers to the overall impression of a product, which is attributable to the *hedonic quality* perception. Hence, the general assumption or belief that women are more interested in hedonic product properties (e.g. *surface feel*) (Jakobs et al., 2008) can be confirmed for the investigated participants.

Contrarily, at the male group the categories attractive (A, n=5) and indifferent (I, n=5*)* – including the multiply

categorized product requirements – outweight. Thus, the male designer concentrates on the one hand in the same way as female designer on the attractiveness of product requirements. On the other hand, male designers are often indifferent (I) concerning product requirements, i.e., neither the presence nor the absence of a product requirement donates satisfaction or dissatisfaction. In parts, the category indifferent (I) is assigned to product requirements that achieved among the female designers the evaluation result attractive (A), such as *clearance, guidance*, and *switch*. In conclusion, the common assumption that men stress more *pragmatic quality* requirements is negated for this particular male designer group. However, at this point, gender-sensitivity for product requirements is most obvious.

Surprisingly, the requirement one-dimensional (O) emerged only twice, which leads to the conclusion that the product requirements are not perceived as performance characteristics for medical devices. Hence, even if they exist, from the perspective of the investigated designers these characteristics do not eliminate dissatisfaction or create satisfaction, depending on the degree of fulfilment. The non-occurrence of the requirement reverse (R), however, is a satisfying result: None of the assumed blood pressure monitor-requirements leads by existence to dissatisfaction nor does the missing of a requirement lead to satisfaction.

In this context, it must be examined in further studies whether this result is an effect of small sample size (number of participants) or an effect of other factors such as participants' age and their proximity to the education. There may be gender-related perception changes in the course of professional life in the sense of a reinforcement, modification, or reversion. Moreover, investigations might focus the question whether and to what extent gender-specific views vary product- and domain-related – are they predominantly evident with regard to consumer goods and services or also with regard to complex technologies such as energy systems (Trevisan et al., 2014, in this proceedings). The consideration of complex technologies would simultaneously mean an extension of the Kansei Engineering approach towards new sectors and product types. In addition, a comparative study should be conducted with users of blood pressure monitors, in order to compare and cross-validate, to what extent the role-and gender-related perspectives and satisfaction degree match or mismatch. Previous studies have shown that depending on role, differences in product perception can be observed (Trevisan et al., 2011, 2012; Trevisan et al., 2014/in press). As a follow up, the evaluation criteria *data quality* and *application effort* may be re-evaluated for the Kano-questionnaire considering the conclusions given above (see Table 1).

Methodical aspects

A major advantage of the Kano-method is a better understanding of customer requirements by the classification in basic-, performance- and excitement-requirements. The classification is used as an aid in decision-making about which requirements must be specially monitored in product design. A major disadvantage is the fact that the application is only useful for complex products with many clearly distinguishable product requirements. Taking this into consideration, the extension to complex technologies such as energy systems seems recommendable, e.g., in the context of acceptance research for the identification of acceptance promoting and inhibiting factors.

Moreover, the required effort for data evaluation can vary, depending on the evaluation method. If the responses are classified according to the given classes and the mean is calculated, less effort is caused than by approaches such as the *customers' satisfaction coefficient (CS coefficient)* (Berger et al., 1993) or the transfer and interpretation of category-relations according to the *evaluation rule M>O>A>I* suggested by Sauerwein et al. (1996). In addition, the evaluation can be simplified with software support.

To summarize, the questionnaire can be used to complement and validate the results of qualitative methods such as focus group-discussion. The main disadvantage of the Kano-questionnaire is its monotony, which the participants explicitly mentioned in our study. If more then ten questions are used, the attention of the participants can – due to the repetitive nature of the questions – be reduced or disappear. With this background, the study should be repeated with other participants, with a minor number of product requirements, and other product types.

CONCLUSION AND OUTLOOK

In the present study, the Kano-method was successfully applied. Gender-related differences of designers in the perception and evaluation of products could be identified, exemplarily. In this context it is assumed that a change in the participants circle (customer vs. designer) as well as the investigation of products from other sectors is promising in the light of role-related phenomenon and product-specific evaluation.

Moreover, the results imply that it is useful to integrate methods and techniques of user-centered and gender-related product design into product designers' education due to the fact that common assumptions on gender perspectives are negated in this study, partly. This includes methods and approaches such as Kano-questionnaire, user tests, quality function development, or Kansei Engineering as well as interdisciplinary views on the object. Melles and Wölfel (2014) came to a similar conclusion for postgraduate students.

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Towards Humor Modelling and Facilitation in Smart Environments

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ABSTRACT

We know about word play, verbal jokes, and about humor that appears spontaneously in conversations. This humor is studied in computational linguistics, together with issues such as verbal incongruities, ambiguities, irony and sarcasm. These appearances of humor are also part of computational humor studies, where a broader view is taken, that is, a view that includes artificial intelligence, reasoning, common-sense and context representations, and machine learning. But there are other kinds of humor. We can laugh about events that appear in our physical world. We can play an active role in having these events happening. Obviously, they can be accompanied with verbal comments and interaction. Nowadays physical worlds are equipped with multimodal sensors and multimedia actuators. Environments do not only have human inhabitants, but also tangibles, wearables, social robots and 2D and 3D display possibilities that can help to create changes in the world that is perceived by its human inhabitants. The possibility of humor creation can be transferred from the purely linguistics worlds of text and verbal exchanges to virtual, mixed, augmented and physical reality intelligent environments equipped with sensors and actuators that can help to create and control humorous events. In this paper we introduce this research area and we survey what is available in humor research literature that may help to establish this research area. Applications of this research include avatar behavior in videogames, robot and product behavior in entertainment, social, and game environments, and in smart physical environments that allow for playful and humorous events.

Keywords: Computational Humor, Verbal Humor, Intelligent Environments, Sensors, Actuators, Physical Humor, Virtual Reality, Videogames, Avatars

INTRODUCTION

Can we have a computer that can both recognize humor and adequately respond to it? Can we expect that there will be computers that can create humor at the right time? Both require a model of humor and both require that model to be formal enough to allow us to make rules for understanding and generating humor, rules which a computer algorithm can process and which also allow taking into account the context of interpretation and generation. That is not all it takes either. To understand humor, it requires the knowledge of a certain amount of 'common sense'. What is normal, and what is different? It requires knowledge of global affairs. ("President Bush and Osama Bin Laden play a game of chess. Bush loses. Why? He had lost two towers before he'd even started.")[1] Perhaps we should just accept that modeling such knowledge, and reasoning about it, is a hopeless task. People are able to make - and understand - the most ridiculous associations. On the other hand, we have also seen that a computer, with the help of sheer computing power and relatively simple modeling, can beat a world chess champion or win a game like

[1] In most European languages the 'rooks' in chess-play are called 'towers'.

'Jeopardy' against human opponents. However, in both of those instances, this follows decades of research into playing strategies, reasoning, learning, retrieval, forming associations, processing natural language and modeling to represent knowledge. Sadly, we have not seen a similar effort has been done on detecting or generating humour in texts or verbal exchanges. Let alone, that we have seen efforts that go into the direction of computationally detecting and generating humor in physical worlds.

Humour can be studied from either a psychological or sociological perspective. What is the importance of humour at work and in relationships? What sort of role does humour play in everyday life, in our dealings with other people and in our home and work lives? The importance of that role has become increasingly visible in recent years as our surroundings have gained sensors and actuators that know all about us and react to us. We expect our surroundings to react to us in an increasingly human way, or to at least be aware and capable of adequately anticipating and reacting to our natural human and social behaviour. Partly because of the presence of physical social robots and virtual social agents with bodies and human-like appearances, in these kinds of environments we increasingly expect there to be natural interaction between an environment and its user or users. Interactions are then based on knowledge of the environment, its events and the characteristics of the 'inhabitants' of that environment, including their behavior. Smart environments get access to knowledge that we, as humans, have access to and can use to create humorous events and fun. In other words, it becomes apparent that not only our future intelligent environments might be able to detect and perhaps even understand verbal humour interaction and non-verbal humour interaction, but we can also 'guide' an environment towards conditions which make humorous interaction possible.

The aim of this paper is to provide some insight in those aspects of humor research that can help to realize environments that are not only intelligent, but also have a sense of humor. Achieving this goal might seem far away. But probably the same could be said about the computer entering the Jeopardy game before it turned out that a concerted effort of computational linguists, artificial intelligence researchers, computer scientists, and information retrieval and machine learning experts could render a machine capable of competing with top human players. Humor needs to be computable in order to provide our intelligent environments with a sense of humor and make them cooperative in creating humor. The notion of computational humor has been introduced before (Hulstijn and Nijholt, 1996). However, most of the efforts to model humor were concerned with modelling verbal humor, in particular jokes and wordplay, e.g., (Binsted and Ritchie, 1997). Now that we can design and control our environments similar to our control of our writings, can we design humorous events just as we can design humorous texts? We can look at this question from the point of view of videogames, augmented and virtual reality environments, interactive art installations, and 'real-world' physical environments equipped with multimodal sensors and multimedia actuators that can make changes to the environment and can make events possible or happen. Obviously, unlike when we write a humorous text or tell a joke, in these virtual and physical environments we have (semi-)autonomous humanoids and human inhabitants that play an active role, that is, they interact with each other and with the environment. And clearly, asking the environment to have a sense of humor requires also that the environment is open for interactive and spontaneous humor.

In the next section we will mention some aspects of theories of humor that are relevant for our investigations here. We will elaborate on the notion of incongruity since it is not confined to texts and verbal jokes. We think that artificial environments, whether they are videogame, virtual training, or ambient intelligence environments can have the possibility to create humorous events and interactions or to help human inhabitants to create such possibilities by introducing ambiguities and incongruities in these environments. In further sections we especially focus on what has been done in research on physical humor (humor in physical environments and involving some physical activity, rather than humor appearing in text, speech or dialogue), multimodal aspects of humor and incongruities, and incongruities in products. At the end we mention why we should also pay attention to humor in videogames.

THEORIES OF HUMOR

Superiority/Disparagement, Relief, and Incongruity

There are various theories of humor, most of them address the analysis of verbal humor, in particular the analysis of jokes. That is to say, how do we analyze and understand a joke like the "Bush..." one above? We can try to theorize about what knowledge and what reasoning is necessary to understand such a joke. But in addition, when talking about appreciation, we should also take into account emotional and cultural aspects that in some way need to be

modelled too. Then it becomes clear that a generalization that goes beyond one or two examples requires a modelling of knowledge and reasoning processes so vast that that theorising will not reach an application level. However, as in the case of Jeopardy, we should be careful with such a negative conclusion. Here we mention the three main theories of humor. Rather than being competitive, they address different aspects of humor, in particular social, emotional, and cognitive aspects.

As mentioned, although not always presented as such, most of these humor theories address verbal humor. Investigations into verbal humor can certainly help to understand humor in general. Moreover, such investigations are being done from a computational point of view, a view that is embedded in computational linguistics research. We might want to learn from that when we want to expand our findings from one-dimensional language to two-dimensional drawings or three-dimensional products, humans and environments. And, in particular when we want to go from a situation where humor is consumed, to a situation where with support of the (intelligent) environment, humor is spontaneously created in interaction with the environment and its human and artificial inhabitants. This latter possibility may look overambitious, but there is no reason not to investigate it. We will return to this in the next sections.

As we said, most of the existing theories of humour apply to modeling verbal humour. These theories can be found in humor text books such as (Raskin, 2008). The first theory we want to mention is the *theory of superiority or disparagement*, which is linked to names such as Plato, Aristotle and Hobbes, assumes that we laugh at the misfortune or inferior position of others. Slipping on a banana skin is an example of that, but mostly we see it happen in jokes. For example, *"How do you make a blonde laugh on Saturday? Tell her a joke on Wednesday."* Or, *"Why do men like blonde jokes? That is because they can understand them."*

A second theory of humor is associated with Sigmund Freud and is called the *relief theory*. Freud describes humour as a necessary means to release pent up frustration originating in unpleasant experiences or social and sexual taboos (Freud, 1905). A nice example, mentioned by Freud is the following joke. *A royal personage was making a tour through his provinces and noticed a man in the crowd who bore a striking resemblance to his own exalted person. He beckoned to him and asked: "Was your mother at one time in service in the Palace?" "No, your Highness" was the reply, "but my father was."* AI expert and philosopher Marvin Minsky built on this by mentioning cognitive taboos that are breached when jokes defy logic (Minsky, 1981). For example, *"Ethel orders a pizza. The waitress asks her whether she would like it cut into four or eight slices. Ethel answers 'Just four, I'm on a diet.'"*

The third theory we should mention is the *theory of incongruity*. This is linked to names such as Schopenhauer, Kant and Bergson (Bergson, 1900). We laugh because something seems incongruous. To be more specific, we have particular expectations of how things should be or how things should go. These can be expectations based purely on common sense, or expectations that are evoked by a situation which is set up to be misinterpreted, or a text, such as the set-up of a joke, which misleads us (like the situation did). That 'misleading' aspect can of course take very many different forms, and it can be seen as a necessary condition for humor, but certainly not as a sufficient condition. Not every misunderstanding leads to a humorous situation. As mentioned, different theories focus on different aspects of humor and they can complement each other. In many humorous situations we have a victim or victims to laugh about, inappropriate things happen and incongruity is present. In the next subsection we have more observations on incongruity.

Incongruity and Incongruity Resolution

The theory of incongruity has in fact become the most influential approach to humor understanding. Refinements have been made to it to try to arrive at the above mentioned 'sufficient' conditions. This also draws on observations from the other theories mentioned above. When is incongruity funny? Does there always have to be something absurd or inappropriate? And how can we describe and define that 'inappropriate' aspect? A standard example of a joke used to illustrate the theory of incongruity is the doctor joke: "A man rings the doorbell of his doctor's house. The doctor's attractive, young wife opens the door. 'Is the doctor home?' the man whispers. 'No,' she answers, 'quick, come in.'" We can model a joke like this, in the tradition of AI scholars such as Minsky and Schank, by talking about scripts and frames that describe particular situations. The set-up of this particular joke assumes that a visit to the doctor is for a medical consult. That assumption is valid, but from the dialogue that follows we change to a different interpretation of the situation. We have been misled and we can also say that some inappropriateness has been introduced. The incongruity is 'resolved' because we find out that we made an incorrect assumption about the situation and only now understand what was really happening. That incorrect assumption is possible because the description at the start leads us to obvious interpretation whilst not ruling out the possibility of a less obvious interpretation. And once we have the new information that follows, we notice that we should have chosen the less obvious one, we are misled. And that can make us laugh. It does take a certain amount of cognitive effort to resolve

incongruity. Some researchers also talk of the incongruity-resolution theory, where it is the resolution itself that is most important rather than the resolved incongruity.

An observation that we can also identify in the literature is how being 'misled' often goes hand-in-hand with the main characters going down in our estimations. We view the doctor's wife differently when we find out that she takes lovers in off the street. And that particularly applies to the mother in this joke: *"A mother is on the phone. 'Doctor, doctor, please come right away. My baby has swallowed my fountain pen.' Doctor: 'I'm on my way. Don't panic!' Mother: 'No, no, but come quick. I really need this fountain pen.'"* There are plenty observations to be made, but you can find exceptions to each one. A more general observation that is also linked to 'sufficiency' was made by Apter, a psychologist (Apter, 1982). He introduced motivational states, including a 'paratelic state of mind', which is a state of mind inclined towards being playful (as opposed to a serious state of mind) in which one is receptive to humour. There are situations when we are expecting humour and we laugh about things that we would otherwise find threatening or sad.

It should be pointed out that the incongruity in the jokes above was constructed. It was not spontaneous. In conversations, we can react in a quick and humorous way to what our partners say or what is going on around us. This often requires us to make an unexpected association or provide an alternative explanation for something which is being said or happening. This spontaneously introduces incongruity, drawing on multiple interpretations - including absurd and inappropriate ones - of what had previously happened or been said (Nijholt, 2007). Taking 'what previously happened' into consideration, also gives the physical world a part to play. How do we perceive incongruities in the physical world and can we actively introduce incongruities, if useful supported by speech and dialogue, in our physical world? Where, of course, with our mobiles, tablets and laptops, wearables to add to our bodies, having our environments embedded with sensors, actuators and displays, and having our environments inhabited with physical or virtual agents, we have more than ever the possibility to control our environment and have more than ever the possibility to let the environment make decisions about what can happen in the environment. If the environment has a sense of humor, whether it is physical or virtual, it can decide to introduce a practical joke at the right time or it can decide to fool an inhabitant by misleading him or her and acting in an inappropriate but humorous way.

Computational Humor

There have been attempts towards automatic interpretation and generation of humor (see (Hulstijn and Nijholt, 1996; Hempelmann, 2008)). But, until now these attempts have focused on verbal humor only. This cannot be a surprise, since natural language processing, with its input from computational linguistics and artificial intelligence, is a well-established and long existing research area. Hence, before we start looking at humor that is not expressed in language only, we should have a look at computational approaches to verbal humor in the hope that are ways to generalize them to other forms of humor, that is humor that is expressed in multiple modalities, rather than in language only. However, as should be clear from the previous observations on humor theories, we have virtually no points of reference to employ when it comes to designing algorithms to analyze and generate humour in language, let alone in any other combination of sensual perception whatsoever. Yet, it can be a hindrance to traditional scholars of humor interested in a computational approach to have a multitude of different ways to approach humor to consider and have to take into account the different modalities and combinations of modalities of expression. This may become different when computational humor becomes, as we argue in this paper, included in multimodal human-computer interaction research.

When looking at the language modality only, we cannot really report success stories. Past research has produced few meaningful results. We began this article with the Bush-Bin Laden joke. The similarities between chess and war have been known ever since the time of Machiavelli. And we may also know there were towers in New York and chess also involves towers (which in contemporary English are known as rooks). We also cannot assume that everyone, let alone a computer, can automatically know the relationship between former President Bush and the late Bin Laden. Equipped with our knowledge of the world and how to reason about it, we can interpret a joke like this in terms of AI knowledge representation formalisms such as scripts and frames. Modelling common sense and world knowledge using such schemes have been tried (Lenat, 1997) and the 'big data' approach in IBM's Jeopardy project would of course be useful here (Ferrucci et al., 2010), but rather than resolving ambiguities, humor requires playing with ambiguities, introducing an additional problem to AI and computational linguistics.

It might seem an impossible task to leave to a computer, and many AI researchers would second that view. But, nevertheless, it is possible to make steps in that direction, i.e. towards computational humour. It is of course possible

to look at the generation and interpretation of jokes in a very limited context. That limited context does not have to include all knowledge of the world in order to generate or understand a humorous comment.

For example, representing the associations between words in puns can make it possible to generate new combinations of words with unexpected and sometimes amusing meanings (Binsted and Ritchie, 1997). That study concentrated on generating puns, such as: "What do you get when you cross a sheep and a kangaroo? A woolly jumper." Representing and using associations between words is of course significantly easier than using associations between world events, like we did with Bush and Bin Laden. But this pun generating program could not guarantee or determine whether a generated 'pun' was funny, that is, whether it was a pun at all. No matter how we try to combine concepts and features we cannot guarantee that it will result in something that people will find funny. Once again, we can try to formulate necessary conditions, but we cannot be sure how necessary they are. We can formulate some 'conditions' which perhaps approach being 'sufficient', but once again there is no guarantee of success. The same can be said of the approach in (Tinholt and Nijholt, 2007) where the authors intentionally try to create misunderstandings in a conversation.

It is not uncommon, in situations when we are unable to find rules, to seek salvation in machine learning techniques. That is what happened in computational humour research too. We can find a useful summary of such research in (Mihalcea, 2007). This kind of research is based on the availability of large quantities of data, especially texts available on the internet, attempting to identify patterns in such data which can be used to distinguish funny texts, paragraphs and sentences from other texts, paragraphs and sentences. We will not go into this any further, although it is possible that this kind of approach could be useful for having an IBM 'Jeopardy' to humor detection and understanding in texts.

All the approaches to computational humor that we included here are about detecting, understanding and generating verbal humour. There have of course been attempts to itemize non-verbal and visual humour, in cartoons, on-stage comedy, sitcoms, and real-life situations. There has been little or no attention for identifying these kinds of humorous situations by computer, let alone for producing these kinds of situations in a physical environment with sensors and actuators or a virtual environment such as a video game. But we may expect to see more research in this direction now that there are growing possibilities to monitor people and to adapt environments to activities of their inhabitants, whether it is in videogames, virtual reality environments or the physical world. In the next section we will look at what has been said about creating and understanding (potentially) humorous situations and events that can take place in the physical world. Obviously, the role of language should not be excluded here, but if language plays a role, then this role is clearly connected to the events that take place or can take place in the virtual, real, or augmented real world.

HUMOR BEYOND THE WORLD OF WORDS

We can use elements of language to construct humor. We can use elements of the physical world to construct humor. The construction can require some intentional preparation, but it can also happen spontaneously, taking advantage of, or triggered by interactions or events that could not have been predicted in advance. Spontaneously, naturally occurring events can be funny. Often it is better to speak of accidental humor rather than of spontaneous humor. America's Funniest Home Videos is a rich source for research on accidental humor. In these video clips language plays a secondary role or no role at all.

Hence, we can encounter and introduce incongruity in the physical world, not just in the linguistic world. It can involve linguistic interaction or linguistic commentary, but not necessarily. We can laugh watching a silent movie or a performance by a clown or mime player. We can also laugh at how a cyclist manages to weave through traffic in a nimble, strange, perhaps even incongruous, way. Or, when we look at how someone manages to perform a task in a particularly clumsy way. Or, when we see a child that finds an unusual yet original way to overcome its physical limitations. We can learn from how humour is enacted on stage, in films and in comedy television programmes even if the linguistic humour in the dialogue frequently dominates. We must remember that, like when we listen to a joke being told, we cannot influence what goes on in the circus, on the stage, in the film or in the television programme. We are spectators, we observe and we can laugh, we are not participants and therefore we are not potential victims of the humour, we are not addressed, except perhaps in a moment like a direct confrontation with a live comedian on stage who directly speaks to us or gives us a piece of his mind. Furthermore, when it comes to theatre (Brecht) and

film, some writers and directors aim for greater audience involvement than others. And, of course, there is an endless quantity of art that is made to trick us, in a confrontational way, yet also in a playful way that makes us laugh as soon as we realize we have fallen for it. 'Pulling the wool over the human perceptual system,' as Douglas Hofstadter puts it in (Seckel, 2004). (Seckel, 2004) is mainly about optical illusions; Hofstadter's point is more general and does concede that various senses, sometimes with partly incomplete and partly conflicting information, do reach a conclusion that subsequently has to be revised. So let us move on from linguistic incongruity to incongruity that involves the various senses we use to perceive the world. Incidentally, we are leaving out discussing humor in cartoons (but, see (Junco, 2008; Hempelman and Samson, 2008; Gerin, 2013)).

Incongruity and Humor in the 'Traditional' Physical World

In this subsection we will look at humor as it can appear, intentionally or accidentally, in the real world, Obviously, nowadays our physical real world is integrated with virtual worlds that we access with smart devices that not only can be used to communicate with others, but also to control the environment or communicate with the environment (domestic appliances, interactive entertainment). But, in traditional humor research, when looking at humor in the physical world, we are more interested in what kind of humor can emerge from having a banana peel on the floor than from having a robot vacuum cleaner on the floor. Traditionally this is called physical humor. It does not necessarily require language support. But of course, language can give a humorous flavor to an activity or event, for example by commenting on it and give it an unusual but not impossible interpretation. But here, we will mostly speak about incongruities in human behavior and objects in physical environments.

We can find views on physical humor from sources such as the philosopher, Bergson (Bergson, 1900). On this, he often refers to 'inelasticity' of movement or behaviour that creates comical situations because of the contrast we see between this and natural movement or behaviour. Natural versus 'mechanical', including when mechanical also means not adapting to changing surroundings and carrying on despite failing. Each of the theories of humor previously mentioned contains aspects we can also apply to potential humor in the physical world. We can see this in Morreal's attempts (Morreal, 1983) to identify humor techniques in the context of the real world. A useful distinction which he makes is the need to separate incongruity that presents itself in the world from how a person constructs and introduces incongruity. Morreal attempts to list all kinds of humor in the real world. When it comes to incongruity, he distinguishes between categories such as imperfection of people and objects or things that create humor. For example, in people these are physical imperfections, thoughtlessness and stupidity, moral flaws and failed actions. Humor can also be generated by misrepresentation of people, objects and things. For example, he mentions imitating someone, pretending to be someone else or claiming to be more important than one is in real life. Morreal identifies other categories too, such as coincidence, repetition and things out of their proper place, with the latter category, indeed, resembling incongruity in general, highlighting an aspect that already features as an element of the other categories.

A more elaborated listing of categories of humor and associated techniques is presented in Arthur Asa Berger (Berger, 1993). He distinguishes four basic categories under which his techniques of humor can be subsumed. The categories are *Language* (the humor is verbal), *Logic* (the humor is ideational), *Identity* (the humor is existential, and *Action* (the humor is physical or nonverbal). We give a few examples from (Berger, 1993) for each category. For example, for *Logic* (making comparisons): "What's the difference between capitalism and communism? In capitalism, man exploits man. In communism it's just the opposite." Or, for *Logic* (accident): Newspaper Headline: "Officer Convicted of Accepting Bride." And so there are many more techniques for introducing humor in the *Logic* category: absurdity, mistakes, repetition, rigidity, reversal, etc. For *Language* we can find techniques such as: allusion, misunderstanding, irony, ridicule, exaggeration, etc. For *Identity*: embarrassment, parody, mimicry, impersonation, caricature, etc., and for *Action*: chase, slapstick, speed, time. Chase scenes involve accidents, mistakes, coincidences, enjoyable escapes. Slapstick often involves degradation by action, physical insults, attacks on status and importance (Berger, 1993). Unfortunately, as may be clear from this summary, there is a multitude of techniques related to *Language*, *Logic*, and *Identity*, while the *Action* category is limited to the few techniques we mentioned. Moreover, the *Action* category seems to be more related to activities on stage and in film than to what happens in real life. We already mentioned America's Funniest Home Videos as a rich source for research on accidental humor. This humor certainly belongs to the category *Action* (the humor is physical or nonverbal), and clearly it involves such aspects, mentioned by (Morreal, 1983), as thoughtlessness, stupidity and failed actions.

Incongruity can occur in someone's appearance or posture, movements, behaviour, clothes, facial expressions and so on. Incongruities can be introduced accidentally and intentionally. In the former case it can lead to funny situations, in the latter it is aimed at creating funny situations. Intentionally introducing funny situations is an obvious thing to do in a circus, in comedy on stage and in movies, and, of course, in texts. It is less appropriate to do so, apart from in

our verbal interactions, in our daily activities. This is not completely true. In our interactions with children we create funny situations and display funny behavior. This is also the case in relaxed situations with our friends or with people with whom we are intimate. Objects and products can be fun too. An object can be used in way that was not intended when it was designed; an object can appear in places where it does not belong. In these cases an incongruity may be accidental or intentional, but it was not part of its design. Obviously, a product can be designed in such a way that it will have a humorous effect when it is used. Our natural environments, that is, our physical locations, contain such products. Children's toys are a good example. And so is a rubber duck that talks like Donald Duck when you squeeze it or that instead roars like a lion. This is a cross-modal incongruity in a product that has been designed to show such an incongruity (Ludden et al., 2012). Obviously, this is different from spontaneously generated humor or accidental humor. Also for this designed humor in natural physical environments, we should take into mind what Apter [1982] said about a receptive state of mind: eating shoelaces like strands of spaghetti can be hilarious too. Defying social and cultural conventions associated with a particular setting can have the same effect. This can likewise evoke illusions that do not correspond to how the world actually looks or works according to the laws of nature.

Incongruity and Humor in 'Traditional' Media

We can have verbal humor in speech, conversations and text. In the previous section we looked at humor as it can emerge accidentally or created intentionally during our daily activities in our physical world. We can also look at humor as it appears or can be created in film, sitcoms, commercials, products, comedy on stage and in performances of stand-up comedians. In these situations the audience consumes humor and although in the case of live performances there can be feedback from the audience to the performers, generally this does not really change the contents of what is conveyed to the audience. In films, circus, sitcoms and comedy on stage we see situations that are designed, that simulate real-life events or that otherwise can be recognized and accepted by the audience as being possible, even if it includes irrational decisions, unbelievable horror or magical events. In the next section we will look at digitally augmented physical environments, that is, environments equipped with interactive digital media, supported by sensors and actuators.

There are constructed worlds around already, of course. We can look at how incongruity and humor have become a part of literature, music, theatre, film and television. This is something we can learn from. We will still accept situations which are not realistic if we are able to empathize with them in some other way. People have had opinions about humor in theatre, humour in film and humor on television (i.e. humor wherever there is also or even predominantly a visual aspect) ever since theatre, film and television were invented. Greek plays have been analyzed for their use of various forms of humor (metaphor, parody, hyperbole, metatheatre etc.) and this was certainly also done to silent film (slapstick, farce, screwball etc.). However, these are not overall categories. Nor are they conditions or tools to generate or understand humor. More can be learned from the real-world humor observations of the earlier mentioned Bergson and Morreal. Obviously, in comedy and film, maybe in an exaggerated form, we have representations of real world situations. There are many books on comedy writing, for example (Byrne, 1999). Clearly, in this paper we cannot survey everything that has been written there. There is less literature on the analysis of humor in films, but interesting views on incongruity can be found in the work of the film philosopher Noël Carroll (Carroll, 1996). Carroll mentions that a 'sight gag' provokes amusement the juxtaposition of incompatible interpretations. He identifies six distinct categories of 'sight gags' in films, in each of them the directors appear to play with different interpretations. We can recognize such playing with interpretations in his opinion, from the perspectives of both the spectator (the viewer of the film) and the characters in the film. The categories that are mentioned are (1) The *mimed metaphor*, where we can see an object either literally or figuratively (Charlie Chaplin treating a boot as a meal); (2) The *switch image*, where we are presented with a view on a particular situation or event, but when zooming in or out, or with a change of camera position we learn that we misinterpreted the initial, visually ambiguous, scene; (3) The *switch movement*, where an actor attempts to have his behavior re-interpreted (e.g., from inappropriate to appropriate) by other characters in the film; (4) The *object analog*, similar to the mimed metaphor in the sense that an object is used or treated in an unusual way, but it has similarities to an object that is meant to be used that way; again, this requires two interpretations, one is the literal one, the other is the metaphorical one; (5) The *solution gag*, maybe not completely distinct from the previous categories, where the audience enjoys the wit of the protagonist to escape from a threatening situation by behaving or using tools in incongruous ways; (6) The *mutual interference or interpenetration* of two (or more) series of events (or scenarios). As mentioned by Carroll, this latter category is the most frequent form of the sight gag. Series of events can be staged with the director's aim to produce different plausible interpretations. Creating different points of view that are plausible can be aimed at the audience, that is, they can be aimed at fooling the audience. But it can also be the case that the audience is aware and gets its enjoyment from the characters that are not aware of an interpretation of events that is available for the audience. In both cases the audience can enjoy what is happening. There are incongruities to be

resolved by the audience, and there are incongruities that can be observed and enjoyed by the audience while watching the characters trying to deal with them.

Commercials and animated films often contain incongruities. Animated films are usually made to provide fun and we love to see cartoon characters subjected to incongruities or causing incongruities. These incongruities can be there, because the design of events in these films doesn't have not to follow rules of physics, biology or evolution. Hence, there are all kinds of ways we can see boundaries being broken, such as the laws of physics and biology (blocks of stone hovering in the air until the right moment to fall; whatever happens to a cartoon character, it never dies) and social norms (always resisting authority rather than accepting it). We can find amusing arguments about the laws of animated films in a June 1980 Esquire article "O'Donnell's Laws of Cartoon Motion" (reprinted in (O'Donnell, 1985)). More recently, and partly based on the work of (Berger, 1993), is the classification of humorous situations in television commercials, as presented in (Buijzen and Valkenburg, 2004). Berger listed humour techniques for verbal jokes. This more recent work expands this to humor in television commercials. The authors initially identified 41 distinct techniques that could finally be grouped into 7 humor technique categories: (1) slapstick, (2) clownesque humor, (3) surprise, (4) misunderstanding, (5) irony, (6) satire and (7) parody. The major difference between this and the earlier work by Morreal and Carroll is its systematic and statistical analysis of collected material so it can also comment on the frequencies of techniques and the preferences of age groups. It should be noted meanwhile that this refers to humour in audiovisual and other advertising material, and generalizing this to other situations requires rethinking of the categories.

Towards Incongruity Humor in Smart Environments

As has become clear of the previous sections, a lot of theory has been developed for verbal humor, drawing on ideas of how to represent and reason about knowledge of objects and events. This focuses on analyzing humor, not generating it. Virtually no research has been done into how to create events in the real world with the aim of facilitating or activating humorous activity. We can reshape and direct our verbal and non-verbal behaviour to strengthen the generation of humor. There is less scope to frame and direct the real world to create humorous situations or to make it more likely that verbal and non-verbal humor will be created. But it is not completely out of the question. For example, we can arrange a small part of the world to orchestrate a practical joke, meaning a seemingly obvious activity has unexpected consequences for its 'victim'. We can play a joke on someone by making unexpected changes in his or her world which turn ordinary acts into hilarious situations.

The question is whether creating these funny situations and initiating amusing turns of events is something we can leave to a computer or to computer-supported environments in which we immerse ourselves increasingly deeply and in which we encounter more and more artificial partners such as social robots and virtual agents with whom we will have social and friendly relationships. Clearly, we can accept humor while interacting with our artificial social agents, whether they are robots, virtual agents, digitally enhanced pets, or other devices to which we attribute human characteristics (Reeves & Nass, 1996). But we also know that interconnected digital partners are also connected to the sensors and actuators in our physical environment. And therefore we may expect that we will accept and enjoy digital humor created by artificial agents and smart environments that involve surprising changes in the appearance of the environment, surprising social behavior, and surprising changes in the usual laws of physics or biology, or the creation of perceptual illusions. Hence, assuming that our smart environments and their artificial inhabitants become real smart, we may assume that many of the techniques mentioned in previous sections on humor generation in 'traditional' physical worlds (Bergson, 1900; Morreal, 1983) and in 'traditional' media (Carroll, 1996) will find employment in future smart environments. Display and augmented reality technology offer us, for example, the *switch image* or the *mutual interference* mentioned above by (Carroll, 1996), to intentionally confuse (and hopefully entertain) the inhabitants of the smart environment, whether the initiative is with the environment, its artificial inhabitants, or other human inhabitants. Interestingly, Bergson mentioned the humorous effect of 'mechanical' behavior, meaning behavior that poorly adapts to changing environmental conditions. This allows us another view on smartness that is displayed by a smart environment and its artificial (physical or virtual) inhabitants. We can laugh about the unintentional failures or shortcomings of the technology leading to humorous situations. Even more interestingly is the situation where the technology is aware of these failures and shortcomings and comments on it with self-deprecating humor.

Humans inhabiting such smart environments can be the 'victim' of humor generated by the environment and its artificial inhabitants, they can create potentially humorous situations using sensor and actuator technology, and they can have humorous interactions with the environment and its inhabitants, where the interactions involve sensor and actuator technology. Rather than using 'text constructs' to create humor, we now use 'digital constructs' that make an appeal to all our senses. Maybe we should emphasize the distinction between intentional humor, whether it is

created by the environment, its human and artificial inhabitants, or in interaction between both, and situations or events that spontaneously occur because of misunderstandings or failures and that need a human observer who is able to understand what is going on in, for example, Jacques Tati's behavior in his 1957 movie 'Mon Oncle', where he has to deal with 'modern' kitchen technology, or Tati in his 1967 movie 'Playtime' where he is struggling with modern, technology enhanced office and city (Paris) life. Introducing new technology in a household can lead to hilarious situations, not only involving family members, but also for pets as is illustrated with many YouTube videos of kitty cats trying to communicate with a robotic vacuum cleaner. This unintentional humor can be expected and therefore be facilitated by a digitally augmented physical world. In the original view of Silber (Silber, 2013) there are more reasons why, when living in a digital media world, we will be confronted with humorous, incongruous situations. In the tradition of many other researchers in human-computer interaction he mentions humor that can arise from shortcomings of (interaction) technology, especially when these shortcomings arise from attempts to provide the interaction technology with human-like properties. But more interesting is his use of Linda Stone's notion of continuous partial attention and observations on scanning behavior, multi-tasking and being a 'life node' on the network (Stone, 2006), that can lead to 'unintentionally muddled information', 'unintended juxtapositions', 'mental mismatches', and therefore, incongruity humor.

Concluding, in our (future) smart environments we have sensors and actuators, wearables and artificial agents. Embedded intelligence can decide about the creation of potentially humorous situations. Human inhabitants can decide about employing this technology to create (potentially) humorous situations or interactions. Moreover, introducing smart and agent technology may lead to lead to humorous experiences (when in the right motivational mode (Apter, 1982)) because of failures and shortcomings in attempts to imitate human-human interaction behavior and not being able to satisfy expectations about such behavior.

Incongruity Humor in Video Games

It is useful to look at attempts to design humor in video games. Video games can be considered as a particular kind of smart environments. The gamer has to follow the rules of the game, the story line, and the interactions that are needed to satisfy the rules, the storyline, and the progress and success in the game. Usually, humor is designed as part of scripted interactions, or it is presented, for example in cut scenes, without any interaction at all. Clearly, scripted interactions can be triggered by events that happen during game playing. There is also humor that happens because a gamer can make certain (incongruous) choices about his or her appearance, movements, behavior and decisions. And there is humor because the gamer is able to find out about game playing possibilities that have not been foreseen by the designer. In addition, in on-line multi-player games there often is the possibility to use a communication channel where players or audience can have text or speech chat interactions while commenting on the progress of the game. So, video game worlds very much restrict the gamer in the interaction choices and decisions. It allows the game environment to lure the gamer into situations where he or she has to deal with humorous comments on his or her game behavior and progress (for example, in *Portal*) or where these comments are meant to distract and provoke the gamer in order to guide him or her into making wrong decisions.

Obviously, introducing humor in video games should be done very carefully. Rather than frustrating a gamer, it should motivate or challenge the player, something to fight against, provide enjoyment or be used as a weapon against opponents. Usually, but there are exceptions, gamers are not given the opportunity to introduce incongruities during game play. Virtual reality, graphics, and interaction technology allow doing so, but it would disturb the scripted story line and current artificial intelligence does not yet allow a satisfactory adaptation of the game to such 'disturbances'. Hence, more than enough reason to experiment with game and gamer created humor in videogames and see how ideas and results can find their way in smart physical environments that don't have a storyline, but where their inhabitants making use of smart sensors and actuators, advanced interaction and display facilities, smart objects and mobile, maybe humanlike, devices, have the opportunity to create their own sequences of humorous events.

CONCLUSIONS

The main argument we have put forward is that the use of sensors and actuators in physical environments, the use of wearables, and having artificial partners inhabiting our physical and virtual environments, we have the possibility to digitally design opportunities in our worlds to create humorous situations, or to facilitate human creation of physical humor in these worlds, almost as if we can create humor in texts, conversations or in comedy. Clearly, the main

distinguishing aspect is the active role the human inhabitants of these environments can play. They are not necessarily passive consumers of humor, but through their interaction behavior and their use of the digital media they can not only consume humor, including unintended humor, but also support and guide humor creation in interaction with the incongruity-sensitive environment.

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Psychophysiologically Evaluated Visuo-Tactile Affection using Printed Fabrics

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ABSTRACT

The present study compared to the three perceptional conditions of tactile affection−tactile tactility, visual tactility, and visuo-tactile affections−using psychological evaluation and psychophysiological methods. A comparative study was performed to fine out the differences of psychological and psychophysiological tactile perception according to the conditions of tactile perception. Furthermore, it also aims to find out the important fabric factor for tactile affection. Through the previous study, we found the fabric factors which influenced in tactile affection of fabrics: weave construction and fabric pattern. Total of six printed fabrics were developed by DTP method on naturally colored organic cotton fabrics as stimuli. Thirty participants were placed by randomized incomplete block design for the experiment. For measuring psychological affection, questionnaire was developed using a 9 points semantic differential scale. Electroencephalogram(EEG) was measured as a CNS response and electrocardiogram(ECG), skin conductance level(SCL), and photoplethysmography(PPG) were quantified as ANS responses. According to the results, perceptional condition had little effect on psychological and psychophysiological tactile perception. Significant effects on perceptional condition showed only on "showy-plain" affection and SCL response. Mostly, weave construction was more important fabric factor to perceive tactile affection than fabric pattern. However, the importance of fabric pattern also observed through the interaction effects.

Keywords: Visuo-Tactile Affection, Central Nervous System (CNS), Autonomic Nervous System (ANS), Electroencephalogram (EEG), Electrocardiogram (ECG), Skin Conductance Level (SCL), Photoplethysmography (PPG), Digital Textile Printing (DTP)

INTRODUCTION

Fabric affection influences purchase decision as the first impression of the clothing products at the moment of decision making and continually affects clothing comfort and satisfaction (Bertaux et al., 2007; Ciesielska-Wrobel and Langenhove, 2012). In addition, it is an important factor for the evaluation of the fabric and quality of clothing products (Bishop, 2010). Fabric affection is perceived through the five senses of human body. Among them, tactile affection plays an important role for an affirmative perception of fabric affection because fabrics are directly and consistently contact with human skin.

Tactile affection of the fabric is perceived by visual and tactile senses together or separately (Baik, 2001). When both senses involved together for perceiving tactile affection, we called this visuo-tactile affection. We can easily assume that the visual tactility, tactile tactility, and visuo-tactile conditions elicit different affection responses from people. However, there have been few studies on this subject. According to Heller (1982), visual tactility and tactile tactility provided comparable levels of performance about the perception of smoothness, but bimodal input

(visuo-tactile) led to greater accuracy. However, Heller's stimuli were aluminum oxide abrasive papers and no study was founded on fabric stimuli in our scope.

Meanwhile, when any emotional changes occur in our mind, our body reacts according to a certain pattern (Cho and Park, 2012). This supports that the psychophysiological evaluation which measure the physiological signals from a human body can be an objective method for evaluating human affection. Researchers are exploring more objective measures of human affection using physiological techniques such as electroencephalogram (EEG) as a CNS response and electrocardiogram (ECG), skin conductance level (SCL), and photoplethysmography (PPG) as ANS responses (Cho et al., 2001; Cho et al., 2005; Kim et al., 1998; Laparra-Hernandez et al., 2009; Sohn and Yi, 1998).

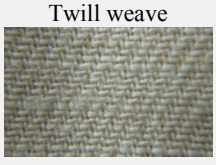
The present study compared to the three perceptional conditions of tactile affection−tactile tactility, visual tactility, and visuo-tactile affections−using psychological evaluation and psychophysiological methods. A comparative study was performed to fine out the differences of psychological and psychophysiological tactile perception according to the conditions of tactile perception. Furthermore, it also aims to find out the important fabric factor for tactile affection. There were two fabric factors manipulated in the study: weave construction (3 levels) and fabric pattern (2 levels).

EXPERIMENTAL

Stimuli

The six naturally colored organic cotton (NaCOC) fabrics were developed as stimuli (Table 1). Two snow crystal patterns were printed onto coyote-brown colored fabrics which have three kinds of weave constructions by digital textile printing (DTP) method (3 weave constructions × 2 fabric patterns). Each of the 6 fabrics was prepared in a 20 × 30 cm size.

Table 1: Specifications of the NaCOC fabric stimuli

No.	Name	Type		Yarn Type	Fabric Density (2.5 × 2.5㎝)	Thickness (㎜)	Weight (g/㎡)
		Weave Construction	Fabric Pattern				
1	P-SS	Plain weave	Simple star	40's staple	120 × 70	0.6	112.9
2	P-RC		Rimed crystal				
3	T-SS	Twill weave 	Simple star	40's staple	120 × 74	0.7	121.3
4	T-RC		Rimed crystal				
5	D-SS	Dobby weave	Simple star	40's staple	125 × 80	1.2	150.3
6	D-RC		Rimed crystal				

Questionnaire for psychological evaluation

The primary questionnaire for psychological affection evaluation consisted using bipolar adjective pairs which can be measured on tactile affection obtained from the literature (Bishop 1996; Cho. et al., 2000; Lee. et al., 2011; Sohn. et al., 1998). It was consisted of 25 bipolar adjective pairs. An initial psychological evaluation using 2 randomly chosen stimuli was conducted to select the appropriate adjective pairs which used in the main experiment. Participants of the initial test were 30 students (mean age 26.4 ± 4.3 years) majoring in Clothing and Textiles. After elimination processes by factor analysis, finally 14 adjective pairs were selected for the main experiment: "thin-thick," "cushiony-hard," "light-heavy," "smooth-harsh," "soft-rough," "flexible-stiff," "warm-cold," "pleasant-unpleasant," "luxurious-humble," "beautiful-ugly," "showy-plain," "static-dynamic," "feminine-masculine," and "like-dislike." Number 1-7 were the primary tactile sensation adjectives and number 8-14 were the secondary tactile affection adjectives. They consisted of a 9 point semantic differential scale (SDS).

Methods for psychophysiological evaluation

Physiological signal data acquisition

CNS and ANS signals were acquired using a Biopac amplifier MP150CE and AcqKnowledge 4.1 software (Biopac systems Inc., U.S.A.). As a CNS signal, EEG was measured from the frontal (F3, F4), parietal (P3, P4) and occipital (O1, O2) lobes of the brain based on an international 10/20 electrode system with a linked ears reference (Jasper, 1958) (Figure 1). EEG measuring sites were chosen by Amedi et al. (2011), Grill-Spector et al. (1998), and Sohn & Lee (1998). These sites are reacted by visual and tactile stimulations. The sampling frequency was 250 Hz and a bipolar lead was applied.

For the ANS responses, ECG, SCL, and PPG signals were acquired. ECG was recorded using a standard 3 leads montage (Lead I configuration). SCL electrodes were located on the index and middle fingers of the left hand. PPG was measured from the ring finger of the left hand. The sampling frequency of ANS signals was 250 Hz.

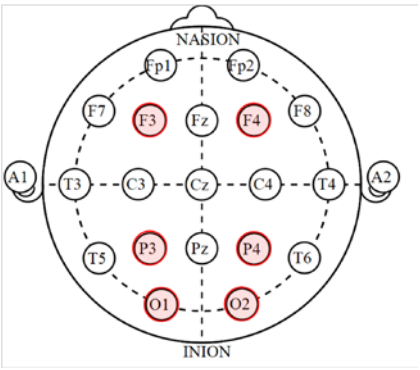


Figure 1. International 10/20 electrode system and the EEG measurement sites in the present study (red circled sites)

Physiological signal processing

EEG signals were firstly analyzed by FFT (fast fourier transform), and the relative power of each frequency band was analyzed. Analyzed EEG frequencies were 0.5-4 Hz (delta wave), 4-8 Hz (theta wave), 8-13 Hz (alpha wave), and 13-30 Hz (beta wave). The first second of all signals were discarded to avoid transitory effects and a total of 30 seconds of each signal was analyzed (Laparra-Hernandez, 2009).

Then, normalization processes was carried out by using Eqs. (1) and (2) (Laparra-Hernandez, 2009). In Eq. (1), X is the signal during the exposure time in each fabric stimulus and P is the signal before exposure of stimuli. Normalization 2 ($N2_{nj}$) was carried out for each participant with respect to the maximum value recorded for the participant in stimuli. This normalization ($N2_{nj}$) was performed according to Eq. (2), where Nx_{nj} is the normalized value (with the first normalization) of the signal, elicited by stimuli "j", from subject "n". Nx_n is a vector with the

normalized values (with the first normalization) of the signals, elicited by all stimuli, from participant "n":

$$N1 = (X - P) / P \quad (1)$$

$$N2_{nj} = Nx_{nj} / (\max (Nx_n)),\ n = \text{participant},\ j = \text{stimuli} \quad (2)$$

HRV was analyzed from the ECG signals, and then RR intervals were calculated from each signal. Like EEG signals, the first second was discarded and a total 30 s of each signal was analyzed. Secondly, LF/HF was analyzed from the RR interval data by Kubios HRV (ver. 2.0., Biosignal Analysis and Medical Imaging Group, Univ. of Eastern Finland, Finland). Lastly, the normalization processes were carried out using Eqs. (1) and (2). From the SCL and PPG values, the mean value was calculated at each stimulus from 1 to 31 s. Then, the normalization processes were performed using Eqs. (1) and (2).

Participant and experimental design

Thirty healthy right-handed female participants (mean age 24.3 ± 3.9 years) were recruited from Yonsei University and their participation was compensated. Before the main test, Ishihara's color blindness test was performed for screening color blindness and two-point discrimination (TPD) was carried out for screening tactile paresthesia on hands. Participants were placed in the experiment by randomized incomplete block design. A total of 6 stimuli were evaluated by one participant.

Experimental procedure

The experiments were conducted in an anechoic chamber under 400 Lux of incandescence. Upon entering the chamber, the participant was instructed about the procedures of both the psychological and psychophysiological evaluations for 5 min, and then electrodes were attached to the participant to record EEG, ECG, SCL, and PPG signals. A 10 min adaptation period was given to stabilize physiological signals, and then pre-stimulus signals (baseline) were recorded for 31 s. Each stimulus was presented in a random order at a 30 cm distance from the participant's eyes under the local lighting by daylight desk lamp over the participant's head (SS-460, Samjung Co. Ltd., Korea). Physiological signals were recorded during 31 s of stimulus presentation. The participants were instructed to avoid speaking and to move as little as possible during the signal recording. Between each stimulus, there was a psychological affection evaluation using the questionnaire and then a rest period was given (Figure 2). The entire process took about 40 min per participant.

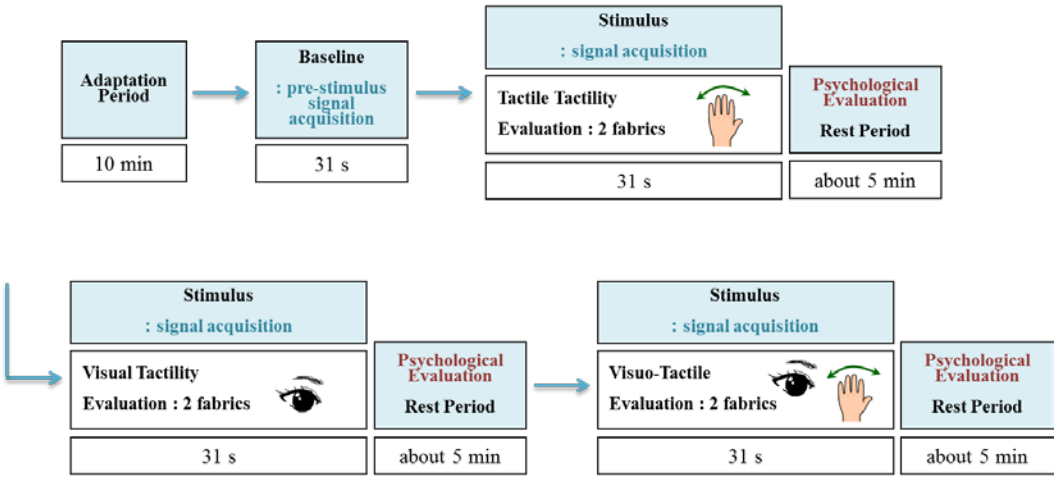


Figure 2. Experimental procedure

Statistical analysis

A single factor ANOVA was used to analyze the differences of psychlogical and psychophysiological tactile affection depending on perceptional condition. Two-way ANOVA was performed to analyze the differences of psychlogical and psychophysiological tactile affection depending on weave construction and fabric pattern. Duncan's test as a post-hoc ANOVA and simple main effect analysis for analyzing interaction effect was manipulated.

RESULTS AND DISCUSSION

Psychological evaluation

Psychological affection was evaluated by questionnaire. The cronbach's alpha of the questionnaire was 0.749. Single factor ANOVAs were used to analyze the differences of psychlogical tactile affections depending on perceptional condition. Most tactile affections not showed significant differences except "showy-palin" ($F(2, 177) = 5.594$, $p < .01$). It means that perceptional conditions were almost no effect on psychological tactile affection. Therefore, the results were re-analyzed using ANOVAs with two fabric factors (3 weave constructions × 2 fabric patterns).

In case of "showy-palin", Duncan's test was performed as post-hoc ANOVA (Figure 3). It showed that visual tactility and visuo-tactile were classified as the same group and tactile tactility belong to another group. It means that showiness affection largely depends on the visual condition.

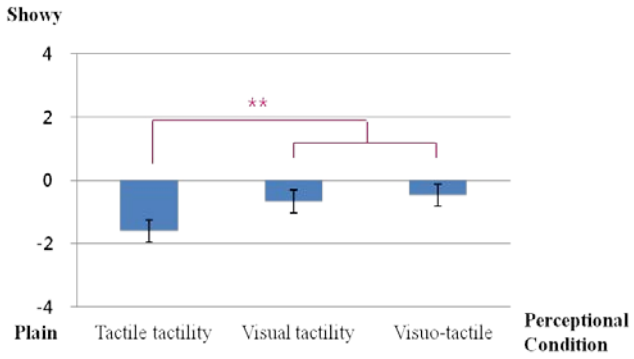


Figure 3. Duncan's test result of "showy-plain" on perceptional condition

Two-way ANOVAs between weave construction and fabric pattern exhibited that significant main effects on weave construction showed in "thin-thick," "cushiony-hard," "smooth-harsh," "soft-rough," "warm-cold," and "feminine-masculine" (Table 2). Figure 4 displayed Duncan's test results. In the "thin-thick," each of the three weaves belonging to the different group. In the "cushiony-hard," "smooth-harsh," "soft-rough," and "warm-cold," differences showed between plain weave and twill, dobby weaves. In the "feminine-masculine" affection, significant difference exhibited between plain and twill weaves. Meanwhile, no significant main effect showed on fabric pattern.

Table 2: A summary of significant main effects for weave construction in psychological evaluation

Variable	Thin Thick	Cushiony Hard	Smooth Harsh	Soft Rough	Warm Cold	Feminine Masculine
Weave	$F(2, 174) = 10.801$ $p < .001$	$F(2, 174) = 16.639$ $p < .001$	$F(2, 174) = 7.293$ $p < .01$	$F(2, 174) = 7.725$ $p < .01$	$F(2, 174) = 12.667$ $p < .001$	$F(2, 174) = 3.506$ $p < .05$

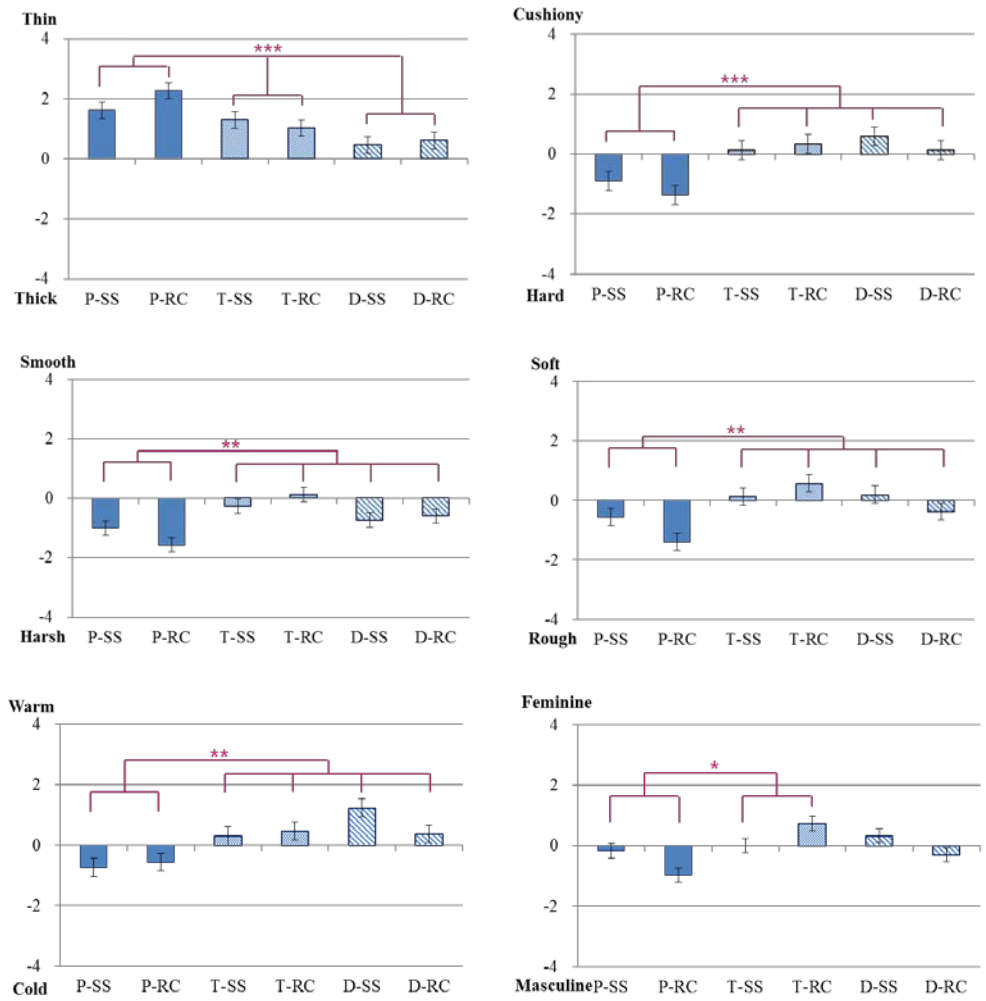


Figure 4. Duncan's test results on weave construction in psychological evaluation

Significant interaction effects between weave construction and fabric pattern displayed in "flexible-stiff," "pleasant-unpleasant," "luxurious-humble," "beautiful-ugly," "showy-plain," and "like-dislike" (Table 3). Simple main effect analysis for interaction effects showed that significant differences between simple star and rimed crystal patterns largely showed in twill weave (Figure 5). The twill weave rimed crystal (T-RC) fabric exhibited significantly flexible, pleasant, luxurious, beautiful, showy affection and preference compared to twill weave simple star patterned (T-SS) fabric. In dobby weave fabrics, simple star patterned (D-SS) fabric displayed significant pleasantness and likeness compared to dobby weave rimed (D-RC) fabric. In addition, plain weave simple star (P-SS) fabric evaluated less plain affection compared to plain weave rimed crystal (P-RC) fabric.

Table 3: A summary of significant interaction effects between weave construction and fabric pattern in psychological evaluation

Variable	Flexible Stiff	Pleasant Unpleasant	Luxurious Humble	Beautiful Ugly	Showy Plain	Like Dislike
Weave × Pattern	$F(1, 174) = 6.251$	$F(1, 174) = 5.254$	$F(1, 174) = 5.397$	$F(1, 174) = 4.887$	$F(1, 174) = 7.441$	$F(1, 174) = 6.375$
	$p < .01$	$p < .01$	$p < .01$	$p < .01$	$p < .01$	$p < .01$

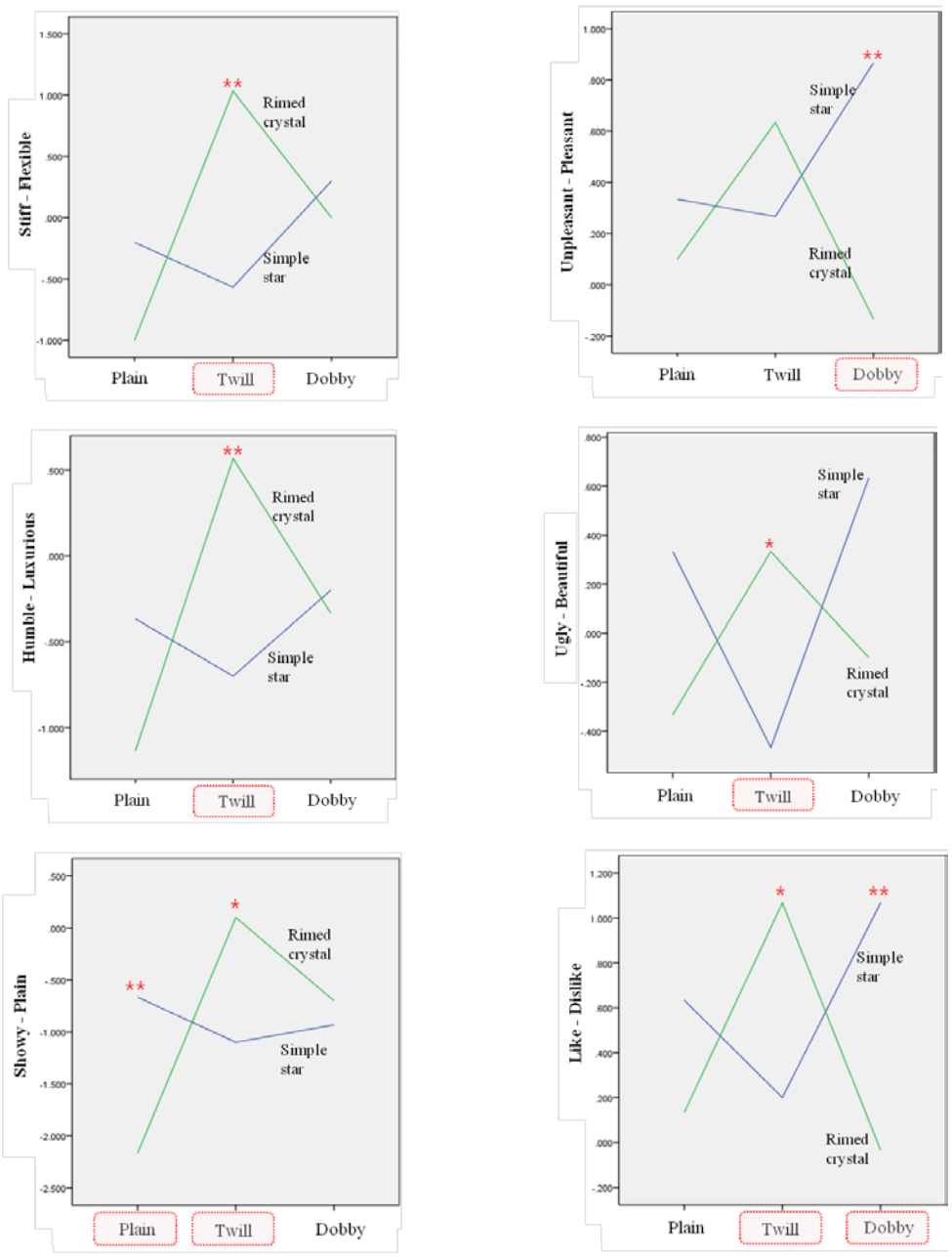


Figure 5. Simple main effect analysis results for two-way interaction effect between weave construction and fabric pattern in psychological evaluation (*p<.05, **p<.01)

According to the results, mostly weave construction was more important factor to perceive tactile affection of fabric than perceptional condition and fabric pattern. Furthermore, weave construction was important factor to perceive the primary sensation such as thickness, smoothness, softness, flexibility, and warmness. In contrast, fabric pattern also affected with weave construction to perceive the secondary affection such as pleasantness, luxuriousness, beauty, and preference. This seems to be caused that participants try to objectively evaluate about the primary tactile sensation while imagine the whole image of stimuli about the secondary tactile affection.

Psychophysiological evaluation

CNS response

CNS response was measured by using EEG signals. They were analyzed based on frequencies. Analyzing frequencies were 0.5 - 4 Hz (delta wave), 4 - 8 Hz (theta wave), 8 - 13 Hz (alpha wave), and 13 - 30 Hz (beta wave). Firstly, single factor ANOVAs were used to analyze the differences of CNS responses depending on perceptional condition. Any statistically significant difference did not observed among the perceptional condition. It means that the differences of perceptional conditions did not affect to EEG responses.

Therefore, the results were re-analyzed using ANOVAs with two fabric factors (3 weave constructions × 2 fabric patterns). Significant main effect displayed on weave construction in alpha (F3) ($F(2, 174) = 3.396$, $p < .05$). Post-hoc ANOVAs, Duncan's test, revealed that clear differences exhibited between plain and dobby weaves (Figure 6). Plain weave fabrics elicited larger amounts of alpha waves on F3 than dobby weave fabrics. Twill weave fabrics were positioned in the middle of the other two weaves. It means that the differences of fabric touch by fabric construction elicited the changes of alpha waves on left frontal lobe. The larger surface changes presented, the less alpha waves appeared on left frontal lobe.

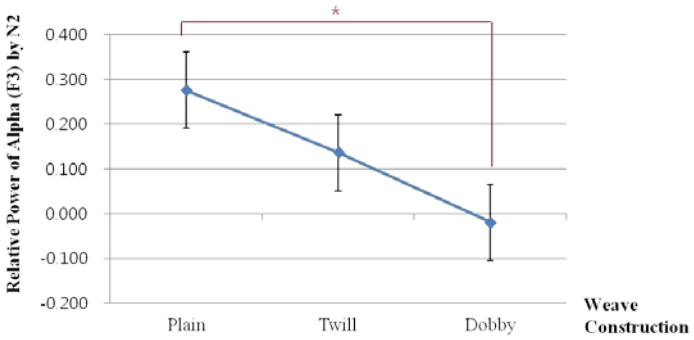


Figure 6. ANOVA and Duncan's test results on alpha (F3) ($F(2, 174) = 3.396$, $p < .05$)

Significant interaction effects between weave construction and fabric pattern displayed on delta, theta, and beta waves in several sites of the brain (Table 4). Simple main effect analysis results are shown in Figure 7. Delta (F3, P3, P4, and O2) waves were significantly higher in the twill weave simple star (T-SS) fabric than in the twill weave rimed crystal (T-RC) fabric. Theta (F3, P3) and beta (O2) waves were significantly lower in the T-SS fabric than in the T-RC fabric. Beta (O1) waves were significantly higher in the plain weave simple star (P-SS) fabric than in the plain weave rimed crystal (P-RC) fabric. It is speculated that, these results related to the psychological evaluation results. In the psychological evaluation, twill rimed crystal pattered fabrics generally evaluated positively while plain and dobby rimed crystal pattered fabrics evaluated negatively.

Table 4: A summary of significant interaction effects between weave construction and fabric pattern in EEG responses

Variable	Delta				
	F3	**P3**	**O1**	**P4**	**O2**
Weave × Pattern	$F(1, 174) = 5.502$ $p < .01$	$F(1, 174) = 4.254$ $p < .05$	$F(1, 174) = 3.832$ $p < .05$	$F(1, 174) = 5.219$ $p < .01$	$F(1, 174) = 6.365$ $p < .01$

Variable	Theta		Beta			
	F3	**P3**	**F3**	**O1**	**P4**	**O2**
Weave × Pattern	$F(1, 174) = 4.095$ $p < .05$	$F(1, 174) = 4.669$ $p < .05$	$F(1, 174) = 3.235$ $p < .05$	$F(1, 174) = 4.013$ $p < .05$	$F(1, 174) = 3.369$ $p < .05$	$F(1, 174) = 3.625$ $p < .05$

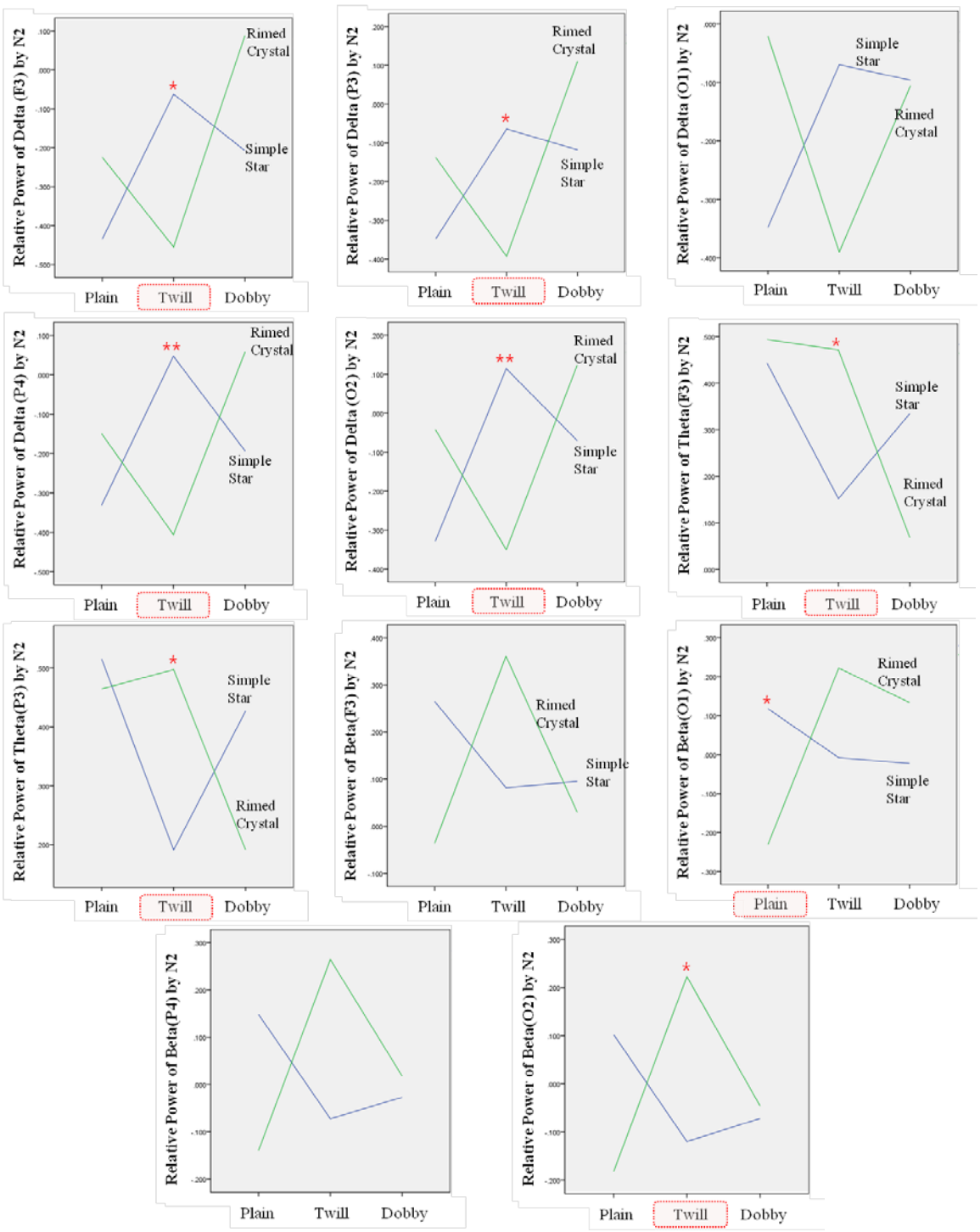


Figure 7. Simple main effect analysis results for two-way interaction between weave construction and fabric pattern in EEG responses (*p<.05, **p<.01)

ANS responses

ANS responses were measured by using ECG, SCL, and PPG signals. A single factor ANOVAs were used to analyze the differences of ANS responses depending on perceptional condition. Among the ANS signals, only SCL showed significant difference on perceptional condition ($F(2, 177) = 15.297$, $p < .001$). Values of LF/HF from ECG signals and PPG did not showed significant results. Post-hoc ANOVAs, Duncan's test, revealed that three

perceptional conditions were classified into separate group (Figure 8). SCL values were highly decreased in tactile tactility (-0.462 μs), slightly decreased in visual tactility (-0.191 μs), and increased in visuo-tactile (+0.142 μs) conditions. The result showed that the perceptional conditions can be distinguished using SCL signals.

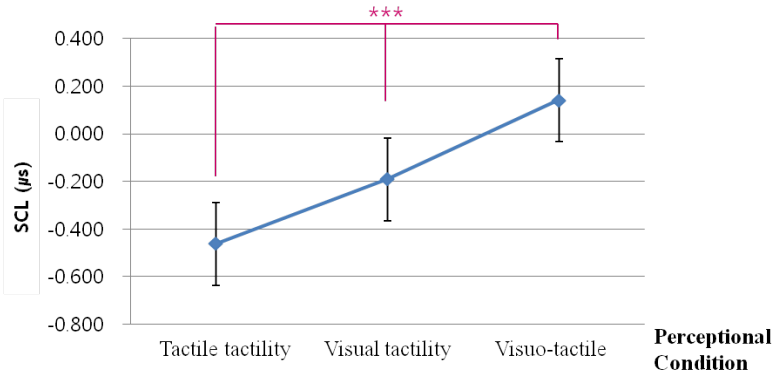


Figure 8. ANOVA and Duncan's test results on SCL ($F(2, 177) = 15.297$, $p < .001$)

The results of LF/HF and PPG were re-analyzed using ANOVAs with two fabric factors (3 weave constructions × 2 fabric patterns). The analysis did not show any main effect. Two-way interaction effect between weave construction and fabric pattern was showed on PPG ($F(2, 174) = 3.524$, $p < .05$) (Figure 9). According to the simple main effect analysis, simple star patterned plain (P-SS) fabric had significantly higher PPG values than plain rimed crystal (P-RC) fabric.

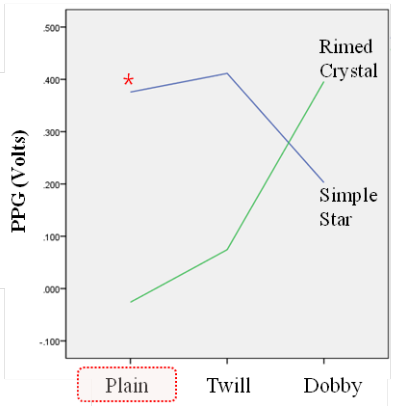


Figure 9. Two-way Interaction effect on PPG response ($F(2, 174) = 3.524$, $p < .05$)

CONCLUSIONS

The present study compared to the three perceptional conditions of tactile affection−tactile tactility, visual tactility, and visuo-tactile affections−using psychological evaluation and psychophysiological methods. A comparative study was performed to fine out the differences of psychological and psychophysiological tactile perception according to the conditions of tactile perception. Furthermore, it also aims to find out the important fabric factor for tactile affection between weave construction and fabric pattern. According to the results, perceptional condition had little effect on psychological and psychophysiological tactile perception. Significant effects on perceptional condition showed only on “showy-plain” affection in psychological evaluation and SCL responses in psychophysiological method. It means that perceptional conditions of tactile affection had almost no effect on psychological and

psychophysiological affection responses. Mostly, weave construction was more important fabric factor to perceive tactile affection than fabric pattern. However, the importance of fabric pattern also observed through the interaction effects. The study also revealed that weave construction was more important factor to perceive the primary sensation such as thickness, smoothness, softness, flexibility, and warmness while fabric pattern also affected to perceive the secondary affection such as pleasantness, luxuriousness, beauty, and preference. Furthermore, it is speculated that the left frontal alpha waves can be used to distinguish the differences of fabric weaves and SCL signals can be sorted the perceptional conditions of tactile affection. Further study needs to be performed to find out the relationship between psychological evaluation and psychophysiological responses.

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Section 6

Pleasurable Design on Support Technology for Elderly and Disabled

Effective Design of Recreation Activities in the Group Home for the Elderly with Dementia

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ABSTRACT

People with dementia spend their daily lives in solitude and anxiety. We aim to provide them with a sense of security and peace through a combination of nursing and medical care. This is the philosophy of the Kaide and Terado group homes, operated by TM medical services. The burden on family members stems more from the behavioral and psychological symptoms of dementia, (BPSD,) rather than from core symptoms like memory and cognitive impairment. Due to this heavy burden on family members, family carers are available as one of the services of long-term care insurance. Group homes are another service covered by long-term care insurance, and allow people with dementia to receiving care in small groups while living as part of a community. The homes we discuss rely on both drug therapy and psychotherapy for treating BPSD, which presents in such forms as delusions of victimization, excitement, violence, and wandering. By providing care that encourages close connections to residents with dementia, and by arranging their living environment properly, group homes become places where people with dementia are supported by care staff and can live each day as human beings. In order to realize the principles on which we base our care, it is necessary for care staff to deepen their understanding of dementia. Also, we have developed various gimmicks based on recognized psychotherapy techniques like reminiscence therapy, music therapy, horticultural therapy, and animal therapy. One of our gimmicks is utilizing Japanese traditional arts to provide quality care in our group homes. In this paper, we report on a workshop in traditional Japanese flower arrangement, or ikebana, which was carried out in the Terado group home. This report includes results verifying the effect of this lesson on the mental stability of participants, using the GBS Scale and interviews with care staff to reveal the secret of the success of this lesson.

Keywords: Dementia care, Person centered care, QOL

INTRODUCTION

"Give elderly dementia patients joyful daily lives through the cooperation of nursing and medical care." This is the philosophy of our group homes, Kaide and Terado. People with dementia spend each day in solitude and anxiety because the core symptoms (impaired cognitive function) and BPSD interfere with their social lives. As dementia progresses, the burden of care placed on the family becomes larger. Eventually, many families finally choose to use one of the services provided by long-term care insurance.

A group home is one such service, which offers residents the care they truly need in small groups. Instead of relying on medication, we support our residents and cope with the symptoms of their dementia by creating a positive environment utilizing psychotherapy, reminiscence, music therapy, horticultural therapy, animal therapy, and other techniques (Gräsel et al 2003).

In this paper, we describe how lessons in Japanese flower arrangement were carried out as a collaboration between residents, their families, and care staff, as part of psychological occupational therapy in the Terado group home. We also evaluate the resulting effects on the care in our group home.

USE OF JAPANESE TRADITIONAL ARTS IN DEMENTIA CARE

While short-term memory is gradually lost, long-term memory remains relatively stable in people with memory impairment due to dementia. It is well known that people with dementia remember episodes from their youth and childhood well, and that by regaining a sense of such periods, they become psychologically stable. For these reasons, it is desirable for them to partake in recreation that reminds them of parts of their earlier life, and to reflect on their life's experiences.

Based on this perspective, the staff at our group home Terado are devising ways to restore their residents' feelings of self-determination, respect their independent lives, and reduce their anxiety from both hardware and software aspects. This consequently provides a better understanding of the residents' role and place in the community.

Providing activities that are rooted in traditional Japanese culture is one such practice for implementing Terado's philosophy. We provide residents with dementia the opportunity to take part in special events like New Year's tea ceremony, a Bon Odori festival, and flower arrangement, where they wear seasonal kimono (Japanese traditional formal ware). Figure 1 shows a scene of New Year's first tea ceremony in Terado. Even long-term residents who need long-term care and don't seem to be able to wear kimono in normal circumstances have a dignified elegance and a reminiscent mood while wearing kimono during these events.

Figure 1. The New Year's tea ceremony at Terado

The lessons in Japanese flower arrangement discussed in this paper were carried out in the Terado group home under the cooperation of the Ikenobo Society of Floral Art of Kyoto. Residents, care staff in our group home and healthy elderly people from the area learned Japanese flower arrangement together. Japanese flower arrangement is part of Japanese traditional culture, and is well-known by all Japanese. It is easy for Japanese people to imagine, even for people without experience. This sense of familiarity is both strong and widespread. Therefore, lessons in Japanese flower arrangement might be utilized for dementia care targeting a large group of Japanese residents.

METHOD

How to Plan Japanese Flower Arrangement Lessons

To conduct Japanese flower arrangement lessons targeted towards sufferers of dementia requires sensitivity to their needs, which are different from those of healthy people. We discussed these considerations with care staff and the instructor. Accordingly, the following steps were carried out to create an atmosphere where residents became willing to take part in the lesson.

1. We talked with residents about Japanese flower arrangement more than a week before in order to encourage their interest in the lesson.

2. In addition to residents, we spoke to their family members to encourage the idea of the lesson as psychological occupational therapy.

3. Care staff started to tune up the physical condition of their residents, especially promoting regular diurnal sleep cycles.

4. The instructor and care staff became familiar with each other in advance.

5. The instructor worked to understand the mentality of people with dementia, and learn more about the disorder. For example, an instructor should not consider people with dementia unable to perform Japanese flower arrangement, "because they cannot understand it."

During the lesson, we decided to keep in mind the following.

6. When we introduced residents to the venue of the lesson, we did not force residents to take part in the lesson. We paid attention to their mental, emotional, and physical conditions.

7. All tools to be used in the lesson, including flower shears, vase, and pinholder, needed to be real equipment.

8. Care staff should call residents by name more frequently than usual, as keeping attention for long periods is often difficult for people with dementia. Also, by sharing the schedule of the lesson between the instructor, care staff and support volunteers beforehand, we should be sure residents always have something to do during the lesson.

9. Small failures in the lesson should be allowed, and we should not damage the residents' pride. For example, if a resident cuts off the head of the flower, the care staff might add a new flower to their arrangement without the resident's noticing, and make the final arrangement look fine.

10. To make the lesson fun for every resident, the members of each table should be assigned with consideration to residents' interpersonal relationships.

How to Perform Japanese Flower Arrangement Lessons

The place, time and frequency of the lesson are as follows:

Place:	Living room on the second floor of Terado
Time:	About two hours, starting at14:00 (including the snack time)
Frequency:	Monthly (lessons are ongoing, and have been conducted five times at the time of writing.)

Figure 2 shows a scene of the lesson. The schedule on the day of the lesson was as follows.

1. In the morning of the day of the lesson, in order to warm up the atmosphere of the group home, care staff spoke to residents more actively than usual, and started the preparation of the lesson.

2. After lunch, care staff spread newspapers on the tables for the lesson, and brought out the tools used in cooperation with residents. After final confirmation of the participants, care staff determined the seating arrangement of the residents.

3. The instructor arrived at 2:00 pm. After greeting the instructor, the lesson began with an introduction to the materials of the flower arrangement.

4. The instructor explained what flower arrangement style residents were to follow in the lesson using a white board. Teaching materials were also used as needed.

5. Then, residents arranged flowers freely as the mood took them, regardless of experience. Support volunteers, the instructor, and care staff supported the residents as needed.

6. Residents took a break around 3:00 pm for a snack.

7. After finishing their flower arrangements, they shared their arrangements with each other.

Figure 2. A flower arrangement class at Terado

Participants in Japanese Flower Arrangement Lessons

The number of participants in a lesson is shown below. In some cases, residents didn't take part in the lesson due to their physical condition at the time. Therefore, the number of participants differed for each lesson. Our group home Terado is characterized by its openness to the community, so we also recruited local support volunteers and elderly members of the community.

Residents of our group home:	5-8
Elderly living in this region:	2-4
Support volunteers:	2-5
Care staff:	3-5

Measuring the Effects of Japanese Flower Arrangement Lessons

To evaluate the effects of the lessons, we assessed the psychological state of the residents. For this purpose, we used the emotional assessment part of the GBS scale for assessing the severity of functional aspects of dementia (Gottfries et al 1982). Assessments on the day of the lesson were timed as follows.

A: Before the lesson (e.g. before lunch)
B: During the lesson
C: After the lesson (e.g. before dinner)

In particular, seven point scales from 0 (normal) from 6 (very bad) were used to assess the following items: “Emotional blunting”, “Emotional liability”, “Reduced motivation”, “Anxiety”, “Reduced mood” and “Restlessness.” All assessments were done by trained care staff.

Also, after the lesson, we gathered additional details that showed the effect and changes in residents that would not have appeared in the GBS scale by conducting interviews with the care staff who participated in the lesson, the residents, the instructor, and the assistants.

RESULTS

GBS Scale Results

So far, ten residents have experienced flower arrangement lessons. However, during these five months, only four residents participated in all five lessons. We show the average assessment results of the GBS scale of these four residents before, during, and after the lessons in Figure 3.

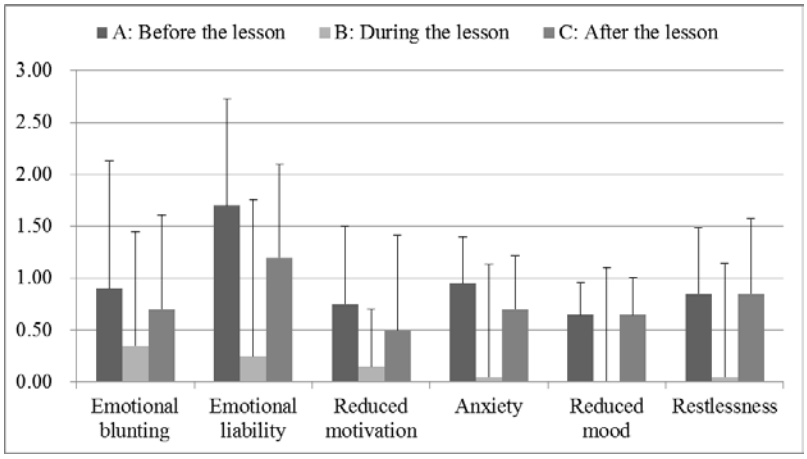

Figure 3. The results of the GBS scale assessment

From Figure 3, we can see a decrease in GBS scale during the flower arrangement lessons, i.e. an improvement in emotional state of the residents has been found. There are items that indicate the improvement of the state after the lesson compared to those before the flower arrangement. From the results of one-way analysis of variance, the averages of the scores for "Emotional liability" ($p < 0.01$), "Reduced mood" ($p < 0.05$) and "Restlessness" ($p < 0.05$) shows significant difference between groups: A, B and C.

Interview Result

The following results became clear from interviews with the instructor and the care staff, residents, and assistants who participated in the lessons.

1. Lessons usually lasted for two hours. Although residents took a break, they could not maintain physical strength and concentration during the lesson, and started to doze off. For almost all residents, it was difficult to concentrate on the lesson for more than one hour. Some improvements in the lesson plan are desired to help accommodate this issue.

2. Some residents had difficulty communicating during the lesson because they did not have a trusting relationship with the elderly community members participating. Due to the residents' personalities, the participation of the community members became an issue. While our group home philosophy requires us to be open to the local community, we should consider the needs of these residents more carefully.

CONCLUSION

We hope that our group home provides hope for people with dementia, who suffer from stress, a sense of loss, loneliness, and despair, and the family members who take care of them. We want our residents to live in our group home and smile every day. However, the reality is that it is difficult for care staff to provide each resident with one-on-one care and a custom program due to a shortage of staff. Under these limitations, residents' participation in the flower arrangement lessons has brought precious times to every resident. Care staff thought it was rewarding work. As shown in this paper, using a traditional Japanese craft like flower arrangement as an activity for people with dementia is acceptable regardless of gender. It touched their hearts and provided some measure of healing.

On the other hand, the effectiveness of flower arrangement is largely dependent on environmental considerations.

For example, Japanese flower arrangement requires such tools as flower shears, a vase, and a pinholder. It is a simple thing to substitute craft scissors for flower shears, and the pinholder, a collection of sharp needles, is also a potential safety hazard. Although it is difficult for residents to handle, we should prepare the real tools for the beginning of the lesson to create an authentic atmosphere. After starting the lesson, we can replace these real tools with simpler, safer ones like craft scissors, an oasis, and so on. By exercising such ingenuity, we allow residents to truly enjoy the activity without safety risks.

The instructor must also be genuine. There is no meaning for care staff to play the instructor role, because residents do not understand the essence of Japanese flower arrangement by language. It is important for residents to take lessons from a certified instructor in the classical school. In fact, one resident with dementia stated that she learned "Shin," "Soe," and "Tai," that are the basis of Japanese flower arrangement very long time ago. Her attitude toward flower arrangement was very mature. We hope that, by touching these aspects of our residents, young care staff will realize the interactive nature of dementia care, and add their experienced care while upholding the dignity of the residents.

The reason why Japanese flower arrangement is accepted by Japanese regardless of experience and gender is because there was a period when it was considered an important aspect of domestic training, along with tea ceremony. Every Japanese citizen understands the cultural significance of this traditional art, as it is rooted in the cycle of seasons and the Japanese respect for nature. It resonates with our minds.

From the point of view of reminiscence therapy, it can be expected to bring a nostalgic feeling by recalling the alcove in a traditional Japanese room where flowers are displayed, school flower beds, or the gardens and fields where residents played in their youth. In fact, one resident requested we use cosmos because she liked its flowers and they were familiar to her.

The instructor from Ikenobo School asks the students of the lesson to face the flowers sincerely. The instructor teaches the students by saying that you reproduce the means by which the plant extends its leaves toward the sunlight. Flower arrangement is a dialogue with flowers, which do not have a language; it is similar to our conversations with people who suffer from dementia, which cannot be shared with healthy people. What we need for both people with dementia who have difficulty with language and unspeaking flowers are imagination, creativity, and the power of compassion.

By seeing the growth of leaves of the flower, we know the way how it grows. By facing people with dementia, we give more than a passing thought to the stories of their lives. In near future, in the field of dementia care, we want to make use of other Japanese traditions, including tea ceremony and incense burning, to improve the quality of our care.

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The Development of a Mental Support System for the Elderly Living in Depopulated Areas of Japan

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ABSTRACT

We have studied a method to improve the QOL for the elderly receiving facility care, or home care in depopulated areas of Japan by taking advantage of information and communication technology (ICT). As part of these efforts, old photos of the elderly were digitized and uploaded to cloud services. We created an environment to make these images accessible to staff caregivers so that they could utilize the data in various long-term care settings. Multimedia, such as interactive digital photo albums and slide show videos were produced by using uploaded photos. The elderly, along with their families and caregivers enjoyed watching personal images which resulted in stronger relationships with family and the care staff. We also created an environment to introduce and promote video chat software in order to increase the opportunity of communication between the elderly and their significant others. Video chat software makes it possible for the person you are talking with to share reminiscent media, as described above, and to be able to listen from a remote location. Finally, we have organized human resources and collaborated with a local welfare service and a local hospital in order to provide support to the elderly living alone. A method was proposed to build a rapport between the elderly and their support systems..

Keywords: The Elderly, Depression, Dementia, Reminiscence, Internet, Local Welfare

INTRODUCTION

Because one in four of the total population in Japan will become elderly in 2015, the establishment of quality care to support the dignity of the elderly is urgently needed. Elderly living alone are often subject to cognitive decline caused by brain disorders, anxiety and fear of disease, loneliness, and thoughts of a hopeless future. Due to anxiety and stress, many develop psychiatric symptoms. In particular, symptoms of depression were reported and resulted in

about 15% of the elderly over the age of 60 having specific symptoms of depression, and about 5% were diagnosed as depressed. Depressive symptoms lead to the deterioration of physical function and cognitive decline. Inactivity led to the inability of self-care and the necessity for medication. Consequently, cognitive function declined even further as a result of the above mentioned data. Mental decline is a negative spiral, and results in the demise of the elderly's life at home. According to the survey of Omori et al., about 30% of community-dwelling elderly were tested positive when given the screening test for depression. The risk of being certified in need of care from the public nursing care insurance system was approximately doubled in the depressed group (Ohmori 2010). In order to improve mental disorders such as depression and prevent cognitive decline of the elderly, it is important to stimulate their cognitive function by promoting communication with others. For example, by combining the intervention of suicide prevention with depression screening, suicide rates were reduced to about 50% (Ohyama 2010). Also, when you turn your eye to elderly facility residents, dealing with dementia such as Alzheimer's disease, which has soared in recent years, has become the most important issue for long-term care facility staff, as well as for the elderly.. So far, there is no radical treatment for most dementia. Therefore, supportive measures which include a combination of non-drug and drug treatments are generally used. Under these situations, we are conducting nursing care research by utilizing information and communication technology (ICT) for the purpose of QOL improvement for the elderly who reside at a facility or home. The content of this paper introduces the mental support system of the elderly living in the Tango area, north of Kyoto prefecture. A collaborated effort was established between our research, the local welfare center, the local hospital and nursing homes.

RESEARCH GOAL

When considering the at home environment for the elderly, the local community, where the elderly previously gathered to socialize played an important role. However, maintaining local communities has become difficult due to rapid aging and a decline in the population. For this reason, mutual assistance between local residents is no longer functional. Such a phenomenon is noticeable in areas which experience a lot of snow, and also areas where settlements are scattered throughout a large region. The current care insurance service mainly serves those with physical disabilities, and does not provide care for those with mental disorders. In addition, a psychiatric specialist rarely collaborates with the home care support team, which consists of a visiting nurse, care manager, and caregivers from the local elderly care management center. In particular, the aging rate of the Tango region where Kyoto Tango health center is located, reports a 28.9% of the overall average, and is noticeably far beyond the 20.1% national average. Numerous elderly live alone or as couples in this region. Due to scattered settlements, it is difficult to expand community-based services as the traffic is often disrupted because of snow during the winter months. A few years ago, a heavy snowfall prompted many elderly living at home to call the local Tango district elderly care management center to express their anxiety. For this reason, the authors are in the development of an ICT system in order to support the mental health of the elderly. The system allows for communication between the elderly, local volunteers, the home support team, and a psychiatric specialist in the Kyoto Tango region. The aim is to rebuild the mutual aid function of the community by introducing the ICT system to the region. Our hope is that the psychiatric symptoms of the elderly will improve, and consequently delay the need for institutionalization. The field of nursing care, is important and is based on good relationships established within the local community. Therefore, nursing homes actively work on intercommunication with local residents. However, the frequent implementation of such intercommunication is difficult due to the busy schedules of the care staff. Also, the elderly with dementia, that reside in a nursing home, experience memory problems which prevent them from sharing common experiences with the local community. Therefore, it is our goal to reconstruct the family ties of the elderly with dementia, and build new ties between the local community. Assisting in memory function, such as retention and recall of old memories and the formation of new memory by utilizing visual information is the goal.

MENTAL SUPPORT SYSTEM FOR THE ELDERLY

Related Work

Currently the ICT system is being used at home and abroad to study assistive technology for nursing care, and research and development in relation to the daily support of the elderly with dementia. A research and development project using network interaction therapy studied subjects with higher brain dysfunction. The project was sponsored by the National Institute of Information and Communications Technology in Japan (Kuwabara et al 2004). In this project, I was mainly engaged in research of remote care support technology. The project researched topics that included the implementation of assistive technology for subjects with higher brain dysfunction. The sensor network

technology and media technology, which began in September 2003, and finished in March 2008 were fully used. Recently, various studies including a partner robot study have been carried out to collect information regarding the support of people with dementia. Example (Inoue et al 2012).

However, such an engineering project which utilizes state-of-the-art technology usually encounters problems. Deployment of the system to general households, and maintaining the operation of the system can be an issue. On the contrary, we are researching and developing a mental support system based on the remote assistance system that has already been proposed (Kuwahara et al 2010). This remote assistance system is available by using conventional technologies like broadband Internet connection and personal computers, and it is cost effective.

Overview of Our Proposed Mental Support System

The ICT system supports the mental state of the elderly and consists of three subsystems. I will introduce each subsystem as described below.

Remote Assistance System

The remote support system consists of a remote active listening system and schedule reminder system, as shown in Figure 1. I continued my research after finishing the networked interaction therapy project. This system is available when a broad band internet connection and a personal computer are available.

Figure 1. A scene of remote active listening system usage

A remote active listening system assists those talking to the elderly during a video chat. In order to promote the conversation, reminiscence contents like photos, videos, and music can be shared between the elderly and their talking partners. The elderly who show signs of depression and cognitive decline due to isolation, experience hypobulia. Less interaction and lack of brain stimulation results in a decline of life and cognitive function. By using this system, the elderly can experience exchanges with others while staying at home. Due to rapid progress of Internet technology, Skype® enables us to perform the same functions as those of our developed remote active listening system. It provides a video chat and also a remote desktop sharing function that makes it possible to share reminiscence content, such as photos, videos, and music. Therefore, Skype® is used as our remote active listening system. In order to assist the elderly who are not familiar with technology, the partner talking with the elder can operate the elder's system remotely by using Chrome® remote desktop by Google Inc. Also, we introduced a Vod Burner® to record the video chat between the elder and the person they are talking with. Facial expressions and utterance rates of the elderly were extracted from the recorded data, and used to perform an early screening for depression.

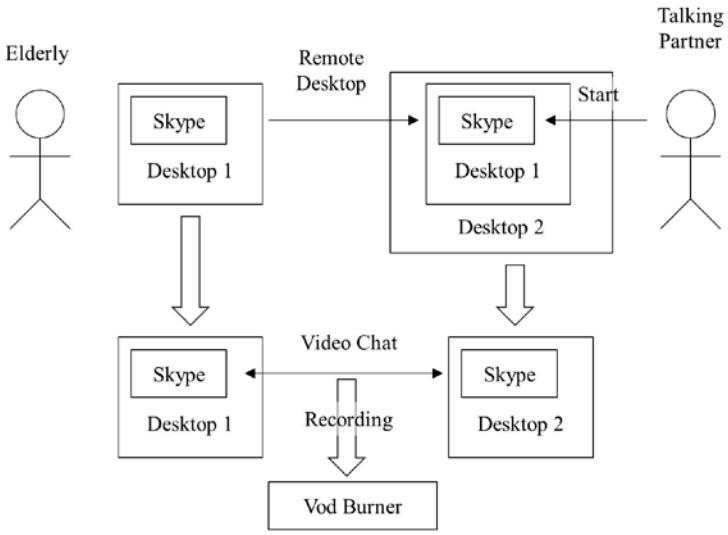

Figure 2. Configuration of remote active listening system

The schedule reminder system provides cues to the elderly reminding them to change clothes, eat a meal and take their medication by notifying them via video from a personal computer. This is a support system for the elderly who are in a preliminary group of depression, and are less likely to take care of themselves due to a lack of initiative to live independently (Kuwahara et al 2010). In addition, by using the remote assistance system, direct intercommunication between the elderly at home and their talking partners is encouraged, resulting in fewer psychiatric symptoms. It also prevents a decline in life style and promotes cognitive function.

Information Sharing System between the Elderly's Family, Medical and Welfare staff

At present, the case conference system between care managers and psychiatric specialists using videoconferencing is currently operational in the Tango district, Kyoto prefecture (Narumoto et al 2011) as shown in Figure 3. We are adding a new function to this information sharing system in order to extract useful information to assess symptoms of depression in the elderly. Primary information, such as video and audio of the video chat data were collected from the remote support system described above. Specifically, when the elderly utilize our proposed remote support system, their fundamental frequency of speech, utterance rate, and facial expressions will be extracted from video and recorded audio.

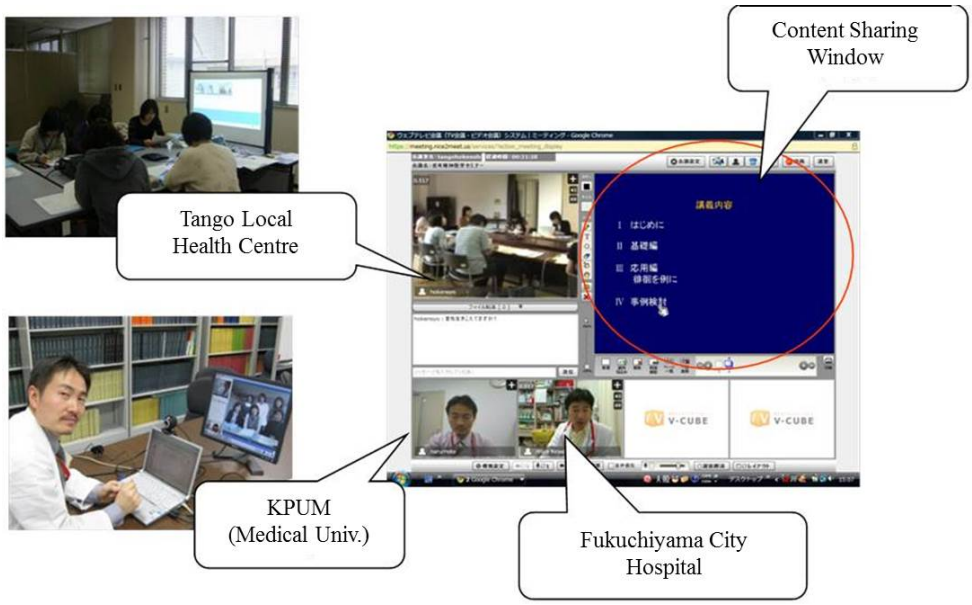

Figure 3. A usage scene of information sharing system between family of the elderly, medical and welfare staff

Facial expressions are analyzed as follows. First, the area of the face is extracted from each frame by classifiers, and a front-view dynamic facial image is included in an Open-CV. The Haar-like feature parameters and Adaboost algorithm for learning are used as the classifiers. It is assumed that the distance between a subject and the camera generally remains constant during a Skype conversation. Next, by using an Open-CV, the area of the mouth is extracted for a frame selected by certain face-area size criteria. The area of the mouth is chosen because the differences between facial expressions of neutral and happy are distinctive in this area.

We compared the facial expression analysis results of one elderly person (gender: female, age: 80s) to the subjective evaluation of her facial expression. The subjective evaluation was conducted as follows. The evaluator scored the facial expression in the recorded video by a seven point scale system from -3 (negative) to 3 (positive) every second. Figure 4 shows the result of the correlation analysis of five minute recorded video footage. The correlation coefficient is 0.28 ($p<0.01$). So far, we obtained a weak correlation between the subjective evaluation results and the facial expression analysis results. We investigated by using these facial expression features to infer the mental state of the elderly subject.

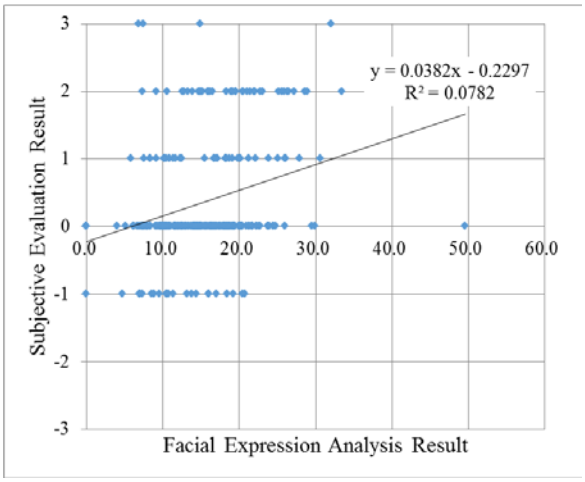

Figure 4. Correlation Analysis Result between Subjective Evaluation and Facial Expression Analysis

Organization of Human Resources for Our Proposed Mental Support System

Figure 5 shows how we organized human resources for our proposed mental support system in the Tango district of Kyoto prefecture. The elderly living alone and experiencing depression usually see a psychiatrist from the local hospital once over a course of several months. Information regarding elderly in a delicate state of mental health is regularly shared between a psychiatrist, health outreach workers from the Tango public health center and local volunteers. Local volunteers communicate with the elderly once a week by using the remote active listening system. . When local volunteers notice something different about the elderly during a remote non-drug intervention, they contact the health outreach workers to request the necessity of a visit to the elder's home. If a health outreach worker recognizes the need for medical intervention, they request that the elder go to the hospital.

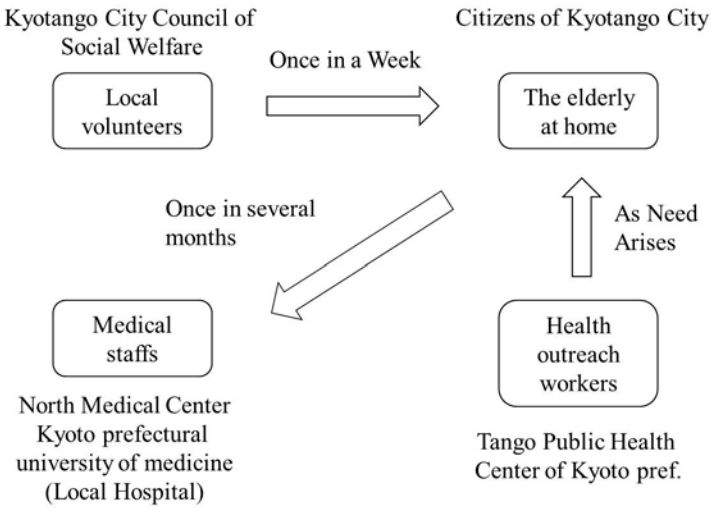

Figure 5. Organization of Human Resources for Our Proposed Mental Support System

MEDIA THERAPY: RAPPORT BUILDING BETWEEN THE ELDERLY AND OTHERS

Overview

In order to operate our proposed mental support system, good relationships between local volunteers, care staff and the elderly are key. In collaboration with a UK university hospital and Microsoft Research, Inc., it was reported that a woman with moderate dementia had the ability to create new episodic memories by reviewing photographs of her husband (Hodges et al 2006). As a result, the couple could share common topics in their daily life, and their relationship was restored. We are researching media therapy as our proposed method to assist the elderly with memory by visualizing their episodes, and utilizing this visual information to build and restore good relationships between the elderly and others. In research on assistive technology in dementia care, the authors confirmed the effects on the emotional stability of individuals with dementia by using a reminiscence video (Kuwahara et al 2005). The above mentioned research indicates the effectiveness of a reminiscence video, not only for emotional stability of individuals with dementia, but also for building good relationships between the elderly and others. This case shows that sharing memories is the key for building a rapport.

Based on this idea, we have devised media therapy. The first step to our approach is to use memorable photographs relating to the elderly while local residents and care staff carry out the active listening system portion with the elderly. By creating media as a reminiscence video based on episodes obtained from the active listening, the elderly, local residents, and the care staff can share memories of the elderly by watching a video. In return, a rapport is built amongst the local residents and the care staff which supports the memory of the elderly at hand. In addition, we continue to record exchanges, both in the real world and the virtual world with local residents and the elderly. We then store the data to the cloud service as a video archive. By utilizing records from the past and present, we attempt to help the memory consolidation of the elderly, and to build relationships between the elderly and others.

Case 1

From 2011, our students regularly visit the Kyotango city, Kyoto prefecture nursing home. They perform active listening with residents from this facility. Students listen actively to a story behind each photograph of the elderly, and make a database of photographs with episodes taken from the elderly. They also create slide show videos for the elderly by using this database. Then, a screening of the videos is held at the nursing home for the elderly, care staff and students. The video creates a new rapport between all parties. After a rapport has been established, our students use the remote active listening with residents from the University in Kyoto once a week in order to maintain a good relationship between them. Figure 6 and Figure 7 show student scenes of active listening and the remote active listening. Figure 8 shows a screening of one of the created videos.

Figure 6. A scene where a student practices active listening with the residents of a nursing home

Figure 7. A scene where a student is performing remote active listening with the residents of a nursing home

Figure 8. Scene from a screening of one of the created videos

Case 2

A group home is one of the community-based services which is a part of the ‘‘Long-term Care Insurance System’’ in Japan. The home helps people with dementia continue to live their lives at ease. The care staff takes care of the elderly with dementia 24 hours a day. In order to provide quality care to the residents, a trusting relationship between the residents, their family members and the care staff is essential. We are conducting other forms of media therapy in a group home called “Terado”, located in Mukoh city, Kyoto prefecture. The evaluation of the effect of our proposed media therapy, as it pertains to quality care is the focus of our research (Doi et al 2013). The media therapy includes interactive digital photo albums which have been created with a collection of old photos of each resident. The residents, their family members, and care staff got together in the multipurpose room of the nursing home and conversed freely about the resident's life by looking at the pictures projected on the large screen as shown Figure 9. At present, we have applied media therapy to three residents. All residents and their families have established a trusting relationship with the care staff, and consequently the quality of care for each resident has been achieved. This paper shows the result of media therapy for one resident and validates the improvement of her quality of life.

Figure 9. A scene of media therapy

A female resident in her 80s was difficult to manage because of her frequent agitation and delusional feelings throughout the day and night. As a result, her family became exhausted trying to take care of her and became apathetic when care was needed. The care staff and residents in the group home were affected in an adverse way to the ongoing demands of this female.

Media therapy was scheduled for her once a week over a course of six weeks. Each session did not exceed 60 minutes. Observations made by her primary care staff were as follows; reviewing her life history with family and the care staff seemed to make her happier than usual. She seemed to feel special because many people gathered to attend her 1st session. In the 4th session, emotional incontinence was observed. However, she became emotionally stable after the topic of the conversation changed to the days when she worked as a nurse for a university hospital. Recalling memories of her nursing career seemed to make her peaceful. Since this experience, a family member gradually expressed their appreciation for her. We compared the recorded data on nursing records when it came to the amount of time the resident slept, the resident's complaints and the amount of time the care staff spent coping with the resident's claims. Data was collected before / after media therapy. Figure 10 shows the comparison of her amount of time spent sleeping according to the nursing care record before / after the therapy period. The average time spent sleeping in a one month period before/after the media therapy remained constant.

Figure 11 shows the comparison of the probability of the resident's occurrence rate of complaints in a day for one month before / after the media therapy. The occurrence rate was calculated in a manner that the number of days when the resident's complaints were observed by care staff was divided by the number of days in one month. Figure 12 shows the comparison of the average time the care staff spent coping with the resident's complaints in a day, and at night for one month before/after the media therapy.

Through media therapy, she shared her history of her life with the care staff , and in return it helped build a more trusting relationship between them. Also, the media therapy gave her family the opportunity to rediscover and appreciate her as a person. In this case, prior to her media therapy sessions, the care staff found it difficult to cope with her agitated behavior, and felt seriously distressed when dealing with her. Because the care staff understood her life history and were exposed to her media therapy sessions, they obtained the skills and confidence to cope with her BPSD effectively. After our proposed media therapy, she established good sleep habits and complained less. Also, the care staff became very good at coping with her claims. These changes improved her quality of life.

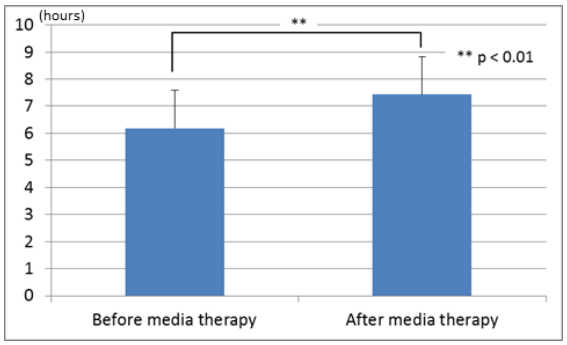

Figure 10. Resident's sleep time per one day for one month

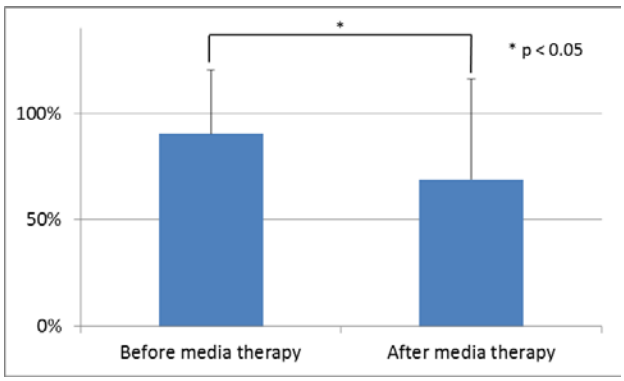

Figure 11. Occurrence rate of resident's claims per one day for one month

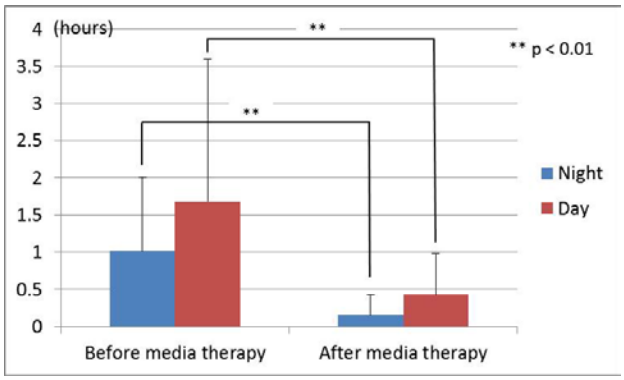

Figure 12. Time of care staff's coping with resident's claims per one day for one month

CONCLUSION

We introduced a mental support system for the elderly living in depopulated areas in Japan, and the human resource organization which can execute our proposed system. The key to success for this system is a trusting relationship between the elderly and all those who support them. Therefore, we also propose utilizing media therapy to establish a rapport between the elderly and their support network.

The mental support system has been operational for almost a year. Four elderly people with mild depression have received remote intervention from local volunteers once a week during this period. Medical staff have evaluated their mental state by using several psychiatric evaluative indexes. Although data analysis is yet to be done, every subject retained a relatively good mental state. We coordinated a smooth transition between local volunteers and health outreach staff. We also showed that media therapy was effective in building a rapport between the elderly and their support group. Despite a few cases, the majority experienced a QOL improvement.

Through our research, we would like to contribute to the realization of a society where the elderly are able to spend their lives with dignity, even in a super-aged society like Japan.

ACKNOWLEDGMENT

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The Effect of Salt-Shrinkage on the Silk Union Fabrics by Continuous Treatment System

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ABSTRACT

The continuous treatment system of salt-shrinkage and their use to improve stretch and crease resistance by silk union fabrics. Calciumnitrate (specific gravity 1.43) were produced on silk union fabrics. The fabric stretch to the ASTM D3107-07(2008) test over five repetitions was determined. When applied to silk/cotton and silk/wool union fabrics by a continuous treatment procedure, in the presence of sodium nitrate, all of these fabrics gave excellent stretch and crease resistance properties, although the times required varied. The continuous treatment procedure required to achieve stretch and crease resistance, about 3 to 5 minute**s.**

Keywords: Silk, Salt Shrinkage, $Ca(NO_3)_2$, Union Cloth, Crease-resistance, Stretch

INTRODUCTION

The silk products, fashion is excellent basically, when it is a chemical process for functionalizing shape stability, such as chemical fiber, various difficult to impart a different functionality from the prior art, silk it is necessary to minimize the characteristics of the compromise.

The fiber exhibits not only excellent affinity for dyes, but also the sense of vitality which is not readily felt in other fibers since it belongs to the animal fibers. Silk fiber, however, has demerits as follows: low dimensional stability, to damages by acid and alkali, yellow discoloration due to ultraviolet rays, and discolorations due to salts including perspiration have been presented.

Novel finishing methods have been developed continuously in order to create the high sensibility out of silk fibers. Salt shrinkage finishing has a long history of utilizing the property of contraction caused by inorganic salts. Most of the accompanying changes by the shrinkage finishing procedures are the increase of shrinkage rate, the decrease of tenacity and Young's modulus, the increase of elongation, and the increase of resilience of elasticity (Lee et. al., 1997).

The method for dimensional stability of silk products, salt-shrinkage process, and the like, these processes are, for using inorganic salts of excessive : Material of the processors used, temperature difference of processing in-flight up and down due to the high percentage, inorganic salts, which are absorbed in the fiber because there are many, the difficulty of maintaining the concentration, short processing time, etc. The product was released risk of damage of the fibers than by such as high, there was little (Lee et. al., 1998).

As a solution to these problems, continuous and how to process material of the material in strong inorganic salt is required. The material of the processing machine can be made to order if there is a variety of materials, even the solution in a number of ways, the other conditions will be maintained to the form stability of the silk products but it vary according to the degree of shrinkage it is necessary to work looking for conditions. In this study, investigated the effect on the stretch effect, dimensional stability, and wrinkle resistance by salt-shrinkage process in order to improve the easy care of the union of silk, and of a continuous process for mass production was considering the application little (Choi et al., 2009).

EXPERIMENTALS

Specimens and chemicals

Fabric Specimens

Use jacquard and dobby, by using silk warp, using silk, cotton, wool, nylon and the weft were woven as described in Table 1. The specimens for the salt shrinkage finishing were cut to the size of 36x44in.

Reagents

Calcium Nitrate ($Ca(NO_3)_2 \cdot 4H_2O$) was used for the salt shrinkage finishing. The reagent was dissolved in the deionized water to reach the specific gravity of 1.35, 1.38, 1.41, 1.43 and 1.45. The test used SP-20 (Hea-sung chemical, Korea) as a dispersing agent for the removal of unreacted inorganic salt.

Table 1 Characteristics of the fabrics specimen

Sample No.	Fabric weave	Fabric composition	density (Ends/in)	weight(g)
DS-1	plain	silk 100%	132×120	55
DS-2	plain	silk 100%	132×120	55
DS-3	1/4twill	warp : silk 100% weft : silk 30% wool 70%	264×130	200
DS-4	plain	warp : silk 100% weft : silk 20% wool 80%	132×76	80
DS-5	satin	warp : silk 100% weft : silk 26% wool 74%	264×105	280
DS-6	satin	warp : silk 100% weft : silk 60% cotton :40%	264×100	123
DS-7	plain	silk 100%	264×100	110
DS-8	1/4twill	warp : silk 100% weft : silk 40% rayon 60%	132×120	177
DS-9	satin	warp : silk 100% weft : silk 60% cotton 40%	264×120	140
DS-10	2/2plain	warp : silk 100% weft : silk 35% cotton 65%	264×120	130

Experimental methods

Effect of specific gravity change on the salt shrinkage

In the case of 1.35 ~ 1.45 of $Ca(NO_3)_2$ in specific gravity, fabric specimens were treated for 3min, while maintaining treatment temperature of 80℃. After removal of inorganic salts unreacted with a dispersing agent, and washed with water. After the treatment, specimens were dried under room temperature.

Effect of temperature change on the salt shrinkage
The effect of temperature on the salt shrinkage was investigated using a $Ca(NO_3)_2$ solution in 1.43 specific gravity with temperature 70, 75, 80, 85 and 90℃. After removal of inorganic salts unreacted with a dispersing agent, and washed with water. After the treatment, specimens were dried under room temperature.

Effect of time change on the salt shrinkage
The effect of time on the salt shrinkage was investigated using a $Ca(NO_3)_2$ solution in 1.43 specific gravity with time 1, 2, 3, 4 and 5min, while maintaining treatment temperature of 80℃. After removal of inorganic salts unreacted with a dispersing agent, and washed with water. After the treatment, specimens were dried under room temperature.

Pilot test
The field test was proceeded time change on the salt-shrinkage was the optimum condition for the laboratory based on the fabric is woven. Pilot test conditions were tested 1, 3, 5 min each specific gravity 1.43, at 80 ± 2 ℃ temperature. After removal of inorganic salts unreacted with a dispersing agent, and washed with water. After the treatment, specimens were dried under room temperature.

Measurement and Analysis

Stretch effects
Stretch effects of the fabric specimens was tested by the method of D3107-07 (2008) ASTM.

Fabric Stretch 10s after Tension, % = $100 \times (A\text{-}O_1)/O_1$
※O_1 : original gage length
A : read the fabric stretch

Measurement of shrinkage by washing
Shrinkage by washing of the fabric specimens was tested by the method KS K ISO 7771

Shrinkage ratio, % = $(L_0 - L)/L_0 \times 100$
L_0 : original fabric length
L : After treatment fabric length

Measurement of washing fastness
A washing fastness was tested by the method KS K ISO 105-c1.

Measurement of crease recovery
A crease recovery was tested by the method KS K 0550.

RESULT AND CONSIDERATION

Effects of salt-shrinkage of silk fabric

Effect of specific gravity change on the salt shrinkage
Figure 1 show the results of the treatment under the condition maintaining 3 minutes and temperature of 80℃. As shown in Figure 1, the silk fabric was shrunk with specific gravity. The reaction hardly occurred at a specific gravity 1.41 or more began to increase with specific gravity. It is found that the effect of salt shrinkage is extremely sensitive to the specific gravity. Treatment of specific gravity in 1.45 reduced the original down to almost half the size.Shrinkage of about 10% is generated lengthwise. In terms of fabric's convention, area reduction down to half the size after finishing is a very high shrinkage rate. It seems to be an highly excessive treatment condition.When we reviewed the 1.43 treatment results, the shrinkage ratio are not so high as we had expected. From this fact, it

seems that the shrinkage is almost completed between the specific gravity in 1.43~1.45 in the case of 80℃ treatment.

Effect of temperature change on the salt shrinkage

Figure 2 show the results of the treatment under the condition maintaining specific gravity 1.43 and 3 minutes. As shown in Figure 2, the silk fabric was shrunk with temperature. It is found that the effect of salt shrinkage is extremely sensitive to the temperature. When we reviewed the 80 and 90℃ treatment results, the shrinkage ratio are not so high as we had expected. From this fact, it seems that the shrinkage is almost completed between the temperature 80~85℃ initial period in the case of specific gravity 1.43 and 3 minutes.

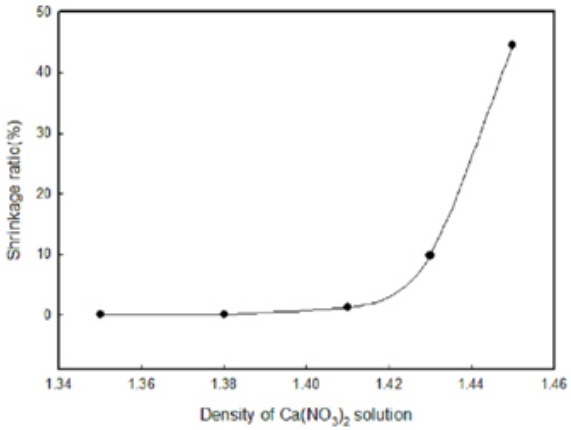

Figure 1. Shrinkage ratio with Density of $Ca(NO_3)_2$ solution

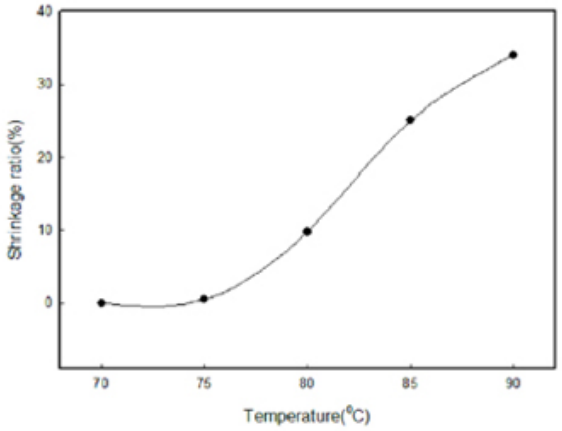

Figure 2. Shrinkage ratio with temperature

Effect of time change on the salt shrinkage

Figure 3 show the results of the treatment under the condition maintaining specific gravity 1.43 and temperature 80℃. As shown in Figure 3, the silk fabric was shrank with treatment time. It is found that the effect of salt shrinkage is extremely sensitive to the time. From this fact, it seems that the shrinkage is almost completed between the time 3~5 minutes initial period in the case of 80℃.

Effects of salt-shrinkage of silk union fabric

The salt-shrinkage field tests of union silk, use a cloth that they offered to the table 1, were studied around the factors that affect the easy care. The main factors of salt-shrinkage finishing evaluated the effect of processing time on stretch effects, shrink, wrinkle resistance and fastness to washing of silk union. The processing conditions of silk I tested 1, 3, 5 min each specific is the optimum condition of silk cloth gravity1.43, at 80 ± 2 ℃. The salt-shrinkage processing union of silk there is a sense of distance cloth after processing slip of silk the surface was very hard when dry. This phenomenon appears to be dried is in a state that is not completely removed by the washing step is an inorganic salt of unreacted. If the removal of the salts of unreacted not fully phenomenon that the reaction proceeds continuously during drying of silk union the fabric may be damaged also occurs when the amount of inorganic salt unreacted large, dough phenomenon break in tense also occurs. Therefore, to remove the unreacted salts silk of union were tested various washing preparation showed the best effect SP-20 chemical agent. Inorganic salt was sufficiently removed at a temperature of 50 ℃ or higher temperature the amount of the auxiliary agent used for washing was 20g / l.

Stretch effects of silk fabric treated with salt shrinkage

Figure 4 and Figure 5 show the stretch effects of silk fabrics and silk union treated with salt shrinkage and washing by SP-20. we did not take into account the shrinkage of the union in the stretch field test. In the final products there is no much sense form of the fabric first. The use of SP-20 was used to sufficiently removed quickly inorganic salts unreacted. As a result of the test union of silk when using wool, cotton by weft of silk union shrinkage does

not occur almost had no stretch. Therefore, in the analysis of the stretch in the union of silk was evaluated on the basis of the warp is being considered to affect only the stretch silk salt shrinkage processing.

Figure 4 show the fabric stretch of silk fabrics treated with salt shrinkage after washing. When we first review of effect on times, regardless of shrinkage of fabrics. As shown in Figure 4, stretch ratio of silk fabrics was highly than using raw silk warp direction stretch was highly than weft direction. This is because the density of fabric in the warp direction is high shrinkage occurs more by salt shrinkage is raw silk. Figure 5 show the fabric stretch of silk unions treated with salt shrinkage after washing. Stretch ratio of silk fabrics was higher in density of warp is small we suggested shrinkage due to salt shrinkage is because so much happened density is small this.

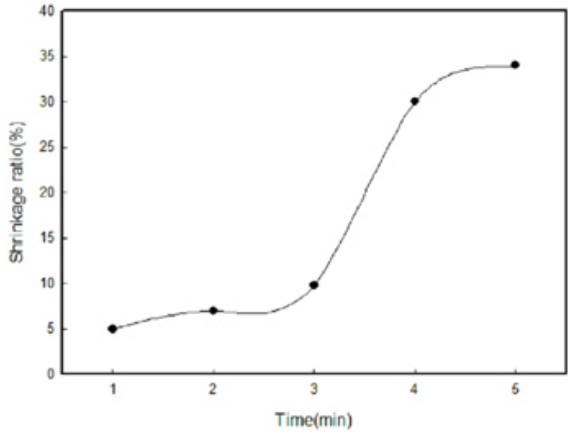

Figure 3. Shrinkage ratio with time

Crease Recovery

Figure 6 and Figure 7 show the crease recovery of silk fabrics and silk union treated with salt shrinkage and washing by SP-20. As shown in Figure 6, crease recovery of silk fabrics with raw silk, since the processing time is longer, the direction of the warp direction is showed a tendency to increase the crease of the raw silk, but weft direction was rather decreased. We considered to have occurred in the excessive shrinkage of the fabric.

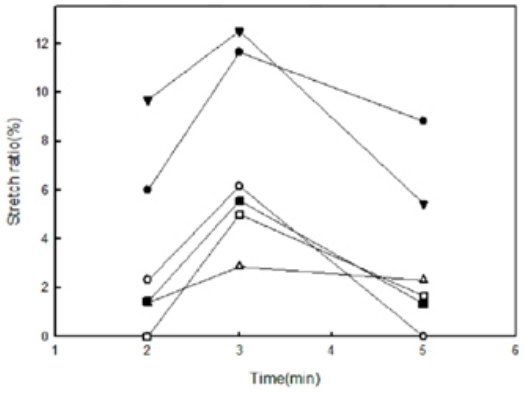

Figure 4. Fabric stretch of silk fabrics with salt shrinkage
(○ : sample 1, △: sample 2, □ : sample7, filled : warp, unfilled : weft)

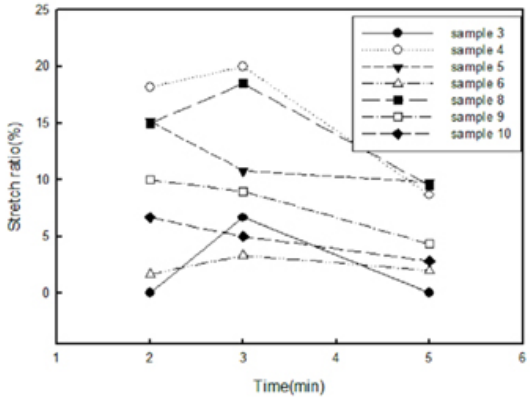

Figure 5. Fabric stretch of silk unions with salt shrinkage

Figure 7 show the fabric stretch of silk unions treated with salt shrinkage after washing. Crease recovery of the union was increased substantially by processing, but when other fiber and silk are mixed in the density of the silk by warp is high tend to decrease slightly crease degree revealed. Under the influence of raw silk wrinkle also slightly reduced in samples that have been mixed in the weft (sample 6, 8). The jacquard fabrics by using the degummed silk, crease recovery increased in mixed product (sample 9, 10).

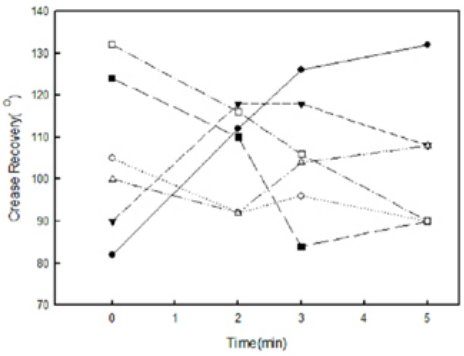

Figure 6. Crease recovery of silk fabrics with salt shrinkage
(○ : sample 1, △: sample 2, □ : sample7, filled : warp, unfilled : weft)

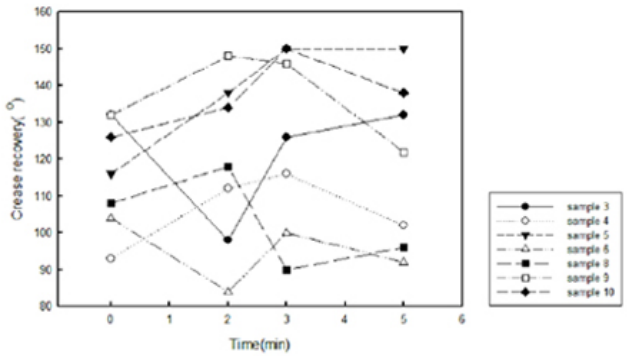

Figure 7. Crease recovery of silk union with salt shrinkage

Shrinkage and washing fastness

The samples that have been with salt shrinkage processed fabrics there was no change in dimension by the test. This appears to salt shrinkage condition has occurred in the conditions contraction stronger than washing field test conditions.

Table 2. Shrinkage of washing

no.		Time(min)		
		2	3	5
1	wp	0.00	0.00	0.00
	wt	0.00	0.00	0.00
2	wp	0.00	0.00	0.00
	wt	0.00	0.00	0.00
3	wp	0.00	0.00	0.00
	wt	0.00	0.00	0.00
4	wp	0.00	0.00	0.00
	wt	0.00	0.00	0.00
5	wp	0.00	0.00	0.00
	wt	0.00	0.00	0.00
6	wp	0.00	0.00	0.00
	wt	0.00	0.00	0.00
7	wp	0.00	0.00	0.00
	wt	0.00	0.00	0.00
8	wp	0.00	0.00	0.00
	wt	0.00	0.00	0.00
9	wp	0.00	0.00	0.00
	wt	0.00	0.00	0.00
10	wp	0.00	0.00	0.00
	wt	0.00	0.00	0.00

Table 3. fastness of washing

no.		Time(min)		
		2분	3분	5분
1	color change	4	4	4
	staining	4-5	4-5	4-5
2	color change	4	4	4
	staining	4-5	4-5	4-5
3	color change	-	-	-
	staining	-	-	-
4	color change	4	4	4
	staining	4-5	4-5	4-5
5	color change	-	-	-
	staining	-	-	-
6	color change	-	-	-
	staining	-	-	-
7	color change	-	-	-
	staining	-	-	-
8	color change	-	-	-
	staining	-	-	-
9	color change	4	4	4
	staining	4-5	4-5	4-5
10	color change	4	4	4
	staining	4-5	4-5	4-5

※ - : Notation is a white product.

It is predicted, not the fabric shrinkage and removal of the inorganic salts goods loosening occurs, the experimental results relaxation actual not occur. Acid dyeing product of raw silk cloth was excellent washing fastness.

CONCLUSIONS

By using a continuous processing apparatus for a scale up process development for the commercialization of salt shrinkage which remained experimentation various sample we have developed a process step of union silk and silk fabrics. We have investigated the effect on the physical properties for easy care for improvement through the field test.

In this study, various aspects properties of salt shrinkage phenomenon were reviewed by applying calcium Nitrate ($Ca(NO_3)_{2)}$ on silk union as object. Fabrics stretch change, Crease recovery and color fastness of washing were

investigated around shrinkage of silk fabric and silk union according to the change of treatment conditions.
The experimental results are summarized below.

In the case of specific gravity 1.43 of $Ca(NO_3)_2$ solution, treatment temperature of 80℃, the salt shrinkage is almost completed within initial 3mins.

Crease recovery is a decline rather than as a change in physical properties due to processing of raw silk. We plan to use the silk thread to use a degummed silk as much as possible.

A stretch effect by imparting salt shrinkage, samples has received a lot of influence of density of fabrics and types of textile and silk percentage of the weft. In the case of the actual sample stretch appears high in satin weave on is loose.

Wash fastness of the fabric has been improved over previous salt shrinkage in 4~5grade, there is no change even shrinkage samples dimension stability was improved.

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Design of Studded Paving Block and Bollard Using LED for Assisting Walk of Low-vision People at Night

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ABSTRACT

Individuals with low vision tend to avoid going out at night. This is because moving around at night can be very dangerous. The number of individuals with vision-related ailments is increasing with the growing elderly population. There is a need to make moving at night safer for them. In this research, 2 devices using LED lights to guide pedestrians suffering from low vision are designed. The first device is a light emitting studded paving block. By blinking LED lights, the location of studded paving blocks can be confirmed from a distance. The second is a light emitting bollard between car lanes and sidewalks. Up until now, the position of bollards has been difficult to detect visually at night. Making bollards illuminate allows their position to be confirmed and creates a safer atmosphere for the pedestrian. In this research, the brightness level that individuals with low vision are most likely to notice was sought through experiment, and technology was developed to retain this light over a long period of time using minimal electrical current.

Keywords: Light emitting studded paving block, Light emitting bollard, LED

INTRODUCTION

For many years, society has desired to create a safer environment for walking at night for the visually impaired (Kim et al., 2007). However, streets and roads have yet to be sufficiently equipped for ensuring the safety of elderly and the visually impaired pedestrians. In order to better support visually impaired pedestrians, studded paving blocks have been set up in the roads, at public facilities, at stations, at the entrances of stores, and in other places that may pose a danger to them. However, since they are almost hidden in the dark at night, it is very difficult for individuals with low vision to see them. There are even cases where they are painted with colors that do not stand out to preserve the scenery. In order to solve this problem, the authors of this research are developing light emitting blinking studded paving blocks and bollards. Because these can make intersections and sidewalks more visible, they are very effective at making night travel safer for individuals with low vision (Kobayashi et al., 2010, Oka et al., 2008). However, an objective evaluation of their visual detectability has not been made. In this research we have carried out an objective evaluation of the visual detectability of light emitting studded paving blocks and bollards and designed more detectable versions of them.

LIGHT EMITTING STUDDED PAVING BLOCKS

Operating Principles of Light Emitting Studded Paving Blocks

We will attain maximum detectability at minimum consumption of electricity by more meticulously controlling the control parameters that cause LEDs to blink. When driven by a general square wave, energy consumption is great and the energy supply is greatly depleted. In order to avoid this, we switched the drive to a pulse current. It is well-known that the brightness of the LED depends on the steep of the rising edge of the electric current in the LED (Morita et al., 2008). Figure 1 shows an example of a drive current waveform.

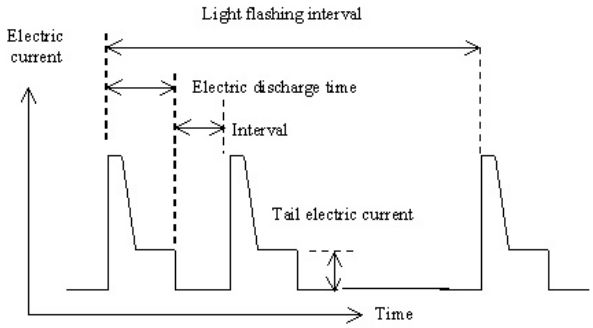

Figure 1. Pulse waveforms during discharge of LED

Figure 2 shows the light emitting studded paving block we developed. The surface colors of the ones we created were red, yellow, or green, but since we found out in preliminary visual detectability evaluations that yellow is the most easily detectable color, we decided to use yellow colored-blocks for performance evaluation testing. Figure 3 shows the nighttime visibility of conventional studded paving blocks and the ones we have developed.

Figure 2. Light emitting studded paving blocks

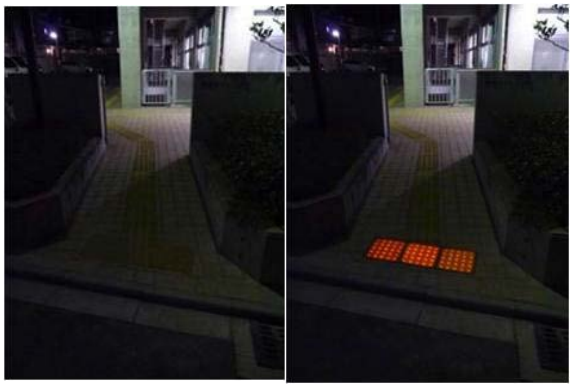

Figure 3. Nighttime visibility of studded paving blocks (left: conventional blocks, right: blocks under development)

Visual Detectability of Light Emitting Studded Paving Blocks

Fukuda et al. (2011) evaluated the visual detectability of studded paving blocks. They discuss the most suitable control formula for the parameters of interval of discharge and number of discharges. They tried 3 patterns where the number of discharges while the device is ON is set at 1, 2, and 3 times. The discharge interval between the 2nd and 3rd times was set to 2.5msec, 7.5msec, and 25msec. 10 individuals suffering from low vision were chosen as subjects. The 10 subjects were asked to walk towards the blocks which were 10 meters away from them. They were directed to stop in their tracks the moment they visually detected the blocks blinking. The distant between the stationary subjects and the studded paving blocks was then measured. This process was repeated 3 times for each subject. An interview was conducted with the subjects at the end of the experiment. As can be seen in figure 4, the results of this experiment showed that the ideal setting for maximum visual detectability was a discharge interval of 7.5 msec and 2 discharges.

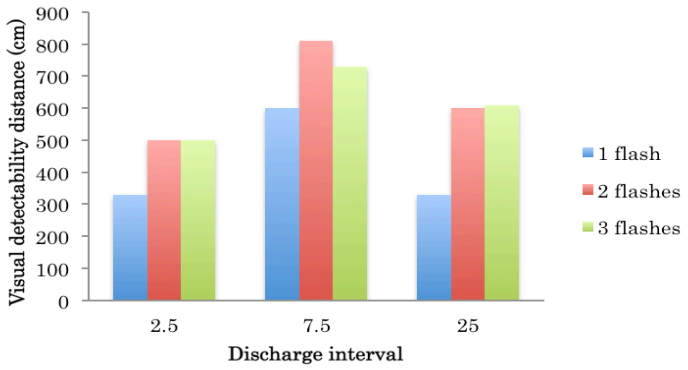

Figure 4. Discharge interval, number of discharges, and visual detectability distance

The following comments were given in praise of the blinking studded paving blocks: “I felt more aware that I needed to search for the blocks.”, “They are a beautiful color” “It is easy to see the blinking as it looks nothing like the lights of a billboard or headlights.” Many ideas about the area of illumination while blinking were heard from the individuals with low vision. For example, there were comments such as: “It’s better if the blinking area is wider.” “The lit up area should be larger.” “The area of the lit up area is important.” Also, there were comments suggesting that it was difficult to detect the blinking: “If I’m walking fast, I may not be able to find the blocks.” “It’s hard to find them.” “It’s difficult until they come into view.” These opinions were common among individuals with field of vision limitations. Moreover, there were also opinions concerning the way the blocks blinked: “All the blinking makes me feel a little ill.” “It’s too dark.” “The border isn’t very clear.”

DESIGN OF LIGHT EMITTING BOLLARD

We received the following feedback from many visually impaired individuals, “We are thankful that the blinking studded paving blocks can help us judge where bus stops and intersections are, but it would be safer and we would be even more grateful if there were some type of hint to guide us in which direction to proceed.” So, we focused on the bollards which in recent years have been set up to protect the safety of pedestrians by separating walking lanes and bicycle lanes and also to keep cars from entering bus stops and intersections. That is, we made it possible for individuals with low vision to be able to make a judgment about which direction to proceed in by making bollards light emitting.

Problems with Already-existing Light Emitting Bollards

The majority of already-existing light emitting bollards run on solar energy. These cannot be set up in the shadow of buildings, in the shade of road-side trees, in tunnels, or under shelters. The repetitive cycle of charging during the day with solar energy and using the stored charge at night shortens the operating time of these devices limiting their lifespan to about 3 years. In their current state, changing reusable batteries is not being considered, and the high maintenance cost of these devices is a problem. Also, it is difficult to consider the shape of the light emitting parts of these devices due to the positioning of solar panels above the equipment for reasons related to effective energy production. For this reason these devices are not necessarily the best choice for providing safe nighttime guidance to

visually impaired individuals.

Realization of a Long Lasting Product through Battery Power

The authors of this research developed a method to retain a high-luminosity blink for a ten year period in LEDs using the feeble electrical current of a primary lithium battery with a self-discharge rate of 1%. This makes it possible to create long lasting light emitting bollards for use in the shadow of buildings, in forests, in tunnels, in underground parking lots, and anywhere else. These will safely guide the movements of the visually impaired and elderly with eye trouble at night.

Realization of a Light Emitting Piece Easily Seen by Individuals with Low Vision

The shape of already-existing light emitting bollards can be roughly divided into point emission, line emission, and plane emission (Figure 5). However, shape design of these parts are limited due to the necessity to set a solar panel on the top part of all of these bollards. In response to this problem, the light emitting bollard that we will develop has no such physical restrictions and, as shown in figure 6, introduces the possibility for designs unthinkable up until now. However, in order to equally produce sufficiently bright light, the design of the light-guiding panel, which guides the LED light to the light emitting part, is important. Therefore, as shown in Figure 7, we conducted a simulation grouping various shapes of light-guiding panels, LED arrangements, and light emitting piece designs, and then examined light emitting pieces easily seen by visually impaired individuals.

Figure 5. From the left: Point emission, Line emission, and Plane emission

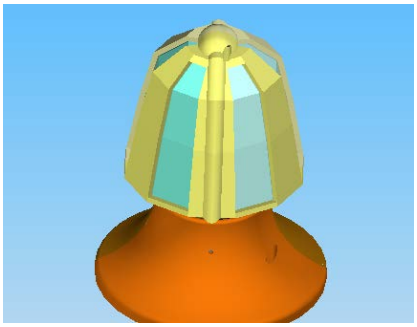

Figure 6. New light emitting piece design for light emitting bollards

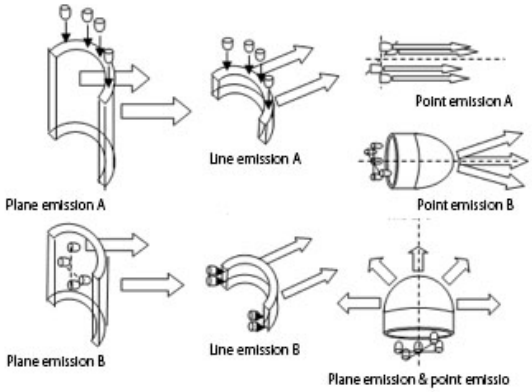

Figure 7. Examination of various light-guiding panels

CONCLUSIONS

Individuals with low vision tend to avoid going out at night. This is because moving around at night can be very dangerous. The number of individuals with vision-related ailments is increasing with the growing elderly population. There is a need to make moving at night safer for them. In this research, 2 devices using LED lights to guide pedestrians suffering from low vision are designed. The first device is a light emitting studded paving block. By blinking LED lights, the location of studded paving blocks can be confirmed from a distance. The second is a light emitting bollard between car lanes and sidewalks. Up until now, the position of bollards has been difficult to detect visually at night. Making bollards illuminate allows their position to be confirmed and creates a safer atmosphere for the pedestrian. In this research, the brightness level that individuals with low vision are most likely to notice was sought through experiment, and technology was developed to retain this light over a long period of time using minimal electrical current. Also, in order to install the light emitting studded paving blocks and bollards we developed in environments prone to continuous strong vibrations, such as roads, we adopted a battery powered drive system to reduce the risk of damage from wires snapping and taking in water. On top of that, we also realized a light producing method that minimizes electricity consumption and maximizes visual detectability, giving our devices a 10 years lifespan when used only at night. Hereafter, we presume this technology will develop into even more useful methods of displaying information not only for the visually impaired, but for able-bodied individuals as well, in various public signs, such as those in smoking areas, no entry areas, and the like.

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Concept and Development of Personal Mobility Vehicles for Indoor Use by Persons with Walking Difficulty

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ABSTRACT

This paper presents a concept of personal mobility vehicles for indoor use by PERSONs WITH WALKING DIFFICULTY and its development approach. In recent years, many persons with walking difficulty desire to live independently in the house as long as possible. Especially, existing means of personal mobility vehicles (e.g. electric-powered wheelchairs) face a lot of problems of obstacles in the house such as there exist many steps, furniture, narrow corridors and aisles and so on. In order to live in house independently, the persons with walking difficulty try to do light working. For these purposes, a new type of mobility vehicles for such persons are required to live independently in the house. In this paper, we investigate the new concept of personal mobility vehicles for persons with walking difficulty living independently in the house and its feasibility of development. The required specifications of the proposed personal mobility vehicles are to have compact size, light weight, and omni-directionality. Furthermore, this personal mobility vehicle has the elevation seat and the softness of the seat to change the person's position for light working.

Keywords: Exemplary Paper, Human Systems Integration, Systems Engineering, Systems Modeling Language

INTRODUCTION

In recent years, people with walking difficulty who would wish to live independently in their homes as long as possible are increasing in Japan, because aging is coming along quickly in Japan. The living environment improvements for such people, barrier-free houses are effective to live. Therefore, many of the old Japanese houses have not been barrier-free, because the cost of barrier-free renovation is really high. In general, a choice of means of transportation is electric-powered wheelchairs for the people with walking difficulty. The corridors in the Japanese houses are narrow, which is from 780mm to 900mm. This breadth is too narrow for the electric-powered

wheelchairs. Furthermore, the kitchens are also small. For these causes, utilization of the existing electric-powered wheelchairs is very hard for such people in Japan. In society to recognize the independent living for the people with walking difficulty in Japan, new characters of personal vehicles based on new concept are required.

The personal mobility vehicles are a novel class of transportation device emerged in the past two decades (Ulrich, 2005). A passenger is transported by the vehicle whose structure is typically open air. The first impact in the personal mobility vehicles was the Segway Series produced in 2001 (Ambrogi, 1999). This vehicle is driven by two wheels controlled so that the vehicle body does not fall down based on the control engineering. However, the existing personal vehicles including the Segways are not suitable for the persons with walking difficulty.

In this paper, we investigate the new concept of personal mobility vehicles for persons with walking difficulty living independently in the house and its feasibility of development. The required specifications of the proposed personal mobility vehicles are to have compact size, light weight, and omni-directionality. Furthermore, this personal mobility vehicle has the elevation seat and the softness of the seat to change the person's position for light working.

CONCEPT OF PERSONAL VEHICLE FOR PARSONS WITH WALKING DIFFICULTY

The target users of our personal vehicle are persons with walking difficulty caused by aging or physical disorders. In order to live independently in the house, they need a mean of transportation, which pass through narrow corridors without assistance. When a person with walking difficulty wants to go to the restroom from the bed, he/she have to get up from the bed and move into the wheelchair. Then he/she go through the corridor to the restroom. These sequences of motions are difficult to do oneself.

The physical conditions of the persons with walking difficulty are infinite in varying with each individual. Therefore, the required features of the personal vehicles are individually different. The required concept of our personal mobility vehicle is as follows:

- Fascinating vehicle design
- Small vehicle size for passing through and turning in narrow way.
- Safety against overturning
- Comfortable and secure seat

Fig. 1 Narrow corridor of Japanese house

We consider the fascinating design of the personal vehicle for the persons with walking difficulty is exceedingly important from the view point of sensibility of the user. The mission of "Design" to the users of our personal vehicles is to present the new style of the personal vehicles for the persons with walking difficulty, which is that the recognition of substitution of healthy legs is changed.

For achieving safety of the personal vehicle in operation by users, we introduce the robotics technology for guidance, stabilization and collision avoidance of the vehicle moving in the house. There are a lot of forms of obstacles on/in the passageways of the house. The vehicle using in such space must avoid these obstacles during moving.

Fig. 1 shows an example of narrow corridors in a Japanese house. In this case, the width of this corridor is 750mm which is not sufficient width for the common electric wheelchairs to pass through and to turn at this corridor. In order to use a personal vehicle in such Japanese narrow corridor, the vehicle must have small size and small turning circle. The weight of the vehicle should be lightweight, because the Japanese house has several rooms having tatami mats made with straws which are softer than the wooden floor.

In the use of the personal vehicle in the house, the safety against overturning of the vehicle with passenger is a serious problem. We introduce control strategies employed in the field of robotics for solving this problem. The overturning of the vehicle occurs when the vehicle is strongly accelerated or decelerated. The controller of the vehicle is designed for the mathematical model of the vehicle based on the observation data, such as the three-axes acceleration of the vehicle body, the three-axes angular velocity, and the angular velocities of the wheels.

The seat of the vehicle for the persons with walking difficulty should be comfortable and secure. The vehicle is considered as the means of the mobility in during almost a day. Therefore, the softness of the seat must be capable to change so that the user feels comfortable. The idea of comfortable and adjustable seat is realized by using the variable cushions.

DESIGN OF PERSONAL VEHICLE

Needs in Design---Eradicating the Recognition as "Substitution of Healthy Legs"---

The common wheelchairs shown in Fig. 2 sufficiently satisfy their purposes of mobility for the individuals with walking difficulty. Even though, there is no fundamental such that the users feel fun to operate auto automobiles or motorcycles (see Fig. 3). The impression of the wheelchair is a special tool for persons with walking difficulty, it is an icon that conveys the handicap of the body. On the other hand, glasses to correct vision are widespread in the world wide society as one of the fashion styles. Therefore, the mission of "Design" to the users of our personal vehicles is to present the new style of the personal vehicles for the persons with walking difficulty, i.e. it is how we can eradicate the recognition of substitution of healthy legs.

Fig. 2 Common (electric) wheel chair.

Fig. 3 Modern vehicles.

The structure and design of our personal vehicle is inspired by the structure and functions of the office chairs on casters. The design of the personal vehicle for the persons with walking difficulty consists of an adjustable seat attached to the polygonal frame and the drive mechanism illustrated in Fig. 4. This seat has multiple adjustable cushions whose softness can be changed depending on the state of the moving vehicle. While the vehicle is moving, the user's bony pelvis and cervical vertebra are clamped by the multiple cushions to support the user's body. The user can move as a unit consisting of the vehicle and user's body. The gas-spring and damper for adjusting the seat height of the office chair on casters becomes altered as an intelligent damper controlled by a computer, which suppresses undesirable shocks due to the motion of the vehicle and adjusts the height and tilt of the seat (see Fig. 5). Furthermore, the arm connected with the front wheel and the body frame of the vehicle can be expanded. This motion allows that the center of gravity of the vehicle can be shifted for finding the suitable body position for stable moving (see Fig. 6). Realizing the all of the above ideas, the recognition of our personal vehicle is changed from "Substitution of Healthy Legs" to "A Part of Person" and the reciprocal recognition of

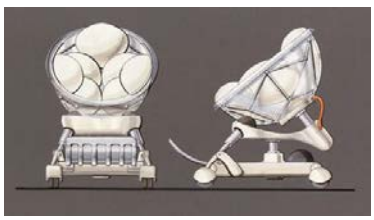

Fig. 4 Image of proposed personal vehicle.

the healthy persons and persons with walking difficulty will be changed. Such change of value in the mind of persons with walking difficulty will be reflected in the life of them, i.e. the new personal vehicles are recognized as "new products with new values" by all people.

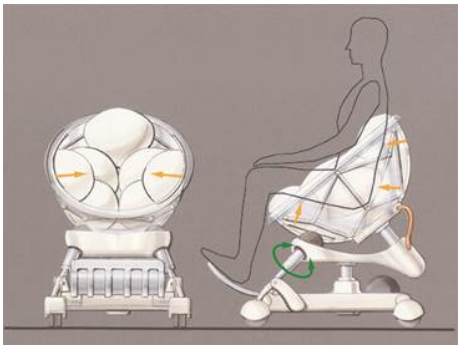

Fig. 5 Design of the seat with the softness controlled cushions.

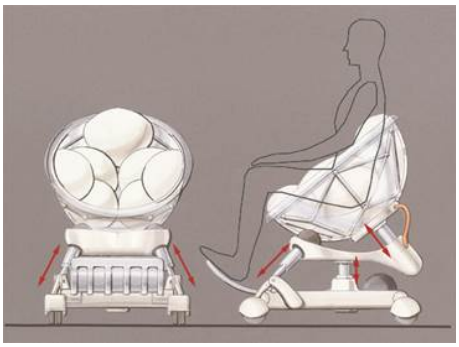

Fig. 6 Variable parts of the vehicle.

MODELING AND CONTROL OF PERSONAL VEHICLE

In order to develop the controller for the proposed personal vehicle for the persons with walking difficulty, the dynamics of the vehicle is required. Especially, the control strategy for avoiding the overturning of the vehicle is emphasized. In this paper, we show an example of simple position controller and its numerical simulation. In this paper, we consider the simplified model of the personal vehicle for the persons with walking difficulty illustrated in Fig. 7, where we just consider the motion of the proposed vehicle in the vertical plane.

This simplified model of the proposed personal vehicle has two traction wheels driven by the control torques $\tau_1(t)$ and $\tau_2(t)$, respectively (see Fig.7). The radius of each wheel is denoted by r; the wheelbase, d_b; the mass of the vehicle body, m_b; and the inertia of the body J_b; the mass and inertia of each wheel, m_w and J_w. The rotational angles of the front and rear wheels are represented by $\theta_1(t)$ and $\theta_2(t)$, respectively. The position of the center of the rear wheel is denoted by $x(t)$. The distance between the mass center of the body, G, and the center of the rear wheel P_2 is described by ℓ. $\varphi(t)$ denotes the angle between the vertical axis and the line $\overline{P_2G}$, which means the inclination of the vehicle body (see Fig.8). When the vehicle's wheels contact on the ground, the inclination angle $\varphi(t) = \varphi_0$. $f_w(t)$ denotes the reaction force from the ground.

The dynamics of the motion of the personal vehicle considered in this paper is derived by using the Hamilton's principle. The derive dynamics of the vehicle is given by the following equations (Li, 2005; Nakamura, 2009):

$$\left(m_b + 2\,m_w + 2\,\frac{J_w}{r^2}\right)\ddot{x}(t) + \left\{m_b\,\ell\sin\varphi(t) + m_w\,d_b\cos\left(\varphi_0 - \varphi(t)\right)\right\}\dot{\varphi}^2(t) + \left\{m_b\,\ell\cos\varphi(t) + m_w\,d_b\sin\left(\varphi_0 - \varphi(t)\right) + \frac{J_w}{r}\right\}\ddot{\varphi}(t) + \frac{2\,\mu}{r^2}\dot{x}(t) = \frac{b_1}{r}\tau_1(t) + \frac{b_2}{r}\tau_2(t)b \tag{1}$$

$$\left\{m_b\,\ell\cos\varphi(t) + m_w\,d_b\sin\left(\varphi_0 - \varphi(t)\right) + \frac{J_w}{r}\right\}\ddot{x}(t) + (m_b\ell^2 + m_w\,d_b^2 + J_b + J_w)\varphi(t) - m_b\,g\ell\,\sin\varphi(t) - m_w\,g\,d_b\cos(\varphi_0 - \varphi(t)) = -\tau_1(t) - \tau_2(t) - f_w(t)\,. \tag{2}$$

The equation (2) is used in the case that the front wheel is lifting from the ground, i.e. $\varphi(t) > \varphi_0$. The reaction force acting at the bottom of the wheels due to the contract with the ground is modeled by the Hertzian contact force theory (Johnson, 1999).

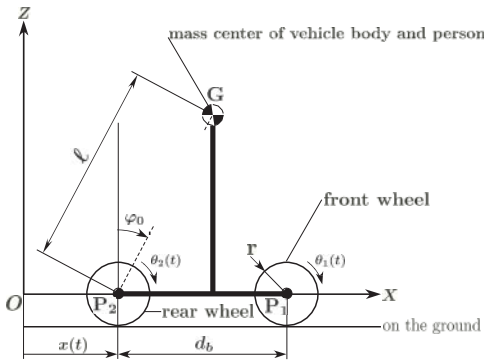

Fig. 7 Simplified model of the personal vehicle.

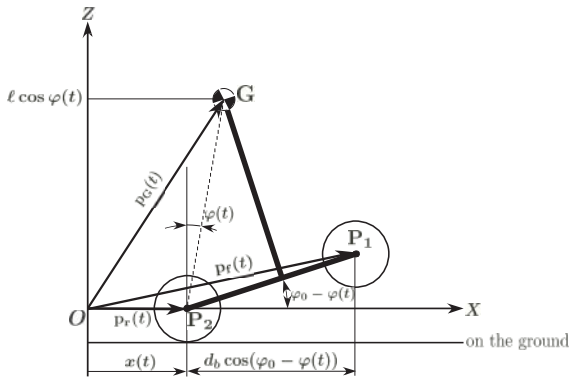

Fig. 8 Personal vehicle in the case of lifting the front wheel.

The controller for the vehicle is simply constructed by the PD-controller based on the position and velocity of the vehicle for the vehicle's position control. In order to avoid turnover of the vehicle, the angle and angular velocity of the vehicle from the ground are used for the control to suppress the lifting of the front wheel. The form of the PD-controller is omitted.

The collision avoidance control is achieved by introducing the robotics technology based on the contactless sensors such as ultrasonic sensors, scanning range finders, and so on. By measuring the distance to the obstacles, e.g. walls, furniture, something obstacles on the floor, and so on, in the direction of movement, the collision avoidance controller reduces the velocity of the vehicle or stop it, when the obstacles are detected.

EVALUATION OF SEATING

In order to realize the adjustable softness seat, the evaluation of the pressure on the surface of the seat should be carrying out. To control the softness of the seat, the measured data of the pressure on the surface of the seat is required. This information can be measured by introducing the sheeted pressure sensor-array installed on the surface of the seat. The example of the measured data is shown in Fig.9. The left picture shows the pressure distribution on the surface of the backrest. The right picture shows the pressure distribution on the surface of the seat. The adjustable softness seat should be controlled so that the peak of the pressure distribution becomes reduced in value.

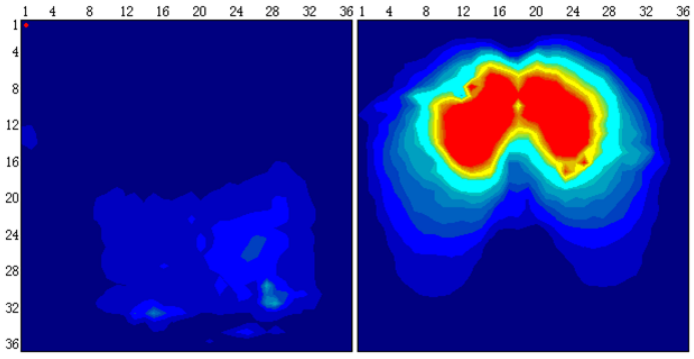

Fig. 9 Pressure distribution on the surface of the seat vehicle.

CONCLUSIONS

In this paper, the new concept of the personal vehicles for walking difficulty has been proposed for developing and designing. The concept was organized by the four elements which were the fascinating vehicle design, the safeness of the vehicle, the vehicle size, and the comfort and safety of the users. The design strategy was considered from the viewpoint of users, i.e. the persons with walking difficulty. The main approach of the design was to eradicate the recognition of substitution of healthy legs. For realizing this concept, the new design of the personal vehicle has been proposed. For the safeness of the vehicle in operation, the control and robotics technologies have been introduced to stabilize the motion of the vehicle and to avoid the obstacles in the direction of movement. In order to develop the adjustable cushions for the comfortable seat, the multiple variable softness cushions controlled by the computer is introduced based on the pressure distribution data measured by the sheeted pressure distribution sensor array.

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Creative Design of Powered Wheelchair Based on Concept Analysis and Pleasurable Ideas Proposed by Designers and Educators

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ABSTRACT

We conducted the pilot study about construction design concept using the development of design ideas in collaboration with educators and designers. The purpose of this study is to examine the effect of design results in which the new design method we devised brings. We set a design challenge a vehicle to assist the movement of difficulty walking person in this study. First, we share the knowledge about the physical and psychological characteristics of the user. Then, we share the knowledge about the traveling and function they understand each ideas. We figured that a point of view of driving characteristics required for the vehicle for the mobile support. Finally, designers make the basic vehicle design based on knowledge shared with educators and designers and propose design plan of educators and designers change recognition that wheelchairs are substitution of legs and understood that the consideration for difficulty walking persons makes a deeper design. Though there are a lot of design methods, we figured that we created designs full of innovative and interesting ideas with fusion of deep sensitivity and knowledge for target to design by using the design method in collaboration with educators and designers proposed in this research.

Keywords: Design concept, Creative design, Pleasurable ideas, User interface design

INTRODUCTION

Modern wheel chairs make it possible for individuals with a walking impairment to get around and in that sense they are very successful. However, they almost always lack the factor that answers to our human sensual desires for pleasure and comfort in operating in the way that a car or motorcycle does. Also, our image of a wheelchair is that of a special tool for individuals with walking impairments. It has even become a sort of symbol for those with physical disabilities. However, when we think about glasses, they do not in any way symbolize people who are visually impaired. In fact, they have become a fashion statement throughout society. It is time for a design that will do away with the stale notion that wheelchairs only exist to provide a function. Therefore, there is a question of how can a statement imposed by a design do away with the concept of the wheelchair as a 'substitute' for the user and introduce a new style defined by the concepts of 'driving is fun' and 'I'd rather be in my wheelchair'? In this research paper, we will propose a new design method to come up with a solution to this question and discuss the effects of the design results. In this research an experimental attempt is carried out at a design concept structure using a wealth of ideas produced through the collaboration of designers, educators, and specialists.

DEVELOPMENT OF A DESIGN METHOD

An experimental attempt is carried out at a design concept structure using a wealth of ideas produced through the collaboration of designers, educators, and specialists. The purpose of this research is to discuss the effects to the design brought about by our new design method. The theme of this research is to create a more enjoyable vehicle to assist individuals with walking impairments with their mobility.

Sharing of knowledge of the physical and psychological characteristics of the user

Normal design development aims to increase the functionality and comfort of the target (Jones, 1973, Cross, 2008). Measurements are taken and design values are decided as an index for development. It is desirable that development is carried out directly with maximum result, in minimum time (Ikebe, 1980). However, it has been shown that this method does not always produce a product that is perfectly fitted for the user. So, in order to overcome the limitations of this design method, it is important to set our eyes on a comprehensive value and consider 'meaning' and 'effect'. Using a wheelchair as a design target, this paper outlines a new design method based on an overall perspective. To do this, designers, mechanical systems specialists, psychological technicians, welfare engineers, and computer scientists from educational institutions have gathered to debate and amass ideas from their respective fields, sharing knowledge about the physical and psychological characteristics of users, in order to create an image of the wheelchair of the future.

Organizing ideas according to the value curve

After a long time of brainstorming, we came up with a value curve. Figure 1 represents the levels of value to consider when developing a wheelchair for individuals with walking impairments. As seen in figure 1, for able-bodied people, the conventional equipment: 'crutches', 'wheelchair', 'motorized wheelchair' correspond to the extent of a handicap and the comprehensive value of each item decreases in the order listed. Litters and stretchers are also mobility support equipment, however, since movement is not voluntary and these items more closely resemble devices to aid others in transporting the target rather than vehicles, comprehensive value is ranked even lower. By drawing this value curve, it became clear where new crutches and other vehicles stood in terms of comprehensive value and this had a great effect on organizing our thoughts for design development. There is a method where one organizes his/her design plan by mapping it out. By using this method and plotting the 'value' on the vertical axis, and then plotting the design target on the horizontal axis, and finally discussing the extent of the comprehensive value, it becomes clear that new vehicles can exist between design targets, and thus ideas for new designs are easily thought up. This rather simple operation of laying out design targets in an ordered manner has proven to be an important factor in coming up with new ideas. And with deep consideration, a value paradigm shift can be expected in the creation of new vehicles usable by disabled individuals.

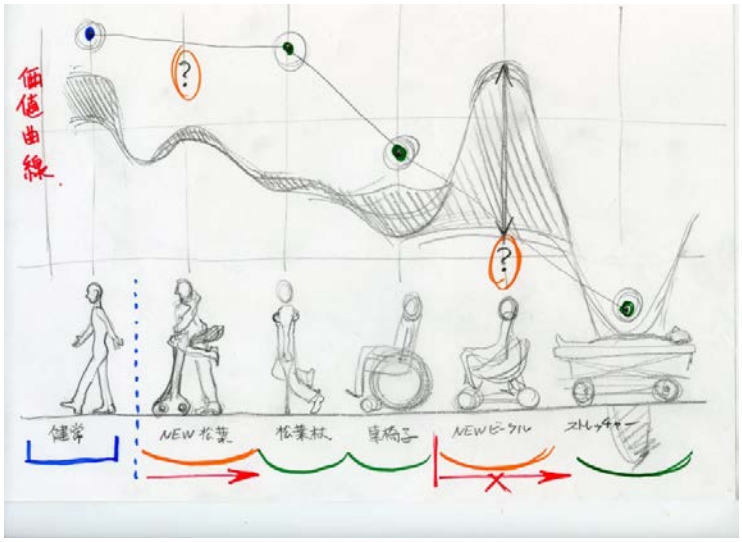

Figure 1. Value Curve of Wheelchairs for Individuals with Walking Impairments

FOUR QUADRANTS OF DESIGN THINKING

In order to further brush up design ideas that have come about as a result of knowledge sharing, we further considered how wheelchairs for individuals with walking impairments are used and have found that the following 2 perspectives are necessary.

We came to the conclusion that a wheelchair is not simply a device for movement, but there is also the perspective that it plays a role in helping the user interact with society. Also, the perspective that there are differences in awareness of the users themselves is extremely important. Therefore, how individuals with walking impairments intermingle with their surroundings (society) is plotted on a horizontal axis, and how he/she is aware of this is plotted on a vertical axis. Figure 2 shows how these perspectives relate to each other. More concretely, the horizontal axis shows [intermingling with surroundings] – [standing out from surroundings]. The vertical axis shows [current state of awareness] – [changes in state of awareness]. Therefore, it can be said that the first quadrant represents the user's awareness of their potential for confidence; the second quadrant represents the user detecting value; the third quadrant represents the user's initial state, and the fourth quadrant represents how the user intermingles with his/her surroundings. By using this whole map for comprehensive thinking we may create a new value associated with wheelchairs and may even create more areas of activity for users.

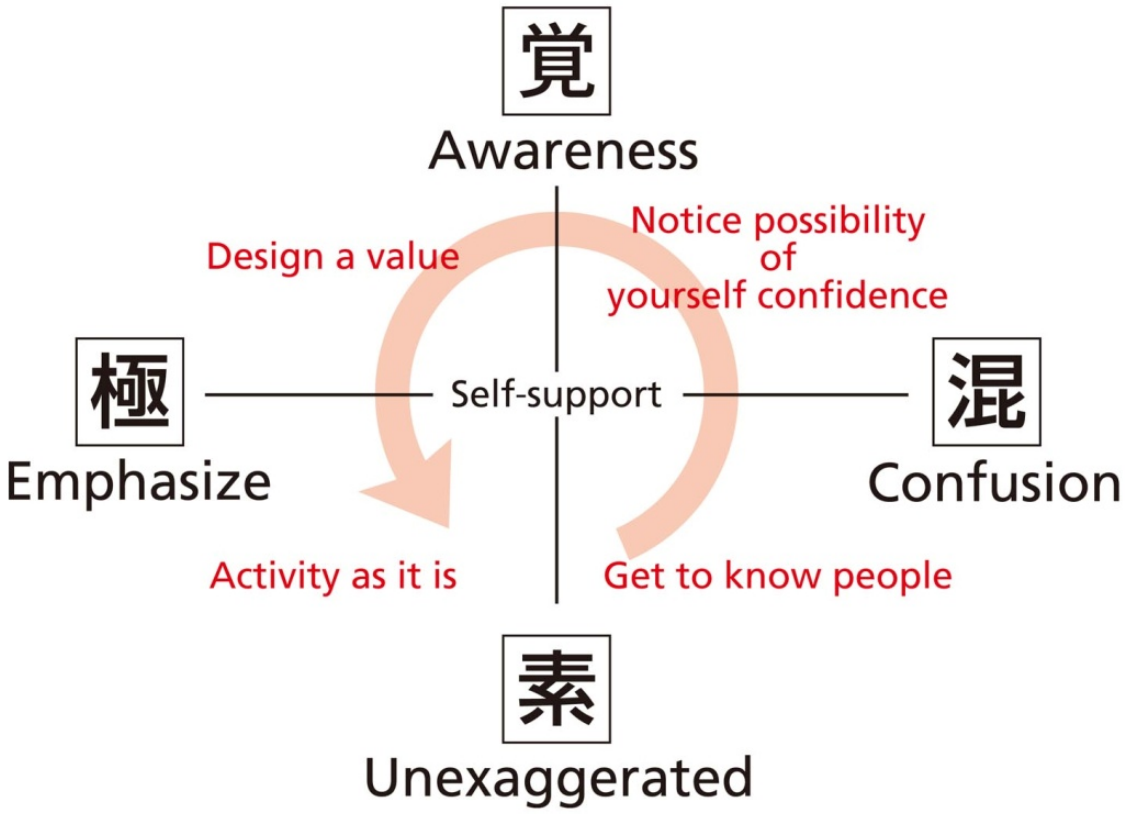

Figure 2. Quadrants of Design Thinking

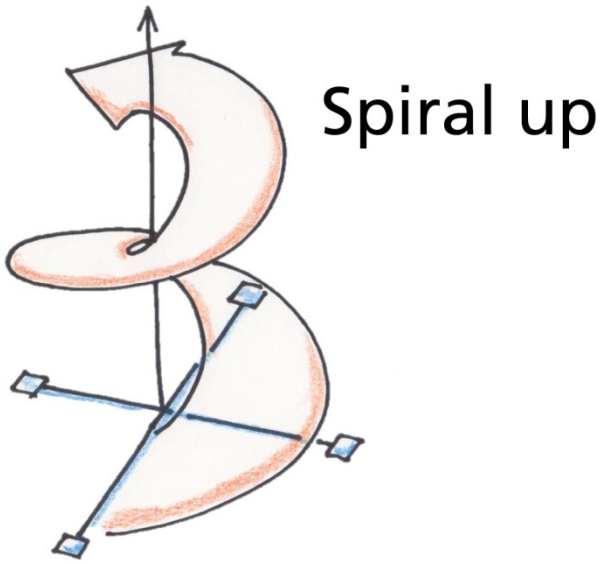

Figure 3. Design Thinking in Spirals

Moreover, as seen in Figure 3, design thinking becomes deeper through consecutively running these four quadrants in order and examining them in a spiral pattern. In short, the specialty of this method lies in the thinking that there is a vector where the functions and special features of a new motorized wheelchair should straddle these four quadrants.

Sharing of Knowledge Concerning Movement Capacity

We will share the movement specs and functions required by mobility assistance vehicles. In this paper, we discuss specifically the gluteal hold function, acceleration feel, and lean. We carried out design development based on office chairs with casters and research results of drive system and control system simulations along with body pressure and other measurements. The seat piece where the passenger sits attaches multiple cushions that can change between soft and hard to frame constructed in the shape of a polyhedron. And while moving, the passenger's pelvis and spine are held in place allowing the passenger to move as one with the vehicle. There are computer controls and a damper at the base so that any shock created from inertia while moving is cancelled out. Also, by leaning back or forth, before, after, or during movement, the passenger increases the feeling of acceleration and can create a more dynamic moving experience by leaning in the natural direction of inertia. We undertake design based on these observations, coming up with and combining new design plans until both parties can appreciate the design together.

VEHICLE DESIGN FOR INDIVISUALS WITH WALKING IMPAIRMENTS USING SPIRAL THINKING

In the first step we develop a seat that invites use of the vehicle (it makes one want to sit in it). I propose the following 4 ideas. There are represented in a rough sketch in Figure 4 and Figure 5. Figure 4 represents a seat that is made to fit perfectly with the user. Figure 5 shows a design plan for a seat that is inviting to sit in.

1) A seat with adjustable position using slide reclining
2) Different sitting options, and a forked seat offering dependable support
3) A bucket seat
4) A sofa-type seat made from low impact material

Figure 4. Design Plan for Proposed Seat

Figure 5. Design Plan for an Inviting Seat

Changeable seat design

Continuing, in order to provide comfortable mobility we present a small seat split into pieces that can be easily adjusted for softness and position. By making these pieces in the shape of polyhedrons, the seat is adaptable and uniform at the same time.

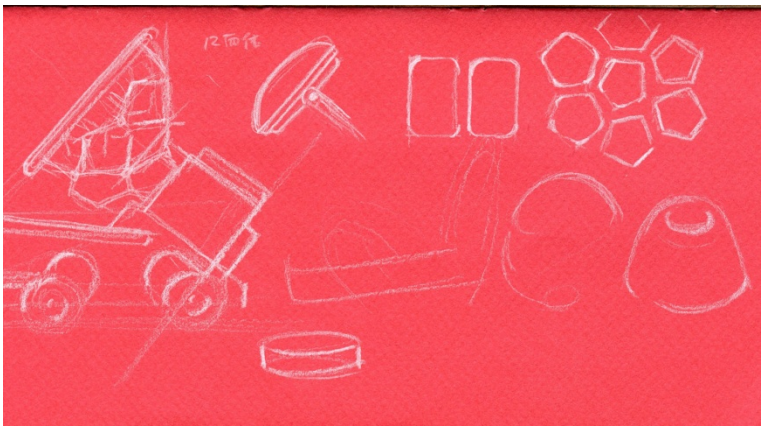

Figure 6. Design Plan for Flexible Seat

Seating position retention design

Furthermore, we contrived a function to improve seating position retention based on this layout design.

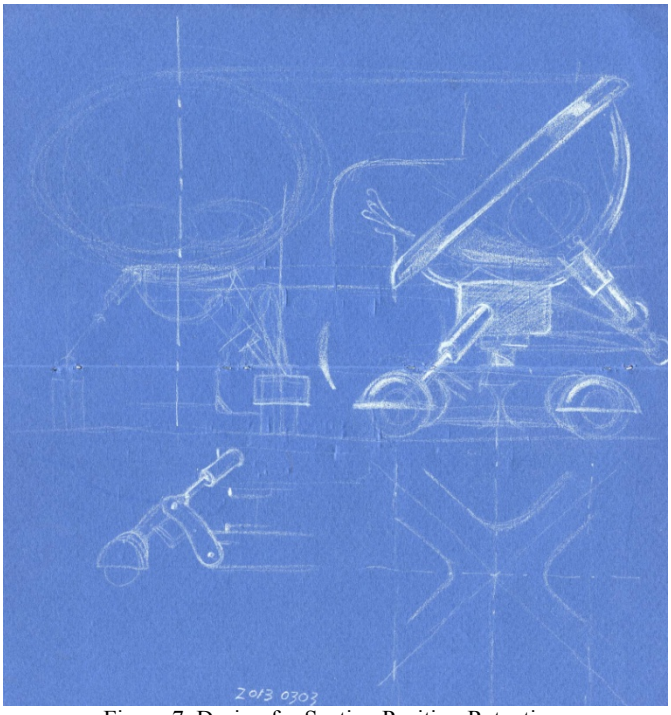

Figure 7. Design for Seating Position Retention

Electronically controlled suspension

Upon review of the above plan, the idea of installing an electrically controlled suspension at each point to supplement the shock absorbers came about in consideration of gravity and direction of inertia other than that of the axle and the pivot. With this, it is possible for the user to feel external forces by counteracting and reversing the shifting inward of posture caused by centrifugal force created while rotating.

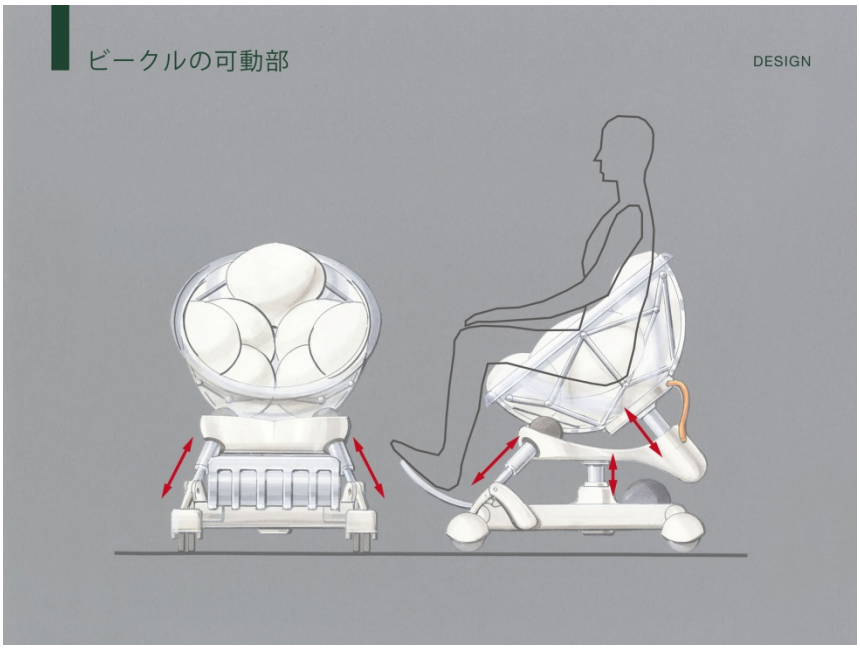

Figure 8. Vehicle with Electronically Controlled Suspension

Figure 9 shows a plan to stabilize the waist by developing a unique structure for seating position retention. This was seen to create ease and add function for the individuals, and possibly lead to an enjoyable and charming vehicle for able-bodied individuals as well. The elastic material in the small cushions allows the seat to contract and expand according to the user, and turned out to be a new seat for a vehicle capable of supporting the spine and hugging the gluteal muscles. Figure 10 shows a rendered sketch of the overall design.

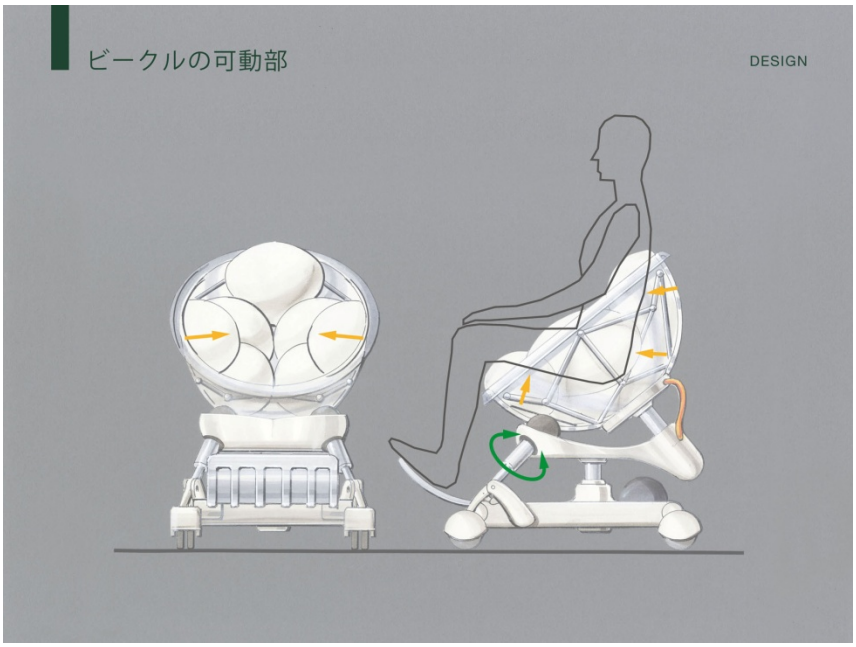

Figure 9. Design of Seating Position Retention Structure

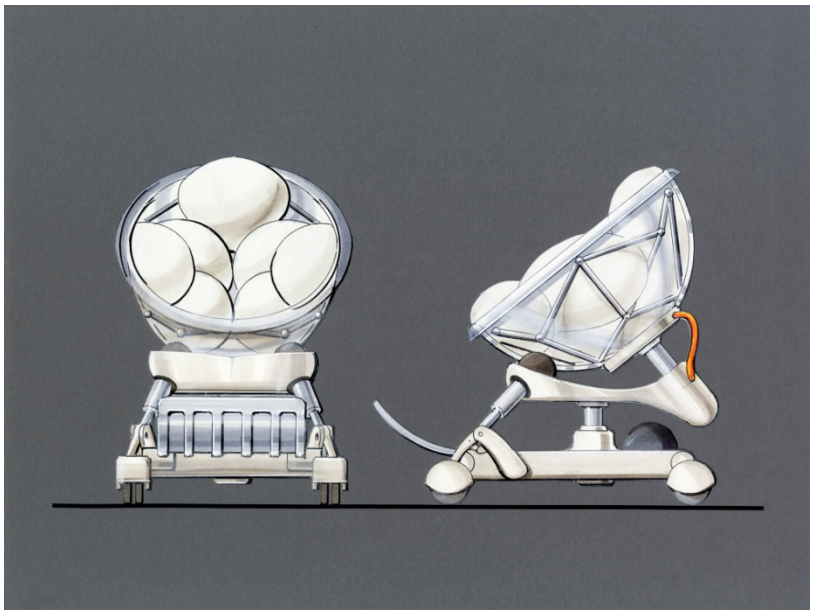

Figure 10 Final Design Using New Design Method

SAMMARY

When designers and educators faced their perspectives against each other, the stale notion of a wheelchair being nothing more than a replacement for legs was completely done away with. Because of this, a more thoughtful design for individuals with walking impairments was achieved. Also, even though many design methods were proposed, by using the method that designers and educators collaborated on for this research, and through a combination of deep knowledge and deep sensibilities towards the design target, it was clear that an extremely revolutionary and fun design could be expected. Technological functions have been realized based on this design research. If the personal vehicle can change from being a 'replacement for legs' to something 'fun to ride' or something 'I'd rather be riding', then all people, those with a walking impairment or those able-bodied, may have a change of attitude towards it. Through making the joy of riding our motivation, we may attain 'dynamism' and 'positivity' from an 'assistive device' which is not usually associated with such terms.

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Section 7

Methods for Emotional Design

Study on Preferred Gestural Interaction of Playing Music for Wrist Wearable Devices

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ABSTRACT

Recently, many gesture-based interactive devices have been developed. Gesture is one of the most intuitive and natural ways to communicate each other, so gesture recognition technology is becoming huge issues in interaction design. Wrist wearable devices such as smart watches, Nike FuelBand, and Samsung Galaxy Gear are vitalized on the market, and there are attempts to control the wrist wearable devices with gestural interaction. In order to design more user-centered devices, development of gesture standards which gesture is appropriate for which operation becomes very important. In particular, there are two different situations gesture interaction is required: 1) people control objects that exist around then such as TV and vehicle, and 2) people control objects put on their body such as smart watch. This paper assumes that the two different situations may require different gesture interactions. The goal of this paper is to reveal preferred gesture interaction for wrist wearable devices. The function of playing music is selected for the experiment because it is most common and popular function on almost all digital devices. This paper consists of three parts: 1) collect existing gesture signal conventions and categorize them, 2) conduct a survey to find out preferred gestures for each function of playing music in two different situations, and 3) analyze the result for defining the most preferred gesture interactions and considering rationales for designing gesture interaction for wrist wearable device.

Keywords: Gesture, Gestural Interaction, Wrist Wearable Device

INTRODUCTION

As diverse technologies develop rapidly, recently many gesture-based interactions have been applied to electronic devices. Quick and easy gesture interaction becomes one of the most intuitive and natural ways to communicate each other. Gesture controlled user interface (GCUI) now provides realistic and affordable opportunities such as the possibility of eyes free interaction which require less attention to the screen (Bhyiyan et al, 2011). Moreover, interests in wrist-based technology accessories such as Jawbone UP, Pebble, Galaxy Gear, or Nike FuelBand are high and rising. As the result, the gestural interactions start to be applied to the wrist wearable devices. For example, MYO is the motion and gesture controlled armband bracelet using arm muscle activity and EMG (electromyography) signals to control digital devices over Bluetooth. In the active movement of applying gestural interaction on the wrist wearable devices, many researchers attempt to effectively build the standards of gesture interaction with many resources from various devices and materials. Song, Hae-Won (2012) drew sets of gestures in manipulating music players, and Yoo, Seoung Hun (2012) tested two different types of display code gestures: verbal code-base and spatial code-based gestures focusing on gesture UX design for tablet devices.

STUDIES ON GESTURE INTERACTION

Gesture and Gesture Interaction

Gesture is a motion of the body that contains information (Buxton, 2007). Gestures are naturally used among contexts and cultures, intimately related to communication. For example, people move hand up and down with the rhythm of speech, or there are different significant gestures that contain meanings and symbols such as peace sign. Gesture interaction enables the easy control without the limitation of the distance between the user and the device, and it has the advantage to support the direct manipulation more cognitive and ergonomic way from 2D surface to 3D space. The ideal goal of the gesture design is to reflect the user's unconscious and natural action, so no extra learning exists. The approaches of studying gestures have to be user-defined and human-centered, start from the users. The preceding research, 'Towards designing more intuitive touchless operation based on hand gestures,' Kim and Song (2012) conducted a study to draw the four non-touch gesture sets for manipulating music players. The set of gestures were based on users' stereotypes, icons' shape, direction of physical movements, and character shape of function names, and the following experiment was performed to verify the gestures. As the result, the study shows that designing the gesture based on stereotypes and directions of physical movements is intuitive and effective. Recently, the conditions using non-touch gesture are divided broadly into controlling the device in front of smart TV or the wearable device worn on the one's wrist. In the process of designing non-touch based interaction, it is a critical point to figure out if people use the same gesture to each function in two different situations: 1) people control objects that exist around then such as TV and vehicle, and 2) people control objects put on their body such as smart watch.

Goal and Hypothesis

. At this point, this study conducted a survey to identify the preference of the gesture in two different situations, 1) Controlling the TV with gesture 2) Controlling the wrist wearable device with gesture, aiming to build the gesture standards that suggests the design direction of the non-touch gestures in operating various devices.

The purpose of the study is to figure out 'the most intuitive gestural interaction that corresponds to the basic function of playing music with general wrist digital device.' It is hypothesized that, people use the same gesture on each function in two different situations, controlling the TV and wrist wearable device,

METHODS

Designing an Experiment

To verify the hypothesis, the research was conducted in the following process.

Step 1: List the basic functions of the Music player

There are 9 different functions in the music player; 'power on', 'play', 'pause', 'volume up', 'volume down', 'next song', 'previous song',' rewind', 'fast forward.' 'Volume up' and 'Volume down' are considered as one function because the result came out as the same gesture with opposite direction. As the result, 6 functions were ready for the next step.

Step 2: Analyze three preceding researches and extract different set of gestures used for controlling music player

a) Gesture & Bio-signal UX Manual, Yonsei University HCID Lab., Samsung Project, 2013

- The purpose of the project was to build the UX scenarios based on the data and context collected from the bio-signal equipped in wearable devices. In the process of the research, 'gesture and bio manual' was established for 42 different functions based on the gestures used in other wearable devices and conventional

gestures such as driving signal, scuba diving signals, and military signals.

b) Establishing a design guide of gestures for touchless interactions, Song, Hae-Won, 2012

The study established a gesture dictionary, mapping intuitive gestures onto each operation through focus group interview, survey, and user participatory design. It became a design guideline of gestures for touchless interactions.

c) How about a motion-controlled music player for smartphones?, Jang, Yung-joo, 2012

It was the project to develop a concept for motion-based interaction using the wearable smartphones. Pilot survey was conducted from 7 people to figure out the gesture for different functions of a motion-controlled music player.

Set of gestures collected from three preceding researches were mapped onto each functions of music player (see Table 1).

Table 1: List of gestures mapping onto different functions of music player

	Gesture & Bio-signal UX Manual	**Establishing a design guide of gestures for touchless interactions**	**How about a motion-controlled music player for smartphones?**
Power on			
Play			
Pause			
Volume up / Volume down			
Next song / Previous song			
Rewind / Fast forward			

As the result, functions with high frequency, ‘Play’, ‘Pause’, ‘Volume up/down’, and ‘Next song/Previous song’ were selected. In designing the survey questions, choices of gestures for each function were firstly listed from three preceding researches (Table 1), and the gestures frequently used and easy to make were sorted out form the choices.

For ‘Play & Pause,’ which implies the meaning of start and end, ’ Finger snapping’, ‘Okay sign’, and ‘clapping

hands' were chosen from first two preceding studies. 'Finger point' was also selected because the action was derived from pushing play button in touch-based interaction, and 'Pushing hand forward' was also selected from the study of motion-controlled music player for smartphones. Choices such as 'Drawing triangle' or 'Clenching fist' were excluded because they are unacquainted or better fit to other function. For 'Volume up / down,' choses were 'Move hand up/down', 'Spin the index finger', 'Grip and turn right/left', 'Spread out the hand', and 'Move to right/left,' mostly derived from the conventional gestures meaning something going up/down or smaller/bigger. Lastly, 'Move to right/left', 'Turn hand and snap', and 'Move index finger right/left' were chosen from the preceding studies for 'Next song / Previous song.'

Survey

The questionnaire consists of two sections: in each section, respondents are situated to control a music player with hand-gesture either on Smart TV or on the wrist wearable device with gesture interaction.

Figure 1. Two different situations

In each situation, respondents can choose the gestures that most naturally correspond to four function up to three options in order of their preference (1 means most natural).

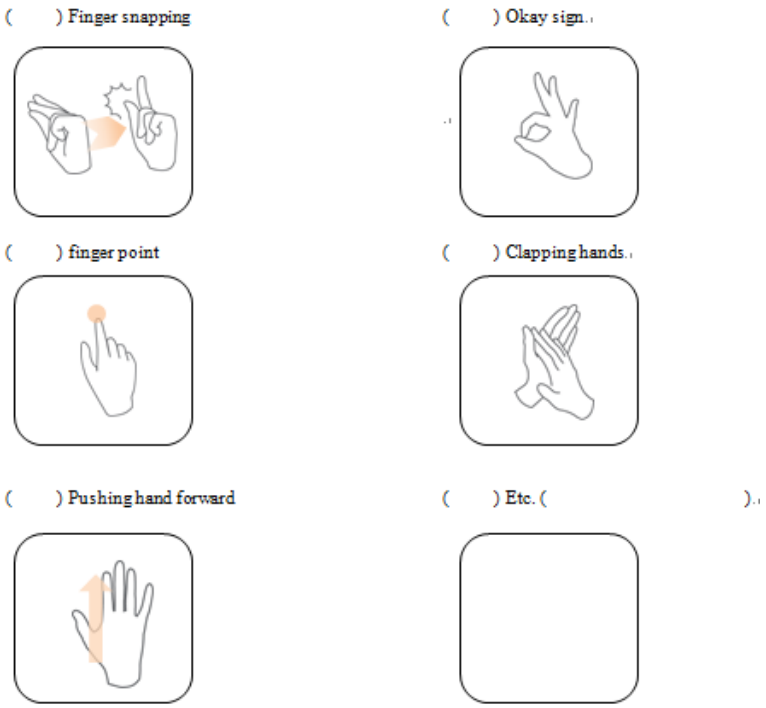

Figure 2. Gestures for play function

To verify the concept, the survey was conducted through questionnaires and focus group interview. In total, 7 people participated, 5 men and 2 women. Most of them were interested in gesture interaction, and they frequently use their smart-phone.

Results

The result of the survey is summarized in tables below, and each table stands for different functions.

Mapping gestures for the function 'play,' the participants chose 'Finger snapping' as their first choice for both situations (See Table 2.1). In the situation controlling TV with gesture, 3 out of 7 participants chose 'Finger snapping' for their first choice, and 3 out of 7 chose 'Clapping hands' for their second choice. Similarly, in the situation controlling wrist wearable device with gesture, 3 out of 7 chose 'Finger snapping' as their first choice, and 2 out of 7 chose 'Clapping hands' for their second choice. Participant 1, 2, 4, 7 chose to use the same gesture in both situations, and participant 3, 5 also chose the same gesture as their second choice. This result shows the desire to use the same gesture for both situations.

In the focus group interview, participant 6 said that he might clench his fist to play the song with wrist wearable device because he imagines controlling the device himself outside. Moreover, it is an interesting point that the result came out from 'play' and 'pause' were exactly same.

Table 2.1 Frequency of gestures on **Play & Pause**

Participant	Controlling TV with gesture			Controlling wrist wearable device with gesture		
	1st choice	2nd choice	3rd choice	1st choice	2nd choice	3rd choice
1	Finger snapping			Finger snapping		
2	Finger point	Clapping hands	Pushing hand forward	Finger point		
3	Etc. clench fist and spread out hand	Clapping hands	Finger snapping	Finger snapping	Clapping hands	Finger point
4	Finger snapping	Clapping hands		Finger snapping	Clapping hands	
5	Finger snapping	Finger point	Clapping hands	Finger point		
6	Finger snapping			Etc. clench one's fist	Okay sign	
7	Clapping hands	Finger snapping	Finger point	Clapping hands	Finger snapping	Okay sign

Mapping gestures for the function 'Volume up/down,' the participants chose 'Grip and turn right or left' for controlling TV but 'Move hand up or down' for controlling wrist wearable device (See Table 2.2). The result shows the difference in association with physical experience in two situations. It is common ways for a user to control remote control device of television, so they are used to interact physically with the controller, hold, touch, and act. Those experience make users to remind about turning the volume knob of the old radio when they are controlling TV. However, in the situation wearing the wrist wearable deive, there is no intuitive physical experience, so participants simply associate with up or down direction which explains the different results.

Table 2.2 Frequency of gestures on **Volume up / down**

Participant	Controlling TV with gesture			Controlling wrist wearable device with gesture		
	1st choice	2nd choice	3rd choice	1st choice	2nd choice	3rd choice
1	Move hand up or down			Etc. Turn wrist		
2	Etc. push with index finger and move up	Move hand up or down		Spin the index finger	Spread out the hand	
3	Grip and turn right or left	Spread out the hand	Move hand up or down	Move hand up or down	Spread out the hand	Move to right or left
4	Grip and turn right or left	Move hand up or down	Spin the index finger	Grip and turn right or left	Move hand up or down	
5	Grip and turn right or left		Move hand up or down	Etc. Move hand right or left		
6	Move hand up or down	Spin the index finger	Grip and turn right or left	Move hand up or down		
7	Spread out the hand	Grip and turn right or left	Move hand up or down	Spread out the hand	Grip and turn right or left	Move hand up or down

'Move to right or left' was relatively high in frequency for the function 'Previous song/Next song' (See Table 2.3). The gesture was selected frequently especially in controlling wrist wearable device, which suggest the preference to perform gestures with minimum movement that propose the direction.

Participant 1, 2, and 3 chose different gestures for two situations. They explained that gestures in controlling TV have more depth and freedom to act, while in controlling wrist wearable device, gesture become smaller but delicate.

Table 2.3 Frequency of gestures on **Previous song/ Next song**

Participant	Controlling TV with gesture			Controlling wrist wearable device with gesture		
	1st choice	2nd choice	3rd choice	1st choice	2nd choice	3rd choice
1	Move to right or left			Move to right or left		
2	Move to right or left	Move index finger right or left		Turn the hand and snap	Move index finger right or left	
3	Etc. Open hand and turn right or left	Turn the hand and snap	Move to right or left	Move to right or left	Turn the hand and snap	Move index finger right or left
4	Turn the hand and snap	Move to right or left		Move to right or left	Turn the hand and snap	
5	Move index finger right or left	Move to right or left		Move index finger right or left		
6	Move index finger right or left	Move to right or left		Move to right or left		
7	Move to right or left	Move index finger right or left		Turn the hand and snap	Move index finger right or left	Move to right or left

To see the hiererchy of the preference of gestures for each functions, each choice of gesture were scored by number(See Table 3.1, 3.2, 3.3). The first choice gets score 3, the second gets score 2, and the third gets score 1. As the result, the most preferred gesture for 'Play and Pause' was 'Finger snapping', 'Volume up/down' was 'Move hand up or down', and 'Previous song / Next' song was 'Move to right or left' for both situations.

Table 3.1 Hierarchy of the preference of gesture on **Play / Pause**

	Controlling TV with gesture	Controlling wrist wearable device with gesture
Hierarchy of the gesture	Finger snapping (score 15)	Finger snapping (score 11)
	Clapping hands (score 10)	Point fingers (score 7) Clapping hands (score 7)
	Finger point (score 6)	Okay sign (score 3)
	Pushing hand forward (score 1)	

Table 3.2 Hierarchy of the preference of gesture on **Volume up / down**

	Controlling TV with gesture	Controlling wrist wearable device with gesture
Hierarchy of the gesture	Move hand u wn (score 13)	Move hand up or down (score 9)
	Grip and turn right or left (score 12)	Spread out the hand (score 7)
	Spin the index finger (score 5) Spread out the hand (score 5)	Grip and turn right or left (score 5)
		Move to right or left (score 4)
		Spin the index finger(score 3)

Table 3.3 Hierarchy of the preference of gesture on **Previous song / Next song**

	Controlling TV with gesture	Controlling wrist wearable device with gesture
Hierarchy of the gesture	Move to right or left (score 13)	Move to right or left (score 12)
	Move index finger right or left (score 8)	Turn the hand and snap (score 7)
	Turn the hand and snap (score 5)	Move index finger right or left (score 6)

CONCLUSIONS

From the pilot survey, some insights were drawn tentatively. There are no big differences of using gestures between conventional gestures for communicating with others and gestures for controlling digital devices. People seem to prefer habitual gestures for similar situation. The participants answered the same gesture for two different situations: controlling the TV and wrist wearable device. As the pilot survey was conducted, some issues on questionnaire were found. The participants seem not to recognize the differences of two situations as they make answers for the survey. So, the new survey form was developed to solve the issues as shown in Figure 3.

The posture of hands for wrist wearable devices is different from the posture for TV control. The updated questionnaire describes the context of controlling functions in wrist wearable devices. Through this research, the research question will be explored again to design gesture interaction methods for wrist wearable devices: 1) gesture differences among gesture for convention hand signals, touch operations, gestures for screen-based devices such as TV, and gestures for wrist wearable devices.

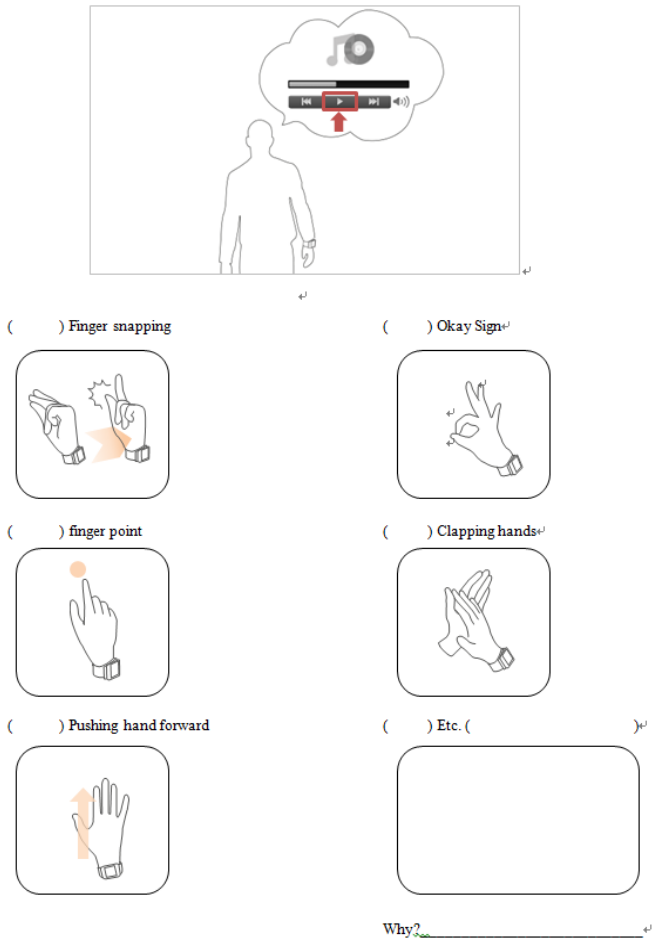

Figure 3. Survey form for wrist control devices

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Industrial Design Modeling for a WiFi Base Station Device

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ABSTRACT

This paper presents the methodologies and the systematic approaches in the industrial design development process to incorporate aesthetic and affective elements in a WiFi Base Station device. EQUID (Ergonomics Quality in Design) design approach was applied where users' requirements were identified in early design stage utilizing Kawakita Jiro (KJ) method. Benchmarking and trend analysis were also conducted in early stage to understand market trends, compare features and faults in existing product in the market, at the same time finding opportunities for improvement in our own product. The development of the fashion driven shape of the WiFi Base Station Device, the color chosen and the branding profile creation were also discussed in the paper. By using a user centered design approach, several design concepts and prototypes have been developed and user's emotions towards each concept in focus group have been captured. The survey was carried out at the end of this paper to assess the design effectiveness.

Keywords: EQUID, aesthetic industrial design, WiFi base station, user centered design.

INTRODUCTION

The WiFi Base Station device is an Access Point (AP) for outdoor and indoor use, enabling Customer Premises Equipment (CPE) device which is part of the solution to bridge the digital divide in Malaysia, are designed to link individuals to the Internet. Current existing products in the market lack aesthetic appeal and unlikely in fulfilling emotional attributes. Most of them looks similar and quickly identified as boring square boxes with antennas and some features to cater for the interconnect functionality. As a result, these products portray and establish industrial, or sometimes military image to one's thought while it may not necessarily be that way. Thus, these products have failed to establish long lasting product branding and differentiate itself in competition.

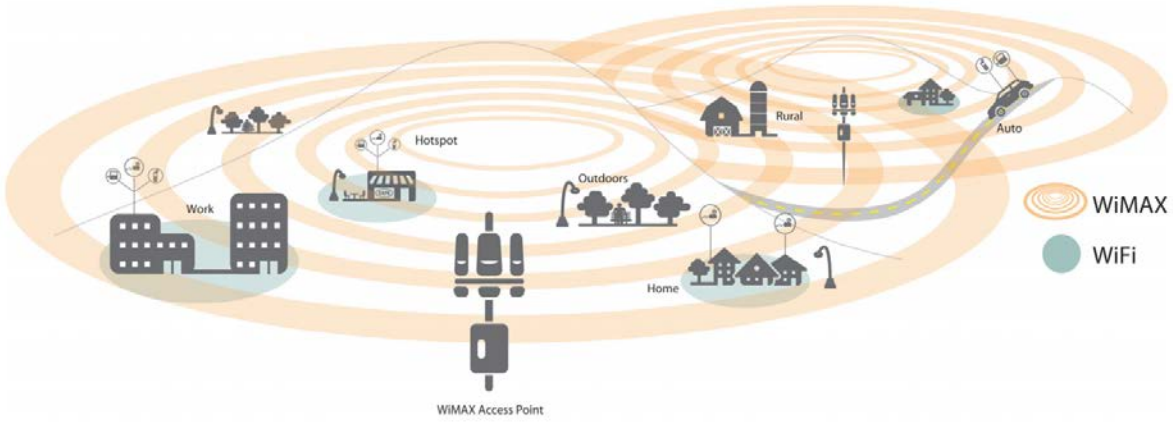

Figure 1. WiFi Base Station Application

In our effort to change the playing field, we have taken a step ahead to incorporate human factors and pleasurable emotion in the product outlook by applying Ergonomics Quality In Design (EQUID) (IEA, 2009) design approach. EQUID is an International Ergonomics Association (IEA) initiative to promote the integration of ergonomics into the design process where the HFE aspects and concerns are addressed during the feasibility stage, conceptual sketches and technical discussions during the design development cycle. During the ID development stage of a WiFi Base Station device, some tools which commonly used in the conventional PDP were used to address Emotional Design and Product Aesthetics' concerns and opportunities such as Understanding User Needs through i.e Kawakita Jiro (KJ) Analysis and Benchmarking. The following sections describe the activities carried out to institutionalize ergonomics quality in Industrial Design in designing a product that meet user's affective requirements.

USER REQUIREMENTS

It is important to design a product with specifications that meet customer demands. Initial product specifications can be generated through competitive benchmarking and market analysis against successful products in the market. These aim to understand market trends, compares features and faults in existing products in the market, at the same time finding opportunities for improvement in the development of own product. By doing so, initial user requirements can be established which will act as the design guideline to be implemented in the design which will eventually be a final, user centred product. In most cases, the initial user requirements can be very broad and these user requirements can usually be grouped separately into functional requirements and affective requirements.

KJ Analysis

At the preliminary stage of the EQUID process, initial design specifications for the product were established by translating the user needs into design requirements. This will ensure the design meets customers' needs and expectations. User needs, in other word, Voice of Customer (VOC) were gathered and categorized into different major titles as shown in Figure 2. The VOC were then prioritized using KJ analysis. The analysis result showed shape is the most important industrial design criteria for the WiFi Base Station device with the highest scoring, followed by size and color.

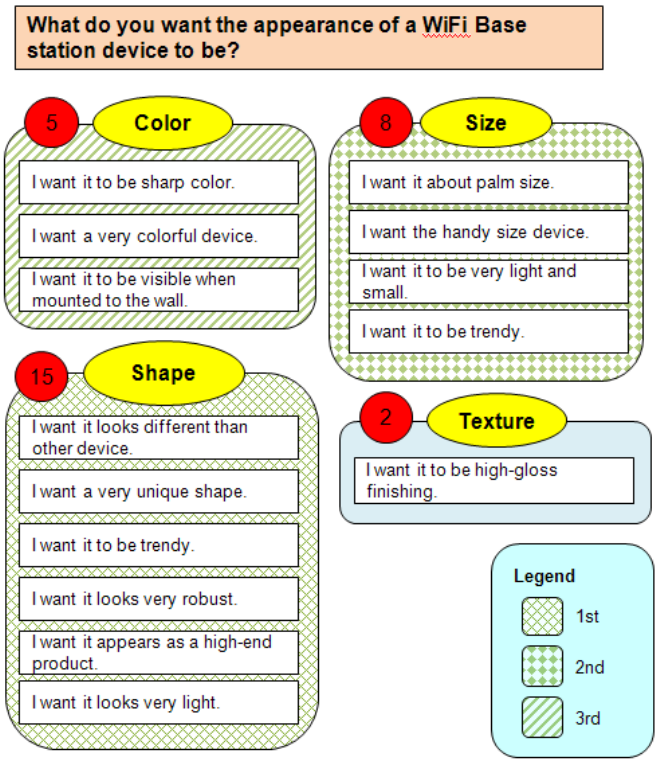

Figure 2. KJ Anaysis

Benchmarking and Trend Analysis

After the design requirements had been identified using KJ analysis, trend analysis and design benchmarking were performed as well to benchmark against similar existing products in the current market to determine the targeted affective keywords. Affective requirements are those pertaining to the look and feel as well as the pleasure a user experiences when using the product. Affective requirements are becoming more important in product design nowadays as they drive the emotion of the users when using the product. The affective descriptors captured from the benchmarking that related to the ID of this WiFi Base Station product including high performance, robust, and classic. This was the opportunity for us to improve from the existing market products by adding new affective descriptors to the new ID of this WiFi Base Station product.

Figure 3. Benchmarking Products

Trend analysis enabled us to understand the direction of the ID design for the current product as demonstrated in Figure 4. In order to be stood out in the market, the product ID design should have more emotional elements while appears as a high performance product. And hence, the design trend direction of the WiFi Base Station Device had been identified and new affective descriptors were added to the ID including minimalist, trendy and elegant.

Figure 4. Trend Analysis

ID DESIGN

In this section, after many concept reviews and design tweaks, a few design concepts had been developed based on the identified design requirements.

Figure 5. Three ID Design Concepts

In order to be appeared as high performance and robust product, a rectangular shape with round was chosen to be the shape of this product. Based on the benchmarking, rectangular shape is widely used in most of the robust products such as military-grade walkie talkie, outdoor enclosures and so on. It is also becoming a trendy shape in recent years as we can see in most of the smart phone devices. On top of that, some profile styling and curves had added to the ID in order to make it becomes more trendy and fashionable. Design 1 is fashion driven design as it had embedded the styling of Iron Man as shown in Figure 6.

Figure 6. Trendy Styling of ID Design 1

Besides the trendy styling, the emotion surface for company branding styling was also embedded into the ID of the WiFi Base Station device as illustrated in Figure 6 as well. Other than shape, color plays an important role in creating an impressive ID. Research conducted by the secretariat of the Seoul International Color Expo when asked to approximate the importance of color when buying products, 84.7 percent of the total respondents think that color accounts for more than half among the various factors important for choosing products. (Jill Morton, 2010). Three colors were considered in the ID concepts including white that associates to safe, basic, purity, efficiency, simplicity, and black that associates to elegance, mystery, expensive (empower-yourself-with-color-psychology.com, 2009-2014) and titanium color, a new color trend in the market recently that used on high performance products such as Tissot water proof watch, Nissan Fairlady Z, Lexus IS that gives impression of high performance, trendy, elegance. However, the final color will be decided based on the survey on the users on their preference color for this product.

USER CENTERED DESIGN

In this section of the development, the ID was evaluated and reviewed with the aim to satisfy the user requirement set forth in the previous process. As we know, ID is more on the appearance and the outlook of a product, however, it correlates with some functional features as well. The traditional design rule is always form follows function. And hence, the functions and the context of use of this WiFi Base Station device need to be captured as well. By establishing the user model, the goal of the design in the context of human factors and ergonomics could be clearly stated. This could be accomplished by defining the user scenario and personas whereby task-centric scenarios were put under careful consideration and how design features could affect user interaction. Two different personas were studied in this case: i) technician; ii) engineer. These two user categories are different due to their educational and experiential level. The interaction of the user with the product were scrutinized and understood in detail by the user

task-centric method. Also, their expectation on the ID of this product could also be addressed. In this process, the ID design was reviewed and iterated based on the developed user model and criteria.

Table 1: User Task Model of WiFi Base Station Device

Type of User	User Goal	Task	Context of Use	ID Interaction
Persona 1: Technician	To install the WiFi Base Station device as fast as possible.	Install the WiFi Base Station device at pole or wall wherever requested.	Installation.	Handy size or gripping feature.
	Zero product servicing and maintenance.	Perform servicing and maintenance to the product.	Maintenance.	Handy size.
Persona 2: Engineer	To design a reliable base station.	Design base station and cell planning for base station.	Product performance.	High performance and reliable appearance.
	To install and service the product with minimum efforts.	Write installation and maintenance manual for the product.	Installation and maintenance.	Handy size or single hand approach.

DESIGN ASSESSMENT

Method

Three designs above were given to the two groups of personas as mentioned above. They are required to write their affective descriptors for each ID design and rate their preference. Rating 1 is the most preferred and rating 3 is the least preferred. Table 2 below shows some examples of affective descriptors given to the respondents as reference and they were allowed to write other descriptors which were not in the table.

Table 2: Example of Affective Descriptors

High Performance	Repulsive	Cute	Bright	Crude	Ugly
Clumsy	Weird	Simple	Curvy	Solid	Stylish
Robust	Elegant	Classic	Powerful	High Technology	
Fashionable	Sleek	Fine	Dull	Pleasing	

Results

Design	Common descriptors	Preference
	powerful, solid, **high technology**, high **performance, trendy** Color preference: **metallic** associated to high technology	Rating 1 – 15.4 % persona 1 – 53.8 % persona 2 Rating 2 – 0 % persona 1 – 0 % persona 2 Rating 3 – 7.7 % persona 1 – 23.1 % persona 2
	robust, **high technology**, powerful, solid, trendy Color preference: **metallic** associated to high technology	Rating 1 – 0 % persona 1 – 15.4 % persona 2 Rating 2 – 15.4 % persona 1 – 38.4 % persona 2 Rating 3 – 7.7 % persona 1 – 23.1 % persona 2
	simple, classic, stylish, **high technology**, fashionable, elegant Color preference: **white** associated to simple and classic	Rating 1 – 7.7 % persona 1 – 0 % persona 2 Rating 2 – 7.7 % persona 1 – 30.8 % persona 2 Rating 3 – 15.4 % persona 1 – 38.4 % persona 2

Figure 7. ID Design Survey Results

The above result (see Figure 7) shows design 1 was the most preferred design by both personas. The design gave the impression of powerful, high technology and trendy to them which had met the initial design requirements. This also showed more than 50% of the persona 2 voted for design 1 as their expectation on the ID was a high technology appearance product. The color preference for the design was metallic color (in this case we selected the titanium color) which associated to high technology as well. Figure 8 illustrates improved ID for the WiFi Base Station device based on the inputs and survey results.

Figure 8. Improved ID of WiFi Base Station

CONCLUSIONS

The need to address Emotional Design and Product Aesthetic aspects for Industrial Design demands structured methodologies which the focal issues normally revolves around visual fluency and perceived hedonic quality while primarily satisfies the usefulness and ease of use. The systematic process, in conformance to EQUID framework, supported by an empirical scientific checklist helped designers to capture user requirements both functional and affective design. With new user requirements addressed, the new product is aesthetically more appealing and more likely to fulfill emotional attributes.

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Exploring the Role of Emotion in the Design Cycle

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ABSTRACT

Scholars have focused on "design and emotion" for more than a decade. Various studies, models, and theories have been proposed and adopted to explore the relationship between design and emotion, and to explain how emotion can be applied in the design process. After the theories are categorised according to the respective focuses, three main components that influence or are influenced by emotion can be identified: designers, design outcome and users or consumers in the design cycle. Based on the relationships amongst these components, numerous similar terms categorised under emotion and design that have clear and concrete rationales and definitions have been developed. For instance, "emotionalised design" refers to design in which designers introduce their emotions into the design process. "Emotional design" is viewed as design that can stimulate users' or consumers' emotion. "Emotion design" is design in which emotional concerns are involved in the interactions between designers and users.

However, few studies have focused on designers' perceptions of these terms and of the role of emotion in design. By conducting an empirical study, we investigated designers' perceptions of three terms, emotion design, emotional design, and emotionalised design, and explored designers' experience regarding emotion and design.

Keywords: Emotion Design, Emotional Design, Emotionalised Design

INTRODUCTION

In recent decades, researchers have increasingly focused on the design process that underlies design practice. Numerous studies have used various methodological approaches to explore the optimal management of the design process (Best, 2006; Noble & Bestley, 2005; Peto, 1999). Some studies have explored the durability of materials and the consumption of designs, and used the findings to develop alternative design propositions. After examining various research methodologies, researchers have developed design processes suited to specific outcomes (Chen & Chen, 2004; Cross & Sivaloganathan, 2004; Gayretli & Abdalla, 1999; Reyman et al., 2006). In general, design scholars seek ways to create interesting and engaging designs that provide users with a satisfactory experience. Accordingly, some design scholars believe that emotion can contribute to creating products intuitively and efficiently, and thereby improve the ease of use. Moreover, Desmet and Hekkert (2009) suggested that the influence of emotion on design does not begin when users consume design outcomes, but is integrated into the product development process and the roles of designers in numerous ways. Psychologists and design scholars have determined that emotion affects how humans treat information, management (internal factors), creativity, and other factors (Skinner, 1968) In other words, the emotion of a designer is a factor influencing his or her ability and manipulation of the design process. Exploring design and emotion has generated new perspectives and key terms on the design process, such as "emotional design", which describes the relationships between emotion and design outcomes, and "emotion design", which describes the relationships between emotion and designers and design outcomes. The individual meanings of these key terms related to design and emotion as well as how they interact based on the concept of design and emotion must be understood. We reviewed the literature on design and emotion

to develop a detailed historical understanding of the terms. The results of this literature review provide a theoretical basis for discussion on how emotions influence the design processes of designers.

THE DEVELOPMENT OF THE DESIGN PROCESS FROM THE PERSPECTIVES OF DESIGN AND EMOTION

Emotion has recently been introduced as a supportive element that optimises the design process (Desmet and Hekkert, 2009; Desmet, 2008; Demirbilek and Sener, 2002). Researchers have explored design processes to improve and achieve certain functions. Chen and Chen (2004) proposed the adaptive design process, which was generated by integrating a systematic design process and a design-patent protection mechanism. However, although some research has focused on exploring the relationships amongst designers, design outcomes, and users or consumers, few studies have focused on the three components of the design process. As the topics and research developed further, emotion (including the flow of emotion amongst these three components), like the target audience, had to be applied as a core element at every step in the design process (including users' emotion in design reflections). This enabled the design process to be reshaped into a new paradigm rather than to remain only an auxiliary that facilitates achieving certain design outcomes. Therefore, the role of emotion in the design process must be understood according to three main components: the designer, design outcome, and user. Consequently, theories on design and emotion can be categorised into three main types based on the components involved in the design process and consumption (i.e., user-driven or consumer-driven, designer-driven, and relationships amongst users or consumers, designers, and design outcomes). This method of categorisation enabled us to understand how emotion functions in the relationships amongst designers, design outcomes, and users or consumers, and to address the studies that have focused on how emotion (including designers' emotions) influences the design process (including the design process, the consumption of design outcomes, and reflection after design consumption). The following sections review the literature on these relationships.

EMOTION AND DESIGN STUDIES

Research on User- and Consumer-Driven Studies

According to the aforementioned research, scholars in the field of design and emotion first explored the user- or consumer-based approach (i.e., the relationship between users or consumers and design outcomes). Desmet and Hekkert (2009) believed that a greater understanding of the user or consumer experience improves designers' ability to design effectively.

Design scholars have used theories of emotion in developing concepts to improve design outcomes (i.e., to improve design products). Gaver, Dunne, and Pacenti (1999) introduced "cultural probes" as a research method to help designers obtain contextualised and rich insight based on the experience of users and consumers. Gaver (1999) proposed that emotion-based products (i.e., products designed based on emotional concerns) stimulate an intuitive and sensitive interaction style that helps designers interact with users or consumers and, thus, gain their insight.

Hummels (1999) illustrated the growing tendency to include emotional concerns in interactive design products and proposed that this reflected the development of technological complexity. Cupchik (1999) offered valuable theoretical insight into how products elicit emotions and asserted that this insight has helped designers enhance the emotional impact of their designs. He proposed that cognitive and behavioural meanings are the keys to improving design because they integrate the structural, functional, and ergonomic features of designs with user expectations and knowledge. In other words, cognitive and behavioural meanings provide a critical bridge between the purpose and structure of design outcomes and the users who must understand and use them. Simple and clear design properties help users or consumers understand and use the designs. Therefore, design scholars have begun investigating simple and clear design properties that help users or consumers understand and use designs; for example, Harada (1999) proposed "Kansei Engineering", which is a design analysis system developed using a research-based approach, to identify and quantify the relationships between product design features and the emotional responses of product users. Desmet and Hekkert (2002) regarded consumers' appraisals as key factors in determining whether a design outcome evokes an emotion and which emotion is evoked (Frijda, 1986; Desmet,

2003). To present their perspective on consumers' emotional responses to products, Desmet and Hekkert proposed the "model of product emotions", in which the emotions associated with products are classified into five classes: surprise emotions, instrumental emotions, aesthetic emotions, social emotions, and interest emotions. They illustrated each class of emotion by using an example of interviewees' emotional responses to a particular product. Their study revealed that products can elicit several emotions and that, although the process through which users experience an emotion based on a design outcome is universal, users' emotional responses are complex and personal.

Norman (2004) addressed this perspective in his book *Emotional Design: Why We Love (or Hate) Everyday Things*, which introduced the "three levels of design" concept, which is based on concerns regarding the "user experience". Norman described the user experience of consuming a design as "cognitive processing". He divided cognitive processing into three levels: visceral, behavioural, and reflective. The visceral level refers to users' or consumers' first impression of the design outcome and their intuitive emotional response. The behavioural level refers to users' or consumers' consumption actions based on the emotions stimulated by the design outcomes. The reflective level refers to users' or consumers' reflections on the consumption experience. Norman's three levels of design concept describes how designs provide users or consumers with emotional experiences. Based on this concept, the respective design outcomes that elicit three types of response in users or consumers (i.e., visceral, behavioural, and reflective) when consuming designs can be referred to as "visceral design", "behavioural design", and "reflective design". Norman conducted a comprehensive investigation on how designs are associated with emotion and observed that providing a pleasurable experience enables designers to establish emotional relationships with users or consumers. Other design scholars have conducted further research on how pleasurable experiences enable designers to meet the needs and demands of users or consumers. Choi (2006) concluded that emotional design can create a strong and positive mental attachment (i.e., emotional concerns in design) between the user and the product that strengthens the usability of the design. Hakatie and Ryynänen (2006) conducted a simple research experiment that verified that the three levels of cognitive processing can be linked to the attributes of various products. The results of their experiment indicated that consumers' selection criteria for products were clearer on the visceral and behavioural levels than on the reflective level. Because users usually derive emotional messages and experiences from the visceral and behavioural levels, emotion design is ideally suited to meeting the needs and demands of users or consumers and, consequently, to creating more marketable products.

Inspired by the research of Norman (2004) and Desmet and Hekkert (2002), Lo (2007) defined emotional design as design that focuses on users' needs and experience, emphasising that emotional concerns can improve the function, form, and usability of design outcomes and, thus, enrich users' experience. Departing from previous studies, Chitturi (2009) stated that an effective design should benefit the user's overall consumption of the product (i.e., in the real market, users experience emotional changes during and after consuming a design outcome). Depending on the quality of a product consumed, users can experience positive or negative emotions. Both positive and negative emotions influence users' evaluations of a product and decision making in subsequent purchasing processes. Therefore, users' positive and negative emotional changes during the consumption of a product affect their loyalty to the product (i.e., design outcome).

The literature has provided few definitions of emotional design. Because some scholars use emotional design to refer to emotion design, the difference between the two terms is unclear. Further research must be conducted in this area. However, according to the aforementioned studies, emotional design focuses on the needs and experience of users and is used to create products that elicit emotion. Other key criteria and conditions related to emotional design are listed as follows:

- Although the process through which users experience an emotion based on a design outcome is universal, each user's emotional response is complex and personal;
- Consuming a product involves three levels of cognitive processing, namely visceral, behavioural, and reflective;
- Emotional design is communicated through the design, function, form, and usability of a product and is developed in relation to users' needs and demands;
- Emotional design affects users' consumption and is likely to appear in the real market; and
- Users' positive and negative emotional responses to the consumption of a product can affect their loyalty to the product (i.e., design outcome).

Although numerous studies have explored the concept of emotional design, a more concrete definition of emotional

design has yet to be proposed. Hence, the findings of the aforementioned studies have been discussed and analysed to obtain a more comprehensive understanding of the concept of emotional design.

STUDIES FOCUSED ON THE RELATIONSHIP BETWEEN DESIGNERS' EMOTIONS AND DECISION MAKING IN THE DESIGN PROCESS

Numerous studies have explored the relationship between designers' emotions and the design process. Some studies have investigated whether designers draw on their own emotional responses when developing designs rather than focus solely on the user's perspective. Based on the existing theories on emotion and experience, Forlizzi, Disalvo, and Hannington (2003) described how emotion is a key element that influences designers, asserting that changes in the external environment, such as social changes and new interactions between people and objects, influence designers' goal setting and reflective emotional responses to design (i.e., emotional experience). Designers' reflective emotional responses are likely to influence their decision making during the design process. However, few studies have investigated the relationship between emotion and the decision making of designers during the design process. Drawing on design process research, Ho (2010) discussed the function of emotions and proposed the E-wheel model[1] (Figure 1) to explain the relationships amongst designers, emotions, and internal factors (e.g., information processing and material allocation) and external factors (i.e., technological, social, cultural, and economic factors) in the design process. According to Scherer (1984), an emotion expresses a pattern of reactions in response to external stimuli and engenders evaluations of the stimuli and of a situation. Thus, introducing emotional concerns into the decision-making process affects the decision-making ability of designers. Ho (2010) explored how internal and external factors affect the design process, which involves numerous decision-making processes. External factors can affect the emotions of designers and cause them to make different decisions that affect the internal factors and, hence, change the design process. This process provides insight into how designers can use their emotions to develop appropriate responses that optimise their designs.

Based on the aforementioned research, the criteria and conditions related to the relationships between designers and design outcomes can be generalised as follows:

- Changes to the external environment influence designers' emotions;
- Designers' emotional changes influence the design process and the structure and function of design outcomes;
- Introducing more personal experience and emotion into the design process can improve the management of the design process;
- Including emotions in design outcomes (including material and visual expressions) can create closer relationships between designers and users;
- Designers tend to use more emotional and intuitive methods in the design process than they did in the past.
- External factors (i.e., external stimuli) can affect the emotions of designers and cause them to make different decisions that affect the internal factors (e.g., information processing and material allocation) and, hence, change the overall design process. This process provides insight into how designers can use their emotions to develop appropriate responses that optimise their designs.

RESEARCH ON THE RELATIONSHIP BETWEEN USERS OR CONSUMERS AND DESIGNERS AS REFLECTED IN DESIGN OUTCOMES

In addition to the user- or consumer-driven- and designer-driven-based research, research has been conducted on how communication between users or consumers and designers is reflected in design outcomes or, in other words, the relationships amongst users or consumers, designers, and design outcomes. Funke (1999) studied how emotions

[1] In the name of the E-wheel model, "E" refers to "emotion".

relate to design outcomes (i.e., design products) in satisfying subjective expectations, and proposed that design acts as a semiotic instrument in an experience market. He observed that emotional concerns were transformed into products (i.e., design outcomes) that fulfilled users' personal expectations and enriched their experience. Hence, the emotional aspects of use should be regarded as more crucial considerations than function in the design process. Jordan (2000) conducted a holistic study of the relationships between people (including designers, users, and consumers) and products, and the criteria for judging the quality of designs, indicating that thoughtful designers are sensitive to the needs of users and apply skill and judgment in designing products that empower users and afford them pleasure. Because the products affect the users' moods, the users gain emotional benefits while using the products. Fulton Suri (2003) studied how design influences the quality of the experience consumers enjoy. In her research on "design expression" (i.e., designer-driven studies) and user experience (i.e., user-driven studies), she observed that emotional concerns affected both designers' and users' relationships with design outcomes. Because design outcomes (i.e., design products) are becoming increasingly similar in many ways, including technology, functionality, price, and quality, designers are required to design more differentiated outcomes to fulfill the needs of users or consumers (Fulton Suri, 2003). In other words, designers must influence people's behaviour and perception through their design outcomes.

Emotional concerns affect both the design process and the consumption of designs, and are a crucial factor driving designers to explore ways of contributing to users' experience and communicating experiential ideas (between users and designers). Based on a concept similar to that of Fulton Suri, Cupchik (2004) proposed the idea of "designing for experience" to describe the interactive relationships amongst designers, design outcomes, and users. In the process of experience design, a designer imbues an object with given meanings or messages. Users or consumers then use the design according to the prescribed function and are thus influenced by the designer's planned creative message. According to this perspective, emotion can be incorporated into design to realise both the expectations of users and consumers and the designers' plans in the interactive experience. Tzvetanova (2007) suggested a similar concept which emphasises the interactive emotional relationships between users and designers. In this context, the factors relating to users (i.e., the feedback from the users) are the most crucial criteria for evaluating the quality of emotion design.

Although some studies have explored how emotion influences design, few studies have focused on how emotion influences the design process. Most of the aforementioned studies provided basic concepts of emotion design, but did not offer specific terms to describe or identify the concept of how emotions influence design outcomes, users, and designers. Therefore, key criteria and conditions regarding emotion design are listed as follows to provide a foundation for further discussion.

- Design often acts as a semiotic instrument that delivers the designer's message to the user.

- Users or consumers and designers interact through the planned function or design of a product. The emotional concerns of users or consumers and designers affect both the design process and the design outcome. By understanding users' needs, a designer can explore design concepts to contribute to users' experience. The design process enables users or consumers and designers to communicate their experiential ideas.

- Emotional concerns affect both the design process and the consumption of design by communicating an understanding of the users' experience, thereby enabling the designer to explore design concepts that contribute to the users' experience and, thus, experiential ideas related to the product to be relayed between the user and the designer.

The foregoing review of the literature indicates that the use of the phrase "design and emotion" is inconsistent (Ho & Siu, 2009). The few studies analysed in preceding sections are the only studies that have explored the basic definitions, natures, and characteristics of emotion design and emotional design (Ho & Siu, 2009). Most of the studies used these terms to refer to design that contained or related to emotion. Moreover, most of the studies investigated the relationships amongst users or consumers, design outcomes, and emotion rather than those between emotion and the design process. The E-wheel model was proposed to clarify the relationship between emotion and the design process. The E-wheel explains the relationships amongst designers, emotions, and internal factors (e.g., information processing and the allocation of materials) and external factors (i.e., factors not directly controlled by designers, such as technological, social, cultural, and economic factors) of the design process. The role of emotion in the interaction between the external and internal factors that affect the design process was discussed. The E-wheel model explains the effect of emotion on designers' decisions in the design process. All of the aforementioned theories were used to describe the effect of emotion on designers, design outcomes, and users or consumers in the cycle of design, consumption, and reflection.

THE NEW CONCEPT OF EMOTIONALISED DESIGN AND NEW PERSPECTIVES ON EMOTIONAL DESIGN AND EMOTION DESIGN

The foregoing literature review revealed that several similar terms are used to refer to design and emotion. However, the definitions of terms such as the emotional aspects of design, emotional design, and emotion design have not been defined adequately. This section provides a clear and concrete definition of design and emotion to enable a comprehensive understanding of the concept to be attained.

The New Concept of Emotionalised Design

Before a final design outcome is sold on the market, designers must complete the design process. Designers often introduce various emotional concerns into the design process before realising the final design outcome (Ho, 2010). Alternatively, the design outcome can embody certain facets of the designer's emotion. In this case, the designer introduces his or her own emotion into the design process to achieve a design outcome, which can be regarded as an "emotionalised design" from the perspective of the designer.

A typical example of emotionalised design is the case of the book *RMX Extended Mix* (Alexander, 2001), which was designed by Rinzen, a group of Australian artists, in 2001. Adrian Clifford, one of the group's members, stated that everyone in the group produced an initial piece on one of eight themes. The files were then passed between the designers, who progressively modified, augmented, and erased the content at each step in the process. The designers were able to express their personal perspectives on the topics that interested them while applying their professional skill. Consequently, the designers were able to introduce their personal emotions, interests, and intuitive evaluations into the design process. However, the consumers' perspective was not initially considered in this process.

Another example of emotionalised design is student design assignments. Student designers often introduce aspects of their emotions into their assignments when striving to achieve the learning objectives of their projects. Although, the design outcome motivates the emotional responses of users in this case, users typically do not consume this outcome in a real market. Therefore, student design assignments can be regarded only as examples of emotionalised design.

Recognising examples of emotionalised design is not easy because designers may introduce certain types of emotion into the design process, and most outcomes are likely to transform into emotional designs when they are sold on the market. Design outcomes can carry certain types of emotion intended to stimulate communication and interaction with users or consumers. These emotions motivate users or consumers to respond to the appearances or functions of designs. *RMX Extended Mix* may have induced emotional responses from the users or consumers because it was sold on the market. Hence, from the perspective of the final design stage, the book can be regarded as a form of emotional design.

The two previously described examples fully support the proposed concept of emotionalised design and the conceptual structure of the E-wheel model. According to the E-wheel model proposed by Ho (2010), when external factors affect designers' emotions, their emotions then affect various decision-making processes related to the internal factors of the design process. This altering of the design process leads to the development of different design outcomes. Thus, the designer's emotions, which are elicited by external and internal factors, become the key element in the design process.

In the case of *RMX Extended Mix*, external factors, such as the development of technology and the cultural background contributing to the theme, affected the logical thinking and the emotional responses of the designers as they developed their design themes. Instead of focusing on the consumers' perspective, the Rinzen artists introduced their personal emotions into the design process. Each designer introduced his or her emotional responses into the decision-making process when he or she began to alter or edit a design. The designers' emotional responses to the external factors, which reflected their professional knowledge, personal interests, and intuitive evaluations, affected their decision making and, consequently, the overall design process.

In the case of student design assignments, factors external to the design process (e.g., the cultural background of the student) can affect the emotions of students while they develop their projects. Moreover, students introduce their emotions into the design process when they make decisions about certain internal factors, such as information processing and the allocation of materials. Therefore, altering the design process affects the design outcomes. According to this example, external factors affect the emotions of designers, and their emotions can cause them to make various decisions regarding internal factors, thus affecting the design process and the design outcome.

This process whereby designers introduce their emotions into the design process to realise a design outcome supports the concept of emotionalised design. Before a final design outcome is sold on the market, designers must complete the design process. Designers often include or introduce various emotional concerns into the design process prior to realising the final design outcome. Consequently, the design outcome conveys certain qualities, aspects, and attributes of the designer's emotions.

A New Perspective on Emotional Design

When a design has been completed and is sold on the market, it may have the capacity to affect the emotions of users or consumers. This emotional attribute (or motivation) is derived mainly from the style, function, form, and usability of the design and the users' experience when consuming the product. In other words, the design outcome may affect the users emotionally by causing them to feel happy, annoyed, or excited. Thus, the design outcome may motivate users to connect, recall, or imagine related events or relevant experiences that cause their emotions to change. This can be regarded as emotional design from the perspective of the user.

A clear example of emotional design is the signage for Umeda Hospital in Tokyo; this signage was designed by the Japanese designer Kenya Hara in 2005. The signs are made of cotton cloth, which elicits a sense of comfort and softness to soothe the patients and ease anxiety and worry. Hence, because this signage can evoke a certain type of emotional response in the user, it can be regarded as a form of emotional design.

A New Perspective on Emotion Design

The foregoing discussion of the process of emotional flow, from the designers who incorporate their emotion into designing an outcome (emotionalising design) to users who respond emotionally to the design outcome (emotional design), revealed that the interactions between designers and users can affect the design outcome and lead to the establishment of strong relationships amongst the designer, the user, and the product (design outcome). This relationship provides the foundation for emotion design.

Emotion design refers to reflection on a design that is generated after the design outcome has been consumed. Although designers can obtain reflections on their designs directly from the users through feedback, they can also indirectly reflect on their designs.

Typical examples of emoticons to illustrate the theory of emotion design. Emoticons are used in electronic communication to express how a sender feels. According to the Microsoft Network (MSN), an eminent developer of emoticons, "Emoticons are emotion graphics—visual ways to express the way you feel when words alone just aren't enough" (MSN.com, n.d.).

This statement suggests that emoticons enable users to convey emotions. The user can choose particular forms and styles of icon to represent their feelings. Thus, emoticons are clearly a form of emotional design, because the design outcomes (emoticons) are designed to evoke certain emotions in users. In addition, based on how these icons are designed, they also embody a form of emotionalised design. Because the icons are designed based on the designers' emotions, emotion is introduced into the design process. In this case, emotionalised design and emotional design coexist, because designers can interact with users within the emotion flow. Hence, emoticons are a typical example of emotion design.

The Proposed Model (3E Model)

Based on the foregoing review of the theory of emotion design, the role of emotion in the design process consists of three main components: designers, design outcomes, and users or consumers. When designers encode information and consumers decode it, the emotional expressions (the design attributes developed based on emotional concerns) of the designer and the user or consumer serve a critical communicative function.

The design process involves a process of information encoding and decoding[2] (Wogalter, Dejoy & Laughery, 1999) in which the interactive relationships amongst the three components (i.e., designers, design outcomes, and users or consumers) are identified. The focus of most scholars such as Desmet (2002) and Norman (2004) has been on the relationship between design outcomes and users or consumers. However, scholars who have studied the design process have proposed that the design process comprises three main components: designers (Vosburg, 1998; Tan, 1999), design outcomes, and users or consumers (Jardon, 2000). To investigate the influence of emotion on the design process, the relationship between emotion and design outcomes and that between users and designers must be carefully addressed. This paper proposes three new design and emotion research categories, namely user- or consumer-driven research, designer-driven research, and research on the relationship between users or consumers and designers as reflected in design outcomes. According to this categorisation method, emotion in the design process involves the three components (i.e., designers, design outcomes, and users or consumers). Emotion should be closely linked and considered throughout every step in the design process. The close relationships between emotion and the three components were developed into three key terms: emotionalised design, emotional design, and emotion design.

A 3E model is proposed to illustrate the relationships amongst the three design types. The 3E model (Ho & Siu, 2009) (Figure 1) provides a framework that explains the close relationships amongst designers, design outcomes, and users or consumers in the topic of design and emotion. The framework models the flow of emotion in the overall design and consumption cycle from the designers who introduce emotional concerns into the design process (i.e., emotionalised design) to the users who experience certain emotional responses in response to the design outcome (i.e., emotional design). The relationships amongst emotions, designers, and design outcomes (i.e., the core elements of emotionalised design) and the relationships amongst emotions, users or consumers and design outcomes (i.e., the core elements of emotional design) are clearly illustrated in Figure 1. The interactions between designers and users shown in the design outcome indicate that strong relationships exist amongst these three components, providing a foundation for emotion design.

In addition, reflection is generated after a design has been consumed. Designers can directly obtain users' reflections through user feedback, and users can provide indirect reflections to the designers. Figure 2 shows user reflection in the 3E model.

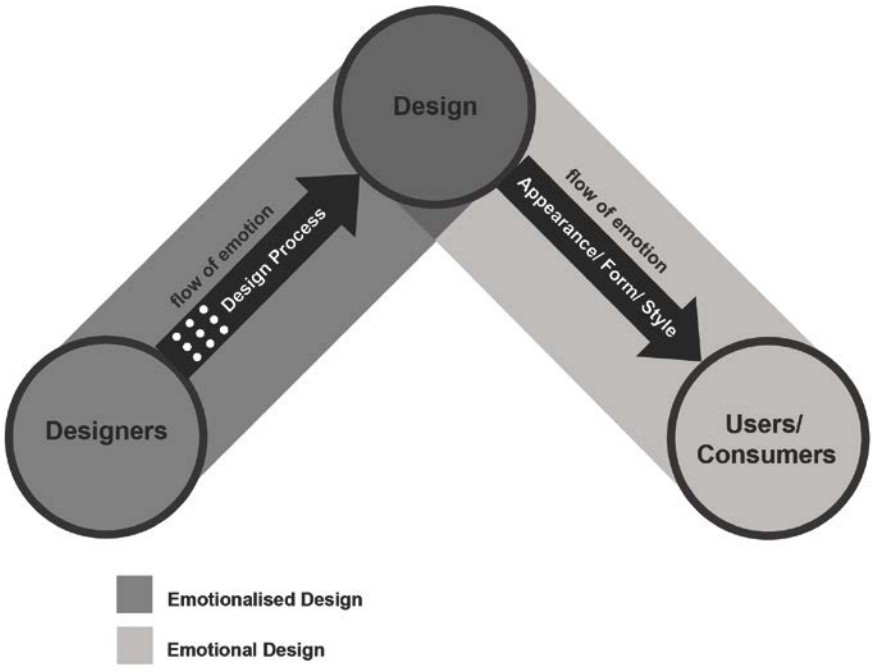

Figure 1. Model to illustrate the relationship between 'emotionalised design' and 'emotional design'

[2] According to Wogalter, Dejoy, & Laughery (1999) designers encode the information and consumers decode it, and the designers and users or consumers interact in the design process through the design outcome.

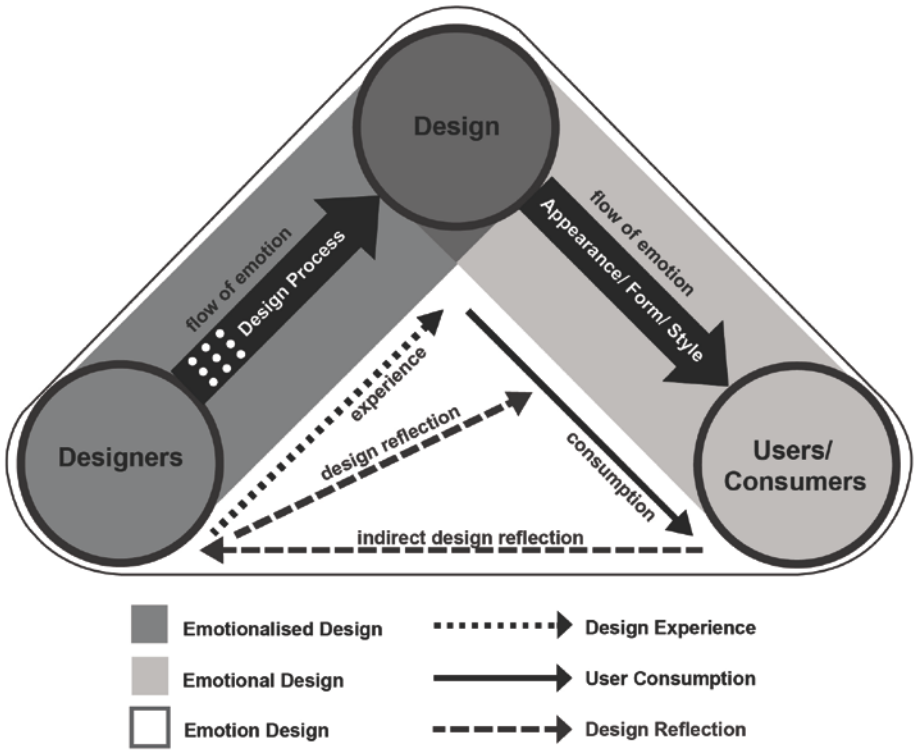

Figure 2. 3E Model (including user reflection)

According to the 3E model, designers introduce certain emotions into the design process to manipulate the design outcomes; in other words, they emotionalise design. The design outcomes embody certain emotional concerns that designers introduce during the design process to elicit the emotions of users. Hence, emotion plays a vital role in the design process and may, in turn, affect the emotional responses of users. Thus, this model provides an understanding of how emotion influences the design process from the designer's perspective. This approach differs from that of other research that has focused mainly on outcomes such as ergonomics (Wickens & Hollands, 2000), sustainability (McLennan, 2004), and accessibility (Mace, Hardie, & Place, 1996) from the user's perspective. In addition, the model explains the flow of emotion and the extent to which it affects designers, design outcomes, and users in the design process.

CONCLUSIONS

The foregoing theoretical review describes various concepts and theories related to design and emotion. The exploration of how emotions influence the design process inspired the application of the 3E models. The 3E models explain the relationships amongst emotions, designers, design outcomes, and the design process by providing new perspectives on key terms (i.e., emotionalised design, emotional design, and emotion design). Different from previous studies of the design process, it addresses the influence of emotion from the user's perspective as well as designers' decisions in the design process. These concepts and terms can be applied and explored in future studies on the role of emotion in the design process. In addition, this approach should be introduced to and understood by designers (Ho and Siu, 2009), because it can enable them to understand how emotion functions in the relationships amongst designers, design outcomes, and users or consumers. Designers must learn this new concept and include emotion along with other design theories throughout the design process. They should consider emotion as a means for optimising certain parts of the process and should combine emotion with the design process to manipulate the process effectively.

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A Suggestion on the Development of Children's Safe Clothes Design Using Complementary Colors Effect

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ABSTRACT

Some of pedestrian accidents are caused the drivers can't distinguish pedestrians from surroundings, especially on the rainy/foggy/snowy days and nights. To reduce the pedestrian accidents, some children's raincoats are designed with evident colors. And street cleaner's uniforms use fluorescent fabric in the same purpose. According to the recent reports, flickering lights can improve object's visibility more than fluorescent colors in the dark environment. The purpose of the proposed study is to develop safe clothes design applying complementary colors and blinking and moving LED lights. The implementation technology of complementary color and blinking LED effect for improving visibility of pedestrians that help to reduce the number of traffic accidents. This study contains 3 contents. First, before verifying a hypothesis that complementary color helps pedestrian to be recognized, it needs to be formed an algorithm. Inevitably, general color sensors hardly detect surrounding colors. Unless they are approached to subject's surface to detect, its accuracy would not have enough effectuality. So, in this paper tries to find the algorithm that helps effective detecting by using camera. It includes computer vision technology and helps to find accurate surrounding environment's colors. Second, this study developed a children's raincoat applying technology that detect main color of the surrounding environment and show LED lights of its complementary color. The raincoat would help to reduce children's traffic accidents on a rainy/foggy/snowy or any type of day. We also developed user scenario in order to explain several situations. The last, we conducted the examination to verify the effectiveness of technology and suggest the possibility of various clothes design. The method and steps for examination are as follows. Build 4 Color sensors(TSC3200S), LEDs, Arduino platform in rain coat. The color sensors attached front, back, right, left sides on raincoat detect each main color of surroundings. Then Arduino platform convert the detected color to complementary color then, show LEDs. This study would be useful to street cleaners' uniform design who exposed to more danger and general pedestrians' accessories.

Keywords: pedestrian accidents, children's safety clothing, complementary color, flickering effect, color sensor, RGB LED strip, Arduino

INTRODUCTION

According to car accident data in 2009, there were 18,092 car accidents whose victims were under 14-years old, 17,810 of preschool children and elementary school students, and 5,785 of middle school students. Among OECD countries, Korea has been ranked to 8th highest country and 1.2 times higher than the average of OECD countries` car accident (1.6 of 100,000).

Furthermore, it is well known that weather conditions are closely related with the number and severity of traffic accidents. The bad weather such as rain, fog and snow has been the cause of thousands car accidents year in and year out. It can be difficult for drivers to see other cars and pedestrians due to less attractiveness. Because the bad

weather makes the light scatter and thus driver's ability to recognize the distance is decreased. Park, Jun-tae(2010) suggested to improve the driver's visibility in order to reduce the probability of car accidents.

One of the ways to reduce children' car accidents, some raincoats for children are designed with evident colors. The uniforms of street cleaner and police use fluorescent fabric in the same purpose. We found that pedestrian attractiveness improvement by color can be main approach to prevent car accidents in bad weather. It was found that the vivid or fluorescent color worked more effectively than achromatic and low chroma color on children's rain coat in terms of visibility and attractiveness.

STUDIES ON IMPROVEMENT OF VISUAL ATTRACTIVESS

More specifically, in order to have validity, we examined the ways of improving driver's attractive through literature review, surveys. Ko, Sangkeun et al.(2012) intended to improve traffic safety in work zones using fluorescent orange color traffic signs. And it was found that the fluorescent color worked more effectively than other colors in terms of visibility and conspicuity in work zone sign system. Won-Jung Choi et al.(2013) analyzed that the main causes of traffic accidents while driving a car is the driver's visual distraction. To solve the problem, they focused on color visibility of driving information device and proved the correlation.

Song Mi, Lim et al.(2012) analyzed public uniform design focusing on typical public uniforms, such as police, fire fighter, and street cleaner in domestic and foreign countries. Its main color is dark PB(Purple blue), to mitigate visual fatigue and enhance comfort, and an accent color scheme is used, to effectively raise visual attention and safety. For example, the street cleaner uniform has high chroma and fluorescent colors, for increased attention during day and night work, to stress safety.

And in recent years, children rain coats with vivid colors can be seen more often in the same context (see Figure 1).

Figure 1. Examples of Children rain coats with vivid colors

To sum up, The color change is one of main strategies to improve attractiveness for preventing car accident through high pedestrian's attractiveness.

DESIGN CONCEPT AND VALIDITY VERIFICATION

Concept suggestion

As a result of prior research, we identifid that attractiveness of color is effective and universally applicable for reduction of car accidents. The purpose of this paper is to suggest children's rain coat design for the prevention of car accidents and develop a working model. The design development, depending on the complementary color and blinking LED effects, were suggested.

First, complementary colors are pairs of colors which, when combined in the right proportions, produce white or black. When placed next to each other, they create the strongest contrast and reinforce each other(see Figure 2).

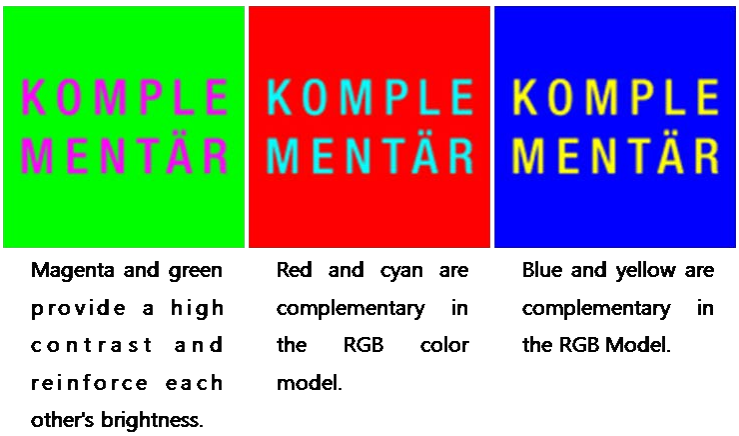


Figure 2. Examples of complementary colors

Complementary colors are widely used in art, design and also have more practical uses. Because orange and blue are complementary colors, life rafts and life vests are traditionally orange, to provide the highest contrast and visibility when seen from ships or aircraft over the ocean. Orange life rafts provide the highest contrast and visibility seen against blue water (see Figure 3).

Figure 3. Example of Complementary color application: orange color life raft over the ocean, blue color

Second, to enlarge effect, Complementary colors are widely used in art, design and also have more practical uses. Nowadays it is suggested that flickering lights effect is more effective than safety reflector (Hankyoreh newspaper, 1997). And Lee, jae-un invented and registered a patent a safety band with itself lighting emitting means applying LED for polices, street cleaners and construction workers (Lee, jae-un 2001). And nowadays LED began to grab the attention in fashion design due to functionality, creativity and uniqueness.

Based on prior research, we summarized the strategy on improvement of visual attractiveness, i) arrangement of complementary colors each other is effective than general, and ii) flickering light effects increase double in the aspect of visual concentration (see Figure 4).

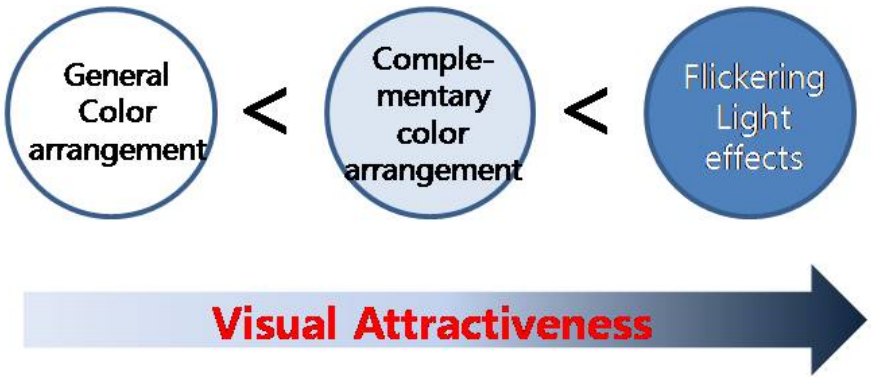


Figure 4. Design strategy to improve visual attractiveness

A experiment for concept verification

To verify validation of suggested concept, the experiment was conducted through questionnaires. In total, 24 people participated, 13 men and 11 women. The mean age was 26. The participants were shown two pair of images and asked to compare and rate the visual attractiveness of each child using 5-point scale(from 1 to 5).

Table 1: Questionnaire for experiments

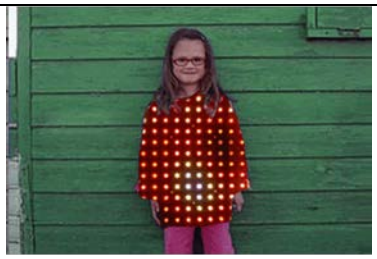
Q 1. Which girl is more visually attractive?

Compare and evaluate from 0 to 5 scales for Image 1-1, Image 1-2..

Image 1-1	Image 1-2

Q 2. Which girl is more visually attractive?

Compare and evaluate from 0 to 5 scales for Image 2-1, Image 2-2.

Image 2-1	Image 2-2
	

At first, to confirm the differences of effectiveness between2 experiments, difference values were calculated and compare the average values. And then F-test and T-test(Independent-sample t-test) were used to compare all variables between two groups(see Table 2). A null hypothesis of T-test is : average value Q1 = average value Q2.

Table 2: The analysis results of experiment

participant	Q 1			Q 2		
	image 1-1	image 1-2	difference values	image 2-1	image 2-2	difference values
1	2	5	3	3	5	2
2	3	5	2	2	5	3
3	4	5	1	5	5	0
4	2	4	2	2	5	3
5	2	4	2	3	5	2
6	2	4	2	2	5	3
7	2	4	2	1	5	4
8	3	5	2	2	5	3
9	2	5	3	2	5	3
10	2	4	2	1	5	4
11	2	4	2	3	5	2
12	2	4	2	1	5	4
13	2	4	2	2	5	3
14	2	5	3	1	5	4
15	1	5	4	1	5	4
16	2	5	3	3	5	2
17	3	4	1	2	5	3
18	3	5	2	2	5	3
19	1	5	4	1	5	4
20	3	4	1	2	5	3
21	3	4	1	3	5	2
22	3	4	1	3	5	2
23	3	4	1	3	5	2
	average value		**2.1**	**average value**		**2.8**
F-test result*	P(F<=f) Two-tailed test		**0.86 (>0.05)**	**P(T<=t)** Two-tailed test		**0.004 (<0.05)**

* Statistical significance was set at P≥0.05

The average value of Q 1., 2.1 was bigger than the average value of Q2., 2.8. And as a result of Independent Sample T-test, a null hypothesis was rejected(P value = 0.004 < 0.05). We could confirm suggested design concept(see Figure 4) is valid.

UNDERSTADING TECHNOLOGY AND DESGIN DEVELOPMENT

In order to make prototype of raincoat for special function application, several technologies have been examined and chosen to perform the features properly. There are a few issues to find appropriate solutions, one of them was which platform is suitable and easy to modify the system, another one was what output object to use for coloring, and the other was how to scan the major color of surrounding atmosphere.

Arduino

For the further research, platform has to be compatible with any other add-on, because this research is yet to finish. So, it is expected to apply unexpected functions or objects. For such reason, arduino is the most adaptable platform, since it has various applications and references. Arduino can sense the environment by receiving input from a variety of sensors and can affect its surroundings by controlling lights, motors, and other actuators. While in lab, it allows to try many things and to imagine various alternatives (see Figure 5).

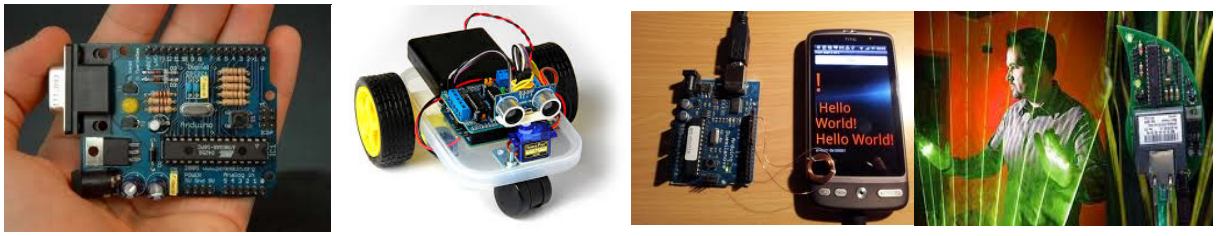


Figure 5. Arduino platform and Examples

Color sensor

Before converting and expressing complementary colors, detecting the original color is needed. True color recognition sensors “read” colors by emitting white light, analyzing three beams of reflected colored light (red, blue, green), then measuring the level of light reflected back on each wave length. Color sensors open up a field of diverse applications in sectors such as packaging technology, robotics, automation, quality assurance, and the process control industry. Simplify and speed up automated processes with diverse color sensors - for the detection of shade in rugs and textiles and of color markings on packaging and labels[i]. And we use the color sensor, TCS3200D that is a appropriate sensor for arduino. It recognizes the color that it is exposed to. That recognized color is then used to select a complementary color which ends up being illuminated through the LED lights i.e. red light recognized with green light being illuminated. Color calculation would be followed the procedure below.

First, the sensor read each RGB values from surroundings. After that, the values should be calculated in 256 RGB color system. They couldn't exceed the 255, because the value on arduino code would represent 0 to 255. Then, complementary color could be computed by algorithm. It would figure out accurate values in way which is using biggest and smallest number. After adding two numbers, each complementary RGB value could be extracted by subtracting original value from added value before.

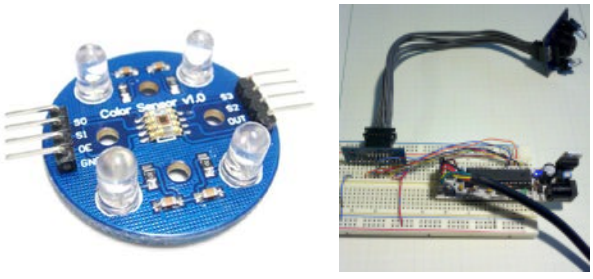


Figure 6. Color sensor(left) and color sensor with arduino board

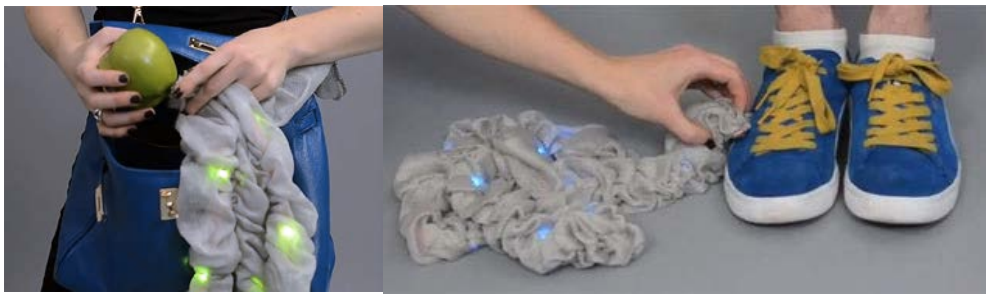


Figure 7. Example of color sensor application : Chameleon Scarf 2.0 with FLORA

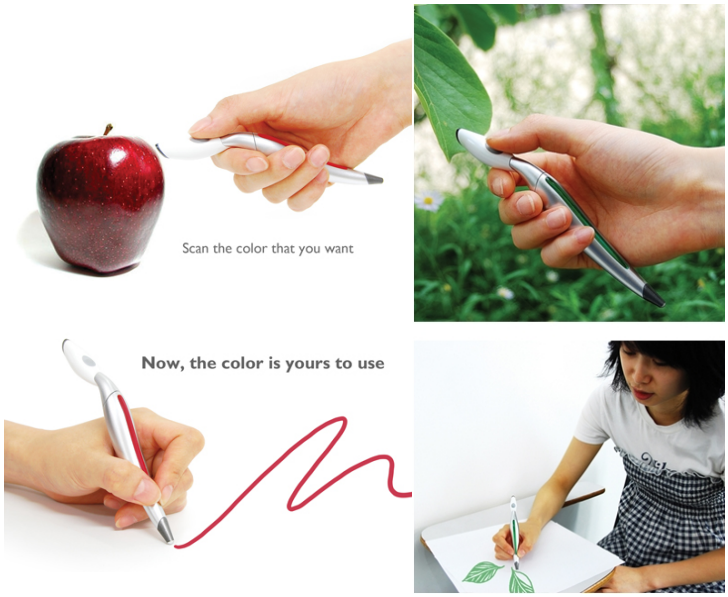


Figure 7. Example of color sensor application : 'Color Sensing' Pen Reproduces Any Color That It Detects

RGB LED Strips

For flicker effects, we considered RGB LED strips. RGB LED is universally applicable and useful in most industries including fashion.

Figure 8. LED application cases in fashion(http://led-clothing.com/)

LED clothing and accessories have become a highly spectacular and unique union of fashion and technology used for extra-modern show and performance. Due to LEDs placement and dynamic lighting effects, we are able to improve specific function, e.g. safety and create a unique design (see Figure 9).

Figure 9. Examples of LED in fashion for certain function

There is LED strip named 'NeoPixel Digital RGB LED Weatherproof Strip' which is able to control each RGB LED separately. It has lots of references and easy to apply diverse animations to show (see Figure 10).

Figure 10. Examples of LED strips in fashion

CASE STUDY: DEVELOPMENT OF CHILDREN'S RAINCOAT IMPROVED ATRRACTIVENESS

Scenario and system design

In this paper, we suggest a children's safety clothes design for prevention of car accident that is expected to improve the attractiveness by applying complementary color and flickering lights. Through prior research and examination, we proved the validation of the suggested design concept and found possible technologies to realize.

Based on the findings, to specify the design concept, we conducted the case study: a children raincoat development. At first, we developed the user scenarios

Table 3: User scenarios for case study

Scenario1 _ If a child stands with green wall in the background, her raincoat's color will be changed to red. So Green and red complement each other.	**Scenario2** _ If a child walks along the road beside the Dark blue wall. And then, her raincoat's color will be changed to yellow. So Dark blue and yellow complement each other.

To realize the scenarios, system design including color sensors, LED strips, Arduino and Arduino source code were also developed (see Table 4, Table 5).

Table 4: System design for case study

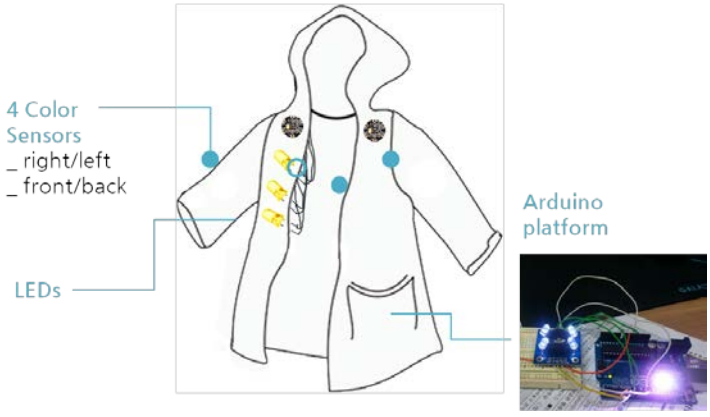
1. Build 4 Color sensors, LEDs, Arduino platform in rain coat. 2. The LEDs should be off initially. 3. When a Color sensor recognizes the color within the vicinity, the complementary color is to be illuminated.	

Table 5: Arduino source code

```
void getComplementaryColor(float red, float green, float blue){


  float temp_high = 0;

  float temp_low = 0;

  float temp = 0;


  if(red >= green)

    temp_high = red;

  else temp_high = green;


  if(blue >= temp_high)

    temp_high = blue;


  if(red <= green)

    temp_low = red;

  else temp_low = green;


  if(blue <= temp_low)

    temp_low = blue;

   temp= temp_H + temp_L;


  comple_red = temp - red;

  comple_green = temp - green;

  comple_blue = temp - blue;


  Serial.println("\ncomplementary color calculation has been finished");
```

According to the arduino source code, the words that named red, green, and blue in parenthesis on the top mean figures of converted color in 255 format. Each of these brings them from global to this function to convert.

Lastly, we made a children's raincoat to apply color sensor, Led strips and arduino platform and confirmed whether it operates well or not. As a result, the LED light colors were changed to complementary colors according to surrounding colors, i) if surrounding color is dark blue, LED light colors become yellow with animation effect and ii) if if surrounding color is red, LED light colors become green (see Figure 11). They are complement each other.

Figure 11. Results of Case study : children's safety clothes

CONCLUSIONS

From various literature reviews, complementary color and flickering LED light issues have been discussed. The methods which are discussed in this paper have adapted on rain coat and applied with several technologies. Examining the hypotheses above, we found complementary coloring and light flickering effects are effective to enhance pedestrians' visibility. It means that the methods would be expected to be helpful to reduce the number of accidents in a day with low-level illumination.

There is limitation that the color sensor works only in several centimeters nearly attached to surrounding, so the problem is that it would hardly get precise color values from surrounding atmosphere. Accordingly, another technology is needed to effectively solve the problem, so further research that finds solution and its adaption would be computer vision technology. This technology on further research will be contained an algorithm. Its details is that cameras mounted on surface of clothe would take a shot of surrounding atmosphere periodically to analyze which color is mainly composed and which is average value, and extract complementary color based on calculation. In further progress, tests will be proceeded and with proper solution.

This study would be useful to street cleaners' uniform design who exposed to more danger and general pedestrians' accessories.

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http://www.balluff.com/balluff/MUS/en/products/Full-Color-Detection.jsp

Section 8

Usability in IT Devices

How to Design Great Emotional Experience for Mobile User Interface?

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ABSTRACT

Emotion is easily recognized but difficult to define. For example, emotion has been a famous topic for a long time in user experience (UX) design. However, it has been a question of long standing how to systematically evaluate and design emotion, while maintaining qualitative aspects of emotion (e.g., not-measurable aspects). We developed the systematic tool for emotional UX design, while leaving some room for designer's creativity. To develop the tool, participants performed various tasks using smartphone, generating both positive and negative emotions. Once people's emotions were identified, ideal emotional journey, consisting emotional solutions, were created. In order to create ideal emotions, general design principles were proposed. Finally, more specific UX solutions were developed based on general design principles. Some of our UX solutions were applied to design new messenger for smartphone, emotionally augmenting communicating experiences.

Keywords: UX, Emotion, Design, Mobile, Smartphone, Solution

INTRODUCTION

What is Emotion?

Emotions are a combination of mental and physical states. The mental side of emotion involves a psychological judgment about an experience, while the physical side comes from physiological reactions in the body caused in part by these psychological judgments and in part because of subconscious physiological reactions (Carlson and Hatfield, 1992).

Emotions are not the only states that involve affect and activation. Desmet (2002) identified four other types. The states are differentiated from each other based on the length of time for which the affect and activation are experienced, on the complexity of the causes and whether they are directed at a specific situation or felt more generally. Emotions are compared and contrasted with the other four states, which are moods, sentiments, and personal traits (see Figure 1).

Emotions tend to have a simple or single cause, be directed at something or someone specific and be comparatively short term, for example lasting seconds or minutes. For example, being annoyed with a friend because they were late for a meeting would be an example of an emotion.

Moods are longer lasting than emotions, typically lasting for hours and possibly days. They often have combined causes and are felt generally rather than being directed only at the things that caused them. For instance, if our alarm clock does not go off we are late getting up, then our partner is rude to us and then we get stuck in traffic we may be in a bad mood by the time we arrive at work.

Sentiments are affects and activations aimed at particular things over the long term. They reflect our likes, dislikes, attitudes and standards. While they are likely to influence our emotions, they are not the same thing. For example, someone might have the sentiment of being scared of snakes but will not actually feel the emotion of fear unless they see a snake (Frijda, 1994).

When we are consistently predisposed to particular moods that we tend to return to over time this can be seen as an emotional personality trait. For example, if someone tends to be in a cheerful mood a lot we might characterize them as a cheerful person, while if someone is often in an angry mood we might describe them as an angry person.

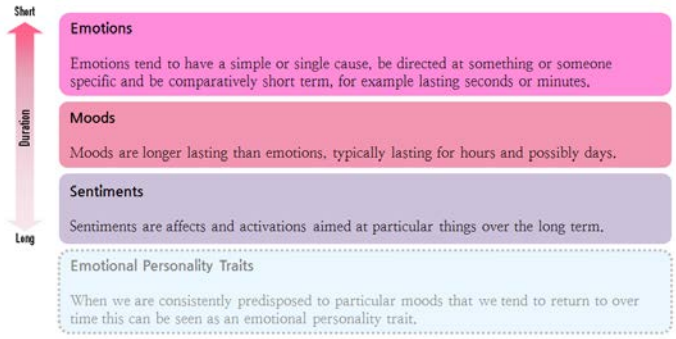

Figure 1. What emotions are and are not

This paper mainly involves the study on the emotional experiences (less on the moods, sentiments, or emotional personality traits), which tend to have simple or single cause of using smartphones. For instance, user might be emotionally satisfied *because of* clear feedback from the interface.

Dimensions of Emotions

Two basic dimensions of emotions are affect and activation. Nearly all models of emotion include these dimensions (e.g., Bales, 2001; Desmet, 2002; Mehrabian, 1981; Russell, 1980; Van Gorp, 2006). Affect, or positivity, refers to whether the emotion is positive or negative. Examples of emotions with positive affect are: excitement, happiness and being relaxed; examples of emotions with negative affect are irritation, disappointment and boredom. Some emotions are neutral in affect (neither positive nor negative). Examples of these include caution and focus. Activation refers to how much energy or stimulation the emotion causes. For example, excitement and focus have quite high levels of activation, caution has a neutral level and relaxation and boredom low levels. One extra dimension that has been proposed is dominance (Mehrabian, 1980). This three dimensional model includes this in addition to affect and activation – they refer to these as 'pleasure' and 'arousal' and call their model the Pleasure, Arousal, Dominance (PAD) Model. For example, fear and anger are both emotions that are negative in affect and high in activation, but they are different in terms of dominance. Fear is an emotion resulting from a low dominance and a sense of not being in control or having any power, whereas anger is experienced when the person feels more dominant and powerful. (see Figure 4 for affect and activation, and Figure 5 for activation and dominance). These three dimensions were used to select final lists of 30 postive and 24 negative distinct emotions among many other similar emotions (see also RESULTS for developing emotion sets).

Our Design Approach to Apply Emotion

In order to optimize people's user experience with products it is important to ensure that they are not only useful and usable but also that they are emotionally engaging. Our emotions influence how we plan to use a product, how we interact with it and our perceptions surrounding the product before, during and after use (Forlizzi and Battarbee,

2004).

Aside from strategic factors such as pricing, advertising and retail channels, emotional reactions to a product are probably the single biggest factor affecting its success in the marketplace (Van Gorp and Adams, 2012).
Likewise, emotion has been important and well-known topic for a long time in user experience (UX) design. However, it has been a question how to systematically design the emotion, while maintaining qualitative aspects of emotion such as designer's creativity and flexibility.

Therefore, the main aim of the project was to create both systematic and flexible tools for emotional UX design and to show how this tool can be applied to mobile interface such as gallery and messenger. To achieve our goal, we followed several steps;

1. Identified emotions associated with smartphone use 2. Converted current emotions to ideal emotions 3. Delivered positive emotional experience using general solutions. 4. Delivered general solution using more specific UX design solution 5. Applied UX solutions to mobile interface with designer's creativity and flexibility (see Table 1).

Table 1: Steps to develop emotional interface

Steps	**Description**
Current Emotions (Emotional Journey)	User's current emotional experience of using smartphones
Emotional Solutions	Ideal emotions that boost up/solves the current emotional status/problems
General Solutions	High level design principle that, if followed, deliver the ideal emotions
UX Solutions	More specific design solution that, if followed, delver the general solutions.
Emotional Design	With selected UX solutions, designer can use his/her experiences and creativity to design emotional interface.

METHOD

Three empirical studies (user diaries, user trials, focus groups), plus a workshop and a subsequent series of work-sessions were carried out (immersion stage) (see Figure 2).

Figure 2. Overall research procedures

32 participants took part in the studies: 16 users of Android smartphones, 8 users iOS smartphones (Apple iPhone), and 8 users of other smartphones (Blackberry and Nokia). The participants were evenly balanced for age and gender and were also evenly distributed according to age and socioeconomic status. All participants took part in both the diary studies and the user trials, with 18—6 of each type of OS users—taking part in the focus groups.

User Diary Study

In user diary study, participants were asked to complete a series of smartphone tasks over the course of a week. They were asked to complete each task twice, once in the first half of the week and once in the second half. The task set included 13 tasks, such as make a telephone call, add someone's contact details to the phone, and send a text by SMS or Instant Messenger, and etc. (see Table 2, for complete task lists). They completed the task 'naturally' (e.g., at home) as part of their smartphone usage, they were simply asked to record their experience of this (see Table 3, for complete questions)

Table 2. Task set during diary study & user trials

Make a telephone call
Add someone's contact details to the phone
Send a text by SMS or Instant Messenger
Upload or send a photograph or video to someone
Browse for text and photographs of their choice on the internet
View a video on the internet
Make a video and then watch it
Take a photograph and then view it
Listen to some music
Use an app of their choice
Sync their smartphone to a computer or other device
Use GPS to get to a location that they had not been to before
Connect to a wifi network

Table 3. Items that participants were asked during diary study

How often they do the task
Whether they succeeded or not on this attempt
If they didn't succeed why not
How easy of difficult the task was
Their emotions before during and after the task

User Trials

In user trials, participants attended a usability lab in order to use a smartphone—the Samsung Galaxy S3—under controlled condition. They were given a selection of tasks from the same 13 that were done in the diary study (see Table 2). The order in which they were asked to do these was randomized and the number of tasks they did was dependent on how quickly they managed to complete them. The session lasted for 90 minutes. Users completed each task that they were set in silence, but were videoed as they did it. The video was then played back to them and they were asked to comment on how they were feeling at each stage of task, which technique is known as retrospective protocol. It has the advantage of enabling participants to complete the tasks without the intrusion of having to verbalize their emotions at the time and removes the risk that the effort of having to do this would make the tasks harder. Experimenter recorded the reactions such as participants' positive and negative emotions as they went through the tasks (see Figure 3, for example). At the end of the trials participants were asked to provide more opinions about the best and worst aspects of the smartphone and the tasks that they found most and least enjoyable (see Table 4).

Table 4. Information recorded during the user trials

Participants' positive and negative emotions as they went through each task
Characteristics of the phone related to these emotions
Participants' comments about the smartphone
How easy or difficult participants found each task

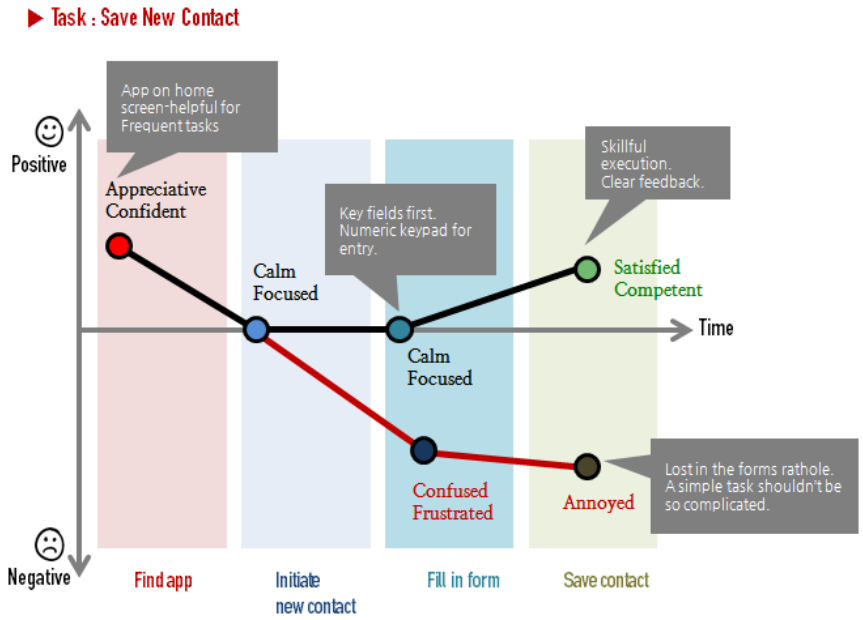

Figure 3. Example of user's emotional journey (task: add someone's contact details to the phone)

Focus Groups

The focus groups were held involving 18 of the 32 people who had already participated in the diary and user trials studies. Each group contained six people who all used the same category of operating system (i.e., Android, iOS or 'other'). Each group started with participants discussing the emotions associated with their favorite products. This was to give us an insight into whether there might be additional positive emotions that can be experienced in product use outside of those associated with smartphones. In the analysis this could be used as a check on the generalizability of the study outcomes to other product areas. They then discussed the emotions they felt when using their own smartphones and the Samsung Galaxy S3 that they had used in the user trials. They also discussed characteristics of the phones that were associated with these emotions. After the discussions, participants were

asked to record their own views with respect to each of the issues discussed (see Table 5)

Table 5. Information recorded during the focus groups

The emotions that each participant felt towards their smartphone
The characteristics of the smartphones associated with these
The emotions that each participant felt towards the Samsung Galaxy S3
The characteristics of the Samsung Galaxy S3 associated with these
The emotions that each participant associated with their favourite product

Immersion

In immersion stage, after completion of the empirical studies, some of the expert used the Samsung Galaxy S3 for a period of three weeks and reviewed the information gained from diary study, user trials, and focus groups. The aim was to give the project team real-life experience of using the smartphones which would generate insights to inform the analysis of the current emotions, the emotional solutions, general solutions, and UX solutions.
An initial workshop, including the whole of the core project team, reviewed the information gained from the diaries, user trials, and focus groups and, on the basis of this, made an initial pass at identifying emotional and general solutions. In a series of subsequent work-sessions, the experts developed these further, to move towards the final set of emotional, general, UX solutions, and the relationships between UX and general solutions and between general and emotional solutions.

RESULTS

Emotion Sets

Based on the empirical tests and experts' insight, 30 emotional solutions, 14 general solutions, and 23 UX solutions were developed. The emotion sets were produced in three stages. First, we listed all the separate emotional descriptors in users' responses across the user diaries, user trials, and focus groups. This meant including all the emotions described at any stage during a task or when reflecting on a product. Second, we judged that some of the items that participants listed were not actually emotions. For example if, when asked about their emotions, someone had put 'phone looks good' or 'difficult to use' we would remove these items as they do not describe how the person is feeling, but rather are their assessments of the phone. After the first two stages, we found 67 of negative emotions and 87 of positive emotions. Third, experts grouped items together in instances where, in the context of product use, we judged them to be essentially the same. For example, although amazement and admiration have qualitative similarities—they are both about being impressed with the product—amazement is significantly greater than admiration in terms of positivity and activation and is lower on dominance (see Figure 5). Similarly, although anger and annoyance are both about the perception that some aspect of a product is unacceptably poor, anger is significantly greater in terms of negativity, activation and dominance. This led to our final lists of 24 distinct negative emotions and 30 distinct positive emotions (see Figure 4).

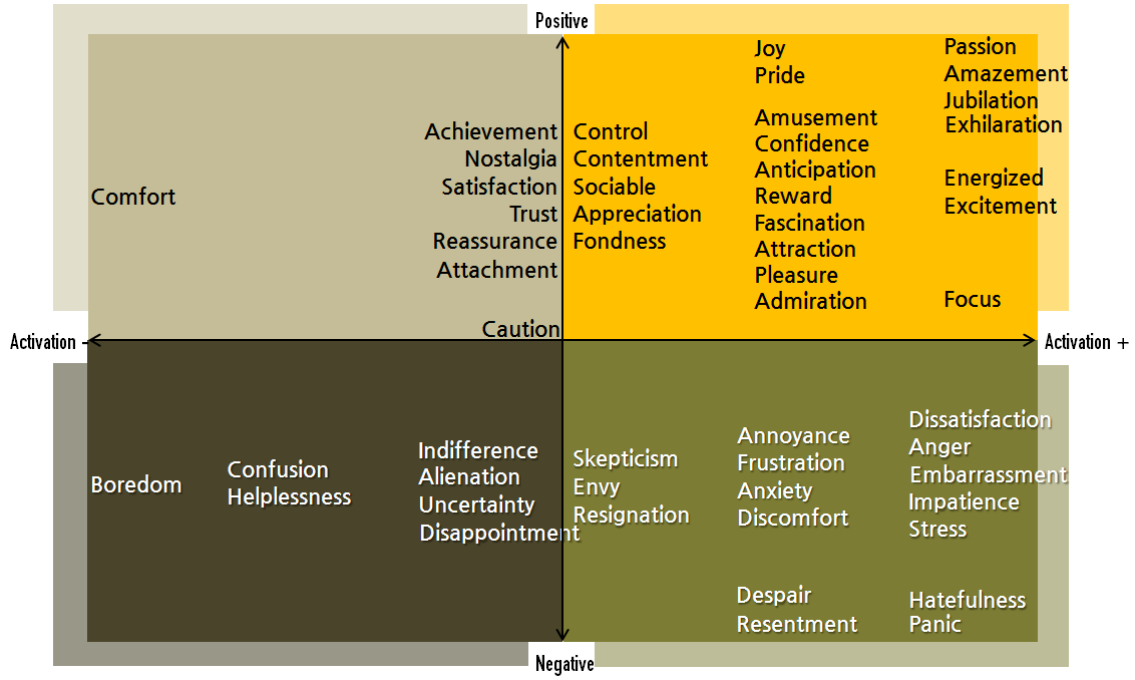

Figure 4. Emotions on activation and affect (positivity) dimensions

Emotional solutions are particular positive emotions that we aim to elicit in order to help improve user experience during an emotional journey with a product. And the set of potential emotional solutions for smartphones is the same as the set of positive emotions that we identified during the studies (see Figure 5).

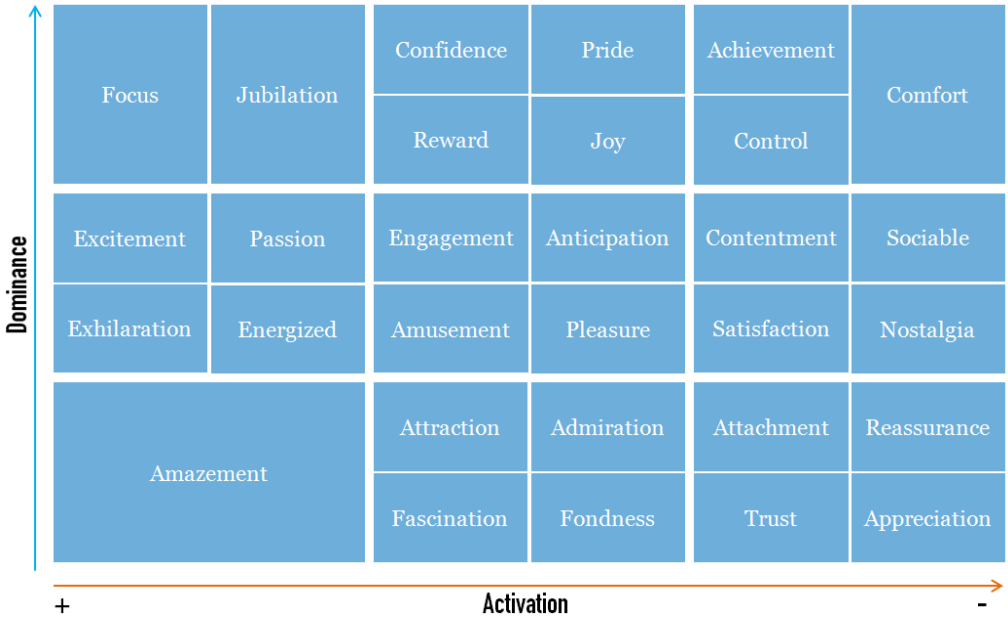

Figure 5. Emotional solutions (positive emotions) on activation and dominance dimensions

General Solutions

General solutions are high-level design principles for delivering the emotional solutions. They were based on linking the positive and negative emotions that had occurred in the studies to qualities and behaviors of the product and then generalizing from these to form the general solutions. In total there are 14 general solutions. Between them they can deliver all of the proposed emotional solutions as well as eliminating all of the potential negative emotions. They are listed in Table 6 with their subcomponents. To understand better with emotions, they are also plotted in the same dimension as emotions. For example, general solution of FLOW can give people feeling focused (compare

Figure 6 with Figure 5).

Table 6. Lists of general solutions and their subcomponents

General Solution	Sub Components
FLOW	Harmony | Rhythm | Unnoticed | Intelligent Consistency | 'Invisible' Help
AFFILIATION	Embody a Philosophy | Part of a Product Family | Noticeable Differentiation | Honesty | Legacy
DEPENDABILITY	Durability | Reliability | Robustness
RESPECT	Tone of Voice | Deference | Behaving Well in Public
SENSORY REWARD	Visual Rewards | Tactile Rewards | Auditory Rewards | Olfactory Rewards | Human Design
FAMILIARITY	External Consistency | Transfer of Knowledge and Skills | Explicitness
CERTAINTY	Task Feedback | Incremental Feedback | Actionable Feedback | Completeness
WOWS	Big Wows | Fleeting Wows | Instant Wow | Pleasant Surprise | Packaging as 'Master of Ceremonies'
MASTERY	Depth | Control and Power | Aided Discovery | Extendibility of Skills | Feeling Special | Savor the Moment
TALKING POINTS	Attention Grabbing | Notable Features | Notable Output | Notable Experience
SUPERIOR QUALITY	Functional Superiority | Build Quality | Aesthetic Superiority | Knowing that Have the Best
TEAMWORK	Clever Help | Knowing When to Step Back | Leadership
GRATIFYING NOVELTY	Notable Novelty | Instant Functional Gratification | Instant Aesthetic Rewards

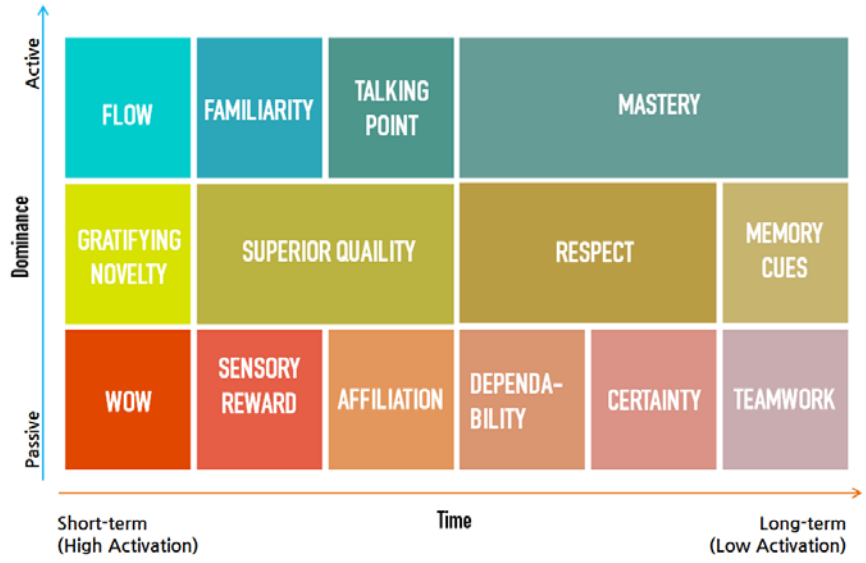

Figure 6. General solutions plotted on emotional dimensions (compare with Figure 5; e.g., FLOW gives feeling of focus)

One of our general solutions is SUPERIOR QUALITY, which has several subcomponents. Since it is a general principle, it applies to both IT and non IT product, such as Lexus (see Figure 7). And the general solutions will form the basis for developing more specific UX solutions.

Figure 7. An example of general solution, SUPERIOR QUALITY

UX Solution

UX solutions represent design directions that embody principles behind a general solution. Based on general solutions, we developed 23 UX solutions which categorizes into ten groups (see Table 7).

In sum, based on ideal emotions, general solutions were developed. And based on general solutions, UX solutions were developed. As shown in Figure 9 it describes the links between the UX solutions, general solutions, and the emotions experienced, showing systematically how UX solutions can enable the positive emotions and eliminate the negative.

Table 7. Lists of UX solutions and their general solution link

Grouping	UX Solutions	General Solutions
It's Showtime!	First Impression | Narrative Arc | Play with Senses	GRATIFYING NOVELTY | FLOW | SENSORY REWARD
Novelty in Everyday Life	Alternative Paths | Point of View	GRATIFYING NOVELTY
Positive Attention	Subtle Movement | Self-Relevant	FLOW
Pleasant Surprise	Hidden Logic | Unpredictability	WOW | GRATIFYING NOVELTY
Forming Lasting Habits	Consistent Experience | Gentle Transition	FAMILIARITY | FLOW | AFFILIATION
Perfecting Every Details	Natural Phenomena | Hidden Secrets | Beautify Errors	SUPERIOR QUAILITY | DEPENDABILITY | CERTAINTY
Welcoming and Welgoing	Inviting You | Adaptation | Non-Verbal Expression	RESPECT | TEAMWORK
Spreading Emotional Contagion	Social Comparison | Mimicking	TALKING POINT
Nostalgic Realization	Reminiscence | Synesthetic Memory	MEMORY CUES | SENSORY REWARD
My and Your Accomplishments	Hopeful Challenge | Team Play or Competition	MASTERY

For example, one of our UX solution group is Perfecting Every Details, which has UX solutions of Natural Phenomena, Hidden Secrets and Beautifying Errors. These UX Solutions were developed from general solutions of SUPERIOR QUALITY, DEPENDABILITY, and CERTAINTY (see Figure 8).

Figure 8. Example of UX solutions which are based on general solution of SUPERIOR QUALITY (compare with Figure 7)

Messenger Design Example

It is possible to apply emotional solutions, general solutions, and UX solutions to communication apps, such as messenger. As shown in Figure 9, for example, to develop "emotional messenger" for smartphone, we need to identify the emotions that user experience when using existing messenger (e.g., embarrassment, alienation, boredom, skepticism, nostalgia, indifference, etc., see Table 8).

Table 8. Possible reasons for current emotions toward existing messenger

Current Emotion	
Embarrassment	I feel *embarrassed* if my private messaging history are exposed.
Alienation	I feel *alienated* when there is no new messages or no response.
Boredom	I feel *bored* because there is nothing special in this messenger.
Skepticism	I am *skeptical* about this online chatting. I prefer the real world.
Nostalgia	It feel *nostalgia* when I read past messages.
Indifference	I feel *indifferent* toward new messages if they are for groups.

When current emotions are identified, ideal emotions are selected, which are already linked with negative or positive emotions (e.g. embarrassment→pride, skepticism→anticipation). Then certain general solutions are selected to deliver the emotional solutions (e.g., general solution of SUPERIOR QUALITY gives feeling of pride; general solution of GRATIFYING NOVELTY gives feeling of anticipation). Finally, sets of UX solutions can be selected to deliver the general solution (e.g., UX solution of Natural Phenomena can generate the feeling of SUPERIOR QUALITY; UX solution of Unpredictability can generate GRATIFYING NOVELTY). When UX solutions of Natural Phenomena and Unpredictability are selected for new messenger design, designers can use their own creativity and experiences based on the suggested UX solutions. For instance, by using UX solution of Natural Phenomena, the space where communication is occurring can be transformed into real paper (e.g., real paper has natural quality of ink spreading, folding, air buffer, resilience, etc.). The resilient nature of paper sometimes creates pleasant Unpredictability for users such as applying pop-up-card effect to the messenger.

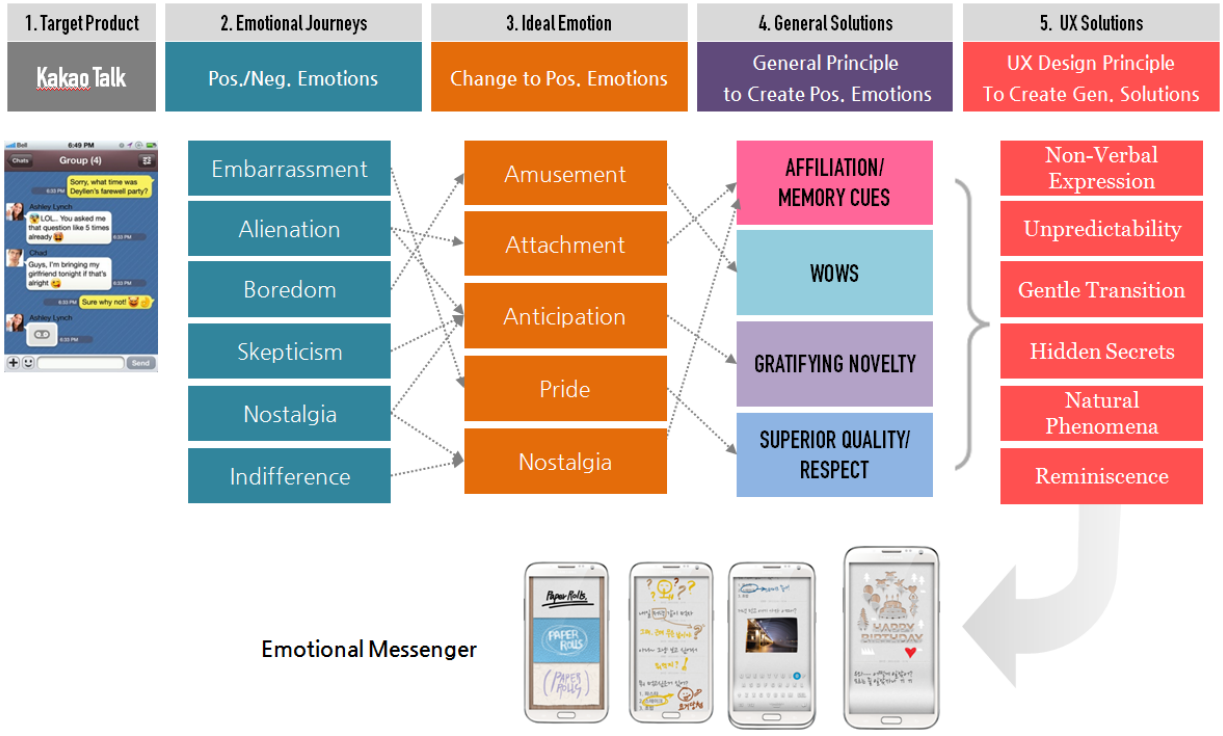

Figure 9. Possible steps to develop "emotional messenger"

CONCLUSION

The main aim of this paper was to deliver a set of design process and principles for delivering a positive emotional experience with product and services. It also describes the systematic links between solutions and the emotions experienced, while maximizing designer's creativity, flexibility, and previous experiences. Some of our concept design and prototypes were submitted as Grade-A patents, receiving certification of originality and creativity.
Moreover, one of patents was directly applied to "Pen Window," Samsung Galaxy Note 3. All of our outcomes were transferred to Mobile Communication Division, Samsung Electronics, which implies that our outcomes have great impact on mobile product.

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A Study on the Behavioral Characteristics of the Elderly Living in a Smart Home

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ABSTRACT

The purpose of this study is to investigate behavioral of the elderly living in smart home using the diary study method and to analyze the characteristic required according to behavior and smart home service. For the research of the characteristics of service-use, the seven types of main smart home services were chosen by analyzing previous research. We carried out a diary study with ten elderly people over the age of 65 in smart home environment. They recorded their every behavior for one week by themselves. Diary study items consist of four parts: 1) time, 2) activity, 3) device, 4) place. The result of this study, findings of behavioral characteristics of the elderly reveal that most of them spend their time on personal care, socializing and leisure activities. While elderly generally did not fully utilize smart home functions, there was high usage frequency and preference for automatic intelligence service compared to manual. Therefore, smart home services related to these characteristics should be considered as a top priority.

Keywords: Diaries, User Behavior Pattern, Home-Based Automated System, Smart Home, Elderly

INTRODUCTION

The most comfortable environment in which people live is home environment. Recently, with the rapid progress of technology, the importance of intelligent residential service to improve the quality of life has increased. As rapid growth of global population of elderly people over the age of 65, developed countries has already entered into aging society in the 1990s and Korea has also entered in 2000. (Mariel et al., 2008) Countries which experienced aging society earlier consider residential issue to be the most important concern. Since scope of activity for elderly is limited to their physical ability, the overall living space environment to support their lives is crucial, and studies related to this are in progress.

In the case of United States, supply of elderly-assisting living spaces, which provides various functions and features to aid independent living of elderly, are increasing through projects such as the aware home to study and solve possible problems which could arise. Other projects in foreign countries like Mav Home Project, Neural Network House and etc. also precede various studies of home environment for the elderly. However, in Korea, which is experiencing rapid increase in aging population, is yet to develop suitable policies for elderly and the elderly-friendly residential area. 59% of the residential type of Korea is an apartment, which is the most common type of housing in Korea, and the proportion is expected to continue to grow. Newly built apartments are providing improved quality of life through smart home functions.

Smart Home, called intelligent residential services, home automation system, and digital home, is an IT-based resident of the convenience, safety and other housing support services that enhance the quality of life. The introduction of new technologies will affect many residents, especially the socially disadvantaged elderly (Chappll, 1998). The currently available smart home services are designed and provided depending on the developers' idea without considering the user's physical and psychological characteristics. Although various services are provided, lack of this consideration causes low utilization of smart home Services and inability to provide the intended convenience. To increase the satisfaction of the residents, the intelligent services should be designed and provided taking nature of the residents into account (Mori et al., 2000).

Renaud & Van Biljon (2008) analyzed the factors which affects the elderly's adoption of mobile phone. They integrated the technology adoption model and domestication of technology approach and suggested the Senior

Technology Acceptance & adoption Model (STAM). According to STAM, key factor which affect the elderly's real usage of mobile phone was 'Learning & Ease of Use', and factor which affect the 'Learning & Ease of Use' was 'Experiment and Exploration'. Giving consideration to user's technology adoption ability could be seen crucial in smart home which is built with different intelligence technology and smart devices. Especially, elderly usually have very low acceptance tendency for new technologies and will require more attention, comparatively (Beamish and Johnson, 1994).

This study elderly living in smart home in Korea with the objective of studying their perception, activity characteristics, and service-use characteristics to escape the current technology-oriented smart home and enable application of user characteristics.

METHOD

Christoffer Bjorkskog (2009) performed assessment of user interface in ubiquitous equipment which are developed to create smart home, and in Martin Krafft (2009), interview with technological solution background took place to find out elderly's though of health smart home, and design trend of health smart home for elderly was suggested. Also, studies of George Demiris (2008) carried out interviews of elderly living in independent institutions for elderly to assess and measure smart home equipment. Other prior studies which incorporate smart home are continuously being performed.

However, general trend of related research is limited to presenting technology-focused one-dimensional utilization plan, and lacks the studies of resident's environment and behavior characteristics. Researches involving the development of a smart home are mainly technology oriented, focusing on the protocol and the sensor network design to build smart home environment, and studies in human centered perspective including the interaction with the user, including the elderly, are relatively insufficient. (Michael C. Mozer 1998). Therefore, to collect information on the users' behavioral and emotional characteristics, the research selects the methodology of diary study, in which the users write their own behavior in person.

Diary Study, which is used by various areas of research centered on psychology, is a method of leaving records of one's own way for a certain period of time. The first diary study was conducted in Darwin's language study in 1887 as a record of children's language acquisition process, and since then, diary study has been developed and settled through a lot of research. The results obtained through diary study can be summarized in following three points (Bolger et al., 2003).

1) Detailed information about individuals

2) Difference in individual changes with time

3) Individual changes in a specified period of time and analysis on the casual relationship between the individual differences

Diary study is divided into two types, based on the method of recording; 1) time-centric approach (the author records events and behaviors by time) and 2) event-centric approach (the author records when particular events happen) (Palen et al., 2002). In the case of user interview and observation methodology, the subject is affected by the presence of the observer, and emotional information of the user is impossible to obtain. On the other hand, diary study can collect a large amount of data on user behavior characteristics, habits, and feelings without direct observation. Also, as they are the records of actual events from the users, this research method can obtain more detailed information than other methods. Diary study was applied in the research by M. Musil (1998) to identify the elderly health problem and characteristics and the research by Victoria Haines (2007) on the general users' need of smart home. Diary Study is also conducted for the many other researches to observe user behavioral characteristics and ways of product usage (Brown et al., 2000; Forlizzi, 2007; Lewis et al., 2005).

However, diary study has some limit as the user may feel difficult to record all details for one day or more than a week, and they may write exaggerated information after presuming the intention of the investigators. Also, since the method is based on analysis of record in a certain period of time, the user's emotional state and experience can affect the results (Reiman, J. 1993).

Recent research has addressed the importance of long period observation to measure the change in a user's experience. Compared to other research methods, ability of diary study to collect information of the real user's

behavior qualifies suitably to the object of this research to understand behavioral characteristics of the elderly (Karapanos et al., 2009; von Wilamowitz-Moellendorff et al., 2006). Accordingly, diary study is used in this study to investigate behavioral and service-use characteristics of the elderly living in smart home.

Before selecting the research subjects, the study first examined smart home services provided in current apartments in Korea, and chose seven kinds of services which are most commonly used. Selected services are as follows (See Table 1).

Table 1: Main smart home services

Digital Security Access Service	**Smart Grid Service**	**Appliance remote control service**	**Elevator call service**	**Indoor environmental control service**	**Emergency service**	**Parking Management System**
Access security services through a variety of ways	Services for efficient power consumption	Remote Controlling appliances service	Elevator call systems in the house	Automatic or remote control system of the indoor environment	Emergency informing system	Information services for parking

The study selected ten elderly men and women over the age of 65 living in the apartment equipped with all seven kinds of smart home service functions. All participants are living in a smart home and most of their work and activities were at the residential district. Participants were given record forms of the diary study, and they self-recorded their behavior of 24 hours in minutes for one week. This was intended to extract the elderly's main repeated behavioral characteristics, service-use characteristics and spatial characteristics through a week observation (see Figure 1).

	Minute	Activity	Device	Place
14:00				
	15	Change clothes in the dress room		Dress room
	19	Watching TV	Television	Living room
	31	Have a snack		Kitchen
	35	Watching Television	Television	Living room
15:00	00	Received the parcel		Front entrance
	10	Doing the laundry	Washing machine	Bathroom
	15	Watching Television	Television	Licing room
	37	Going to the toilet		Bathroom
16:00				

Figure 1. Diary study form

The research by Kahneman (2004) conducted survey on 'when', 'what', and 'how do you feel' about the events of the

day. This study used the same structured survey with additional items of 'used equipment' and 'place' to analyze behavioral characteristics of the elderly.

Also, taking into consideration that this is a diary study for the elderly, without full explanation of how to record, it is difficult to obtain valid data (Bolger et al., 2003). The guideline of diary study was made for the elderly to help them understand the method, and a full description and practice session were conducted to create one full day recording, which was used to judge the go-ahead of the study. In each day of the diary study, daily home visit was done to encourage the periodical recording and short interview enabled the study to supplement shortcomings of the diary study.

RESULT

Behavioral Characteristics

The data collected through the diary study of the elderly are analyzed focusing on behavior to identify behavioral characteristics. Before analyzing the collected data focusing on behavior, the study used classification standards for behavior based on report of elderly lifestyle classification of time by the Korea National Statistical Office and other existing relevant research (See Table 2). Utilizing the following behavior classification standard, all activities of the elderly collected from the diary study were matched, and through the rearrangement, the final behavior classification sheet was designed for the research analysis.

Using the behavior classification sheet, behaviors and time are entered on the sheet. Type of behavior on which the participants spend most time in smart home environment is analyzed examining the time share of each type of behavior. Also, this paper provides additional analysis on their main behavior at home. Through the behavior classification sheet, the result of comprehensive analysis on behavior of the elderly shows that the type of behavior that they spend most time is personal care, socializing and leisure activity, and housekeeping in the order named.

Table 2 : Classification of behavior type of the elderly

Item	Note
Personal care	Sleeping, eating, washing, etc.
Health management	Taking medicine, sports activities, etc.
Housekeeping	Meal preparation, cleaning, house organizing for environment management in home
Family care	Family care including spouse and direct family at home
Socializing and leisure activity	Socializing, reading newspaper and books, watching TV, etc.

In the case of personal care on which the elderly put most of their time, it is mainly consumed by sleeping activity. Other than sleeping, other activities like eating, washing, and toileting, which are critical life activities, take high proportion (see Table 3). Most of these activities can be seen as physiological necessities. Therefore, smart home Services which can be provided in spaces where those activities are performed should be considered. Observing activities of personal care through spatial separation, living room and bedroom had environment control system which controls the air quality and temperature, and bathroom and bedroom had emergency measure system to monitor accidental fall and account for emergency situation, to be considered. Frequent use of cooking fire in the kitchen needed the support of environment regulating system which prevents fire and gas leak.

Socializing and leisure activity take up 22.8%, the second highest percentage. Watching TV accounts for most of these behaviors, and aside from sleeping, it takes up most of the time for activity of the elderly (see Table 4). Meanwhile, preparation time for going out had lowest proportion, and diary study showed elderly to be spending more time in the house compared to going out. This is considered to be the result of physical aging to create difficulties for elderly to enjoy outdoor leisure. However, indoor leisure activities of elderly was limited and showed

high reliance on TV. There was need to support various indoor leisure activities for elderly.

Table 3 : Personal care

Behavior	Proportion	Overall proportion
Sleeping	40.19%	54%
Eating	4.50%	
Snack & Drinking	1.91%	
Bath, Shower, Washing	4.46%	
Toileting	2.78%	
Dress out and Make-up	1.54%	

Table 4: Socializing and leisure activity

Item	Proportion	Overall proportion
Socializing	0.59%	22.80%
Grow flowers	0.62%	
Make a call	1.97%	
Learning	0.23%	
utilize media	0.28%	
Reading	2.14%	
Watching TV	16.77%	
Other	0.21%	

In the case of housekeeping, meal preparation, dish-washing, cleaning and organizing showed even proportion to some extent. Checking indoor power, gas, and heat is 2.13%, but this shows relatively large difference in time among the participants compared to other classification. On the other hand, health management and family care take up less time than other activities, but the elderly people who participated in the diary Study regularly spend their time on sports activities in common. Another common denominator of elderly's activity was taking medicine, which can be closely related with elderly characteristic of physical aging. To fulfill physical capacity based basic needs of Elderly, indoor space to perform indoor exercise will be required, and there was essential need to offer health support system which notifies medicine taking times.

Use of services

To identify smart home service-use characteristics of the elderly, collected data from the diary Study are analyzed focusing on the seven types of smart home services selected before. While elderly generally did not fully utilize smart home Functions, there was high usage frequency and preference for automatic intelligence service like indoor environmental control service, compared to manual services like appliance remote control service, smart greed service. Automatic intelligence service can automatically recognize household condition and control operations while manual service needs to be operated by the user. Manual service is mostly controlled by integrated controllers

installed in most home. The following <Table 5> is the result of classification of seven services of smart home by automatic intelligent service and manual service (see Table 5).

Table 5 : The type of smart home services

Type	Function	Note
Automatic intelligent	Indoor environmental control service	Automatic or remote control service for the indoor environment
Manual	Digital Security Access Service	Access security services offered through various ways to
	Smart Grid Service	Service for Efficient power consumption
	Appliance remote control service	Service to control appliance remotely
	Elevator call service	Elevator call service at home
	Emergency service	Emergency call service inside home
	Parking management service	Information service for parking

Indoor environmental control services detect household situation and presence of the residents, to control the indoor environment automatically. It is easy to use this service without lot of effort, thus, the very high use frequency by the elderly compared to other smart home services. The interview with the elderly indicates that the majority of the elderly had a low recognition of smart home services, and indeed, the indoor environmental control services is considered simply as a convenient feature rather than a smart home service. Considering the fading ability in memorizing and physical movement which elderly experience, automatic intelligence service would be the suiting path for smart home service to progress.

Digital security access services provide security for each householder by using a variety of methods (card, fingerprint, and password), and most of the elderly are indicated to use a card for access services. Even the elderly who feel difficult to use manual services shows their voluntary utilization of the service since this service is necessary for the residence. If they do not recognize Smart Grid services, they do not use it. However, a lot of needs in term of power management are observed as they check the monthly amount of electricity through the electricity bill, and turn the light off before they go out. Appliance remote control, elevator calls, emergency calls, and parking management services are controlled by the integrated controller installed at home. However, the elderly do not fully understand each function of the service and some of them give up using it as they feel high difficulty in operating the integrated controller. Therefore, Lack of accessibility and experience to use each service are the factors which rise above simple lack of elderly's needs. Most of the smart home Service currently uses integrated controller which is constructed with touch interface. But most elderly are not skillful with the touch interface and supplemented control method which can be skillfully operated by elderly is required

CONCLUSIONS

Currently a great number of smart home services have been developed and provided unilaterally without considering the characteristics of the occupants. This study is designed to analyze behavioral characteristic and smart home service-use characteristics of the elderly living in smart home, using the research method of diary study beyond the existing technology centered researches on smart home.

The findings of behavioral characteristics of the elderly reveal that most of them spend their time on personal care, socializing and leisure activities, which are essential activities in life. Therefore, smart home services related to these activities should be considered as a top priority, and although "sports activities" do not take up a lot of time share, those are in the same vein as health management, the main interest of the elderly. Indeed, this was the common characteristic of all the elderly participants verified by the interview. Additionally, after excluding sleeping which is

basic physiological phenomenon, watching TV takes up most of the time share. Therefore, suggestions for smart home service configuration which consider both TV watching Activity, as well as 'health management', which is another big interest of the elderly, would provide suitable functions for the elderly. Current smart home services are mainly the manual operation type. The analysis results from service-use characteristics of the elderly demonstrate that they can make use of automatic intelligent services, with some help, without struggling in usage. However, they feel great difficulty with the manual operation type of services, and thus show less frequency of use. Therefore, the support of automatic intelligent services which help the elderly to take advantage of natural and intuitive services should be extended, and in the case of manual type of services, additional research is needed for the controller in which the elderly can better accommodate and make better use of the manual type of smart home services.

This study indicates that most of the elderly living in smart home has low level of awareness about smart home, and are not able to utilize the smart home services effectively in their daily lives. The observation results on behavioral characteristics and service-use characteristics of the elderly will contribute to improving convenience and satisfaction of the elderly by making practical use of their behavioral characteristics in their daily residential environment.

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Development of Visual Complexity Model Framework in Driving Context

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ABSTRACT

Recently, in-vehicle environments have become smart environment with advances in IT technology. The vehicle is no longer just a means of transportation but gets the nature of information system. Therefore, in order to convey more information than in the past, a variety of displays are set up in vehicle. The object of this study is to develop visual complexity model framework for evaluating system interface. To accomplish this, we reviewed the literature about complexity measures in terms of Human-Machine Interaction and analyzed the characteristics of in-vehicle environment characteristics. Then we suggest visual complexity model framework.

Keywords: Visual complexity, Human-Machine Interaction, IVIS

INTRODUCTION

The development of information technologies changes the context of driving. In-Vehicle Information System (IVIS) provides a lot of functions. As the number of function of system is increasing, various displays are used for providing drivers with information. (e.g. Cluster, Head-Up Display, Center- facia Information Display, Rear mirror display, etc.). So driver is exposed to much information. Considering visual sensory is most critical modality (Sivak, 1996), risk of accident could be increased because visual information leads to driver distraction.

According to National Highway Traffic Safety Administration (NHTSA), 25% of traffic accident happened because of driver inattention (Wang et al., 1996). Stevens and Minton (2001) reported that one of the critical factors of traffic accidents is high-tech equipment, i.e. infotainment system, navigation system, telematics system, etc. Wickens(2002) presented that increasing in-vehicle technology is the cause of traffic accidents because visual attention resource of driver is limited.

As previous research analyzed, using large amount of information doesn't only have effect on driver, also it is the cause of deterioration in driving performance (Chisholm et al., 2007; Horberry et al., 2006). Thus it is important to predict and measure accident risk. Previous studies of in-vehicle environment analyzed driver mental workload with driving task. In order to analyze the effect of non-driving task on driving performance, many variables were used, e.g. response time, missed events, lane-keeping ability, speed control (Castro, 2008). However, previous studies have mainly focused on driver workload rather than the complexity of system itself. So, it is impossible to verify whether complexity of system influence on driver perception or not. But, it is difficult to find cause and effect relationship between system and driver. Thus the object of this study is to suggest "Complexity" for analyzing effect of In-Vehicle Information Systems on driver and the framework for measuring it. Utilizing complexity, we will predict and control driver workload from parts of system being increased.

A study of complexity deals with various aspects. But, few studies analyzed Human-Machine Interaction (HMI) in the context of driving using the concept of complexity. Therefore our study includes three questions: What is visual complexity from HMI perspective? How visual complexity is explained based on theoretical basis? How do we measure the visual complexity? To answer these three questions, we analyze in-vehicle environment and driver behavior from the perspective of HMI. Then we suggest the framework for measuring visual complexity.

LITERATURE REVIEW

It is difficult to define complexity because the concept of complexity is complicated itself. Also, definitions of complexity are differentiated by purpose of analysis. Complexity stems from Latin word 'complexus' meaning entwined or twisted together. Generally speaking, complexity of certain system could be increased if more parts of system are districted or connected with each other.

Many researchers have been studied the complexity in various field of studies : information theory, general systems theory, cybernetics, non-equilibrium thermodynamics, catastrophe theory, deterministic chaos, complex adaptive systems (Heylighen, 1993). Xing and Manning(2005) also presented that complexity have been studied in many fileds, e.g. Physics, System, Mathematical science, Software engineering, Biology, Psychology.

Visual complexity also has been studied in various domain fields, such as image, web page, aesthetics etc. Olivia et al. (2004) studied perceptual dimensions of visual complexity of scenes. Michailidou et al. (2008, September) studied relationship between visual complexity and aesthetic perception. Guo et al. (2011) represented relationship between visual complexity perception and texture image. Forsythe (2009) evaluated different measures of complexity. Harper et al. (2009) analyzed relationship between use's visual perception of web page complexity and user's cognitive efforts. Lavie and Tractinsky (2004) assessed dimensions of perceived visual aesthetic of web sites.

In this way, many researchers studied on complexity depending on the characteristics of study domain. But there have been relatively few studies on visual complexity from the perspective of Human-Machine Interaction. Especially, There are also few studies on visual complexity in vehicle environment. So we use the complexity in order to analyze interaction between human and system in vehicle environment.

Characteristics of visual complexity in terms of Human-Machine Interaction (HMI)

In this study, we would define 'Visual Complexity' from a HMI perspective, especially, when driver perceive the visual information from in-vehicle display. In order to achieve this, we analyzed the characteristics of complexity in terms of system and driver.

Complexity of system in Human-Machine Interaction (HMI)

In-vehicle systems collect data about internal/external environment, vehicle condition, etc. Systems provide drivers with information on the ground of the collected data. Drivers drive the car on the basis of this information and vehicle states are changing. These processes continue iteratively (figure 1). In these processes, drivers interact with systems through system interface. Drivers perceive the visual information through the display of system interface. Continually, drivers control the input device of system interface. So driver's perceived visual complexity is the interface complexity in terms of system.

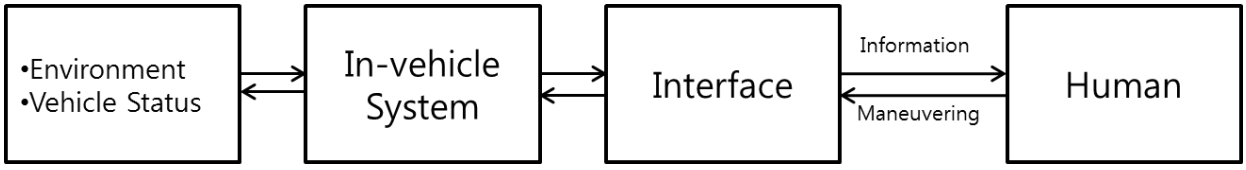

Figure 1. Process of Human-Machine Interaction in the context of driving.

The environment of in-vehicle system interaction is similar to the environment of in-aircraft system interaction. Cumming et al. (2010) suggested Human Supervisory Control complexity chain composed of Environmental complexity, Organizational complexity, Interface complexity, Cognitive complexity in Air Traffic Control Environment. According to this, interface complexity was defined "the complexity derived from controls and displays, which could include display font size, number of colors used in the display, or numbers and variety of buttons, levers, etc." In conclusion, in-vehicle interface consist of visual information displays and maneuvering areas. Based on this study, we focus on information display as domain of perceived visual complexity.

Complexity of Human behavior in Human-Machine Interaction (HMI)

Edmonds(1999) stated that complexity is meaningful relative to individual person. Moreover, information is perceived by each driver's visual information process (Mihal & Barrett, 1976). Therefore, in order to define complexity, there should be discussion of these issues. Henneman and Rouse(1986) categorized complexity as Non-Behavioral complexity or Behavioral complexity in order to emphasize interaction between human and system in terms of cognitive engineering. Non-Behavioral complexity studies include complexity interested in certain system's condition. Most studies on complexity belong to Non-Behavioral complexity, e.g. computational complexity, software complexity, physical system complexity, redundancy and complexity, subjective nature of complexity. Behavioral complexity studies include complexity interested in human's psychological-behavioral characteristics. Relatively few researchers studied Behavioral complexity. Behavioral complexity studies are divided into Perceptual complexity and Problem-solving complexity. Perspective of this study is a perceptual complexity within behavioral complexity

According to Wickens(2002), steps of Human Information Processing include Sensory processing, perception, Response selection, Response excution in order. Human allocate their attention resource to each step and use working memory. In these processes, Sensory processing and perception steps are main focus of Perceptual complexity.

Characteristics of in-vehicle environment

The definition of visual complexity of this study differs from that of web page or image studies. So it is important to consider characteristics of in-vehicle driving situation. There are two kinds of characteristics of visual display and visual search task.

First, several characteristics of in-vehicle visual display should be considered. As previously stated, there are increasing introduction of new information technology into in-vehicle environment. So there is an abundance of visual information provided to driver in vehicle environment. As a result, various visual displays are embedded in the vehicle. Different characteristics of each display have effect on visual task (Tan and Czerwinski, 2003). Also information is presented in different forms, e.g. text, icon, image, graph, etc. Diverse information formats influence Human Information processing. Especially, perception and cognition processes of visual information are different depending on information formats. . Lastly, visual displays are dynamic. Information is continuously changed with driving condition.. Xing(2004, 2005, 2007) studied the information complexity of Air Traffic Control automation displays. In-vehicle environments with advances in IT technology have become similar to in-air traffic control environment. Thus, it is also important to consider complexity in vehicle environments..

Second, characteristics of visual search task should be considered. In-vehicle situation, drivers were required to perform two or more tasks concurrently. Drivers perform additional visual task while they perform driving task at the same time. Many studies on IVIS, HUD analyzed the effect of using the system while driving task. Also there are many attributes that will affect driving such as driving experience, gender, age, others. And driving contexts also exit like a road conditions, weather, day, night, light, others. Lastly, Even minor error in driving context could become the cause of traffic accident. Therefore safety issues are first priority in driving context. The increasing complexity of in-vehicle systems leads to increase the possibility of driver's error increased. So, Complexity can be used in order to predict and to decrease the possibility of traffic accident.

RESEARCH FRAMEWORK

Visual complexity of this study includes two points of view. Visual complexity is display complexity in terms of system and is perceptual complexity in terms of driver. Besides, we will focus the complexity when drivers perform the visual task while driving context. On the basis of these perspectives, we analyze the visual complexity.

Visual complexity has been studied in a number of different fields. Among these studies, Cummings(2010) and Xing(2004, 2005, 2007) studied on complexity in similar environment of this study. Following these studies, we will suggest the factor of system, i.e. information structure attributes of in-vehicle display. Cummings(2010) revealed that general factors of complexity are size (of parts), variety (of parts), rules/interconnections (between parts). Also, Xing(2004, 2005, 2007) suggested that information complexity of Air Traffic Control(ATC) automation display composed of three factors : Quantity, Variety, Relation. Like this, Quantity, Variety and Relation are widely accepted factors of complexity. According to studies, we also used these three factors.

Quantity

First factor of visual display is Quantity. The term "Quantity" means amount of something to measure or count. Generally, an increase in the quantity means that the amount of system parts is increased. Increasing the number of parts makes relationship more complicated. This leads to increase the possibility of interaction between parts. Many previous studies use Quantity as factor of complexity. Quantity measurements of related studies are summarized in the table below (Table 1). Especially, there are two complexity studies relative to Human-Machine Interaction. Xing (2007) chose "number of fixation groups, number of functional units, amount of action cost" as quantity measurement of information complexity. Cummings et al. (2010) defined "number of displays, icons, alarms, shared control devices, shared displays, animated display features, required unit conversions, redundant displays, control devices, redundant control devices" as quantity measurement of Human-System Interface.

Quantity factors of complexity are available for measuring visual complexity in vehicle environment. As the amount of information increases, the relationship between information and information become complicated. Especially in the driving situation, drivers perceive it as complex scene. Thus, in this study, we define "Quantity" factor as the number of units of visual display. The number of text, icon, gradation, indicator is quantity measurement of in-vehicle visual display. There are positive correlation between these quantity measurement and visual complexity.

Variety

Second factor of visual complexity is Variety. The term "Variety" means that there are different aspects of parts. Generally, if system has variety, it consists of parts which are different from each other. An increase of variety in parts of system leads to increase their relationships. Variety attributes of system make to feel complex. Many previous studies use Variety as factor of complexity (Table 1). Xing (2007) defind "background color, component color, shape, size" as variety measurements of information complexity. Cummings et al. (2010) defined "variety of fonts, icons, colors, alarms, displays, control devices" as variety measurement of Human-System Interface.

Variety factors of complexity are available for measuring visual complexity in vehicle environment. Complexity of driver is different depending on type of information even though same amount of information. Thus, this study defines "Variety" factor as diversity characteristics of individual information of display. There is diversity of units of in-vehicle visual display, such as background color, component color, shape, size. There are positive correlation between these variety measurement and visual complexity.

Relation

Last factor of complexity is "Relation". Relation means that relationship between parts and parts of system. Quantity factor and Variety factor are characteristics of individual part. But Relation factor composed of structural aspects. Relation is a key factor in many studies (Table 1). Especially, Xing (2007) uses "degree of clutter, relational complexity, number of action cost" as relation measurements of information complexity. Cummings et al. (2010) defined "clutter, distance between control devices, displays, controls" as relation measurements of Human-System Interface. According to Tullis (1983), how user perceived information from the display is determined by four characteristics, i.e. overall density, local density, grouping, layout complexity.

Relation factors of complexity are available for measuring visual complexity in vehicle environment. It is different to perceive the level of complexity depending on "relation" even though same amount of information and level of variety. Thus, we define "Relation" factor as relational characteristics of units of in-vehicle visual display. Relation factors of in-vehicle visual display are clutter and number of division.

Table 1: Related study of three factors of complexity

Factor	Study	Measurement
Quantity	Xing(2007)	Number of fixation groups, number of functional units, amount of action cost
	Kemp(1999)	Number of block
	Michailidou et al (2008)	number of images, visible links, words
	Olivia et al(2004)	Quantity of object, detail, color
	Mccabe(1976)	Difference of the total number of transitions and the total number of states
	Bieri(1955)	Number of construct, matches between the constructs
	Cummings et al. (2010a)	number of displays, information amount, number of icons, number of alarms, number of shared control devices, number of shared displays, number of animated display features, number of required unit conversions, number of redundant displays, number of control devices, number of redundant control devices
Variety	Xing(2007)	dynamic complexity
	Cummings et al. (2010a)	variety of fonts, variety of icons, variety of colors, variety of alarms, variety of displays, variety of control devices
	Michailidou et al. (2008)	variety of colors
Relation	Xing(2007)	degree of clutter, relational complexity, number of action cost
	Kemp(1999)	text to graph ratio
	Bieri(1955)	matches between the constructs
	Cummings et al. (2010a)	clutter, distance between control devices, displays, control devices and displays, controls and their associated displays

CONCLUSIONS

In conclusion, we suggest a framework for measuring visual complexity in order to evaluate in-vehicle interface. We reviewed previous study in order to analyze the complexity from the perspective of Human-Machine Interaction (HMI). First, we focus on in-vehicle visual display by analyzing in-vehicle systems. Second, we chose perceptual complexity by reviewing previous studies. For this, we define factors of complexity by analyzing previous complexity study and characteristics of in-vehicle environment. The framework composed of three factors : Quantity, Variety, Relation. This framework integrates human factors in the context of driving. We defined "Quantity" factor as the number of units of visual display, "Variety" factor as the diversity of units of in-vehicle visual display, "Relation" factor as relational characteristics of units of in-vehicle visual display.

Future study is needed to find measurement of each factor of visual complexity. Moreover, we will develop structural equation of visual complexity. This equation enables us to evaluate the n-vehicle system interface. Then we will be able to predict the driver's workload arise from in-vehicle interface.

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Cognitive and Affective UI for Enhanced Usability

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ABSTRACT

Dynamic working conditions along with the user's physical and emotional state have significant impact upon the usability and security of the system. As applications continue to provide increasingly sophisticated and complex functionality coupled with the widespread deployment of smart phones and tablets, critical information is at the fingertips of users. This level of accessibility substantially increases the possibilities of cyber security breaches. The impact of usability on reliability and security of the system are well understood, but what is not addressed is the impact of changing environment and cognitive load on the usability of the system. In this paper, we present the framework that constantly determines the user's affective state, cognitive load, and context information and makes real-time adaptations to the User Interface to enhance the usability and security of the system. The framework can operate in a multi or single-mode configuration. The multi-mode configuration considers all factors before making a decision, whereas the single-mode automatically learns to use only the available information.

Keywords: Cognitive and Context-Aware User Interfaces, Cognitive Load, Affective States, Usability, Reliability

INTRODUCTION

Computers are ingrained in our lives and in today's world of mobility and powerful tablets we have unprecedented access to information and decision-making (even in the most uncongenial environment). Though we constantly strive to ensure that the information shared during our interaction with the system remains effective, safe, enjoyable, and entertaining (Agah 2001), not all systems meet our expectations. The vast majorities of the systems still assume consistent working conditions and do not adapt to the user's situational influences and intrapersonal states (Hudlicka & Meneese 2002). Most of the user interfaces are designed for masses. Although many customized UI options are available, none of them provides dynamic customization based upon the user's affective states, cognitive load, and context.

A fluctuating work environment and the physical and intrapersonal state of the user can increase cognitive load on an individual's working memory (Morey & Morey 2011). This load refers to the burden or the impact that a task bears on human information processing (Sweller 1994). The mental resources of a user are directly proportional to the difficulty level of the task and presentation of the task. Since working memory is limited, the task imposes a load on the user during that interaction. This load is referred to as Cognitive Load. The working memory directly influences user performance. The higher load on working memory results in the lower performance (Barouillet, Bernandin & Portrat 2007).

The Dynamically Adaptable User Interface (DaUI) framework establishes the groundwork for dynamically adaptable applications capable of reacting to changes in the user's psychophysiological state as well as the working environment. The DAUI framework facilitates real-time security decisions based upon the combination of biometric data (e.g., pupillometric indices of cognitive load), environmental analysis, location, time and other details. The DAUI framework fundamentally changes the scope of cyber security to encompass whether the user has the mental capacity to carry on the task, and whether the user is to be allowed access based upon his/her current affective/cognitive state and/or usage pattern (Robins, Fraley & Krueger 2009). This framework is not intended to replace traditional access control (Ravi & Sandhu 1994) mechanisms but makes the argument that traditional access control is no longer sufficient. Effects of emotions and cognitive load on the user's ability to make decisions are widely known (Cao, Theune & Nijholt 2009)(Block & Hancock 2010). This framework enables applications to use psychophysiological sensing and context-awareness to selectively control access and provide user interface adaptations.

The DAUI framework determines cognitive load and affective states of the user using pupillometry (Laeng & Sirois 2012). The measurement of pupil diameter is referred to as Pupillometry. Specifically, changes in pupillary diameter correlate with cognitive load and affective change. External context is inferred from the location, time, background noise, and lighting. Factors such as time, location, and close proximity to others are used as input into security decisions. The DAUI framework includes the capabilities of providing Dynamic Ambient Intelligence (DaI) by constantly monitoring the user's environment. While doing so, it considers distractions (such as noise, crowd, and lighting) that have impact upon the user's security. For example, the application can hide sensitive information, or disable critical functionality if the user is fatigued or if non-authorized users are in close proximity. Additionally, the DAUI framework considers the user's location information. For example, applications can be restricted to only operate in certain locations, retract user access, or encrypt/destroy certain information if the device roams in an un-trusted area. Similarly, the time-of-day, and the day-of-the-week would contribute to security and application usability.

The framework constantly learns from non-intrusive surveillance and intelligence information and builds the knowledge-based system. The system shifts its operation to a heightened alert and vigilance state if it is outside the normal operating conditions. Higher vigilance results in lower tolerance of error. The objective is to customize the user interface to best meet the user's cognitive load and current working conditions to enhance security and usability. It is proven that the environment always plays a pivotal role in the performance of a user, but applications mostly ignore its impact. The cognitive load along with external factors, such as the environment, noise, crowd, and lighting contribute heavily in determining the usability and security of the system. These factors are taken into consideration as these elements impede the user's performance as well as pose potential security risk. The DAUI framework can disable critical functionality if the user's working environment is too distracting or unsafe. Location information is used to enhance both usability and security of the application. Sensitive applications can be restricted to operate in certain locations. If the device roams in an un-trusted area, information can be hidden, encrypted or completely destroyed. Similarly, time of day, and day of the week would contribute in security and application usability. The core of the DAUI Framework is the Dynamic Analysis Engine (DaE) that performs real-time data mining for the big data received from sensors.

COGNITIVE, CONTEXT-AWARE SECURITY FRAMEWORK

Overview

Current computing systems (desktop, laptop, and smart phones) are equipped with built-in devices such as cameras, microphone, and global positioning system (GPS) to operate with the framework. This system will use the built-in capabilities of the device to determine location, capture sounds, and perform other functions. The following is the list of high-level functions of the DAUI framework:

- Collect and analyze data from video, microphone, GPS.
- Determine the intensity, and duration of the collected data.
- Remove outliers and evaluate reliability.
- Represent behavior in a quantifiable manner.
- Perform continuous real-time gathering and analysis.
- Provide real-time feedback to the application.

Each application reacts differently to these events. For example, a GUI based application can increase the font size, modify the interface speed, or in some cases totally shutdown/disable certain parts of the interface for security reasons. A surveillance application can modify the monitoring interface to enhance visibility and focus.

Figure 1 provides a high-level view of the systems architecture as well as shows how applications fit into the DAUI Framework. Data are captured from a variety of sources and analyzed. Application developers use the newly proposed Markup Language (DaUIML) to develop their applications to enable dynamic adaptions based upon the events received from the Analysis Engine. The Analysis Engine generates events after real-time analysis of the data captured using built-in sensors.

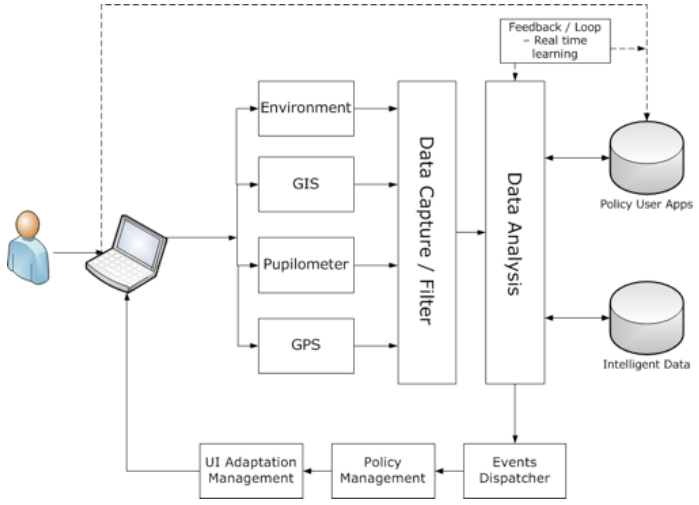

Figure 1: The DAUI Process Flow

DAUI Framework Contributions

The DAUI Framework has the following contributions

1. Dynamic Analysis Engine that captures, analyzes, and filters all data at real-time using built-in devices.
2. Real-time determination of cognitive load and affective states using pupillometric measurements.
3. Dynamic user context determination.
4. A dynamic User Interface Model (MIDM).
5. Enhanced XML-compliant (DaUIML) language that enables dynamic adaptations based upon biometric, ambient, time and location data.

DAUI Architecture

The fundamental concept of the DAUI framework is built around speed and the ability to easily extend functionality. The design of the DAUI framework is intended to be modular, efficient, and interoperable, and provides a generic infrastructure for the dynamically adaptable user interface for any application. All inputs would be aggregated from multiple devices such as: traditional/virtual keyboard, mouse, touch panel, front/rear camera, microphone input.

The framework provides an additional layer between the application and underlying operating system, and facilitates a seamless integration with the existing applications. The input parameters and subsequent desired actions would be modeled and represented as state machines and push down automata. Moreover, the modularity of the design facilitates using the framework in variety of deployment scenarios. Figure 2 illustrates the high-level proposed architecture of the DAUI. There are three basic components of the DAUI framework:

i) Analysis Engine

ii) Cognitive Load and Context determination,

iii) XML-compliant grammar, and

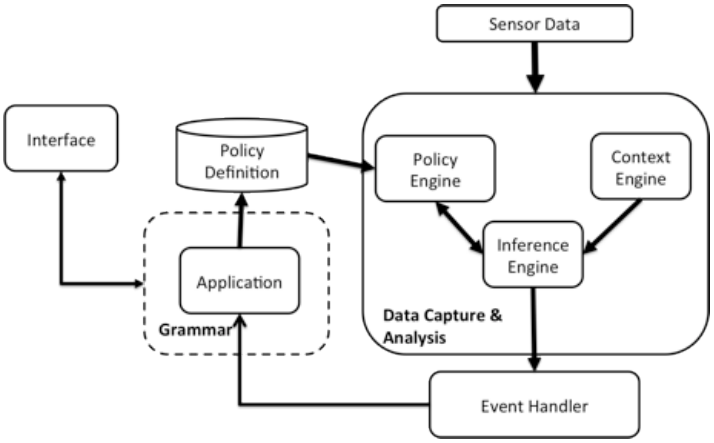

Figure 2: DAUI System Overview

The Dynamic Analysis Engine (DaE) is an integral part of DAUI framework, and it extends the framework's capabilities to harness the potential of external devices and various computing resources, and ensure that they have a real-time adaptive user-interface. Additionally, DaE can be deployed as a distributed system utilizing numerous computing resources available via a cloud based computing engine. Moreover, multiple Analysis Engines can run simultaneously in a single deployment installation mining data from various sources to ascertain features. The DaE transformational and adaptation layer facilitates transmission and reformatting of relevant key data points from one system to another. This is required to ensure harness of the large amount data available from application past usage history, interactions of multiple users of the application and behavioral predictions of the usage pattern.

COGNITIVE LOAD

Any complex application requires extensive resources from users to build and maintain situation-awareness. This is certainly true in any complex system. Endsley & Bolte (Endsley & Bolte, 2003) describe what they call "situation-awareness demons"; these are the factors that negatively impact upon situation-awareness in many systems. This includes memory trap, workload, anxiety, fatigue, boredom, and other psychological states. The memory trap is directly related to the limited working memory wherein chunks of data are stored temporarily prior to information processing. Since situation-awareness requires greater use of the working memory, any system that overloads working memory directly obstructs user performance.

The other impediment of situation-awareness is the individual operating environment (Endsley & Bolte, 2003), in which some of the common conditions are fatigue and anxiety. All of these factors directly impact the ability of the individual to process information. The system has to be designed in such a way that all these limitation can be countered. We make the argument that the mobility and ubiquity of computing devices make it very challenging to overcome these impediments in a statically designed system.

Previously, studies have been conducted to determine ways to reduce cognitive load in the multi-media learning environment (Mayer & Moreno 2003)(Riddle 2002). In addition to providing great insight into ways to enhance usability, analysis also asserts that cognitive load is the essential component of human machine interaction and learning (Zhang & Rau 2009). Riddle (Riddle 2002) proposed a framework to reduce the cognitive load associated with navigational activities in e-commerce domain. E-commerce applications are extremely competitive and need to keep the user engaged in the buying experience if users experience higher cognitive load that can have a direct impact on their buying experience and result in loss revenue.

There are numerous ways that a human computer interface can cause cognitive load to increase (Paas, Renkl & Sweller 2003). This includes both essential processing load and incidental-processing load. Incidental workload refers to the processing that the brain has to perform, and is not related to the core function.

Measuring Cognitive Load

Measuring accurate cognitive load has always been a challenging part of the Cognitive Load Theory (CLT) (DeLeeuw 2008), but this is also the most important aspect for providing real-time cognitive aware security modulation. Incorrect or untimely cognitive load determination can have adverse effects of adding more cognitive load rather than reducing it. According to the Cognitive Load Theory there are three types of cognitive loads (Sweller 1994) Intrinsic, Extraneous, and Germane.

- Intrinsic – The Intrinsic load is related to the difficulty of the task at hand, and lack of familiarity with the task. This load is the thinking part of the CLT and mainly considered as unalterable. This is because the fundamental complexity of the task cannot be modified. Though the difficulty of the task cannot be modified, it can be broken down to reduce the load. Complexity of any task is directly proportional to the number of different elements considered to complete the task.
- Extraneous – The Extraneous load is the material part of the cognitive load. It is directly related to the presented information. **Note**: Information presented in a poor manner adds to the load.
- Germane -- The Germane load signifies the effort required to process the information and construct schema and automation (Sweller 1994)

This DAUI framework primarily focuses on reducing the Extraneous load and increasing the Germane load by framing and modulating information that is more intuitively comprehensible. The automation of schema generation will help in minimizing the load on the working memory. Our objective in this study is to measure the user's current cognitive load, make dynamic adaptations to the presented information, and thereby reduce the working load. Methods of measuring Cognitive load fall into two categories, Subjective (Self-report)(Robinson & Clore 2002) and Objective measures (DeLeeuw 2008)(Chen, Epps & Chen 2011)(Klingner 2010).

TABLE 1: COGNITIVE LOAD MEASUREMENT CATEGORIES

Measurement	Category
Self-Report	**Subjective**
Physiological behavioral, Task performance	**Objective-indirect**
Brain Activity, Dual-Task performance	**Objective-direct**

These methods of measuring Cognitive Load are useful and provide different levels of performance and accuracy as defined in (Chen, Epps & Chen 2011). Appropriate selection of the method however depends upon the requirements. Self-report is a widely acceptable and extremely common test to determine the emotional experiences of a user but it relies upon the user providing accurate and timely information. In certain mission applications, self-report can be used to determine the cognitive load but it is not feasible where continuous real-time cognitive load determination is required.

Another area of research pertains to the use of psychophysiological response-based measurements in determining the cognitive load on the user (Iqbal, Zheng & Bailey 2004) (Klingner 2010) (Haapalainen, Forlizzi & Dey 2010). Various studies have been conducted to support the conclusion that variations in the mental load generate involuntary psychophysiological responses (MacLachlan & Howland 2002)(Rubin 1980)(Richman, McAndrew, Decker & Mullancy 2004).. These psychophysiological responses can range from heart rate variability, galvanic skin response, and pupillary dilation (Haapalainen, Forlizzi & Dey 2010). In the DAUI framework we use pupillary responses (pupil dilation) as a means to measure cognitive load. The reason we chose pupil dilation as the measure of cognitive load is that it provides real-time information and does not require any explicit actions from the user. Moreover, depending on the methods of measuring the pupil dilation it can be very non-intrusive (Iqbal, Zheng & Bailey 2004) (Klingner 2010). Much research has been done to establish the correlation between cognitive load and pupil dilation. Iqbal et al (Iqbal, Zheng & Bailey 2004) conducted a user study to successfully determine the use of pupillometry for measuring real-time mental load while the user is interacting with the computer. Similarly Klingner

(Klingner 2010) conducted an extensive study to validate the use of a remote eye-tracking device to accurately measuring real-time cognitive load.

The DAUI framework measures pupil dilation based upon the average change in pupil dilation (ACPD). The user's baseline pupillary diameter is established against which any changes are measured. Unlike strictly task-evoked pupillary response measurement (Klingner 2010) where the baseline is taken at the beginning of the task, the DAUI framework learns and stores the baseline pupillary diameter and uses this to measure variation in pupil size. For example, if the user starts to use the system when s/he is fatigued, the DAUI framework will capture the user's current pupillary diameter and compare it to the stored baseline pupillary diameter to conclude that the user is fatigued. This is important as this can result in the DAUI framework precluding the user from using the system altogether or blocking that part of section of the system.

MacLachlan & Howland (MacLachlan & Howland 2002) conducted a study to determine the normal pupillary diameter for subjects ranging from birth to 19 years. As a result of this study approximate formula based upon subject age were developed. The DAUI framework uses these formulae to validate the captured baseline pupil dilation.

- The approximate male pupil diameter:
  Pupil Diameter (mm) =
  $5.83 + 0.181 * \text{age in years} - 00.53 * \text{age in years}^2$

- The approximate female pupil diameter:
  Pupil Diameter (mm) =
  $5.40 + 0.285 * \text{age in years} - 00.53 * \text{age in years}^2$

Correlation between Pupil Size Variance and Cognitive load/Affective States

Correlating the variance in pupil size with (i) cognitive load, (ii) emotional and (iii) physical state is an integral part of the DAUI framework. The Average Change in Pupil Dilation determined dynamically is compared against pupil variance guidelines. The following pupil diameter changes described in Klinger (Klingner 2010) are used as a benchmark to determine the cognitive load:

TABLE 2: PUPIL DILATION TO COGNITIVE LOAD CORRELATION

Average Pupil Dilation	Cognitive Load
0.17 mm	Light
0.21 mm	Medium
0.27 mm	Heavy

Furthermore, the average pupil size variance can also be related to other user's conditions such as fatigue, alcohol level, etc. (Tryon 1975)(Rubin 1980)(Richman, McAndrew, Decker & Mullancy 2004).

DYNAMIC GRAMMAR

The DAUI framework defines a new XML-based grammar, Dynamically Adaptable User Interface Markup Language (DaUIML). This is used to develop cognitive and context-aware applications that can dynamically alter behavior based upon external events. The DaUIML leverages some key characteristics of UIML and describes the user-interface in abstract declarative terms. Using UIML (Oasis UIML Specification)(Phanouriou 2000), a one-to-one tag mapping for various existing graphical frameworks could be formulated to structurally represent the user-interface for an application and define static components and associated properties. This includes the generic event processing mechanism utilized in the current frameworks from various input devices. Furthermore, this may include real-time Web/Mobile application characteristics that involve updating the user-interface based on external events such as updating the backend Data store.

The DaUIML extension to UIML provides a true dynamic nature to an application using the events generated by the dynamic analysis engine (DaE). This would mean that an application developer could use the DaUIML as a meta-language to specify policies to update any of the properties associated with existing user interface components, in terms of structure, style, content and behavior using events generated by the DaE. This provides application developers a finer grain control over the individual UI components. The following table shows a small subset of DaUIML tags:

TABLE 3: DAUIML TAGS

DaUIML Tag	Purpose
<application-context>	Represents user/system state throughout application life cycle.
<dae-event>	Represent event from the analysis engine in meta-attribute format.
<dae-core-policy>	Specify policy/action as the application receives an associated event.

MESSAGING MODEL

The messaging model deals with the unidirectional relay of events from sensors to the analysis engine as well as bidirectional exchange between the analysis engine and the application. In order to facilitate high throughput communication messages are exchanged in a fixed format with labeled number of fields. The messages are divided into mandatory and optional fields such as compression, encryption and versioning. In order to facilitate faster index based access all enumerated fields in the message can be encapsulated as a single structure. Additionally, message specification can include attribute/field validation. Examples for a basic binding for a user-defined complex data-type is as follows:

TABLE 4: BASIC BINDING

```
<structure field-ordering-binding=’strict’ field-count=’x’>
  <field type=’signed-integer-16’ field-name=’device-detected’
verification=’optional’ defatul=’1’ range-check=’true’ min-value=’1024’></field>
  <field type='string'  field-name='device-name' verification =  'not-null' > </field>
  <field type='uuid'  field-name='device-identifier' verification ='not-null' ></field>
</structure>
```

Using the above technique the application developer can introduce custom data-types that can represent events, and exchange request/response between DaE and embedded/external devices.

Policy Management

The policy management provides a dynamic capability to a user interface application by introducing meta-tags related to the application state and complex event processing. Policies are the intrinsic part of user-experience, and enhance and update the user-interface components to assist a user in operating the application with utmost efficiency and clarity. In addition, the updates in each user-interface component are guided by the defined application policy. The policy enforcement is aided by the real-time inputs from the analysis engine, which ensures that user-interface representation constantly meets the expectation of the application designer with respect to the usage criteria. This is required to guarantee that the user-interface updates and restructuring are always within the specific implementation boundaries.

Sample Policy

Following is the abbreviated example of a very simple policy that specifies policy to make patient prescription protected (un-editable):

TABLE 5: SAMPLE POLICY

```
<event>
  <dae-core-event class=”user-cognitive-load”>
  <dae-event-source-name=”dynamic-analysis-engine” level=”1”
</dae-core-event>
</event>
 <op name=”greater-than”>
   <property event-class=”user-cognitive-load” name=”current load”
     <! – Cognitive load measured as Low=1, Med=2, High=3 >
       <constant value=’1’ />
  </op>
</op>
</condition>
  <action>
    <! Make sensitive information uneditable >
    <property part-name="PatientPrescription" name="editable">false</property>
   <! Update property “Application-State” to value returned from analysis engine -->
     <property part-name="Application-State" name="user-profile-state">
    <call name="ApplicationFunction.updateApplicationState">
         <param><property part-class="application-state" name="current-
   state"/></param>
           </call>
         </property>
     </action>
```

EXTERNAL EVENT INTERFACE

Dynamic Analysis Engine (DAE) can issue notifications to an application requiring real-time analysis services from various sources. The information to be included in these notifications and event can be configured as per application requirement. Also, apart from these the user-interface application developer can optionally include additional information as per application criteria for each of these notifications. These application notification feedback responses for each respective event is intended to be stored in the user/application knowledge base and used later for further enhancing the overall user experience. These events are used to update the following aspects of the user-interface application:

- Application content
- Component Layout/presentation
- Application Navigation
- Application logic/control flow (additional security criteria)

The Dynamic Analysis Engine [DAE] is intended to provide in depth analysis of events processed from multiple sources in real-time. An application using the services of Dynamic Analysis engine can use more than one DAE engine to provide analysis from multiple and/or remote sources as well. Additionally, an application like DaUIML rendering application could process events involving real-time user/group administration, enterprise application usage policy updates and various diagnostic checks. These events could also be generated from other administrative application apart from DAE. The application using Dynamic Analysis Engine service can establish a real-time event feedback loop by providing update application state and updates which could be required in application content, navigation and behavioral aspect as per the usage criteria as part of response sent after processing the DAE events.

The Dynamic Analysis Engine [DAE] utilizes JSON (JavaScript Object Notation) specification for interaction with external application. The JSON (Crockford 2006) specification is a lightweight data-interchange format. We can use JSON to represent structured information in a human readable form. Additionally the information could contain additional tags to validation message contents using checksum and enforcing strict field ordering. Along with message checksums the message contents could be encrypted as well. Following is an excerpt of the JSON schema definition for DAE event request/response:

TABLE 6: JSON SCHEMA

```
{
   "event-name": "Generic event name for informational purpose only",
   "id": {
         "type": “UUID Universally unique identifier",
         "description": "Distinguishes each individual event instance",
         "required": true
   },
   "source-identifier": {
         "type": “UUID Universally unique identifier",
         "description": "Distinguishes event generator module",
         "required": true
   },
   "destination-identifier": {
         "type": “UUID Universally unique identifier",
         "description": "Distinguishes event target module, can be a broadcast message",
         "required": true
   },
   "event-type": {
         "type": “Enumerator",
         "description": "Event type either of request/response or notification",
         "required": true
   },
```

APPLICATIONS

There are numerous applications where DAUI framework can be used to build applications intending to provide dynamic adaptation to enhance usability and security.

Homeland Security Applications

The DAUI framework can turn normal video surveillance into an advanced eye performing real-time reconnaissance to identify suspicious behavior, unaccompanied baggage, cross border activities, behavioral patterns, and identify subjects, etc. This system could automatically sift through big data and provide timely alerts. The adaptations to the user interface of the monitoring system are made to reflect the cognitive load of the monitoring agent. The system can be deployed in a centralized as well as distributed configuration.

Medical Instrumentation

All of the current medical system are all based upon the static interfaces and are prone to costly errors and inefficiencies. In addition, medical systems such electronic medical records (EMR) are vulnerable to data integrity and confidentiality issues. A Physician’s job of entering patient’s records, reviewing test results, prescribing medicine or simply finishing up the paper work at the end of the long working day, can be a frustrating and time-consuming experience (Pertet & Narasimhan 2005). This can lead to costly human errors. Physicians told Health and Human Services that the “usability does not appear to be the focus of these EMRs” (Fiegl 2011). Amongst other things these user errors can also compromise data integrity. The DAUI framework can enhance the security of the EMR system by granting selective access depending upon whether the user is tired, angry, asleep, etc. In addition, the DAUI framework can be used to make user interfaces of other medical instruments for dynamic such that physicians and nurses can be prevented from making mistakes.

EXAMPLE APPLICATION

Since the development of the complete DAUI framework involves many components (such as Grammar, Analysis Engine, Input and Analysis of real-time events information, context determination, and real-time UI adaptation) we have divided the implementation into multiple phases to facilitate the development. The first phase is focusing on a simple application using the CCAML grammar that receives events such as multiple users detected, cognitive load high, etc. from a test driver simulating the Dynamic Analysis Engine. The test driver uses the JSON interface

described above to communicate information from the test driver to the application. The current application, which is simply a registration form, has rules defined to adapt the UI based upon these events. A basic registration form used for entering personal details for an applicant enrolling for a service. The application comprises of a set of paired label and text-field components displaying individual's name, date of birth, social security number, address and additional personal notes. The example application contains the following policy criteria:

- Use-case I
  - If user's cognitive load is high then system makes critical fields un-editable.
- Use-case II
  - If the system detects other people in proximity who can possibly view information on user's screen, system automatically hides critical information.
- Use-case III
  - The framework also adjusts to the outside lighting by changing the background colors.

Figure 3 shows one such case where the user has full access to all information when application is first started. As soon as application receives the cognitive load event, the application makes critical information un-editable as shown in figure 4. Any of the policies specified here are strictly arbitrary, as it depends upon the how application developer would like the application to respond to these events. The policies are customized to an application to best fit the business needs. A similar event in a different application may result in a totally different behavior.

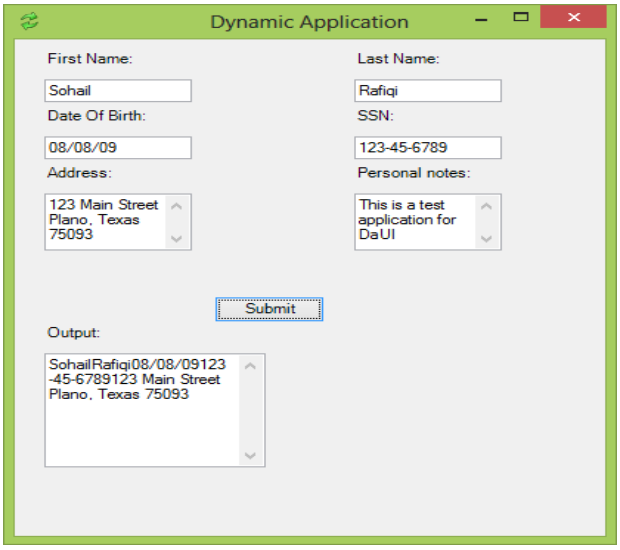

Figure 3: Registration Window

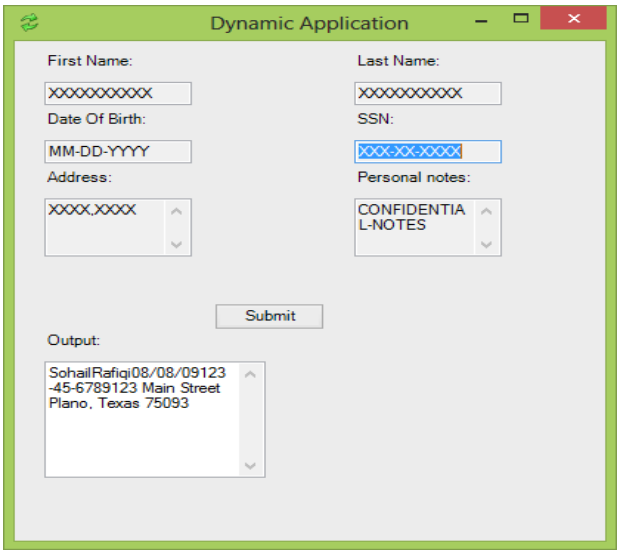

Figure 4: Critical information un-editable

The following is the excerpt of the code showing three use cases.

TABLE 7: **APPLICATION CODE**

```
<?xml version=”1.0”?>
<!DOCTYPE ccaml PUBLIC "-//DX-CORE//DTD CCAML 1.0a Draft//EN" http://dxcore.site/dtds/CCAML1_0a.dtd>

    <!-- dynamic behavior introduced using dx-core-events -->

    <!-- USE-CASE I :: If the user's cognitive load is high with the user location being out of office and time is outside normal working hour then restrict the ability for user to edit the sensitive information -->
    <behavior>
      <rule>
        <condition>
          <op name = "and">
            <event>
              <dx-core-event class="user-cognitive-load">
                <dx-event-source name="dynamic-analysis-engine" level="1"/>
              </dx-core-event>
            </event>
            <op name ="greater-than">
              <property event-class=”user-cognitive-load” name=”current-load”/>
              <!-- Cognitive load measured in values between 1-10 with 10 being the highest -->
              <constant value="7.5"/>
            </op>
          </op>
          <op name = "and">
            <event>
              <dx-core-event class="user-location">
                <dx-event-source name="dynamic-analysis-engine" level="1"/>
              </dx-core-event>
            </event>
            <op name ="not-equal">
              <property event-class=”user-location” name=”current-location”/>
              <constant value="registered-office-work-area"/>
            </op>
          </op>
          <op name = "and">
            <!-- current device system/local time is either less than 08:00 AM or greater than 07:00 PM -->
            <op name ="less-than">
              <property class=”device-properties” name=”system-time” qualifier-format="24 Hours format"access-format="HHMM"/>
              <constant value="0800"/>
            </op>
            <op name = "and">
              <op name ="greater-than">
                <property class=”device-properties” name=”system-time” qualifier-format="24 Hours format"access-format="HHMM"/>
                <constant value="1900"/>
              </op>
            </op>
          </op>
        </condition>
        <action>
          <!-- Make sensitive information uneditable -->
          <property part-name="SocialSecurityNumberInput" name="editable">false</property>
          <property part-name="PersonalNotesInput" name="editable">false</property>
          <!-- update property “Application-State” to value returned by Dx-Core method -->
          <property part-name="Application-State" name="user-profile-state">
            <call name="ApplicationFunction.updateApplicationState">
              <param><property part-class="application-state" name="current-state"/></param>
             </call>
          </property>
        </action>
      </rule>
    </behavior>
```

CONCLUSION

In this paper we presented a multi-modal, dynamically adaptable framework that dynamically adjusts a user interface based upon the user's cognitive load, affective states and the context. The high-level architecture showed the use of pupillometry to determine the cognitive load. We provided information about the new grammar, external event interface as well as the example application currently under development along with the code. In addition, we also discussed two potential applications for the framework. We argued that the ubiquity of technology adoption and our total reliance on technology has fundamentally changed the landscape of security as well as our interactions with computers. Moreover, the usability of the system directly impacts upon the reliability and security. The DAUI framework constantly adjusts the user interface to ensure consistent usability. These cyber attacks come from both external hackers as well as internal trusted sources. They can be both malicious in nature as well as accidental, but either way the costs are extremely high. We do not have enough resources to rely on humans to do all security screening and behavior detection. We need a system that can covertly perform that function to identify potential threats. The presented framework is a perfect union of two disparate sciences, computer science and psychology. The combination of understanding human mental and emotional characteristics and real-time data mining of large amount of data makes this framework unique.

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Effects of Loading Lags and Displays on Television Viewing Experience

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ABSTRACT

Information communication technology industry now focuses on the market of interactive televisions. However, user requirements in this growing market have not been fully understood. Television viewing experience can be regarded as a type of user experience, and this study aims to assess the effects of video loading lags and displayed loading indicators on users' television viewing experience. A 2×5 between-subject factorial experiment was designed. The first independent variable was the loading display with two types: a text-only animation and an animated text with a running percentage bar. The second independent variable was the loading lag with five durations: 1, 5, 10, 15, and 20 seconds. One hundred university students were recruited as participants to watch two music videos with an assigned loading lag and display in between, and then to complete a questionnaire about their satisfaction and pleasure. Results showed that there was a significant effect of loading lags on user interaction satisfaction and pleasurability. A marginal significant effect of loading displays on pleasurability was also found. Post-hoc comparisons revealed that the loading lag should be limited up to 15 seconds for maintaining satisfaction, and up to 10 seconds to sustaining pleasure. Findings of this study can provide useful guidelines for the design of interactive televisions.

Keywords: User Experience, User Satisfaction, Pleasurability, Loading Time

INTRODUCTION

Interactive television is predicted as the next surge in the market following the widespread use of mobile phones and tablet computers. There are several relevant terms about the interactive television, such as internet protocol TV (IPTV), connected TV, and internet TV to highlight the connection with the internet, digital TV to emphasize the digitalization, and smart TV to feature various types of application software. These terms are interchangeable with the terms used in this paper, interactive TV, which gives emphasis to viewers' interactions with TVs. With the capability of interaction, people now can "use" TV instead of just "watching" TV.

A set-top box linked to a digital TV screen is the most popular approach of connecting the networks. While many manufacturers of set-top boxes exist, few of them have considered user requirements in their product development process. Consequently, specifications of interactive TVs are mainly decided according to development costs but not user requirements. Thus, users often have degraded experience when they watch interactive TV through a set-top box. One commonly found annoyance is a loading lag. A loading lag may be due to limited bandwidth of networks, poor performance specifications, and/or information content sizes. All these issues are resolvable through the technology. However, many manufacturers hesitate to take any action since it is difficult for them to estimate the return on investment, that is, the extent to which viewing experience will be improved by an investment in enhancing specifications. To provide a clearer picture of this issue, this study aims to assess the relationship between loading lags/displays and television viewing experience, so that some useful guidelines can be derived for the design and development of interactive TVs.

Television viewing experience can be regarded as a type of user experience (UX). As defined by the ISO 9241-210 standard, UX is "person's perceptions and responses resulting from the use and/or anticipate use of a product, system or service" (ISO, 2010). This perception and response process is influenced by both a top-down (knowledge-driven) processing and a bottom-up (stimulus-driven) processing (Wickens et al., 2004) so that people's UX is influenced by their prior knowledge and expectation of the use as well as by the interaction with products, systems or services during the use. While it appears that no research findings are yet available concerning the relationship between loading lags/displays and television viewing experience, it seems worthwhile to review literature on the waiting time for downloading a web page. Several recommendations have been made about the upper time limits of loading a web page. While Nielsen (1996) suggested 15 seconds as the threshold to maintain users' interests, Zona Research (2001) applied its 8-second rule. Various empirical results can also be found. Selvidge et al. (2002) reported that no significant effect of loading delays among 1, 10, and 20 seconds on user frustration, but significant increases of frustration level were found from the delay of one second to the delay of 30 seconds, and from the one second to the 60 seconds. Ramsay et al. (1998) manipulated loading delays from two seconds to two minutes and suggested that users would lose their interests as the delay exceeded 41 seconds. Hoxmeier and DiCesare (2000) examined the relationship between the system response times of 0, 3, 6, 9, 12 seconds and user satisfaction. Their results showed that satisfaction decreased as response time increased, and a significant decrease of satisfaction was found around the response time of 12 seconds. Nah (2004) concluded that the majority of users would abandon a downloading web page if the delay exceeded two seconds, but their waiting times would be prolonged as a feedback during the wait was displayed on the screen. In general, the increase of loading lags accumulates demerits. Furthermore, as shown in previous research, different tasks and contexts seem to have different tipping points about the lag limit that make significant shift in terms of users' attitudes and behaviors. Therefore, this study attempted to examine the tipping point of TV viewing experience with the method described in the next section.

METHOD

Participants

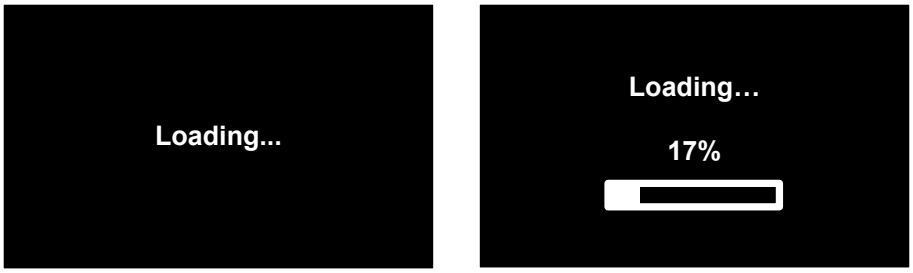
One hundred university students were recruited as participants. Thirty-seven were female and sixty-three were male. Their average age was 24.5 years old with a standard deviation of 2.1 years old. Among the participants, 58% of them have had the experience of watching interactive TVs, and 96% of them have had the experience of watching TV programs through the internet.

The Experiment

A 2×5 between-subject factorial experiment was designed with loading displays and loading lags as the two independent variables, and participants' responses about their satisfaction and pleasure as the dependent variables. While the two types of loading displays were a simple text loading animation and the text animation with a percentage progress bar, five durations of the loading lags were 1, 5, 10, 15, and 20 seconds. Responses from participants were collected through a questionnaire modified from the questionnaire for user interaction satisfaction (QUIS) (Shneiderman, 1997) and the questionnaire for pleasurability (Jordan, 2000). The scale of the questionnaire was from 0 to 10.

As shown in Figure 1, two loading animations were designed. The text-only feedback (Figure 1 (a)) just displayed the text of "Loading" with three running dots behind, whereas the other feedback (Figure 1 (b)) added a

percentage progress bar below the text.



(a) (b)

Figure 1. Loading displays: (a) text only; (b) text with percentage bar

The experiment was conducted in a typical living room set-up with a TV, a remote control, and a sofa. Participants were randomly assigned to one of the ten experiment conditions. For each condition, participants were first asked to watch a four-minute music video on a TV, then to play the next music video with pressing a button on a remote control. Once the button was pressed, the assigned loading display was shown on the screen for the duration of assigned loading lag. The second music video would be displayed on the TV after the lag, and was stopped at about ten seconds for participants to complete their questionnaires.

RESULTS

User Interaction Satisfaction

The relationship between loading lags/displays and user interaction satisfaction ratings is illustrated in Figure 2. In this figure, the dotted line represents the trend of ratings as the loading text with a percentage bar was displayed, whereas the solid line represents the trend as only the loading text was displayed. As can be seen, both dotted line and solid line have declined in a similar manner with an increase in the loading lag. Compared to a relatively flat trend for the lags from five to 15 seconds, there appear steeper decreases from one to five seconds, and from 15 to 20 seconds.

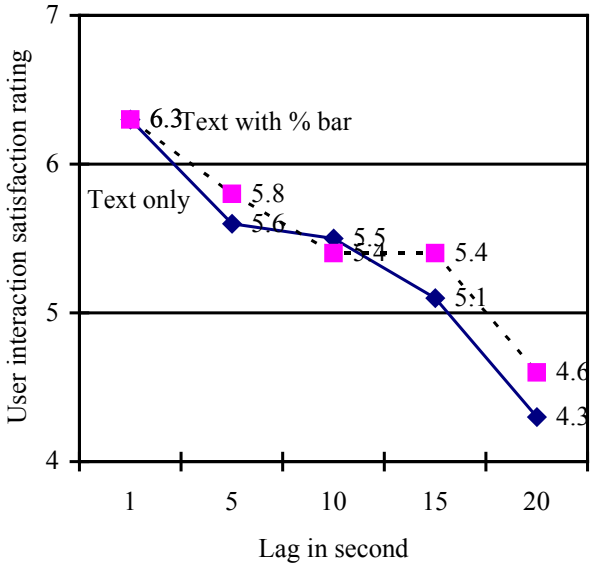


Figure 2. Relationship between loading lags/displays and user interaction satisfaction ratings

Results of the ANOVA showed that there was a significant effect of loading lags on user interaction satisfaction ratings ($F_{(4, 90)} = 2.936$, $p = 0.025$), however, the effect of loading displays, as well as the interaction effect of the lag and the display, were not significant on the rating. Results of the post-hoc comparison of the ratings among five loading lag levels revealed that significant difference existed for the lags of one second and 20 seconds at the $p < 0.05$ level.

Pleasurability

The relationship between loading lags/displays and pleasurability ratings is illustrated in Figure 3. Same as in the previous figure, the dotted line in this figure represents the trend of ratings as the loading text with a percentage bar was displayed, whereas the solid line represents the trend as only the loading text was displayed. As can be seen, both dotted line and solid line have declined with an increase in the loading lag. However, different from the satisfaction ratings in Figure 2, all the dotted line is above the solid line. Moreover, the downward trend for the dotted line seems relatively convex compared to the trend for the solid line which is relatively concave.

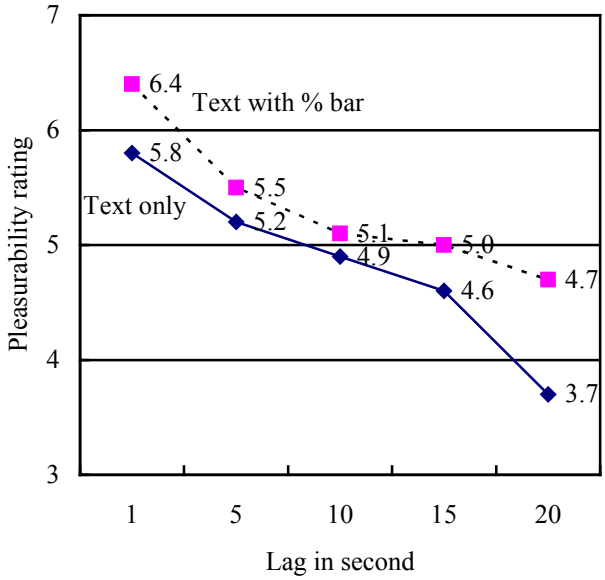


Figure 3. Relationship between loading lags/displays and pleasurability ratings

Results of the ANOVA showed that there was a significant effect of loading lags on pleasurability ratings ($F_{(4, 90)} = 5.367$, $p = 0.001$). A marginal significant effect of loading displays on the rating was also found ($F_{(1, 90)} = 3.431$, $p = 0.067$), however, the interaction effect of the lag and the display was not significant. Results of the post-hoc comparison of the ratings among five loading lag levels revealed that significant difference existed for the lags of one second and 15 seconds, and for the lags of one second and 20 seconds. Both were at the $p < 0.05$ level.

DISCUSSION

In conclusion, the loading lag may be limited under 15 seconds to achieve a better user interaction satisfaction, and under 10 seconds to obtain a more pleasant viewing experience. This result is in line with previous reports (e.g., Hoxmeier and DiCesare, 2000; Nielsen, 1996; Zona Research, 2001). The addition of a progress percentage bar on the loading display could marginally enhance the viewing experience compared to a simple text loading animation. This finding is consistent with previous research (e.g., Nah, 2004). It is expected that this loading display would be significantly enhance the viewing experience if it compared to a dark screen without any loading indicator.

It appears that the lag limit for a pleasant viewing experience is shorter than the one for the user interaction satisfaction. Since the questions for user interaction satisfaction are more about functional aspects of usability and the questions for pleasurability are more about emotions and feelings, this finding implies that users' feelings rather than attitudes towards functional usability are easier to be affected by loading lags. Additional research in this issue should prove quite beneficial.

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Section 9

User Centred Design

Impact of Multidisciplinary Teams on the End-User Consideration in the Building Industry

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ABSTRACT

Building construction projects are characterized by a sequential process that includes an important amount of stakeholders. In most cases the end-user is a direct customer of the contracting body which is a direct customer of AEC (Architecture, Engineering and Construction) companies. Literature tends to describe the consideration of end-user needs by the building construction industry as less developed than the manufacturing industry. The objective of the paper is to study how the multiplicity of actors impacts the consideration and therefore satisfaction of the end users by the companies. The study was realized with the help of a contracting body company throughout a project which allowed us to interview actors from different professions. Exploratory analysis is divided in two parts. First of all we produced a mapping of the building design process, then we identified to what extent decisions of professionals are based on identified end-users needs. The first results tend to indicate that the level of awareness of companies toward the requirement of the other stakeholders differs depending on their level of interaction with those stakeholders. Further development of this analysis will help to conclude on the interdependence between the fragmented organization and the end-users needs consideration by the companies.

Keywords: Building, Design Process, End Users, Architecture, Process Integration, Customer Satisfaction

INTRODUCTION

With the application of new thermal and accessibility building regulations, French AEC industry is facing new challenges, and has to adapt his working process to these new constraints. In this context of change, we had the opportunity to follow a French company which activity consists of developing council house projects. This company is in charge of three main functions: country planner, property developer and property manager. In order to maintain and develop its market share in a tense and dense building market area, with a lot of bigger competitors, this company has taken the decision to concentrate its future strategy into giving a higher focus on the end-users consideration to increase their satisfaction.

This paper reports the findings of a study that was a first step in the development of this new strategy. The objective was to study the interactions between the different professionals during the development of a new building project,

in order to be able to identify how and when in the building process would it be pertinent to implement end-users input. The study was realized

The paper will start by reviewing how the literature describes the specific characteristics concerning the actors and the process of a building project and how it differs from a manufacturing project. Theses peculiarities have consequences on the end-users consideration in the AEC industry. Even if they have to work together to produce a building for a common "end-user", AEC professionals in charge of those projects have different tasks and objectives to fulfill. Naturally those companies have also different backgrounds, cultures, procedures and vocabulary to achieve their work. In order to be able to complete the construction, all professionals from the architects to the engineers and craftsmen have to consider each other requirement as well as those from the entity from which they are accountable for, which is frequently different from the end-users. We believe that the multiplicity of professions and the complex multiple level of customer ship could be a reason that explains the lack of consideration for the end users that is described by the literature.

Secondly the study will focus on the specific process of the company and explain their design process. First of all we produced a mapping of the building design process through interviews and document analysis which allowed us to ponder the interactions between different categories of actors. The second step consisted in semi-structured interviews that helped to identify to what extent the decisions of professionals are based on identified end-users needs. Finally we will discuss on the importance of integrating end-users in the design process of a building project to increase their satisfaction.

CHARACTERISTICS OF THE BUILDING INDUSTRY

The Actors of a Building Project

In this section we are going to present the main actors of a construction project and what are their functions and responsibilities.

Most of the time, the end-users or the owner doesn't actively take part in the building design process. Generally they hire a Contracting Body (CB) that is in charge of supervising and validating the proposition of the Project Managers, who generally consists of Architects and Engineers. The CB is in charge of embodying the owner needs and most of its work is realized on the early stages of the design process.

Table 1: Function and Actors of a Building Project (Inspired by Morand, 1994)

Function	Actors								
	Owner	Contracting body	Architect	Engineering Companies	Economist	Control Office	Sales Department	Accountant	Construction Company
Direct interaction with end-users	X						X		
Contracting Authority		X							
Project Management			X	X					
Architectural Design			X						
Technical Design				X					X
Works contract		X	X		X			X	X
Coordination		X	X						X
Cost Supervision		X	X		X				X

Safety control		X				X			
Construction									X
Sale							X	X	

The CB has to produce a feasibility study then realize (or hire someone to assist him to do it) the architectural program. This program defines the needs, the requirements, and the environment surrounding the future building, and will help to produce the future design. The program is a base for the Architects and Engineers (PM) to develop and design concepts that will have to be validated by the CB. Once that the Project Managers are hired, the CB is responsible for controlling and validating each of the design suggestions made by the PM along the whole building project. The Project Managers need to have their proposition validated by the Contracting Owner as well as comply with the different regulations. The coordination between the architect and the different categories of engineers (Structural, Thermal, Fluid etc…) is essential for a good completion of the project even if it is difficult. Apart from the technical functions, there are other professional that play an important function during the building construction process; especially those who are in charge of assuring the economical and safety parts of the project. It's important to not underestimate their weight because economic and safety issues can have an important weight on some design decision.

Even if they have to work together to produce a building for a common "end-user", AEC professionals in charge of those projects have different tasks and objectives to fulfill. Naturally those companies have also different backgrounds, cultures, procedures and vocabulary to achieve their work. In order to be able to complete the construction, all professionals from the architects to the engineers and craftsmen have to consider each other requirement as well as those from the entity from which they are accountable for, which is frequently different from the end-users.

A Sequential process

AEC design process follows generally a sequential process, with a rather clear definition of tasks assigned to each actor along the different stages of a project. (Lee & Jeong, 2012, Kamara, Anumba, & Evbuomwan, 2001)). It generally consists of a series of distinct stages during which the contractor asks for a feasibility study, technical specifications, defines a budget and has a tender before designing and constructing the building. Obtaining the cooperation and a constructive dialogue between the different actors is a complex but necessary task to complete the project. According to Carassus (2003), French AEC industry fragmentation is a consequence of the diversity of building requests as well as the diversity of technical expertise required for said projects.

Contrary to the manufacturing industry, the AEC activity does not produce a repeatable product that will be produced at an industrial scale. A building is generally designed and built once (Tric, 1999) by several actors that will generally work together once. Reaching collaboration, as well as a constructive dialogue between the different actors is a complex yet necessary task in order to achieve the construction process. This fragmentation between actors all along the different stages and the temporary nature of relationship between organizations (Crespin-Mazet & Ghauri, 2007) are mentioned as an obstacle to the use of manufacturing industries project management methods (Kubicki, 2006). For Bougrain & Carassus (2003, cited by Kubicki, 2006) «On multiple occasions, the teams involved on a project decompose after a project. In fact, any experience capitalization is delicate. (Lahdenperä, 1998 ; Egan, 1998).

However the fragmentation of the process and the actors is also considered as a necessary evil for some because it allows a lot of flexibility in a system under a high uncertainty (Egan, 1998). The construction site is "outdoor, ephemeral, complex, and uncertain" (Bougrain & Carassus, 2003), it is not a controlled or reproducible environment, on which it is possible to anticipate potential disruptions that will affect the work or even be totally sure you can transpose local solutions for future projects.

According to Tertre (1995), *"fragmentation should not be considered as a negative factor neither as an anachronism, but as an essential characteristic of the sector that is actually its strength and its dynamism."*. For Hoyet (2007), the fragmentation and instability of the system of actors is a rather positive thing that prevents the industry from adopting a routine in intellectual behaviors. Moreover this kind of organization allows an important adaptability.

End-User consideration in AEC industry

Customer's and end-user's needs are a crucial data for building projects. An appropriate understanding of those requirements is essential in order to achieve results that fulfill user's expectation. In order to develop a privileged relationship between a client and a company then maybe reiterate the commercial experience afterward, customer satisfaction is primordial in any commercial activity. However, the "one-off" nature of building construction projects from a customer point of view, impacts on the significance of customer loyalty comparing to, for example the manufacturing industry where the consumption act is more frequent and strengthening the customer loyalty more essential. Nonetheless in an industry where informal communication is preponderant, reputation and word-to-mouth can have a considerable effect on company's image.

While integrating end-user's requirements is important, it is necessary to clearly define who the end-users are, and take into account their diversity as well as the multiplicity of their needs. If the buyer is represented by the contracting owner which isn't necessarily the future user of the building, the contracting owner could be more focused on deadline and budget factors rather than functionality or other specifications...The diversity of end-users that need to be satisfied, as well as the divergences between their priorities, explains the difficulty of integrating their requirements into the design (Zeisel, 1981, quoted by Kamara et al., 2000).

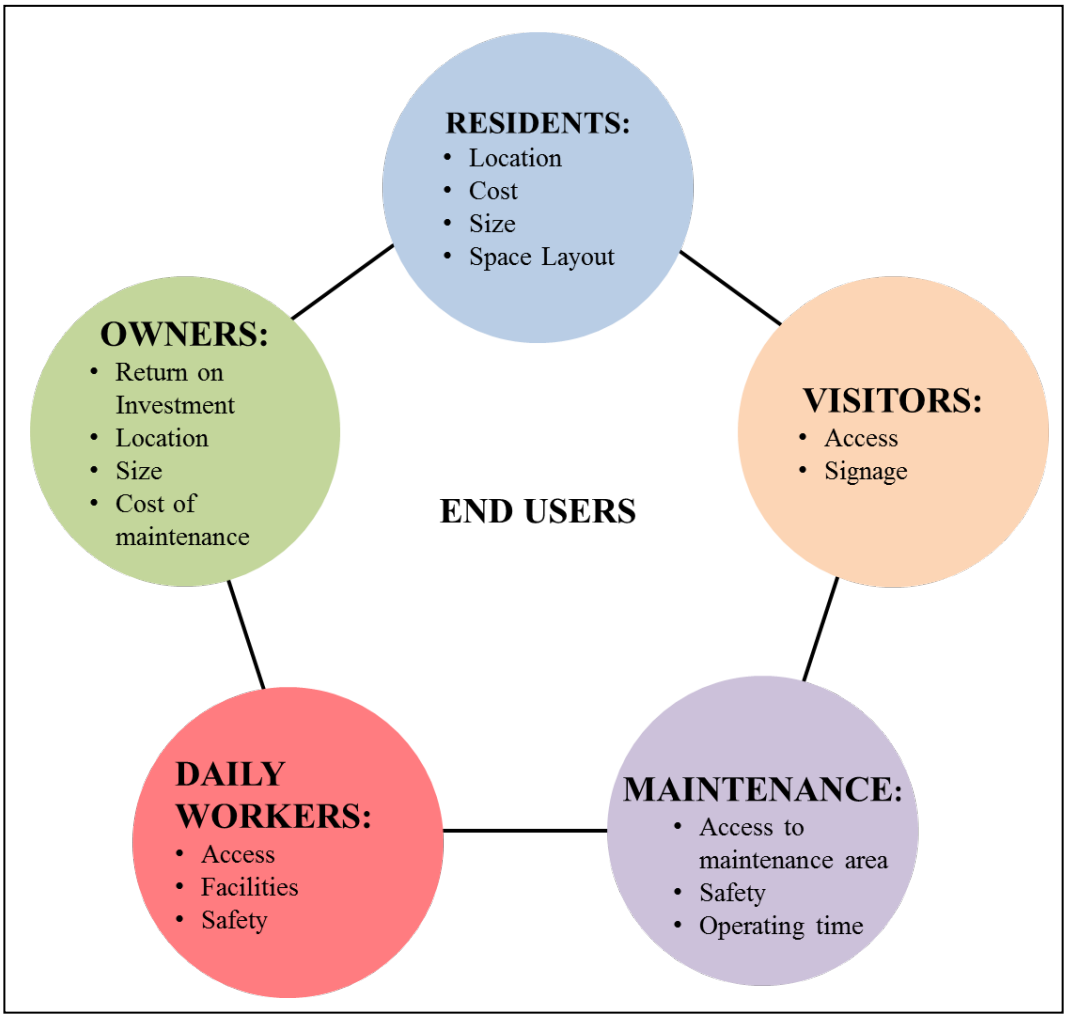

Figure 1. Building end-users diversity

Figure 1 illustrates the diversity of end-users that is observable in a building. It would be incomplete to reduce the end-users to the residents of a building. A building is used by multiple categories of people that have all their satisfaction criteria. While it could be considered that the residents are more focused on the location, cost, size ,and general space layout, for the owners (if not living in the building), the building is an investment, and requires to be profitable. Therefore owners will be more prone to be focused on the Return on Investment, the cost of maintenance, and the general attractively of the product. All these factors will have an impact on the price of the rent, then its

profitability. Visitors, Maintenance technicians, and Daily Workers (Postman, building manager, delivery men) have also specific needs even if their use frequency of the building is lower than the residents.

This diversity of needs and the materialization of end-users expectations have consequences on all the stages of the project, and would need a collective effort from all the project's actors on a common and neutral vision of users. This common vision requires to be translated into quantitative and qualitative terms that would be understable by all the professionals in charge of the project, and depending on their respective tasks (Kamara et al., 2000).

CASE STUDY

Company's building design process.

The partner of the study has the particularity of having multiple responsibilities and activities during the building construction process. The company is not only country planner, but also a property developer and a property manager. It means that in some of its projects, it is not only the owner, but also the project manager, the real estate programmer, the accountant and the sale department. They rent and sell council houses. This specificity allows the company to have a wide vision of the process and to develop numerous interactions with the end-users at different stages of the process. One of their objectives is to develop a long-term relationship with their customers and allow them to evolve from a tenant position to a home ownership status. Having both kind of activity (rent and sell), this status evolution from their customer allows the company to maintain and develop their activity by having an important customer base. However, in order to maintain this customer base, their objective is to increase the satisfaction of their clientele by a better integration of their customer needs in the design process of the new buildings.

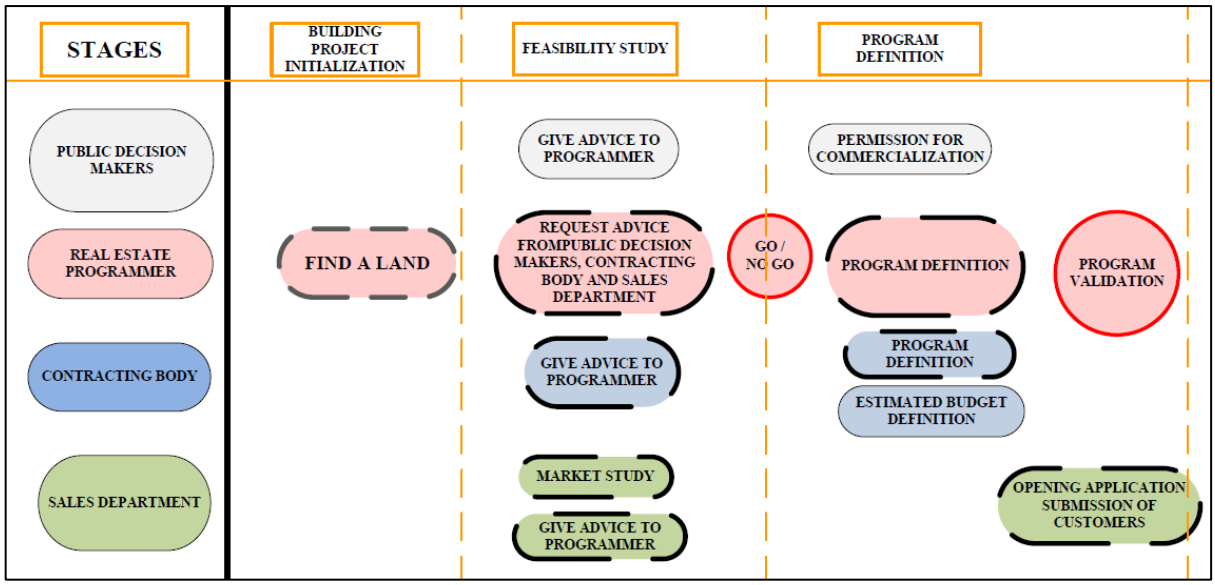

Figure 2. First stages of the building design process

Figure 2 represents the first stages of a new building design process. Activities with a dotted circle indicate the activities that have a direct impact on the end-users functional needs.

The project begins with the finding of a land by the real estate programmer. Once that the land is identified and corresponds to the company's requirements, the feasibility study starts and consists of analyzing the possibilities associated with the land: from a technical, economical, and legal point of view. This feasibility study requires for the programmer to gather public decision-makers advice to ensure the compliance of the project with local real estate regulations. Once that legal compliance is validated, the economical and functional aspects are validated by the contracting body and the sales department of the company. If the feasibility study is positive, the program is defined by the programmer with the help of the contracting body, which allows the contracting body to give a first

estimation of the budget to the sales department that start to open application submissions to its customers. With the program validation by the company begins the contracting of Project Managers (Architects, Engineers etc…) that will have to produce a preliminary design then submit this preliminary design to the approval of both the sales department and the contracting body (Figure 3). Once that the building permit will be released, the project managers will have to complete a final design of the building while the contracting body updates the budget estimation (Figure 4).

This brief summary of the company's design process allows showcasing that a lot of different actors have a direct impact on the end-users need but that the only one to have direct interaction with the future residents is the sales department.

Moreover the weight of the sales department on the design process consists primarily in giving a feedback to designs that are produced by the Project Managers. Furthermore architects and engineers base their design on a

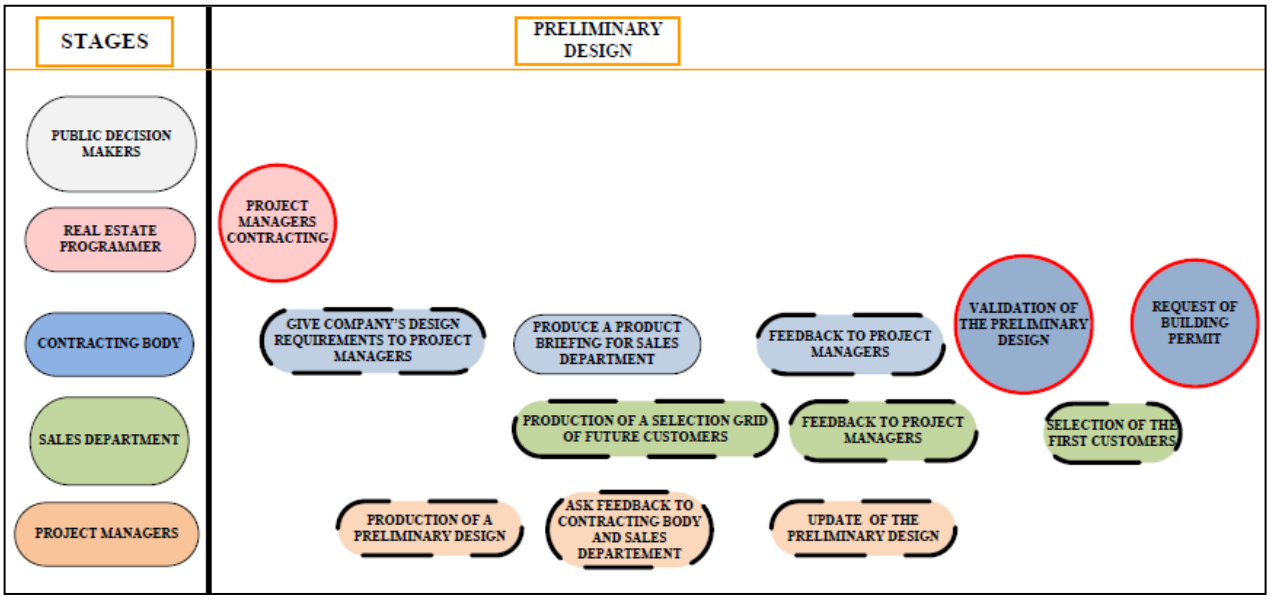

Figure 3. Preliminary Design Stage

program that is already defined by the real estate programmer and the contracting body. What appears from a brief analysis of the building design process of the company is the fact that the sale department is the only one to have a direct interaction with end-users yet only have a low impact on design decision. However, it doesn't mean that end-users needs are not taken into account by the other professionals.

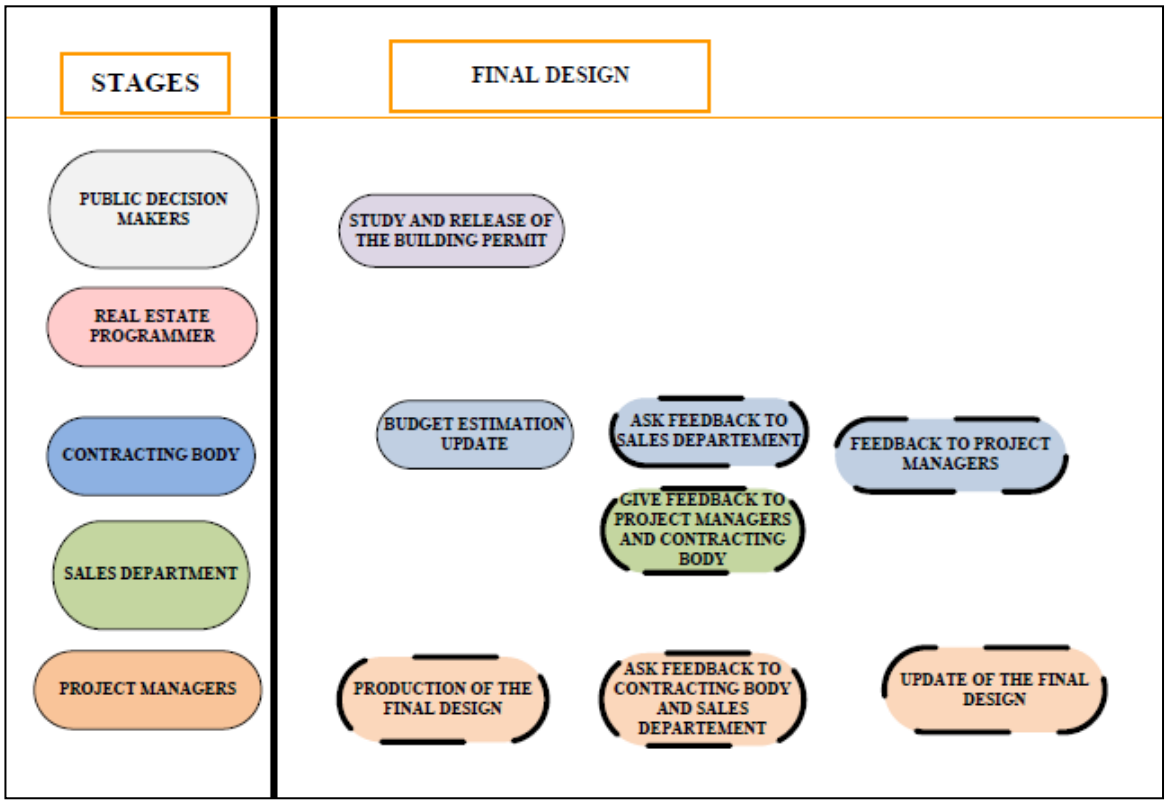

Figure 4. Final Design Stage

End-users needs and specification are taken into account by some of the building regulations, and of course professionals can rely on their experience and their knowledge to take decision that translate end-users requirements, however these inputs are some general inputs that are not necessarily pertinent for each end-users and/or the specific and identified customers of the company.

These arguments lean to promote an increase of the implication of the sale department in the design process by increasing the communication between the real estate programmer, the contracting body and the sales department who are part of the same company. Nevertheless, as explained in the literature review, this communication between different professionals that have different backgrounds, vocabulary and objectives is a complex task. Moreover, if the goal of the company is to increase their customers' satisfaction, what is the guarantee that increasing the focus on the integration of the end-users needs will increase their satisfaction?

DISCUSSION

According to Kärnä et al. (2004), consideration of end-user's satisfaction in the AEC industry is something relatively recent, moreover "The innovation (…) based on market analysis or the expected behavior of potential users or customers, has a minor weight in construction" (GTM, 1997). Nonetheless the importance of satisfaction of end-users for the evaluation of building quality is perceived as essential by numerous authors (Kärnä, 2004)).

According to Soetanto et al. (2001), satisfaction differs between categories of actors, for example architects tend to have a less positive perception of buildings than the future owners of the same building. Moreover, Torbica and Stroh (2001) explain that the observation of the customers satisfaction isn't possible until the last stages of a project, when a large part of the investments have already been spent, and when the questioning and modification of the construction works would be problematic.

The ignorance of end-users requirements during construction briefings has been criticized for a long time. Kaya (2004) highlights the "insufficiencies of the construction industry in the way that the client's needs are met". However end-users have little background to consider different spatial solutions (Dewulf and Van Meel, 2002).

They are far from being experts, but still have some knowledge and opinions in relation to their own goals (Lai and Yik, 2007). This lack of skills may explains the" communication gap between end-users, designers and owners as well as the negative stereotypes and images that can exist among professionals (Pemsel, 2010). The effect of this situation is that end-users can feel like a hostage, because the building design issues cannot be understood by them (Mumford and Sackman, 1975).

Nevertheless, when end-users aren't involved in the design stages of building, they tend to be more reactive and critical of the building (Kaya, 2004). According to Pemsel (2010), "End-user satisfaction is contingent not only on the outcome but the way it is achieved". For Auchterlounie and Hinks (2001), customer satisfaction is based on several aspects, from the inherent quality of the building and facilities to the relation with the different stakeholders. This emphasizes the fact that considering user-needs is not enough to gather customer's satisfaction, the relationship and interaction factors also appear to be essential. End-users have to own their space and feel they have control over their environment in order to feel more comfortable (Kaya, 2004). Moreover a need is often hard to express, while requirements are statements related to existing products. For Peña and Parshall (2001) only the understanding of the real needs can help succeeding in improving the quality of the building.

CONCLUSION

The nature of the building design process, the number and nature of its stakeholders and the diversity of end-users can explain part of the difficulty of integrating end-users needs into the design process. Regulations and experience from the professional help to consider users' requirements, but it is essential to distinguish requirement from real needs. Moreover integration of the real needs of end-users into the design briefing of a building is not a guarantee to satisfy future residents. Not only end-users require to be understood but they also need to feel they are part of the process in order to increase their satisfaction. As a conclusion to the case study, it appears that the company not only should give more input to the sales department because they are the one with direct interaction with future residents, but they should also find a way to integrate directly the future end-users to the process. As a result, one of the decisions that were taken by the company to increase the customer satisfaction was to test to produce a building including participative design stages where future residents participate to the design decisions. It will be interesting to study how the direct consideration of future residents needs impacts their satisfaction as well as the quality of the design in a future study.

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Integrating User Attention for Design Evaluations in Customer-Oriented Product Development

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ABSTRACT

The importance of user-oriented design enhancing Perceived Quality increases. The impact of customers' emotions on purchasing decisions increases the interest in applying multi-sensorial measurement methods during the product development process (PDP) in order to objectify emotions. It is important that emotional information about products can be gathered and applied by the combined usage of visual impressions with different modalities for capturing and objectifying user attention and emotions. Furthermore, rules are necessary to define a sufficient level of data as well as to communicate it into product development. This paper describes a methodology based on principles of Kansei Engineering and presents selected results of the research project CONEMO. An overview is given on how to measure and to use emotion and objectified data about quality perception for decision-making during a customer-oriented product development. CONEMO aims at a standardized procedure with an easy-to-follow methodology that is based on a Quality Gate systematics which involves customers' attention and emotional evaluation of design alternatives during early phases of PDP and contains descriptions, requirements, measurement parameters, product structure and function. Specifications were developed to transfer Eye-Tracking data into design requirements to combine both latent, objectified and explicit, conscious data during the PDP. The presented methodology intends to support product designers by evaluating product concepts and innovations.

Keywords: Kansei Engineering, Product Development, Design Evaluation, Quality Gates, Eye-Tracking

MOTIVATION

In a time of globalized markets and the increasing technical competence of low wage countries the importance of user-oriented design that enhances customers' perception and the active design of Perceived Quality increase dramatically. A good understanding of user perception makes the difference between success and failure. During the design of new products it is a company's aim to make right decisions in choosing product design alternatives at early phases and to be aware of customers' demands, especially of those which strike customers the most. The Product Development Process (PDP) is one of the core processes of manufacturing companies and significant to the companies' success (Ehrlenspiel, 2009). By transferring requirements into products with high Perceived Quality and selling them especially well, manufacturing companies will be able to differentiate from their competitors. However, companies have to focus on the evaluation of visual impressions before in order to succeed. The fact that nearly 80 percent of all information is gathered by the eye shows the importance of visual impression and how it influences the evaluation of products (Berghaus, 2005). Thus, a methodology for product development is needed that concentrates on the objectified evaluation of visual impressions by applying measurement systems, e.g. Eye-

Tracking. As a result, the difficulty of gaining a comprehensive customer demand profile including both explicitly mentioned as well as implicit, latent needs, which customers often are not able to describe accurately, can be reduced. Right decisions about product design alternatives can only be based on comprehensive, valid customer data. Therefore, a methodology is needed to elicit data and information about customer attention and emotion, to integrate these data and information into the PDP and to ensure the enriched PDP for a continuous customer-oriented development process.

IMPORTANCE OF CUSTOMER-ORIENTED DESIGN EVALUATIONS FOR PRODUCT DEVELOPMENT

The PDP (2.1) is the core process to transfer customer requirements and needs into product specifications and product characteristics. This process hast to be ensured by applying an appropriate Quality Gate approach in order to generate a continuous and robust process (2.2). Since the importance of Perceived Quality is increasing, the measuring of customers' attention and comparing different design concepts by objectified data are important to develop products that evoke positive emotions (2.3). Thereby, knowledge about customers' different levels of perception (latent and explicit perception of products) and a common product understanding between companies and customer target groups are essential for emotional product design. One of these methodologies integrating the evaluation of emotions and having the potential to integrate data of visual impressions for product design is Kansei Engineering (2.4).

Product Development Process and Failure Costs

The PDP defines the product on basis of an abstract *product idea* which adapts desirable product characteristics to customer demands (Figure 1). The subsequent step is the product development conducted on the basis of a concept of the product and its stepwise design and realization (Beaujean et al., 2011). Moreover, *component development* and process planning are necessary in order to realize prototypes as well as the *pre-series production* (Ehrlenspiel, 2009). As the PDP proceeds, the determination of product characteristics restricts the companies' possibilities for design alterations and technical adjustments and subsequently it is crucial to focus early phases since the expenses for the correction of failures are relatively low (Lindemann, 2005; Schmitt and Pfeifer, 2010).

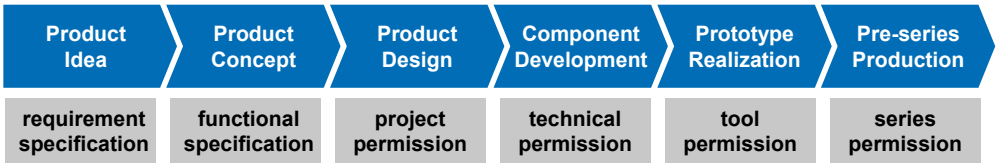

Figure 1: Phases of the PDP (based on Ehrlenspiel, 2009)

Studying established products runs the risk that customer requirements have already been misinterpreted or neglected in previous design decisions and any future change of the product can lead to high costs for redesign. The economic dimensions during PDP indicate that 75% of all production costs are induced at the phases of *product concept* and *product design* (Schmitt and Pfeifer, 2010). Thus, the evaluation of different design alternatives is important in all phases of the PDP, but crucial in early phases.

Quality Gates Systematics

Quality Gates or Gating (Prefi, 2003) is often used in industry as a monitoring and controlling systematics during development processes. A typical process is the stage-gate-process (Cooper, 1994) which is often used in order to stipulate clear and effective rules for a successful PDP (Schmitt and Pfeifer, 2007). Stages are phases in which activities are bundled and performance and results are achieved. Gates are decisions and checkpoints which subdivide the PDP. Critical success factors for defining Quality Gates are the implementation on critical positions of the PDP, the definition of internal customer-supplier-relationships, the selection of an appropriate evaluation model and the continuous application. Main attributes of the Quality Gate systematics are input, performance of activities, criteria catalogue (checklist) and output. There is the same procedure that applies for each stage. First the development team determines the criteria catalogue which includes the measured parameters. Later these parameters are compared to the measured output value during the monitoring at the Quality Gate. To meet the demands of

criteria with different urgency and rating, it is helpful to differentiate criteria in “must-meet” and “should-meet”. At each gate, the product is assessed by a relevant authority. The objective of having checkpoints after each development phase is to reduce the probability of failure.

Perceived Quality and Eye-Tracking

The PDP should strongly focus on Perceived Quality in order to anticipate customers’ evaluation of product alternatives. *Perceived Quality* became an important issue in companies’ strategies to differentiate from competitors (Falk, Quattelbaum and Schmitt, 2008) and is defined as the emotional and cognitive comparison between product characteristics and requirements and needs of the target group (Figure 2). The comparison is based on conscious as well as unconscious perception and linked to customer experiences and expectations (Schmitt, Quattelbaum and Lieb, 2008).

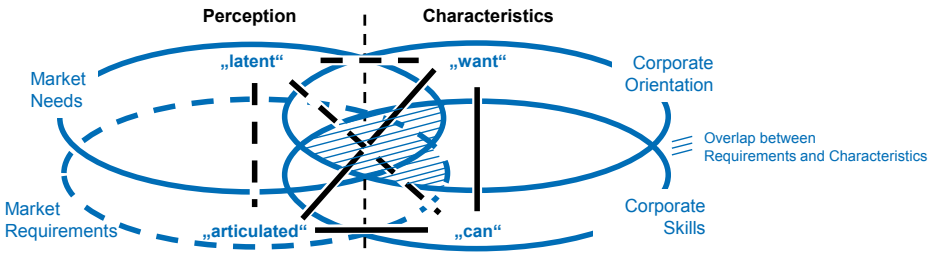

Figure 2: Understanding of Perceived Quality (Köhler, Falk and Schmitt, 2013 based on Schmitt, Quattelbaum and Lieb, 2008)

Due to the fact that the customer’s product perception is complex and can be structured in different levels of perception which differs in their level of detail (overall impressions down to technical parameters) an application which captures latent needs and articulated requirements is necessary in order to compare different product concepts and alternatives on different levels of perception. (Falk, Quattelbaum and Schmitt, 2008).

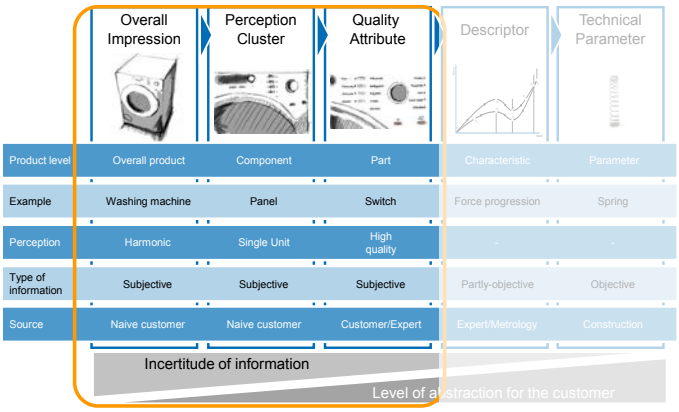

Figure 3: Structured approach towards Perceived Quality (Schmitt and Pfeifer, 2010)

An appropriate application offers the structured approach towards Perceived Quality by Schmitt and Pfeifer (Figure 3). This approach focuses on subdividing a product beginning from the overall product impression perceived by a customer down to technical parameters. Elements that are perceived as one entity are called perceptive clusters, which again can be divided into quality attributes. The quality attributes are described by descriptors and their correlation with technical parameters leads to physical quantities (Schmitt and Pfeifer, 2010). Customers looking at a certain product do not look at every single part of the product rather than grouping certain areas to clusters of perception. These clusters are firstly perceived as one system element and are situated in a high structure level (e.g. a door or the hood of a car).

The measurement of user attention and design evaluation can be divided into verbal methods (e.g. face-to-face survey, phone interview, online survey) and non-verbal methods (e.g. Eye-Tracking, ECG). Concerning the measurement of visual attention and evaluations, the oldest and simplest approach of detecting the eye movements

of a target person is direct observation of a trained observer (Hofer and Mayerhofer, 2010). Nowadays, *Eye-Tracking systems* are mainly used to deduce the attention evoked by product components and to visually evaluate different designs. Thereby, fixations, saccades and scan paths are the most important key figures to record valuable and objective input data for product development. Fixations are time intervals in which the eyes rest in one special position, taking in or encoding information. Saccades are rapid eye movements between fixations and scan path means a sequence of saccade-fixation-saccade. Some additional metrics as gaze (look), pupil changes and blink rates are also studied. (Mello-Thomes, Nodine and Kundel, 2004; Hoeks and Levelt, 1993; Stern, Boyer and Schroeder, 1994) The visual impression can be influenced, as the gaze track is affected by current thoughts. Therefore, while thinking of a product attribute, the attention and the view are focused on the components that are considered as connected to it (Yarbus, 1967). Thus, it is possible to capture useful information on the implicit, latent customer requirements by applying visual measurement via Eye-Tracking.

Kansei Engineering

Kansei Engineering is a product development methodology which aims at the development or improvement of products by translating customers' psychological feelings and needs into specific product's design parameters. The term *Kansei* derives from the Japanese language and combines the two different signs *Kan* (feel, emotion, impression) and *Sei* (heart, mind, believe, dynamic) (Lee et al., 2002; Schütte, 2005; Schütte, 2002). The traditional methods of Kansei Engineering try to translate impressions, feelings and demands regarding established products or concepts into new design solutions and precise technical parameters (Nagamachi, 1989) in order to actively design a product with a high Perceived Quality (see Figure 2). The main method of Kansei Engineering in order to grasp customer's feeling about the product is the *semantic differential* (Osgood, 1957; Nagamachi, 1995). Further typical methods like the *Kano Model* (Kano, 1984), *systems and functions analysis* and measuring physiological signals (e.g. *GSR*, *EMG*) should be used later during the application of Kansei Engineering.

Semantic differential is a type of a rating scale designed to measure the connotative meaning of products and product components from customers' point of view. The semantic differential scales are based on semantic opposites such as "good-bad", "soft-hard", "fast-slow" which helps to define most important semantic concepts regarding a specific product (Osgood, 1957). It is mostly used for standardized questionnaires (articulated and explicit information, self-reporting methods) (Figure 4, right). Due to the fact that people always describe products by using words which reflect their feelings and opinions, these words can be grouped in semantic concepts.

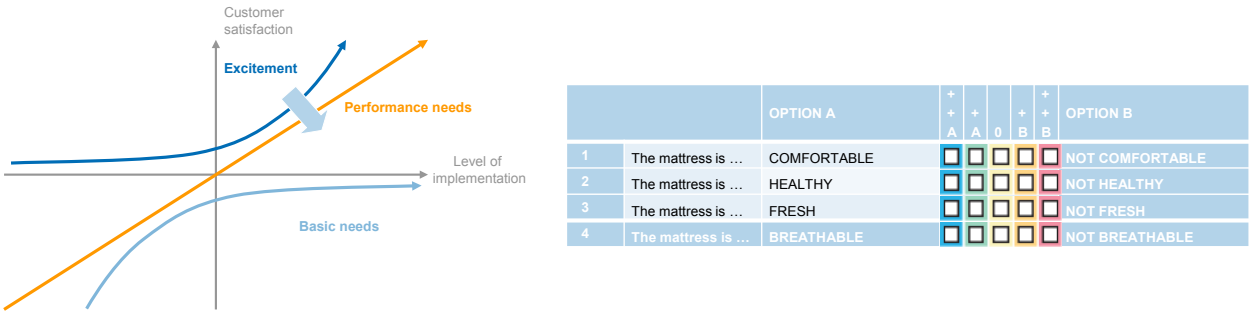

Figure 4: Kano Model (based on Kano, 1984) and Semantic differential (based on Osgood, 1957)

The *Kano Model* (Figure 4, left) can be applied to classify product characteristics which technically meet the basic requirements and additionally foster emotionally inspiring product characteristics (Schmitt and Pfeiffer 2010; Kano et al., 1984). This anticipation of emotional customer requirements (excitement) helps to differentiate a company from its competitors and represents a critical success factor, especially in those markets with little difference in technology (Kano et al., 1984). It turns out that the quality of a product in classical understanding as a technical excellence might no longer be sufficient to delight customers.

KANSEI ENGINEERING BASED METHODOLOGY FOR INTEGRATING CUSTOMERS' VISUAL PERCEPTION INTO PDP

Based on the state-of-the-art contents, different questions regarding the implementation of multi-sensorial

measurement methods into the Kansei Engineering methodology have been raised (3.1). These research questions have been analyzed during the research project CONEMO and lead to an extended methodology (3.2). This methodology was presented and validated together with different SMEs. Results of this step are exemplarily mentioned in chapter 3.3.

Research Questions and General Methodology

The following extended Kansei Engineering methodology to be applied during a PDP shows solutions on how to use methods for emotional product design. The challenge will be to make use of appropriate methods accomplishing these steps successfully and to integrate these methods into an existing product development environment. That way it is important to summarize the used concepts of emotional design and to implement these concepts in an easy-to-use approach which is systematically used during PDP.

Based on chapter 2, the subsequent research questions are of importance for ascertaining a high Perceived Quality, for enhancing Affective Engineering and consequently for entrepreneurial success:

- Which are the most relevant components according to the visual cognitive impression?
- How can Eye-Tracking be applied to objectively detect relevant components?
- How can product ideas be implemented into semantic concepts based on a common product understanding between customers‘ and companies‘ perspectives?
- Do semantic concepts have any influence on the attention of the most important product components?
- How can emotional evaluations of special design alternatives be measured?
- Do semantic concepts have any influence on emotions concerning special design alternatives?
- Which impact do semantic concepts have on the relevance of visually perceived product components?
- How can this methodology be integrated and ensured in a product development environment?

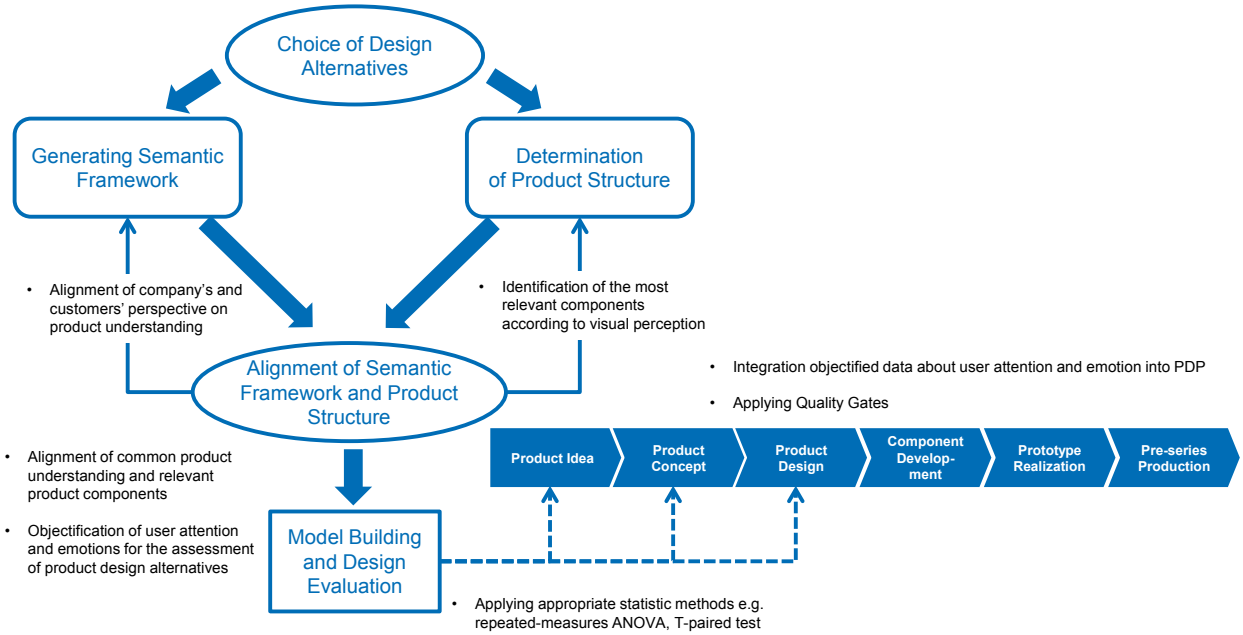

Figure 5: Methodology for integrating customers' visual perception into PDP based on Kansei Engineering (based on Schütte, 2005 and Ehrlenspiel, 2009)

As part of a comprehensive methodology based on Kansei Engineering (see Figure 5 and Köhler and Schmitt, 2012; Schmitt et al., 2013; Köhler, Falk and Schmitt, 2013) the following methods and steps are used to answer the aforementioned research questions:

- Structuring the product by systems analysis and structured approach towards Perceived Quality
- Applying Eye-Tracking to identify most important components of a product design alternative by investigating user's attention
- Collecting and reducing systematically different product ideas, descriptions and deriving semantic concepts
- Aligning customers' and company's product understanding by methodical collection of words representing

the product understanding
- Applying semantic concepts to differentiate between design alternatives
- Linking product understanding with perceived product components and delivering design rules
- Applying appropriate statistic methods in order to derive significant decision
- Objectifying the explicit and latent emotional response
- Extending Quality Gates of PDP by integrating elicited data of user's attention and emotional evaluation

Methodology of CONEMO

Since measuring visual impressions is often more decisive than other impressions (e.g. haptic, acoustic) especially during the early phases of PDP (Duchowski, 2007), the research project CONEMO (Köhler and Schmitt, 2012; Schmitt et al., 2013) focuses on an extended Kansei Engineering methodology enabling to evaluate the visual perception of product concepts and designs. The developed methodology aims at collecting objective data and parameters about visual perception of design alternatives by Eye-Tracking combined with traditional methods (e.g. questionnaires) in order to evaluate different design concepts and to gradually integrate the collected knowledge into the PDP.

Figure 6: Extended Kansei Engineering Methodology

Definition of the Semantic Framework

Already in the phase of *product idea* of the PDP, it is important that both, company and target customer group are "talking about the same things". Therefore, the central goal is to align the company's orientation on upcoming products with the customer perspective in order to define a semantic framework consisting of semantic concepts describing best a common product understanding.

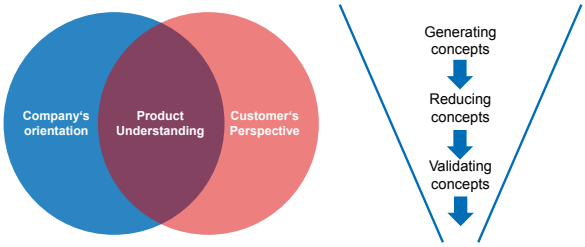

Figure 7: Creating a common product understanding (left) and reducing the number of product ideas (right)

A first step is to transfer company's ideas for upcoming products into describing words or *semantic concepts*. Supporting methods are focus group workshops and semi-structured interviews conducted with company representatives. Further, the company has to identify the potential target groups taking into account demographic criteria. The customer perspective is defined by using standardized questionnaires or open interviews. The assessment of these semantic concepts applying semantic differentials and scales should be done without knowing the future product. Correlation analysis is used in order to assess the consistency between customers' and company's requirements regarding a product understanding of an upcoming product. Then, appropriate methods to reduce the amount of words are affinity diagrams, factor analysis and structural equation modeling. Moreover, the Kano Model can be used in order to classify semantic concepts, e.g. into "must-be"- and "attractive"-requirements (Köhler, Falk and Schmitt, 2013). The results of this step are strategy requirements catalogues or strategy matrices overlapping both semantic spaces in order to find a framework for the according product understanding.

Product Structure

The deduction of the product structure from product prototypes, sketches or even computer-rendered pictures and the definition of relevant product components (Product tear-down via Eye-Tracking) are the central goals of this step

and are e.g. part of the phase of *product concept* of the PDP. It is a breakdown either by technological properties (systems analysis) or perception clusters based on the evaluation of customers' perception (see chapter 2.3). The technical method for conceptual disassembling a system into its subcomponents is the systems analysis that lacks the ability of visible evaluation.

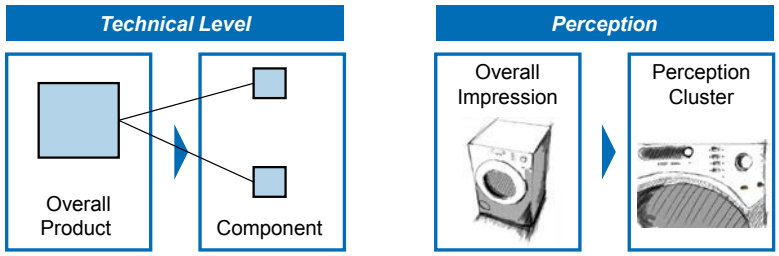

Figure 8: Systems analysis (left), structured approach towards Perceived Quality (right)

Therefore, a structured approach towards Perceived Quality (Schmitt and Pfeifer, 2010) in combination with an Eye-Tracking system provide a solution to objectively subdivide a product beginning from the overall product impression perceived by a customer down to technical parameters. With the help of Eye-Tracking systems, the perception of customers can be followed, measured and collected which finally leads to the identification of the most relevant components according to the visual impression. The most relevant components and data are pointed out with methods like Pareto-Analysis.

Alignment of Semantic Framework and Relevant Perceived Components

This step consists of the correlation between semantic concepts and relevant product components or the linkage between semantic concepts and design alternatives on the level of overall impression. Results of this step could be applied in the phase of *product design* of the PDP. This can be achieved by connecting the derived semantic framework (3.2.1) with the deduced product structure by using the most relevant product components (3.2.2). Moreover, sub strategies can be derived for single semantic concepts as well as for single product components. Results of this step are product design recommendations (design rules) and a reduced number of appropriate product design alternatives.

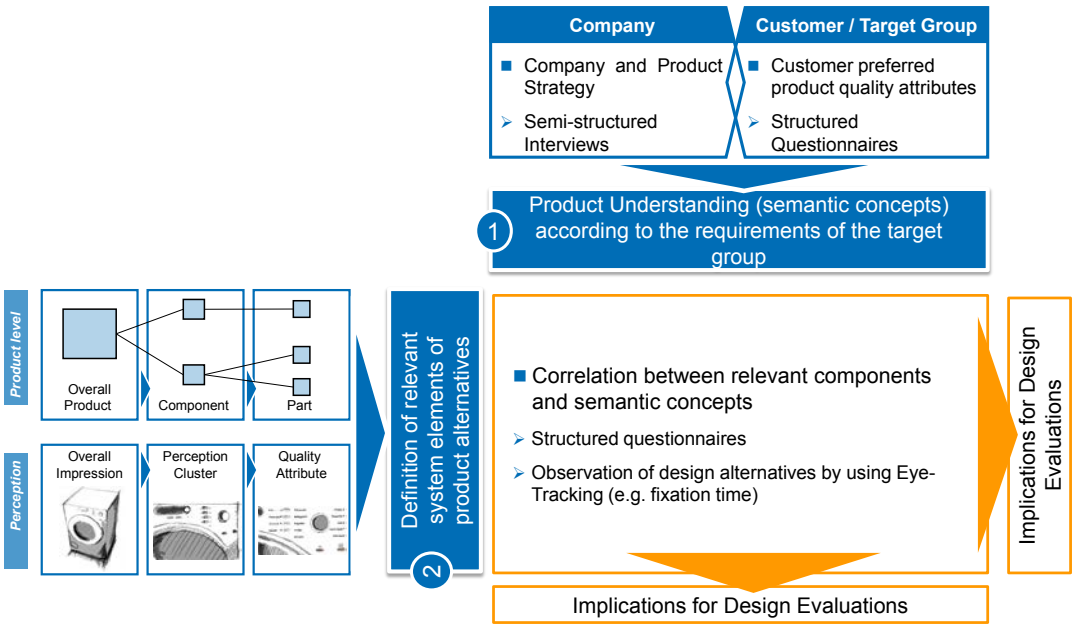

Figure 9: Alignment of product understanding and quality attributes (based on Köhler and Schmitt, 2012)

By linking product components with semantic concepts a resulting matrix consisting of product understanding and quality attributes (*strategy-quality attribute-matrix,* (Köhler and Schmitt, 2012)) provides information about product design alternatives and shows which of these components or even entire product alternatives have higher importance

concerning a semantic concept than others (see Figure 9). Therefore, for a certain time period gaze tracks, the order and the duration of eye fixations are recorded by the usage of Eye-Tracking in order to deduce the attention provoked by certain product elements. While thinking of a semantic concept, the attention and the view are focused on the components that are considered as connected to this concept (Yarbus, 1967). Thus, it is possible to capture the implicit customer requirements. To validate results, a comparison of both self-reporting-methods and gaze tracking identifies similarities and differences between explicit expressed and implicit recorded customer requirements. Consequently, this step considers the discrepancy analysis of customers' answers regarding the overall impression of a product collected by semi-structured interviews and standardized questionnaires (articulated and explicit information, self-reporting methods) and visual measurements (latent and implicit information).

Capturing Emotional Evaluation

The objective of this step is to survey the emotional response in order to investigate whether customers' evaluation is positive or negative. Besides visual measurement systems, like Eye-Tracking, , self-reporting-tools are applied as well as methods for measuring physiological signals to gather user's attention provoked by Perceived Quality. However, self-reporting-tools are only useful to obtain information about the conscious part of customers' emotions. Therefore, there is a need for measurement methods measuring the changes of physiological signals (bio-signals). The most suitable physiological measurements are Facial EMG (Electromyography), measuring valence (like-dislike) and GSR (Galvanic skin response), measuring arousal (intensity). To distinguish between product design alternatives, physiological signals could be evaluated by a two-dimensional approach (GSR, EMG) to objectify the emotional response (Schmitt et. al, 2013).

Implications for Product Development and Implementation of Quality Gate Systematics

Finally, the gathered information about customers' attention and emotions are extracted and integrated into the PDP. The presented extended Kansei Engineering methodology provides the necessary information regarding perceived product quality to pass the Quality Gate and enter the next phase. Before integrating the gathered information, the existing product development environment must be adjusted and Quality Gates must be accurately positioned. After having accomplished the preparation, the next step focuses on the definition of objectives during the PDP. The main objectives are decomposed into stage-related objectives. These specific objectives of each PDP stage represent the criteria, requirements and methods used as control points for each Quality Gate. Furthermore these objectives are derived by the different contents of the extended Kansei Engineering methodology. Especially in the early periods of the PDP (*product idea*, *product concept* and *product design*), it is essential to focus on a customer-centered design.

RESULTS

The illustrated methodology was investigated and proven in several user studies, continuous as well as stepwise, during the research project CONEMO and validated together with SMEs from different branches. The considered products were a mountain bike, a car exterior and a watch. Different product alternatives were emotionally evaluated and compared in different phases of the study schedule. Each study revealed specific findings and indications for a well-structured and successful study design.

Generating a Semantic Framework

First of all studies, an overview of semantic concepts was generated in order to find out what customers and company associate with the respective product. That procedure is crucial for aligning customer's product understanding with the companies' strategy (Köhler and Schmitt, 2012), because semantic concepts ensure that customer and company think similarly about the product's requirements and emotional perception. There are several methods to find semantic concepts such as internet research, interviews with experts and focus group workshops. For an effective study design the amount of semantic concepts was reduced to a maximum of 6 concepts. Thereby, logical exclusions, diagrams of affinity or factor analysis can be applied to discover these semantic concepts that emotionally describe the product best. In conclusion, the revealed concepts have to be validated, for example by a customer- or company-oriented questionnaire, a Kano study or statistical analysis (Köhler, Falk and Schmitt 2013).

Determination of a Product Structure (Focusing on Visible Product Components)

Nearly 80 percent of all information about a product is gathered visually by the eye (Berghaus, 2005). Therefore, a

specific knowledge about the respective product structure perceived visually is necessary to align the level of customers' perception with the level of technical parameters. Systems analysis and a structured approach towards quality perception were applied to detect relevant clusters of perception. These perception clusters are represented by so called *areas of interest* which are important for setting up a subsequent Eye-Tracking study. The results of the presented methodology revealed that the amount of perception clusters mainly depends on the complexity of the studied product. For example, a car exterior was structured into 20, a watch into 11 and a mountain bike into 6 clusters of perception (Köhler, Falk and Schmitt 2013).

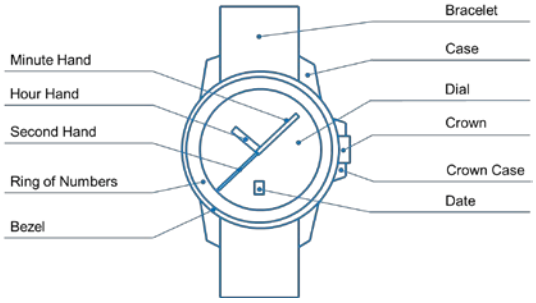

Figure 10: Example of defined areas of interest (Köhler, Falk and Schmitt 2013)

Alignment of Semantic Framework and Relevant Perceived Product Components

Since Eye-Tracking systems are able to track the gaze of subjects while watching the studied product and the gaze track is affected by current thoughts and emotions (Yarbus, 1967), the presented methodology mainly applied Eye-Tracking to gather objective data about visual product impressions. Moreover, these visual impressions were also used to reveal implicit and latent customer requirements. To align semantic concepts with the defined perception clusters, the Eye-Tracking studies were also organized in three phases:

During the first phase (*free interaction*), pictures of each design alternative were separately shown for 10 to 12 seconds in order to capture reference values and to gather information about most relevant product components. Since learning effects and initial excitement can influence the results, the order of the presented pictures can organized randomly. The presented methodology revealed that seeing a specific product alternative for the first time gives precise information about the most relevant components - relevant components were identified by applying, e.g. Pareto-analysis. Pareto-analysis derives, which areas of interest were focused more than 80% of the whole mean time during free interaction. Moreover, it could be revealed that the duration that each picture is shown to the test subject also depends on the product structure and complexity. The second phase slightly differed in all conducted studies. On the one hand, the product alternatives were separately shown, connected to one of the pre-defined semantic concepts. Thereby, the test subject should think at the presented semantic concept and visually evaluated the shown product alternative. On the other hand, in another study, pairwise comparisons were conducted in combination with one pre-defined semantic concept. In this process, the test subjects should cognitively focus the semantic concept and compare both product alternatives. During the last phase, pairwise and overall comparisons of all alternatives were conducted in order to gather preferences and design evaluations in general (Köhler, Falk and Schmitt 2013).

Figure 11: Example of an Eye-Tracking schedule for watches (Köhler, Falk and Schmitt 2013)

Capturing and Evaluating Emotions

Each conducted study revealed specific results about customers' requirements and product evaluations. For analysis of the gathered data, statistical procedures like Pareto-analysis, T-Paired Tests, ANOVA or repeated-measures ANOVA were applied to detect statistically significant influences of semantic concepts on product alternatives and to interpret preferences and evaluations. In addition, questionnaires were used to compare explicit and implicit user opinion. The questionnaires were structured similar to the Eye-Tracking studies and gave additional data about preferences and requirements.

Some selected results of the studies revealed that semantic concepts could have a significant influence on design evaluations. Moreover, the most important components of the respective products could be determined and connected with specific semantic concepts. The data also revealed which design alternatives were preferred and, subsequently, how designers could advertise the product or product components. All this information can be summarized and used to build models that ensure a high Perceived Quality and indicate how a product should look like with regard to the companies' perspective and latent as well as explicit customer requirements.

Implications for the PDP

The integration of the most useful information of the extended Kansei Engineering methodology into the PDP was analyzed during CONEMO and validated by SMEs. After collecting different kinds of requirements (SME specifications, specifications based on Quality Gate Integration) a software-based tool was developed which maps the implementation of the Quality Gate systematics. It aims at supporting SMEs in order to collect, edit and provide relevant information which are relevant for objectifying customers' emotions systematically, especially in early phases of the PDP. The tool provides a project plan with strong focus on the implementation of emotion evaluation methods. Information about *main objectives*, *task descriptions*, *requirements*, *criteria* and *recommended methods* are given, especially for the early phases of the PDP (e.g. *Product Idea*). Furthermore, *responsibilities* for each phase are shown as well as the *maturity level* of tasks and phases based on a *traffic light systematics* (see Figure 12). By integrating a Quality Gate systematics, SMEs are sensitized to focus on emotional product design. Based on a traffic-light systematics the product developer can recognize the status of the PDP and the level of consideration which was taken into the implementation of visual measurement methods increasing perceived product quality.

Selected Product Category	physical product	Zurück zum Projektplan	Quality Gate Systematik Customer Emotional Quality Gate 1							
Select next PDP Phase		Phase wechseln								
Product Idea	**Quality Gate 1**	Product Concept	**Quality Gate 2**	Product Design	**Quality Gate 3**	Component Development	**Quality Gate 4**	Prototype Realization	**Quality Gate 5**	Pre-series Production
Objectives	Generating a Semantic Framework									
Traffic Light Systematics	0 - 11 %	12-22 %	23 - 33 %	34 - 44%	45 - 55 %	56 - 66 %	67 - 77 %	78 - 88 %	89 - 100 %	
Maturity Level	0,4									

#	Maturity level / Status		ID	Task Description	Requirements	Criteria	Methods		Process Customer		Process supplier		Checklist
	Traffic light	Require-ments					Recommened Methods	Applied Methods	Depart-ment	Internal / external	Depart-ment	Internal / external	
1		100%	T1.1	Collecting company's perspective on new products	Semantic under-standing (company's perspective)	Semantic Concepts	Workshops, Interview		Market research	-	Market research	-	-
2		100%	T1.2	Collecting customer's perspective on new products	Semantic understan-ding (customer's perspective)	Semantic Concepts	Customer Surveys		Market research	-	Market research	-	-
3		0	T1.3	Alignment of company's and customer's perspective	Common Product understan-ding	Semantic Concepts	Factor Analysis, Cluster Analysis, Affinity Diagram		Product Development	-	Market research	-	-

Figure 12: Screenshot of the software-based tool using the extended Kansei Engineering methodology

DISCUSSION

In a critical review the presented methodology, the study design and its results have to be analyzed. Regarding the

study design, different useful lessons learned can be derived for practical application of the methodology. The conducted studies showed that Eye-Tracking can be applied to indicate relevant product attributes. Furthermore, semantic concepts affect the individual gaze-track and the attention evoked by relevant product attributes. The results should be interpreted on a very detailed level of quality attributes in order to link feelings expressed by semantic concepts with the attention measured by the time ratio. In general, for improving the result significance of the study the number of subjects has to be increased.

Regarding the validation by SMEs, some useful lessons learned can be deduced for describing their general situation and their product development environment. Results of expert interviews with representatives of the SMEs' product development department highlighted the fact that most SMEs do not have a systematic procedure for collecting customer requirements and transparency about their own PDP. Additionally, SMEs usually do not focus on customers' perspectives during early phases of the PDP. Moreover, SMEs do not have either any financial capacities or specific know-how or methods in order to conduct multi-sensorial studies, e.g. via Eye-Tracking. The feedback of SMEs regarding the usage of the software-based tool underlines that the collected requirements have been implemented well. The usability and the layout of the developed software-based tool based on Microsoft Excel® have been pointed out as intuitive, clear-structured and the tool was assessed as cost efficient. In conclusion, SMEs assessed the extended Kansei Engineering methodology and its implementation into a software-based tool as a communication structure for handling new emotional data which supports their decision-authority during the PDP.

CONCLUSIONS AND FUTURE RESEARCH ACTIVITIES

The presented extended Kansei Engineering methodology reveals how to gain valuable input data of customers by applying visual measurement systems as Eye-Tracking in order to determine relevant product components and to compare different product designs on different levels of perception. Additionally it is also revealed how to implement these comprehensive customer data into different phases of the PDP, especially in the early ones. The integration of gaze tracking into the Kansei Engineering methodology can be applied to align customers' product understanding with technical parameters in order to design products with a high Perceived Quality. Nevertheless, the results show that usual techniques for gathering customers' product impressions (e.g. questionnaires) should be supported by more objective applications in order to understand customers' product evaluations and decisions entirely which leads to a more comprehensive basis for decision-making during the PDP. Moreover, the methodology is to be extended stepwise by studying further and detailed levels of customers' perception. Further research should also concentrate on deeper analysis of recorded Eye-Tracking data to interpret why subjects really focused one component longer than another as well as on the influence of the number of subjects on more significant results. Besides the different possibilities of sensorial measurement systems, the implementation of Quality Gates and the resulting software-based tool can be adapted and extended by assessment heuristics in order to consider different significance levels concerning the defined tasks (objectives) during each stage of the PDP. Based on these assessment heuristics, traffic light systematics, as a part of the Quality Gates systematics, can be applied more accurately in order to grant approval for passing the Quality Gate and entering the next stage of the PDP.

Possible extensions could be the implementation of research studies regarding the haptic perception at a later stage of the PDP when prototypes are already designed. During the *prototype realization* stage of the PDP research studies regarding the perceived usability of products and multi-sensorial, combined visual and haptic, perception can be applied in order to objectify most of the sensorial perception of the customer.

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Development of Interactive System for the Visually Impaired using Tactile Sensations and Gestures

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ABSTRACT

Even though previous studies have confirmed the superior abilities of the visually impaired to identify tactile sensations, few systems use such abilities. In this study, we developed and evaluated an interactive system that utilizes the superior abilities of the visually impaired by adding active elements of gestures to increase their enjoyment. We employed the TECHTILE toolkit as a device to give tactile sensations to players and Kinect for Windows as a device to recognize their gestures and developed an interactive system with different types of tactile sensations and corresponding gestures. We experimentally evaluated our system.

Keywords: Tactile sensation, TECHTILE toolkit, Gesture, Visual Impaired, Interactive System

INTRODUCTION

We previously developed game systems for the visually impaired (Ishii 2006, Takahashi 2011), one of which uses the TECTILE toolkit to generate tactile sensations (Ito, 2012). However, since strong demand exists for active physical exercise for the visually impaired, we developed a more active system by incorporating gestures into it. Our interactive system utilizes the superior abilities of the visually impaired with additional active elements of gestures to increase their enjoyment. This article describes the construction and evaluation of our system.

SYSTEMS DESIGN

We used a Kinect sensor as an input device for PCs because it can detect human gestures using infrared sensors. We employed tactile sensations and sound for the feedback of the game information. We used the TECHTILE toolkit for the tactile sensations (Minamisawa). When using the system, players stand in front of the Kinect sensor and the speakers and hold a hand-made device in their left hand for the tactile sensation output. The following is our system flow:

1. The PC outputs tactile sensations thorough the TECHTILE toolkit.
2. The PC outputs sound through speakers.
3. A player makes a gesture that corresponds to the tactile sensation.
4. The Kinect sensor detects the player's joint positions.
5. The PC receives information from the Kinect sensor and processes it.

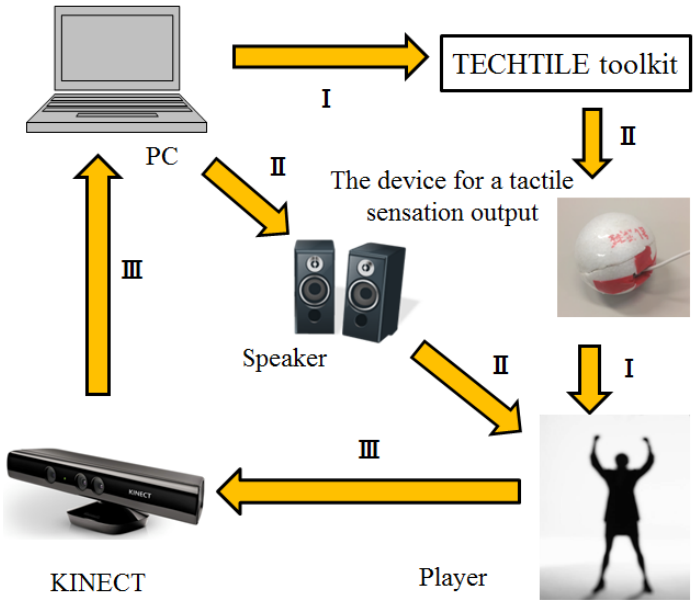

Fig. 1 Diagram of system

Table 1 Enemy sounds and relevant gestures

Game situation	Tactile sensation	Relevant gesture
Pot seems to fall	Shaking	Raise right hand
Device is attacked by	A ball turns inside	Put right hand on the device
Floor is wobbly	A thing is grind	Raise right knee
Ghost is near	Air bubbles are broken	Squat

Game Content

The game content is shown in Fig. 2.

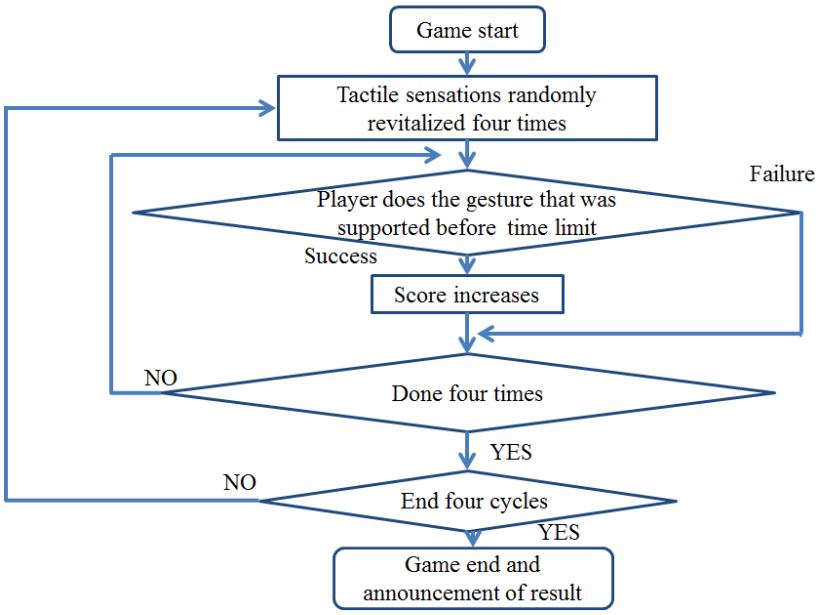

Fig. 2 Game's flowchart

Preliminary Experiment

We made a prototype and experimentally evaluated it with six sighted participants. We took log data during the game and asked the following questions:

- Did you enjoy this game?
- Do you want to play it again?
- Are the tactile sensations and gestures related naturally?

Our analysis of our experimental results confirmed that our participants enjoyed the game. Fig. 3 shows the relation between the tactile sensations and the gestures. The sensation which shows that the device was attacked by enemy was judged natural, but not the others. Fig. 4 shows the game's degree of difficulty. The participants felt that it was difficult.

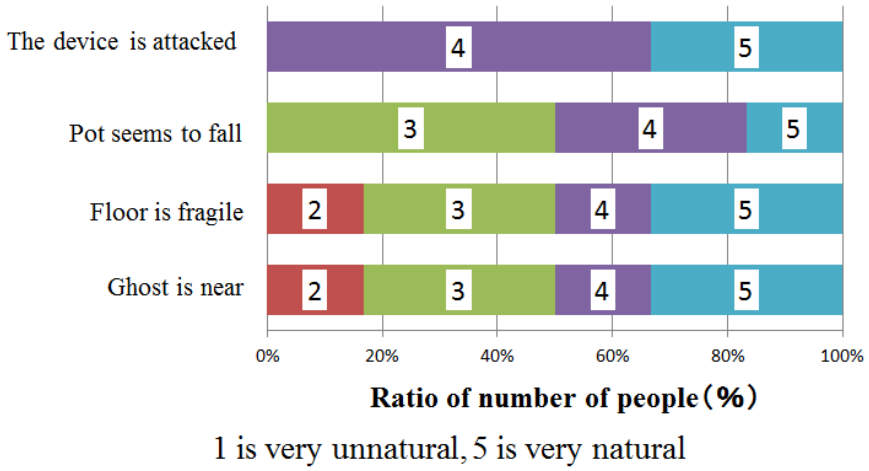

Fig. 3 Evaluation of naturalness between tactile sensations and relevant gestures

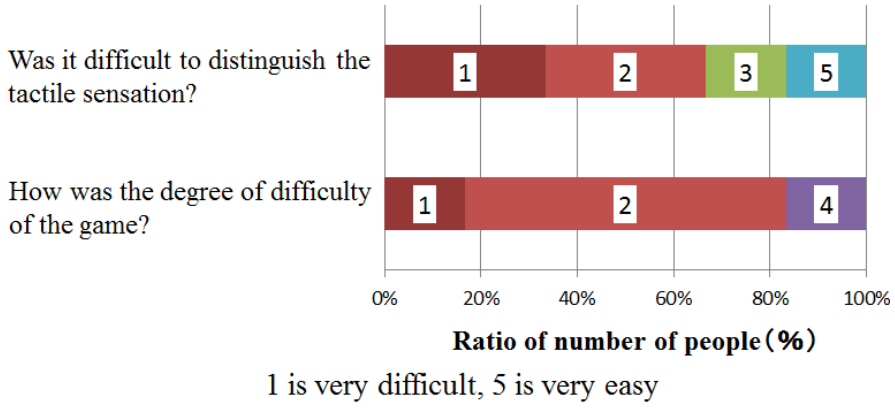

Fig. 4 Evaluation of naturalness between tactile sensations and relevant gestures

Improvement of System 1

Based on the results of our preliminary experiment, we made the following improvements:

- Revised the relations between tactile sensations and game situations
- Added exercise time
- Carefully designed the tutorials

We revised the relations by changing the tactile sensation from “Air bubbles are broken” to “Cellphone vibration.” We also changed the game situation from “The floor is wobbly” to “A monster is crawling on the floor” and “The pot seems to fall from the top right corner direction.”

Table 2 Revised tactile sensations and relevant gestures

Game situations	Tactile sensations	Relevant gestures
Pot seems to fall from the top right corner	Shake	Raise right hand
The device is being	A ball turns inside	Put right hand on the device
A monster is crawling on the floor	A thing is grind	Raise right knee
A ghost is near	Cellphone vibration	Squat

Evaluation Experiment 1

We experimentally evaluated our system by employing eight visually impaired participants. We took log data during the game and asked the following questions:

- Did you enjoy this game?
- Would you want to play this game again?
- Are the tactile sensations and gestures related naturally?

Figure 5 shows the evaluation results about whether the game was enjoyable. No subjects felt that it was unenjoyable. Fig. 6 shows the evaluation results of the question about difficulty. Many thought that it was difficult. Fig. 7 shows the evaluation results of the question about the relations between the tactile sensations and the situations they represented. The ratio of the answers showing naturalness increased for “The ghost is near” and “A monster is crawling on the floor.”

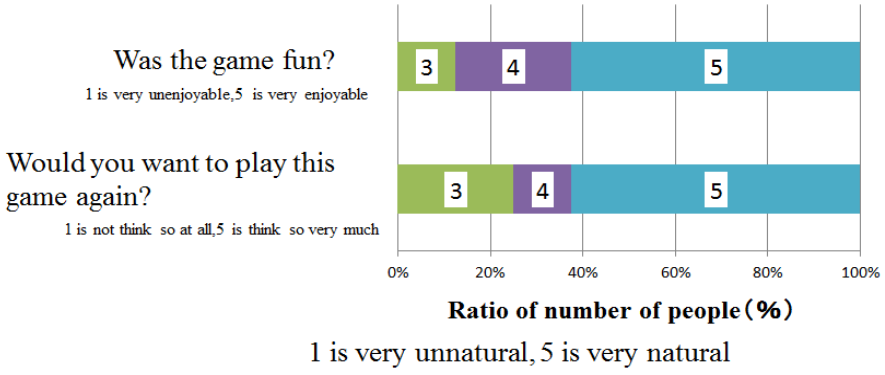

Fig. 5 Evaluation of enjoyability

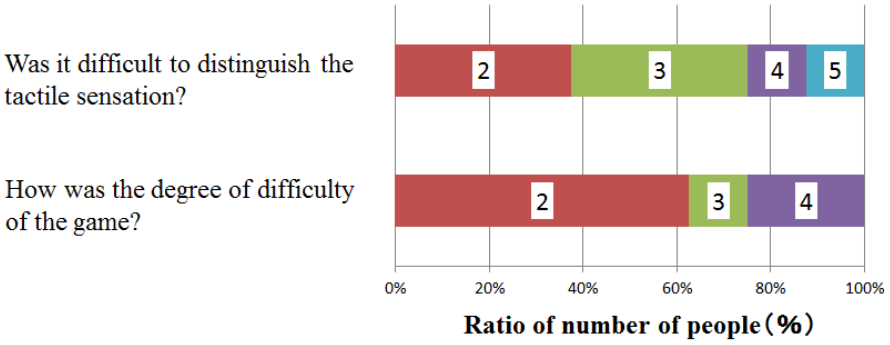

Fig. 6 Evaluation of difficulty

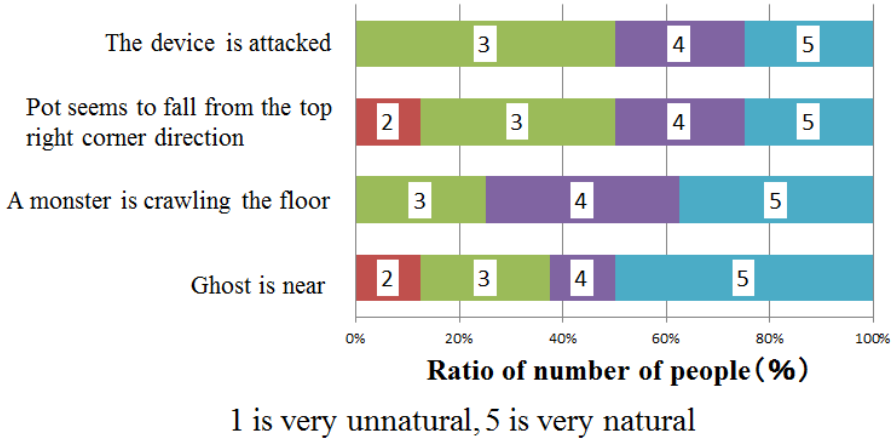

Fig. 7 Evaluation of naturalness of high knee to relevant enemy sound

Improvement of System 2

Based on the results of evaluation experiment 1, we made the following improvements:

- Changed the game so that the number of tactile sensations increases one by one.
- Added background music and sound effects.
- Added a physical strength parameter.

If a player fails the gesture, her physical strength decreases. When her physical strength is depleted, the game is over.

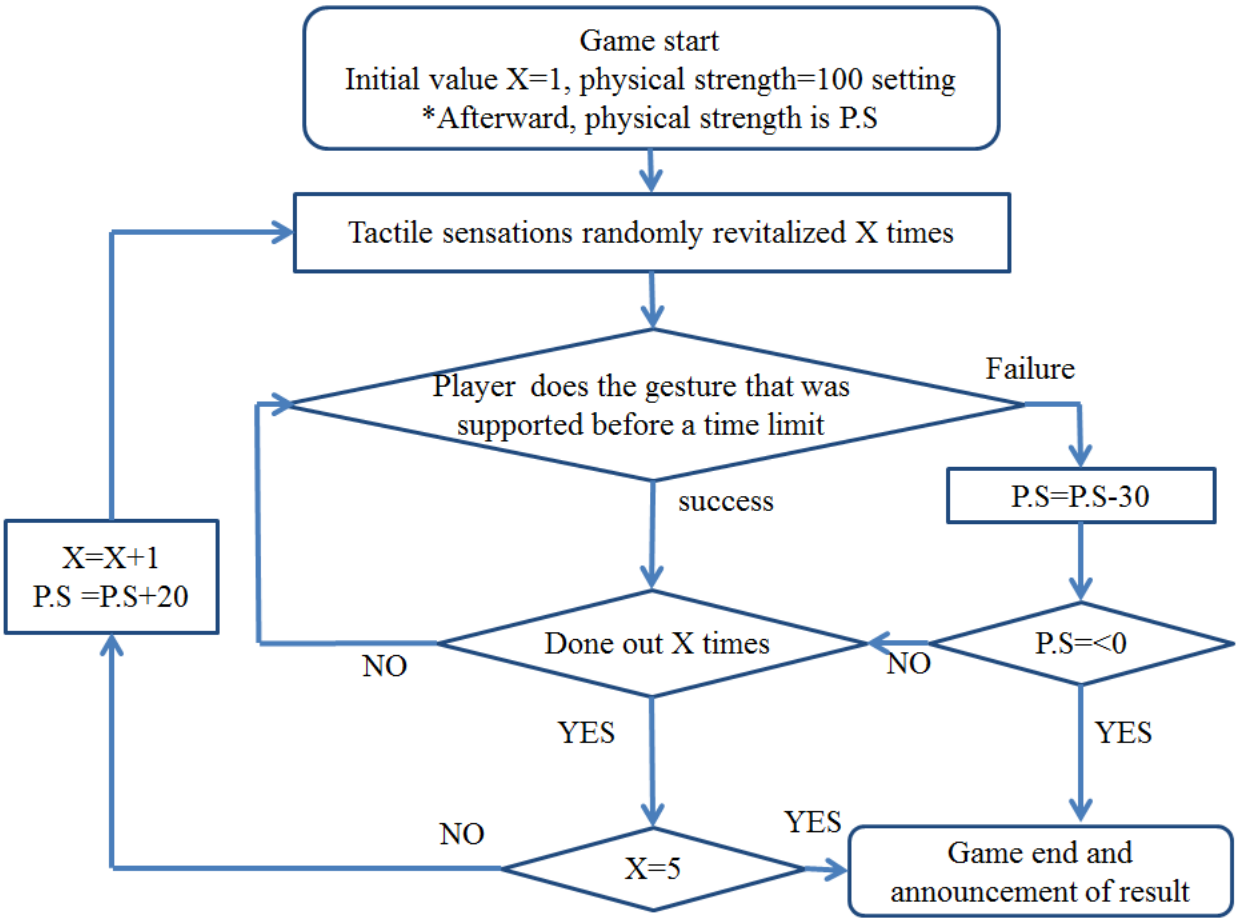

Fig. 8 New game's flowchart

Evaluation Experiment 2

We made a prototype and experimentally evaluated it by employing eight sighted participants(eight teenage boy). We took log data during the game and asked the following questions:

- Did you enjoy this game?
- Do you want to play it again?

Figure 9 shows the evaluation results about whether the game was enjoyable. No subjects felt that the game was unenjoyable. We also obtained the following opinions:

- The game's progress was monotonous.
- This game is too short.
- I had difficulty distinguishing the differences among the tactile sensations.

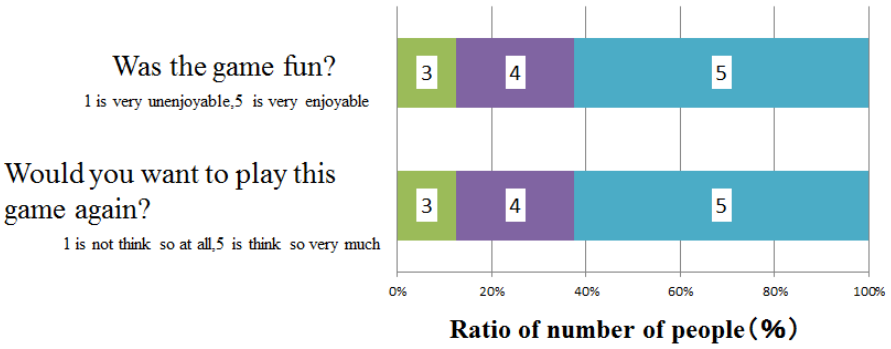

Fig. 9 Evaluation of enjoyability

Improvement of System 3

Based on the results of evaluation experiment 2, we made the following improvements:

- Revised the content in which two tactile sensations were added to the last cycle.
- Edited the sound sources to increase the loudness of the tactile sensations.

Evaluation Experiment 3

We experimentally evaluated our system by employing six sighted and eight visually impaired participants. We took log data during the game and asked the following questions:

- Did you enjoy this game?
- Do you want to play it again?

Figure 10 shows the evaluation results about whether the game was enjoyable. No subjects felt that it was unenjoyable. Fig. 11 shows the evaluation results of the question whether they wanted to play it again; many do. Fig. 12 shows the evaluation result of the question about the tutorial's length. We found a difference between the sighted and the visually impaired.

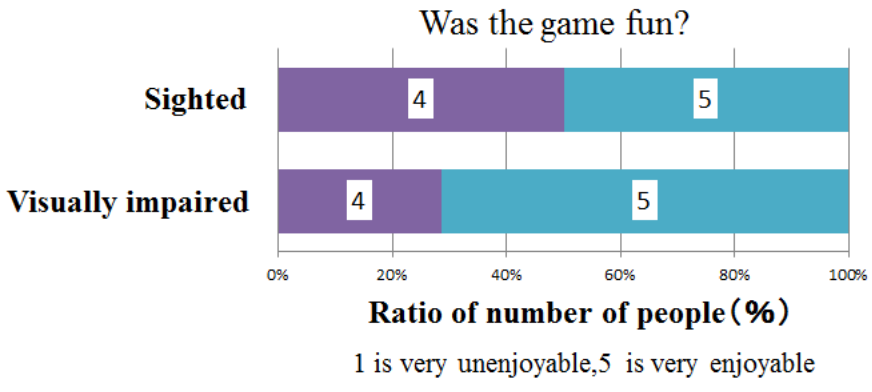

Fig. 10 Evaluation of enjoyability

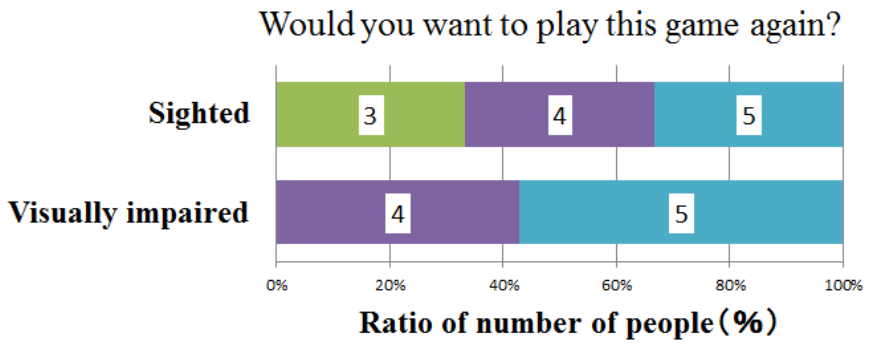

Fig. 11 Evaluation of want to play game again

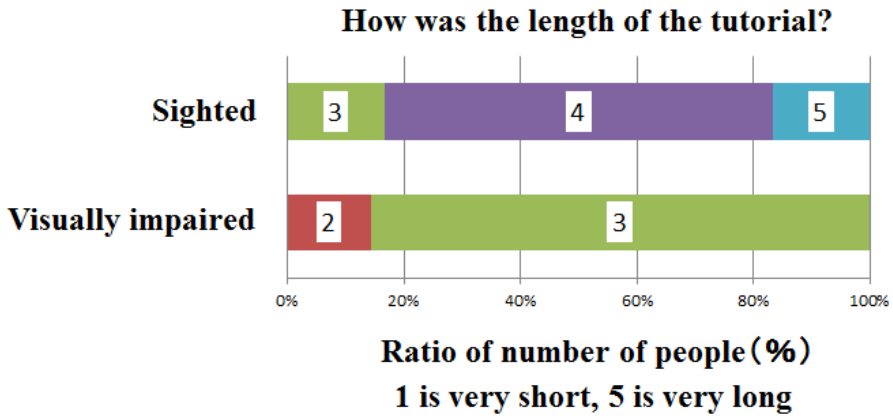

Fig. 12 Evaluation of tutorial length

CONCLUSIONS

We developed a game system for the visually impaired that utilizes gestures and tactile sensations. We evaluated it on the basis of experiment results and obtained the following:

- Our game system is enjoyable for both the visually impaired and the sighted.
- The visually impaired accepted longer tutorials than we expected.

Since we only did evaluation experiments on young generations, we need to improve the game for wider generations.

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Human Concepts Applied on School Design

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ABSTRACT

The project to an early childhood school started from this problematic: why do not schools offer efficient quality spaces to early childhood education? As an answer, it was suggested that the school building, besides presenting a fitting spatial solution to a pedagogical proposition, should consider playing as a very important activity in the learning process. Have been considered the hypothesis that most schools do not present appropriate environments for child education and that playful activity in a complex scholar space is essential to this process. The confirmation of these hypothesis led to an idea which embraces the human concepts of welcoming, complexity, versatility, transparence and playfulness, determinative to the project guidelines: integration with the community; open sketch/nature interaction; school as a small learning community; natural lighting and ventilation; cozy environments; walking as a learning tour; adaptability/flexibility/variety; transparence and passive supervision; architecture that teaches/sustainability; exterior spaces and playful stimulus; material, textures and colors as identity elements.

Keywords: Exe School Design, Human Concepts, Playfulness

INTRODUCTION

This paper presents a projected exercise and theoretical reflections of a doctoral research project in the field of architecture. The investigation had as its starting point the interest in studying general aspects which involve architecture and education. It aimed to understand the school environment. It was contextualized and limited to schools that serve children from birth to six years of age. The objective was to develop an architectural design for a school of early childhood education to present spatial, playful and environmental quality solutions necessary for learning and child development.

Although there are many studies about the importance of spatial dimension for activities related to education, this subject has not been exhausted yet. Thus an issue especially involving public schools in pre-schools has arisen: How come schools do not offer these quality efficient spaces and responsive to children's education, even when one realizes that there is a co-relation between the project and the adopted pedagogical school building?

In response to this question, which also presents itself as an architectural problem, it was suggested that the school building, beyond submitting a response regarding adequate space for the realization and implementation of a particular pedagogical project, should also consider play as an activity important in the learning process for children, and should therefore provide solutions that addressed this need.

The problem has been delineated. Considering common sense that children learn playing, that space is required to play, and that spaces for play in cities are becoming spaces for automobiles and violence, the school environment becomes even more relevant since children spend most of their time at school. It is at school that children can recover play spaces that have been lost in cities.

From this reflection, it is considered the hypotheses that most preschools do not present opportunities for quality education for children; that playful activity is essential in the development and early learning and that a complex and multipurpose school space presents itself as a facilitator for the process of teaching and learning.

DEVELOPING HUMAN CONCEPTS APPLIED ON SCHOOL DESIGN

Based on authors such as Hertzberger, Rapoport, Lynch, Tuan, Frago and Escolano and research involving this subject, the investigation considered important concepts related to the space quality in architecture and the importance of perception in the child-environment relationship.

From the studies related to the quality of the spaces in architecture (Zevi, Hertzberger, Coelho Neto), it became clear that it is important to provide users with spaces that determine a positive interaction between themselves as well as between them and the architecture itself. It was found that this interaction can be facilitated and enhanced by sensory perception (Hall, Tuan, Lynch, Rapport), since the stimuli received by the receptor systems of sight, hearing, smell and touch intensify the relationship between man and the environment, thus contributing in apprehension and identification of places for people.

The studies of play (Brougère, Huizinga, Kishimto, Bomtempo, Friedmann, Mazzilli, Tornquist) allowed a deeper insight into the importance of play in children's lives and proved the hypothesis that playful activity is essential to children's development and learning. It stimulates children in language, thought, socialization, exploration, invention, motor skills, imagination and fantasy.

Complementing these studies, research data from Escolano Frago, Lima Castro, Elali, Mazzilli, Bastianini, Chicco and Mela helped to prove the hypothesis that a complex and multipurpose school space presents itself as a facilitator for the teaching and learning process.

This idea is based on the theoretical principles of knowledge building designed by Piaget, according to which a person learns about herself and constructs their knowledge from interactions with the environment. This construction starts from birth and is extended throughout life. Hence the importance given to places that receive children, since their intelligence can be affected by interaction with the space, especially in the first years of life. This spatial experience should influence the process of learning and child development, both physical as well as in the social-emotional and intellectual aspect.

These reflections show that playing and space are critical in children’s formation. The space provides the opportunity to play, and playing freely in a given space facilitates children to develop movement, intelligence and social and affective relationships. Also, it allows the recognition and the conquest of space.

The hypothesis that most establishments destined for children’s school do not have quality spaces for children ages 0-6 was proven during visits to public preschools in the city of Uberlandia, Brazil. During these visits, it was found that the potential of the spaces have not been explored, and that the architecture was monotonous, dull, cold and standardized, both in form and organization of environments, offering few opportunities for children to engage in play activities. In other words there were few opportunities for quality and interactive education, suitable for pre-school education.

From the evidence of these hypotheses a central idea was found. It is a synthesis of several discussions addressed in the research, covering the humanization of architecture: welcoming, complexity, versatility, transparency and playfulness. These concepts substantiate the thesis that the play dimension of school spaces - those qualities that make them more interactive, attractive, stimulating and welcoming - contribute to an environment that promotes the relationship among its users, meets the needs of the child, participates and interacts with the construction of their knowledge.

Inserted into the idea of welcoming there are spatial qualities related to the valuation of the interior space, the inviting way and the ambience.

From complexity, it was noted the importance of perception in human-environment relationship, the way the shapes fit to create an open design, the respect of existing topography and vegetation, the manipulation of space, interaction with the natural environment, the integration with the community and obtaining spatial quality.

From versatility, the importance of shape's articulation, of flexibility, adaptability and variety of spaces for different types of learning and to create incentives to increase the use and accommodation potential of spaces.

Gathered in the concept of transparency: the idea that learning should be visible, encouraged and celebrated; the fundamental phenomenological dimensions of living, expressed in the relations that establish an indoor / outdoor, the visibility relations, where gaps, doors and windows act as articulators elements between internal and external spaces, making them visible or hidden and the appropriation, which reveals how to experience the environment.

Finally , the importance of playfulness which , allied to these spatial qualities can stimulate child's intelligence .

These concepts also determined the guidelines, the design parameters (Nair, Fielding & Lackney) that defined the essence of architectural design (see figure 1, figure 2, figure 3) of the proposed school: integration with the community (see figure 4); open plan/interaction with nature; school as a small learning community; natural lighting and ventilation (see figure 5, figure 6); cozy environments (see figure 7); circulation as a stroll for learning (see figure 8); adaptability / flexibility / variety (see figure 9, figure 10, figure 11); transparency and passive supervision (see figure 12), architecture that teaches/sustainability; exterior spaces and playful stimuli (see figure 13); materials, textures and colors as elements of identity.

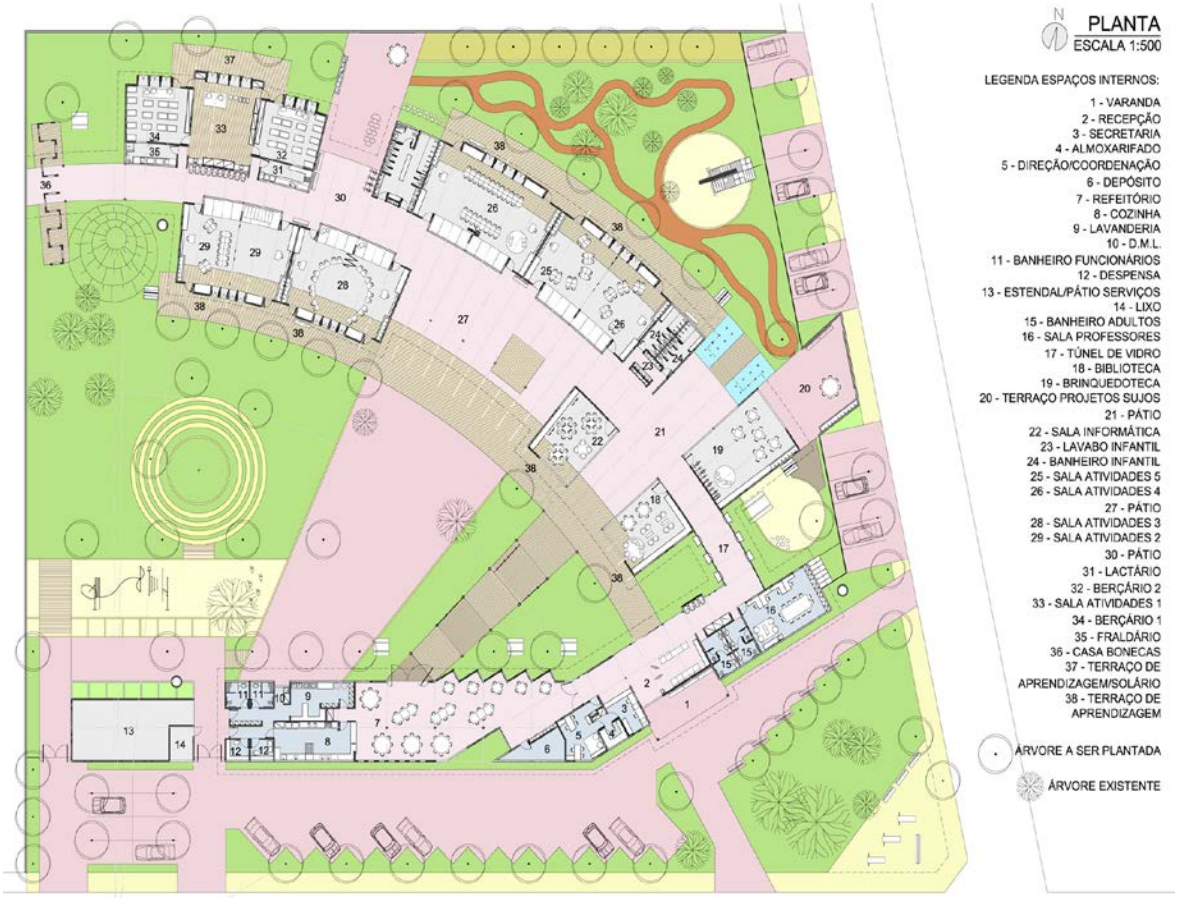

Figure 1. Interior spaces layout. (Image produced by Elza Cristina Santos, 2011)

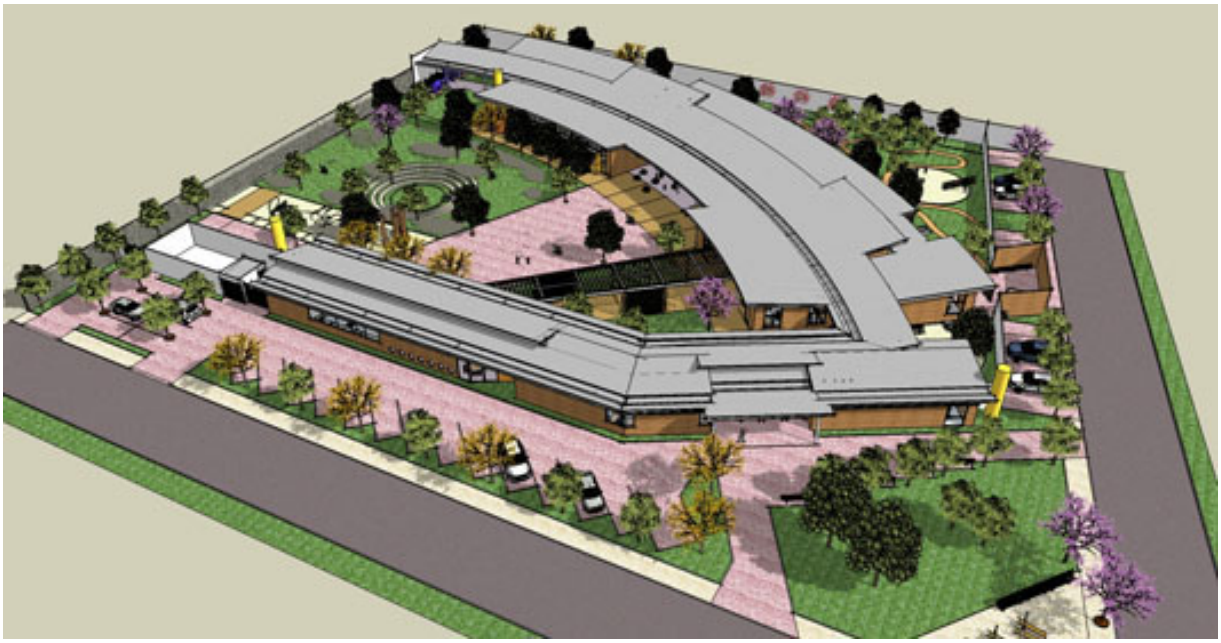

Figure 2. Overview. (Image produced by Elza Cristina Santos, 2011)

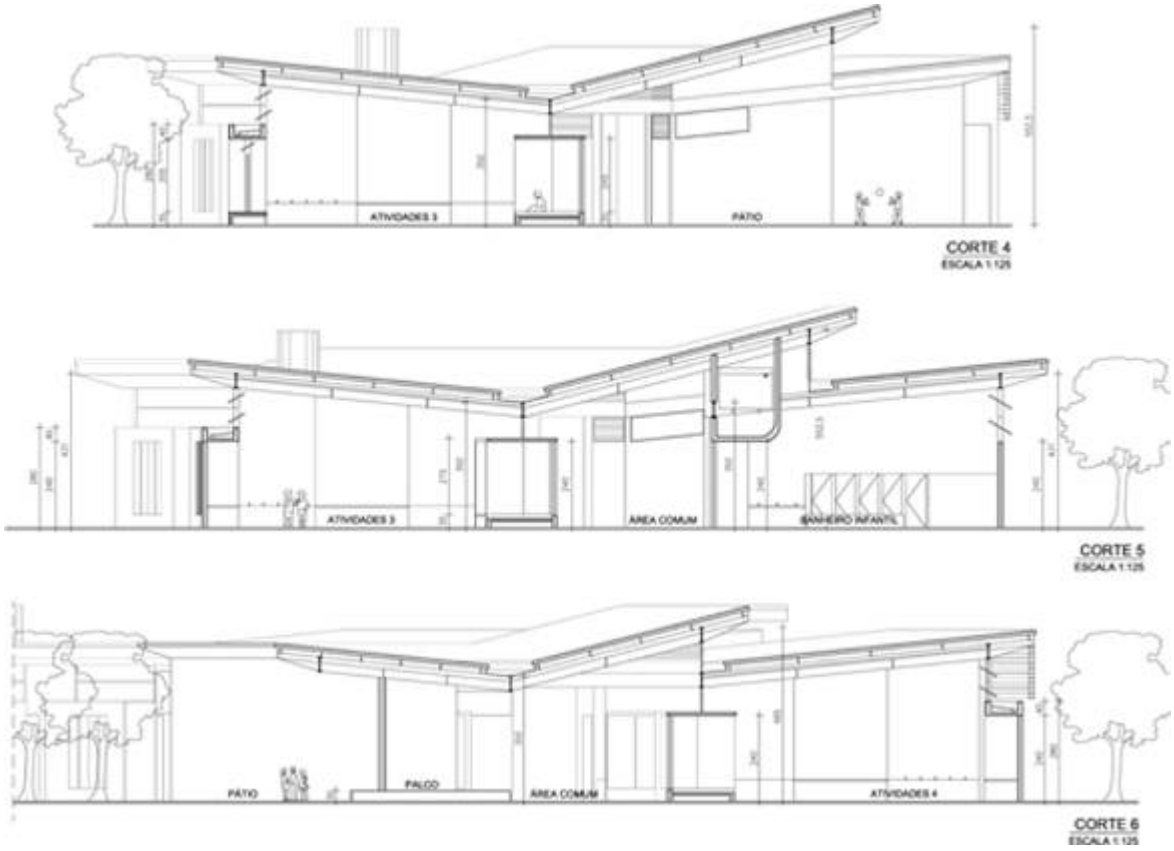

Figure 3. Sections. (Image produced by Elza Cristina Santos, 2011)

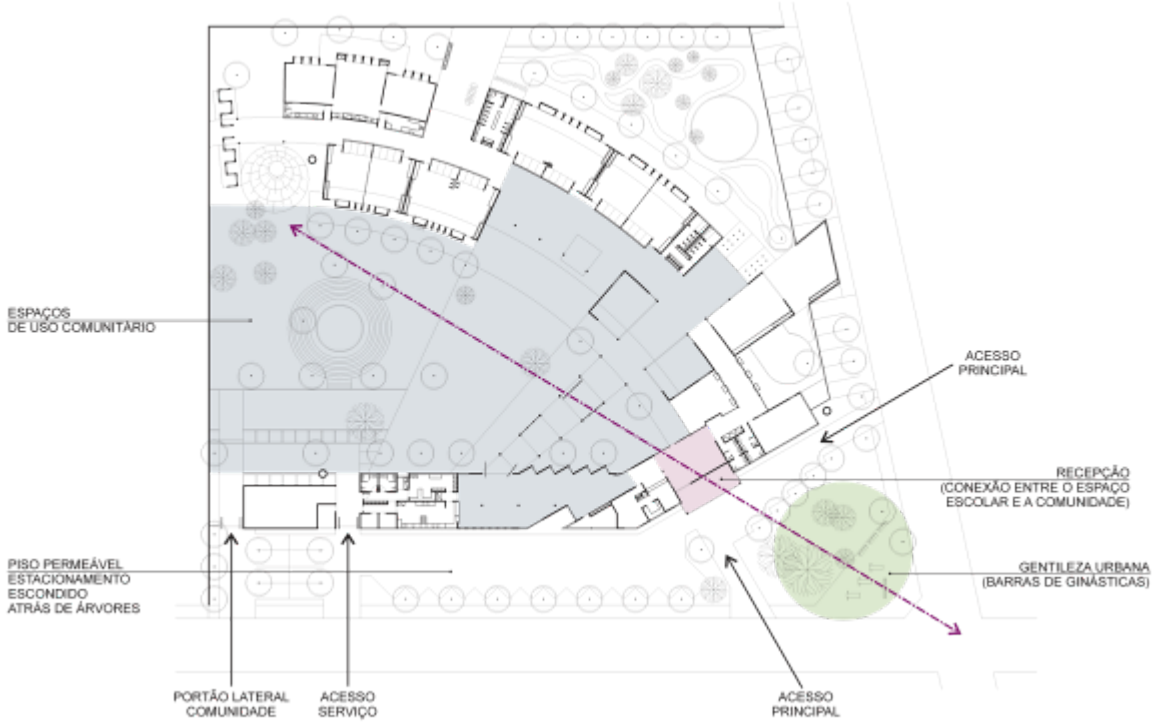

Figure 4. Space school integrated with urban space. (Image produced by Elza Cristina Santos, 2011)

Figure 5. Natural lighting. (Image produced by Elza Cristina Santos, 2011)

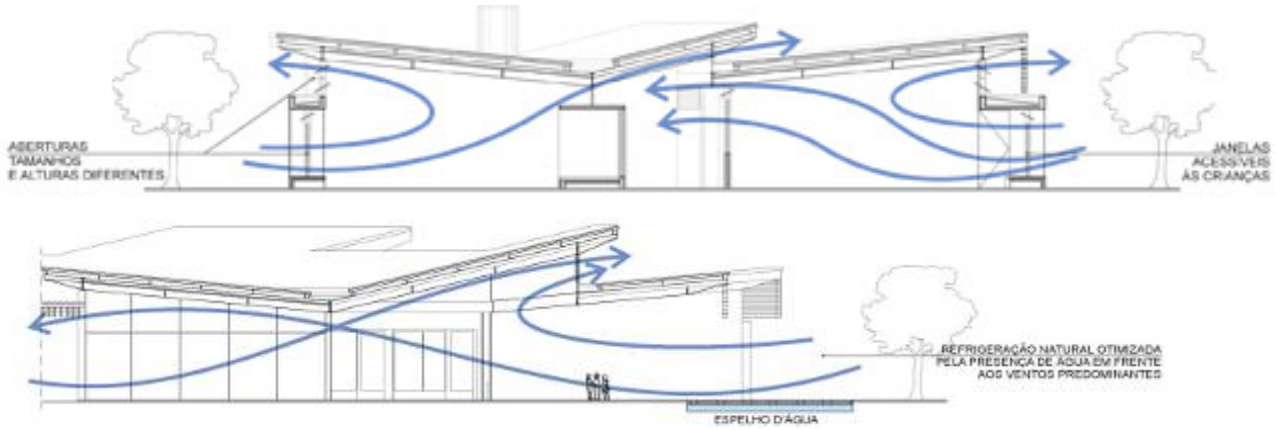

Figure 6. Natural ventilation. (Image produced by Elza Cristina Santos, 2011)

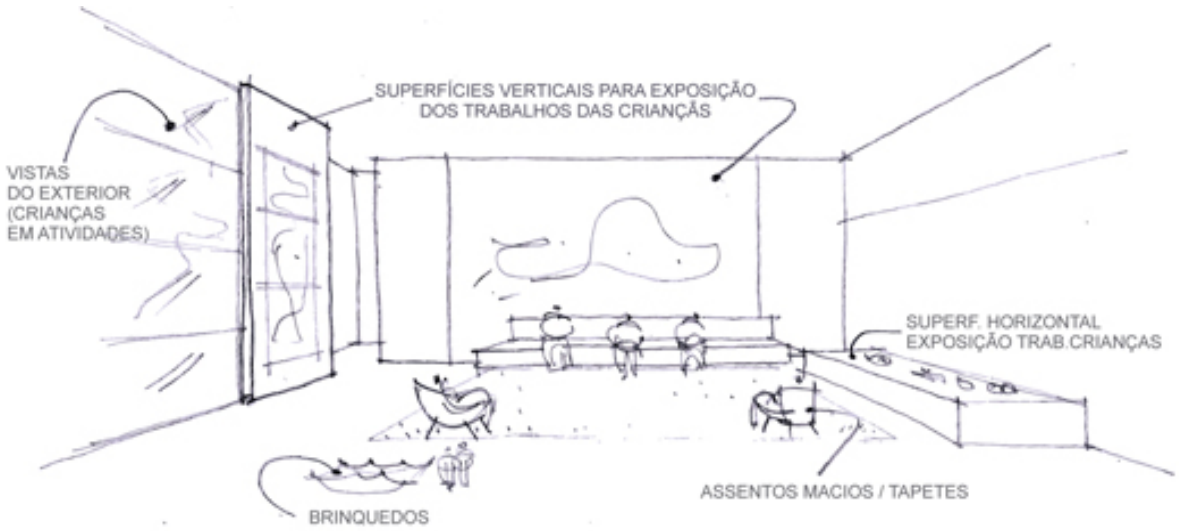

Figure 7. Welcoming spaces: welcoming. (Image produced by Elza Cristina Santos, 2011)

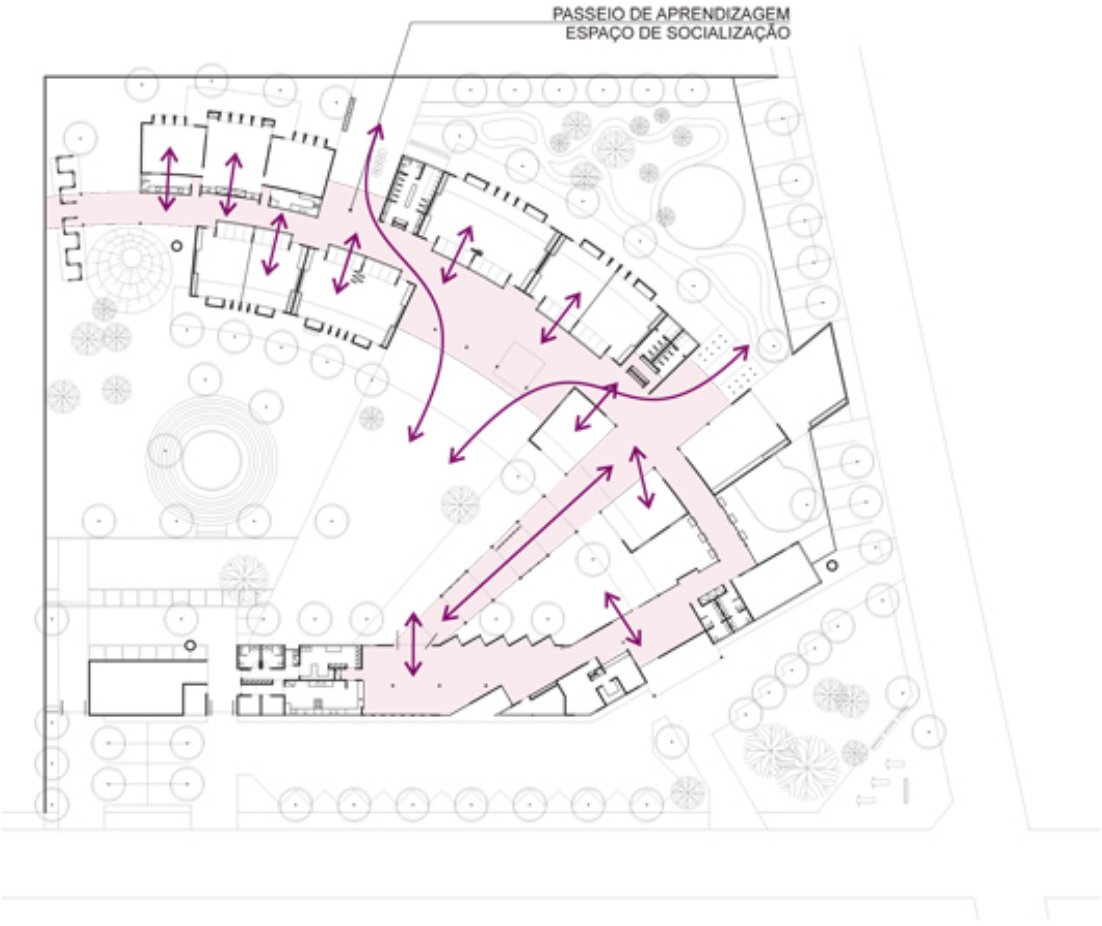

Figure 8. Circulation as a stroll for learning. (Image produced by Elza Cristina Santos, 2011)

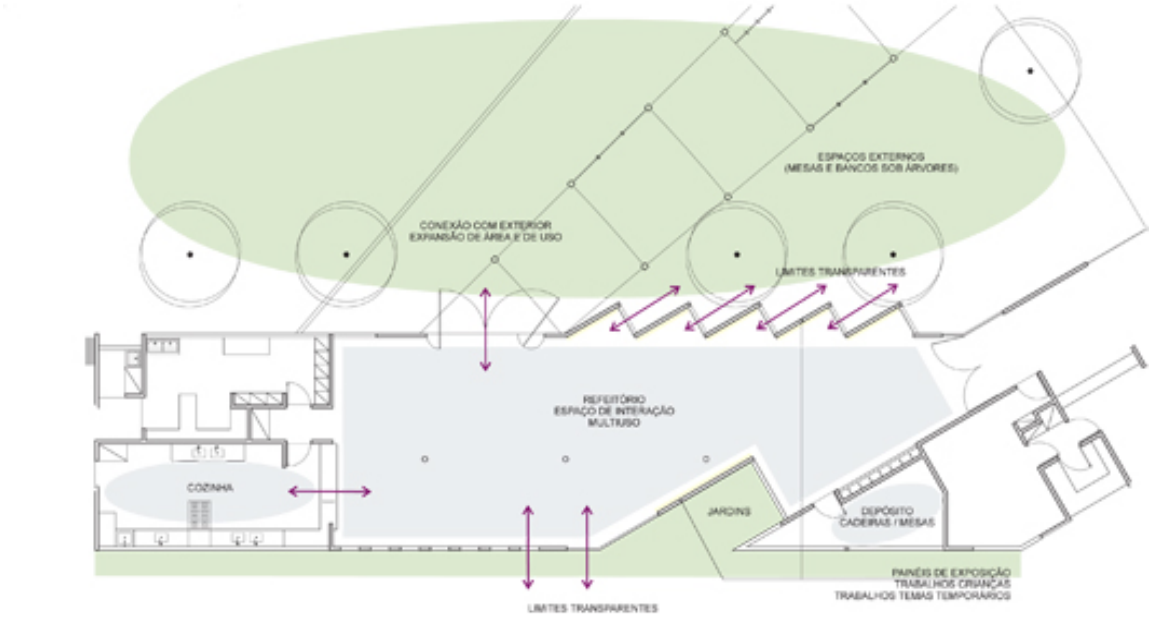

Figure 9. Adaptability / flexibility / variety: cafeteria. (Image produced by Elza Cristina Santos, 2011)

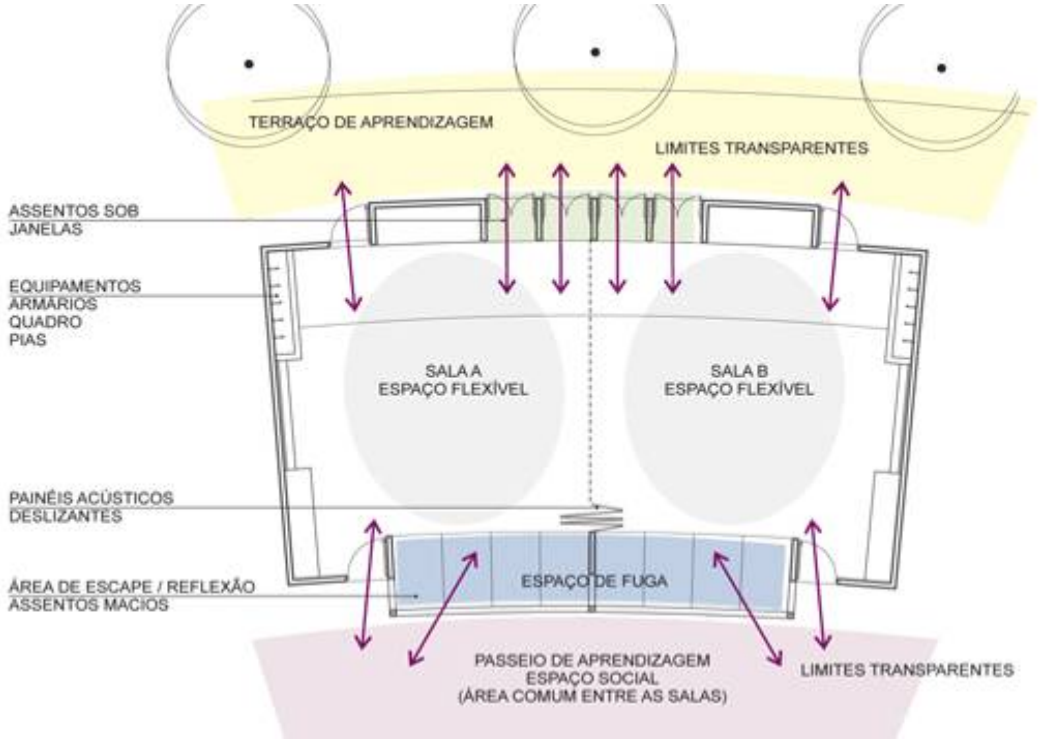

Figure 10. Adaptability / flexibility / variety: activity rooms. (Image produced by Elza Cristina Santos, 2011)

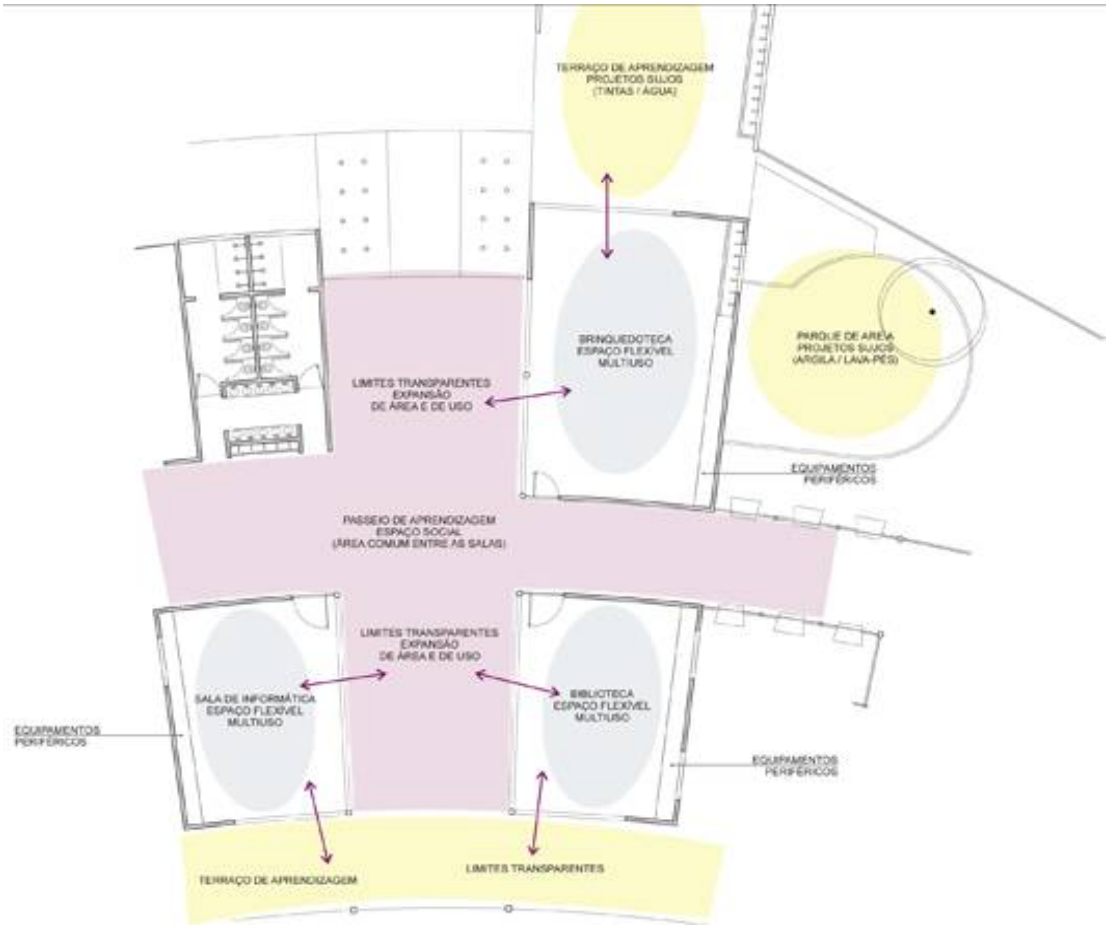

Figure 11. Adaptability / flexibility / variety: special rooms. (Image produced by Elza Cristina Santos, 2011)

Figure 12. Visibility between school environments. (Image produced by Elza Cristina Santos, 2011)

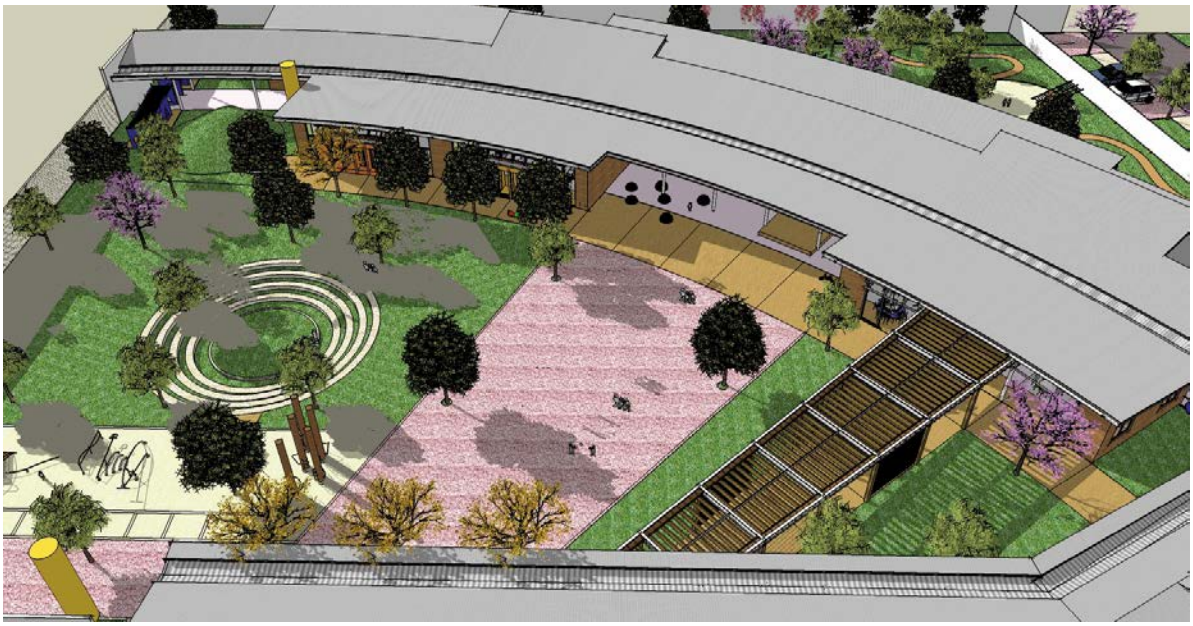

Figure 13. Exterior spaces and playful stimuli: uncovered patio. (Image produced by Elza Cristina Santos, 2011)

The design process began with the theoretical studies and was developed after checking the relevant legislation pertinent to early childhood schools. Also analysis of program needs, the region and site climatic characteristics as well as the consideration of the proposition mentioned above.

This proposition which would be the answer to the initial question of the research, lead to the reflection of some factors that could act as catalysts in the interpretation of data obtained initially, thus fleeing from predictable solutions that would serve only to satisfy the obvious needs of a program for a preschool.

Thus, from the beginning, it was considered important and as project items the following factors:

• valuing the corner, establishing a dialogue between the building and the surroundings (see figure 14);

• use of a typology that resembles a "plaza", meeting point and socialization of its users, where the playful space character can be revealed (see figure 15);

• respect for the original features and preservation of existing trees, elements of great importance to the architecture and the microclimate of the region.

From there, the design process naturally evolved, always based on the theoretical framework that guided the research and assured the quality of the desired solution. It should be noted that the act of designing is not a linear process that is developed from a concept to reach a final solution. Projects (drawings) can also lead to the formulation of concepts (ideas) and vice versa. There is a mutual relationship between them, where all aspects must be analyzed and adjusted in order to reach a solution that satisfies all requirements and all expectations.

Thus, even before the central idea was fully developed, some designs were developed. It was found that they already contained some important theoretical aspects pointed out in the established concepts.

Figure 14. Valorization of the corner. (Image produced by Elza Cristina Santos, 2011)

Figure 15. Central Plaza. (Image produced by Elza Cristina Santos, 2011)

CONCLUSIONS

This research did not aim to establish a norm for the creation of designs for children's schools. However, the design of this school, defined according to these guidelines, complements the thesis and its purpose is to exemplify and reflect the concepts covered, enabling a path to a deeper understanding of architecture.

Some of the guidelines specified in this design process considered some contributions from other research and analysis projects. Other guidelines just confirm some suggestions contained in the legislation and literature relevant to preschools. Still others represent an attempt to solve certain problems identified in the case studies and finally some of them represent an attempt to add innovations in the field.

Nonetheless, it is important to remember that these guidelines and these concepts - welcoming, complexity, versatility, transparency and playfulness - can be useful when one wants to develop school designs whose focus is on learning, especially playful learning, which considers both playing as well as the space, crucial to child development. Schools that have spaces with these qualities can become sources of stimuli, learning and inter-relationships.

Finally, it is recommended, in order to continue the research, to apply these concepts in developing projects with other uses and other architectural typologies and solutions, especially when the humanization of space is needed.

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Section 10

Cognition and Emotion in Serious Gaming Design

Using Game-Based Collaborative Learning to Enhance Critical Thinking Skills

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ABSTRACT

Critical thinking is an essential quality in complex problem solving. Many researchers have proposed that collaborative peer learning could enhance critical thinking, because learners could understand more diverse views by sharing different perspectives on a given situation. The work presented in this paper aims to explore a possible relationship between game-based collaborative learning and critical thinking. A serious mixed reality business game was developed and employed in the present study. Twenty-five undergraduate students were recruited and divided into three groups: an individual learning group, and two collaborative learning groups with distinct learning conditions. After completing the experimental learning tasks, the participants were asked to create presentations, either alone (for the single players) or with their partners, to outline their approaches to solving the problems presented in the game. The results indicate that the three groups showed only slight differences in learning performance (e.g., memorization); however, the difference in their levels of critical thinking was more significant. There appeared to be a strong relationship between learning in pairs and an array of positive intellectual outcomes. Further, the different learning conditions between the two collaborative learning groups also led to significant differences in the level of critical thinking.

Keywords: Critical Thinking, Collaborative Learning, Problem Solving, Serious Games

INTRODUCTION

Critical thinking is an integral part of many common activities. It has long been considered an important ability, and not just in the field of education. For example, the ability to analyze given information and propose new solutions that did not exist before has been a core part of thinking skills in many workplaces. Willingham (2007) referred to critical thinking as "[…] seeing both sides of an issue, being open to new evidence that confirms your ideas, reasoning dispassionately, deducing and inferring conclusions from available facts and solving problems". To develop critical thinking, many kinds of skills are needed. Bullen (1998) defined four categories of critical thinking skills in his study, as shown in Table 1.

Table 1: Critical thinking skills (Bullen, 1998)

Skill	Description
Clarification	The attempt to appraise and understand the exact nature of the problem, issue, or dilemma. This includes attempting to understand different points of view on an issue.
Assessing evidence	In order to establish a sound basis for inferences, the evidence used to support those inferences must be assessed. This involves judging the credibility of sources of information and making and judging the credibility of observations.
Making and judging inferences	Inductive and deductive inferences and value judgments are involved in making a decision about what to believe or do. Critical thinking involves the ability to judge the soundness of inferences and to make good inferences. Using evidence to support arguments is included in this category.
Using appropriate strategies and tactics	Critical thinking is not a matter of following steps or procedures, but some strategies or heuristics can be useful in guiding thinking

Collaborative learning has been proposed as one way to enhance critical thinking. According to Dillenbourg (1999), collaborative learning can be defined as "[…] a situation in which two or more people learn something together." Interacting with other people in collaborative learning is thus different from individual learning in all of the four aspects of critical thinking described in Table 1. Gokhale (1995) suggested that collaborative learning could enhance the development of critical thinking through the process of evaluating, discussing and clarifying a partner's thinking, in conjunction with externalising one's own thinking process to the partner.

Numerous studies have shown the positive relationship between collaborative learning and critical thinking. However, most research on collaborative learning has been conducted through an examination of its effects on the individual setting (Dillenbourg, 1999), by which an individual learns something independently, and collaborates later to discover some things they have missed. The ability of collaborative learning to enhance critical thinking skills has thus been largely tested in a traditional multiple-choice setting. In contrast, Ku (2009) demonstrated that open-ended problems seem more appropriate for evaluating the level of critical thinking, by allowing people to demonstrate their own thinking more flexibly.

Frameworks for the Evaluation of Learners' Thought Processes

Hew and Cheung (2005) proposed a generic framework to evaluate the quality of a learner's thinking skills. In their study, students' thinking processes were divided into two types: *surface thinking* and *in-depth thinking*. In surface thinking, learners tend to use ideas or concepts that have already been presented in the learning material when proposing their own solutions. According to Hew and Cheung (2005), surface thinking is revealed by (1) using given learning materials without advancing one's own ideas (2) repeating what has been said or learned without adding new elements (3) proposing several solutions but refraining from deciding on the most suitable one. By comparison, with in-depth thinking, learners are more likely to create new information from collected data, and develop new strategies with wide and diverse interpretations (Hew & Cheung, 2005).

How to Measure Critical Thinking in Collaborative Learning

According to Gokhale (1995), collaborative learning can enhance critical thinking skills through evaluating, discussing and clarifying a partner's thinking and, at the same time, revealing one's own thinking processes to the partner. These are common views about the relationship between collaborative learning and critical thinking. However, most of the previous studies have been carried out by using multiple-choice formats or questionnaires, and little has been done with qualitative analysis (e.g., the California Critical Thinking Skills Test (CCTST)).

When it comes to qualitative analysis, content analysis has been widely applied to uncover critical thinking

indicators in collaborative learning. In particular, Henri (1989) explains about two types of messages (independent and interactive) that come into play when interacting with a partner. Independent messages cover the topic of discussion, but there are no implicit or explicit references to any other messages. Interactive messages, on the other hand, respond to and elaborate on others' messages. Such interactive messages could convert surface thinking into in-depth thinking during collaborative learning, and this could enhance critical thinking.

In the present study, when evaluating critical thinking, we applied content analysis. The main point of content analysis is to analyze the conversation that takes place during the learning process (however, the learning outcome also needs to be considered through other quantitative analysis methods), by which we try to uncover differences in performance between single players (individual learning) and pair-players (collaborative learning) when measuring critical thinking in decision-making situations.

RESEARCH QUESTION

The main research question addressed in this study was: Is there a difference between individual learning and collaborative learning with respect to demonstrating critical thinking skills?

EXPERIMENTAL DESIGN

Participants

The study evaluated critical thinking through a mobile game modeled on a real world business situation. Twenty-five undergraduate students majoring in Industrial Engineering at Hanyang University participated in the experiment. They had similar prior knowledge levels. Participants were randomly assigned to one of three groups:

- Group 1: Individual learning group with single player mode
- Group 2: Collaborative learning group with pair-player mode
- Group 3: Collaborative learning group with two single player modes

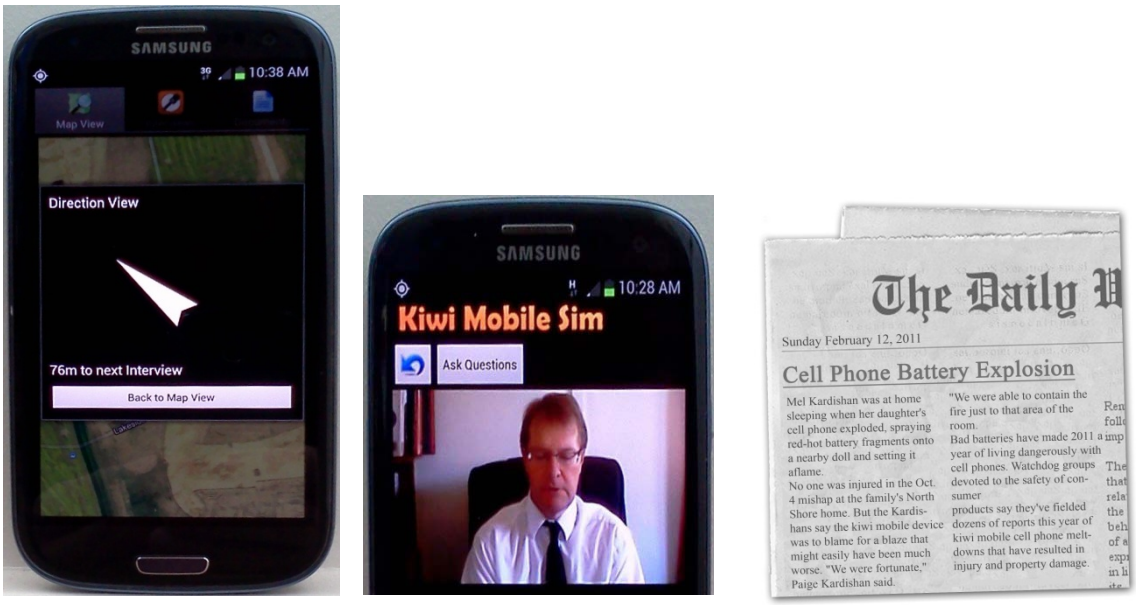
Materials

(A) "Kiwi MobileSim"

A serious business mobile game, "Kiwi MobileSim", was used for the present study. It was designed based upon location-aware and mixed reality technology. The purpose of the game is to recognize each department's[1] position in a virtual company (Kiwi Mobile) and identify the problems or issues the company is facing. In the game, players have to move around a specified area separately using the direction view in Figure 1(a), in order to find specific locations that provide information for them. When players arrive at a given location, an interview video file begins to play automatically (Figure 1(b)). After viewing the video, players can gather extra information by asking experts in the mobile game and searching for artifacts around the location (Figure 1(c)).

There were a total of five locations that players had to visit for their learning about a simulated business situation. In the single player mode (group 1), the player individually visits all the locations. In the pair-player mode (group 2), each player visits only four departments; one player does not receive information about the Marketing Department, and the other one does not receive information about the R&D Department. In the two single player mode (group 3), both players visit all the locations together. We intentionally designed the game setting like this in order to examine how well participants would collaborate with their partners, to see how sharing the missing information triggers their collaborative process.

[1] Assembly Department, R&D Department, Marketing Department, Quality Assurance Department, and CEO's office



(a) (b) (c)

Figure 1. Mobile game "Kiwi MobileSim"

(B) Presentation Files

Critical thinking is processed by a learner's basic situational understanding of the learning material. By introducing an intentional step focused on the learner's basic situational understanding, we expect that the participants would recall and organize their basic situational understanding before moving on to the next step of evaluating their critical thinking level. This experimental setting would encourage our participating learners in both individual learning and collaborative learning groups to be critical thinkers.

To identify basic situational understanding, a reference for how well participants learned by using the mobile business game, the participants were asked to write down the information that they got from each business department (Figure 2(a))

To identify critical thinking levels and observe the differences between groups, we asked the participants, "If you think some departments have some relationships between them, link them and write down the specific reasons why you have linked them". (Figure 2(b)).

Procedure

The experiment consisted of two parts. In the first part, the participants played "Kiwi MobileSim" for about 30 minutes. In the following 30 minutes, they were required to create presentations to evaluate their memorization and critical thinking levels. When evaluating memorization, the main experimental task consisted of writing down information about each department's situation in detail, while the critical thinking part consisted of linking the related departments and providing reasons for this thinking. Group 1, the individual learning group, made the presentation file alone, while Group 2 and 3, the collaborative learning groups, made the presentation file together in their pairs. Apart from this, the remaining conditions during the experimental procedure were identical for all groups.

(a) (b)

Figure 2. Presentation files to evaluate memorization and critical thinking levels

RESULTS

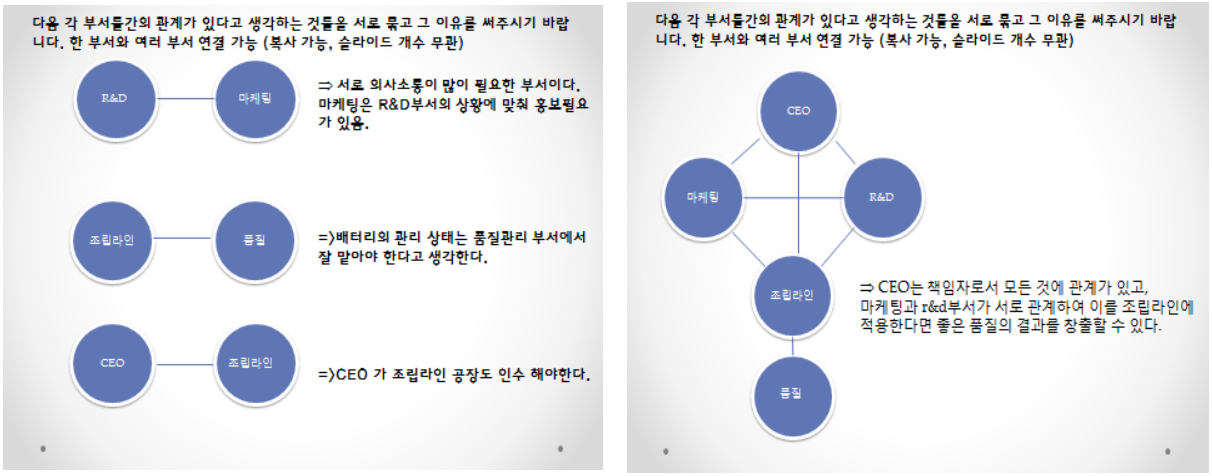
Evaluating Basic Understanding Level

Through this step, we identified that all three groups had a solid understanding of the main departments' situations. However, there were slight differences among the three groups with respect to their representation of this information. The individual learning members (Group 1) tended to write more specifically compared to the collaborative learning members (Groups 2 and 3). For example, concerning the marketing department, one of the additional learning materials was a product brochure from Kiwi mobile (Figure 3). Most of the individual learners listed each product line one by one, *"1) Silver line 2) 4D line 3) Basic line 4) Business line",* while the collaborative learning groups tried to write down the information in a more simple, summary format, including their own interpretations of the artifacts, for example, *"There are many product lines for targeting a wide range of markets and diverse age groups"*

Figure 3. Product brochure of the marketing department

Critical Thinking Level

As to surface thinking, our participants usually illustrated simple organizational structures (such as single links with other departments (Figure 4(a)), using ideas or proposing solutions based on the given learning materials. There are no new ideas in their presentation files. However, with in-depth thinking, some participants explained the corporate situations using complex links (Figure 4b)) rather than single links, and also proposed solutions that considered wider perspectives not referred to in the learning material.



(a) (b)

Figure 4. Presentation files of Group 1 and Group 2

Table 2: Results of critical thinking levels in surface and in-depth thinking

		Performance test with surface thinking (# of teams)	Performance test with surface thinking + In-depth thinking (# of teams)
Individual Learning	Group 1 (Single player mode)	4 (2)	1
Collaborative Learning	Group 2 (Pair-player mode)	1	4
	Group 3 (Two single player mode)	3 (2)	2

Table 2 illustrates the overall results of this study. In Group 1, only one outcome was evaluated as being the output of in-depth thinking, while four outcomes of Group 2 and two of Group 3 were evaluated as such. Through this result, we could identify that the collaborative learning groups were thinking more critically, especially when faced with deficient information.

More interestingly, among the teams whose learning output was evaluated as surface thinking, two teams of Group 3 and two participants of Group 1 provided the identical learning output (Figure 5). Among the two types of messages – interactive and independent – we thus infer that independent messages were conveyed between team members in Group 3, while more interactive messages were conveyed between Group 2 members. Relatively less information made team members more collaborative.

The results revealed that 7 in-depth thinking teams were also able to process surface thinking. When comparing Groups 1 and 2, Group 2 (= 4) outperformed Group 1 (= 1) in terms of in-depth thinking. Comparing Groups 1 and Group 3, however, there seems to be no difference in either surface thinking (4 vs. 3) or in-depth thinking (1 vs. 2). A closer investigation indicates that the performance produced by the two surface thinking teams in Group 1 are identical to that provided by the two surface thinking teams in Group 3 (Figure 4). A plausible explanation could be that simply grouping individual learners with full information does not in itself guarantee effective in-depth thinking in collaborative learning.

Group 2 (= 4) outperformed Group 3 (= 2) on the measure of in-depth thinking. Although Group 2 did not have full information from their learning materials compared to Group 3, Group 2 might have better grounds for collaboration due to their pair-player mode. On the other hand, although Group 3 teams acted in a collaborative learning mode, they might have less motivation for in-depth thinking compared to Group 2.

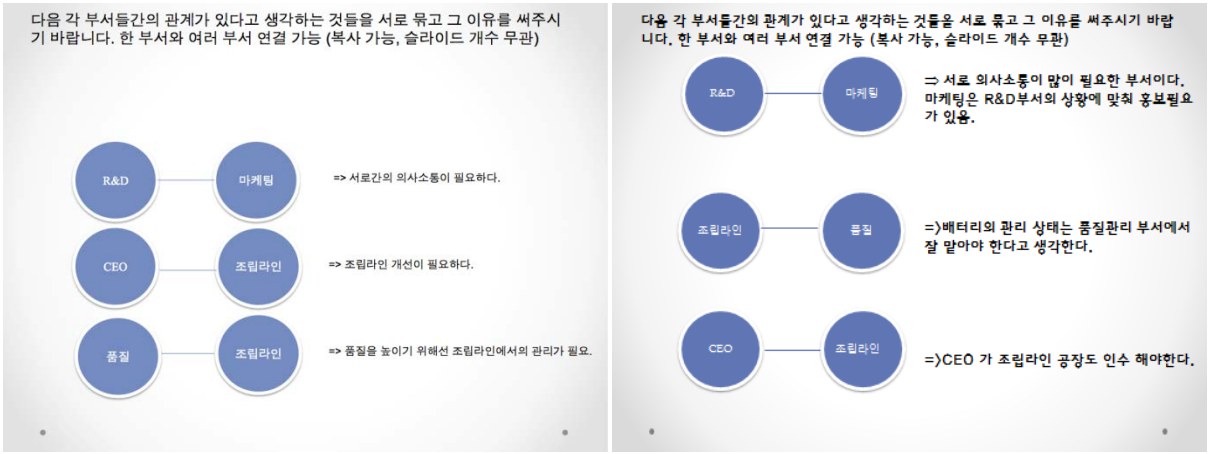


Figure 5. Presentation files from Group 1 and Group 3

CONCLUSIONS

In this study, our first research goal was to compare the critical thinking of individual learning groups and collaborative learning groups by using a mobile business game. Additionally, the second research goal revolved around how deficient knowledge motivates collaborative learning processes, which we tested by constructing two collaborative learning groups with different game playing modes.

When evaluating memorization abilities, results revealed that there are no significant differences among the three groups (one individual learning group and two collaborative learning groups). Learners in individual learning groups tended to depict and understand situations in greater detail. Collaborative learning groups usually described situations in a simplified manner as a result of the knowledge externalization that took place among partners.

When evaluating critical thinking, there were significant differences between individual learning groups and collaborative learning groups in our study, and also between the two types of collaborative learning group. Most individual learning groups provide simple analysis, in other words, surface thinking. Collaborative learning groups with deficient information performed relatively well (in-depth thinking) compared to the collaborative learning groups that had sufficient information, and interactive messages rather than independent messages were conveyed between the team members during their collaborative learning due to their need to get the information that was unavailable to the individual.

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Challenges of Designing a Life-Log Sharing System – The Pensieve

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ABSTRACT

Although the privacy issue is still debated, an incessant interest and attention on the life-log could be explained by its potential applications. Though there are many challenges to realize its potentials, life-log as one's memory aiding tool has been paid much attention. A series of images captured by the wearable camera are too voluminous and useless to keep the whole data to the collection owner. What the users really want to get from the device is not to review their own whole past life, but retrieve their meaningful moments, further share their meaningful experiences with others. In this regard, the author limited the role of life-log, as resourceful life hints that could give opportunities to reminisce one's meaningful experience and exchange their experience with others. In this position paper we discuss what is necessary to consider to build a life-log data sharing system for our future research direction, (i) what one's meaningful experience is; (ii) How the meaningful experience could be defined with life-log data; (iii) How the meaningful data conveys to the 3rd person to exchange and share one's experience effectively.

Keywords: wearable camera, visual life-log, experience-transferor, experience-transferee, meaningful experience model, experience-sharing system, medium, storytelling.

INTRODUCTION

Wearable sensing technologies let a small device store the user's personal information by tracking their daily life in the unobtrusive way. As the user wears the device, several built-in sensors simultaneously record what the user did and how she or he did it to keep personal data, so called *life-log data*.

The life-log data can be utilized in many applications. For instance, it can notify the user about their health and activity status immediately when it is recorded as an activity tracker (e.g., Fitbit™, Jawbone™, MIO alpha™). It also records every moment that the user faces in their daily life with captured images, audios or videos (e.g., Autographer™, Narrative™, Mecam™**).** More recently, many research offered the life-log data as a memory extender ("Memex"), which is similar to Vannevar Bush's assertion (1945), by means of self-examination, reflection, and reminiscence (Byrne and Jones, 2009; Doherty and Smeaton, 2008; Gemmell et al., 2005; Hodges et al., 2006).

These two types of life-log devices have been of much interest in the commercialized application domains, in particular, Health. It led many commercialized products (shown in Figure 1). However, they are more or less used for personal purposes, and appropriate services on the wearable devices are not distinct. For instance, SenseCam™ and Autographer™ do not suggest any unique user experience, compared to the previous digital cameras. It only offers convenience to take a picture without distraction. We therefore discuss in this paper how the visual life-log data (e.g., photos, video) can be used for a new service, i.e., potential experience-sharing channel service, addressing the following three research questions: (i) what one's meaningful experience is, (ii) what possible factors to define the meaningful experience are, and (iii) how we could convey the owner's collection of experiences to the 3rd person effectively.

Figure 1. Wearable device as an activity tracker (Left: (a), (b), (c)) and a memory extender (Right: (d), (e), (f))

Personal life-log

As briefly discussed, activity tracker and memory extender have been widely employed in the personal use. As to the activity tracker, it monitors personal health status such as heart rate with the bio-physical sensor (Photoplethysmography; PPG) and informs their activity status with accelerometer, gyroscope sensor, GPS sensor that could figure out the user's physical status (e.g., how fast and how long they exercise) (Fábián et al., 2008; Lee et al., 2011). Therefore, delivering the accurate and direct information at the right time is a key to meet the user's needs on the activity tracker.

On the other hand, life-log as one's memory aiding tool lets the user to recollect their whole life events with series of images, for instance, what they saw and met on July 23th 2014 at Gyeongbok Palace in Seoul, Korea. However, one's captured daily images are much voluminous, and the opportunities to review their whole collection of images seem useless (Whittaker et al., 2010). Although the visual life-log data should be the primary medium to convey one's experience, of less importance is to simply deliver the one-dimensional raw data without considering what the experiences mean to the user. As promising computational algorithms, various approaches to organize many images have thus been suggested, such as image recognition (Corcoran and Costache, 2005), time-based clustering techniques (Graham et a., 2002; Platt et al., 2003).

More important, as many researchers have acknowledged is to offer the user to collect life-log data and use it for self-exploration on the meaningful experience (Li et al., 2010). Nevertheless, the current momentum of life-log data application rests on the technical issues such as how to minimize the devices and improve the quality of the life-log data (Gurrin et al., 2008).

Sharing life-log with others

Although there are incessant controversy over the privacy issue related to the life-log data, its application is inevitably extended to sharing one's own experiences with the 3rd persons, following the success of Social Network Service (SNS). A lot of commercialized activity trackers thus connect their own life-log data with SNS such as Facebook™ and Twitter™ or build their own services to set a digital image-sharing playground. It takes a role as an implicit communication channel with others or a bullet board to share their exercise histories with others. It actually leads to boost up the user's motivation to work out outside. Due to the characteristics of the collected data, which is quantitative, the experiences to share with others are just their records to show off (see Figure 2(a), (b)). Indeed, it does not reinterpret the original data but it directly shows how much and how long the user has exercised.

The visual life-log data is able to support experience-sharing in the community spaces for friends (Memon and Tanaka, 2013), families (Caprani et al., 2011) beyond and over the boundaries of the personal space. A series of empirical study carried out by Crete-Nishihata research team (2012) suggested that digital life-logging technologies should not be just confined as systems for extending an individual's capacity for accurate recall of personal events,

but instead should support the groups of people who are socially close and tell their life stories to share. Many researchers have thus tried to develop a system to support the way of sharing personal daily life (Caprani et al., 2013; Lee et al., 2008). For instance, "ShareDay" (Zhou et al., 2013) is an automatic life-log classification system based on the type of lifestyle events and derives the social interaction between families. Memon and Tanaka (2013) also suggested an approach to share one's digital life-log with their friends based on the locational data. The form of the sharing system is not quite different from the personal photo album (except the way how it organized), however.

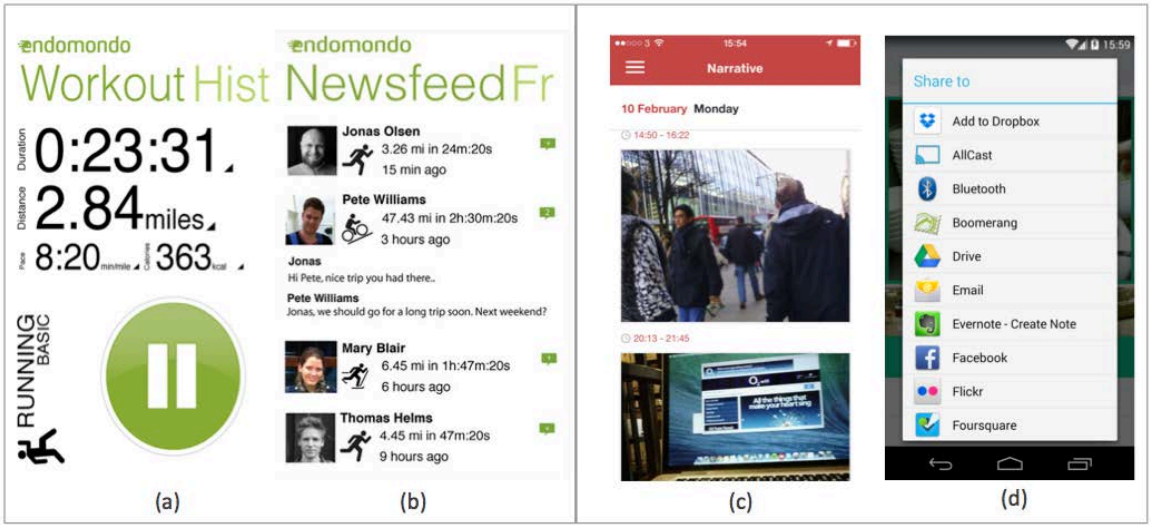

Figure 2. Left) Activity tracker (endomondo™) (a) personal workout history (b) newsfeed from the friends; Right) Memory Extender (Narrative™) (c) personal photo viewer (d) function to share one's experience

Most of the commercialized wearable cameras do similar things, simply connecting a Social Network Service to give a way to share their moments with 3rd persons as shown in Figure 2(c), (d). Likewise, the life-log data sharing system is very similar to the personal life-log data album, showing or grouping the series of images in terms of the time and/or location that the images are captured. It does not motivate a significant interaction between the participating users to have empathy or intention to exchange (or share) experiences with others as we believe it is the future of the *life-log sharing system.* A note of Blažica research team (2013) is further needed here. They claimed that a lot of implicit meanings to the owner such as emotions, mood could not be delivered by a picture itself.

FUTURE RESEARCH DIRECTIONS : VISUAL LIFE-LOG, A PENSIEVE AS A SHARING EXPERIENCE CHANNEL

Figure 3. Pensieve in Harry Porter

Visual life-log data do not re-tread one's whole experience (Petrelli et al., 2008). Its existing purposes should resort to a medium to keep one's valuable moments and support to build an experience-sharing system like a pensieve in Harry porter (see Figure 3). It is not for simply viewing and navigating one's experiences, but for doing reminiscence and understanding one's and/or others' past moments for the implicit experiences such as emotions

and feelings (Byrne and Jones, 2009). Therefore, the visual life-log could offer new opportunities to the users to accept others' experiences (i.e., mimesis) or extend it to their own experiences in the process of re-interpretation (e.g., alterity).

In this regard, we formed our main research directions to build an experience-sharing platform for both the experience-transferor who is the owner of the life-log data and the experience-transferee who likes to share the owner's significant and meaningful moments. To achieve our research goals, we set three steps research questions shown in Figure 4 as below.

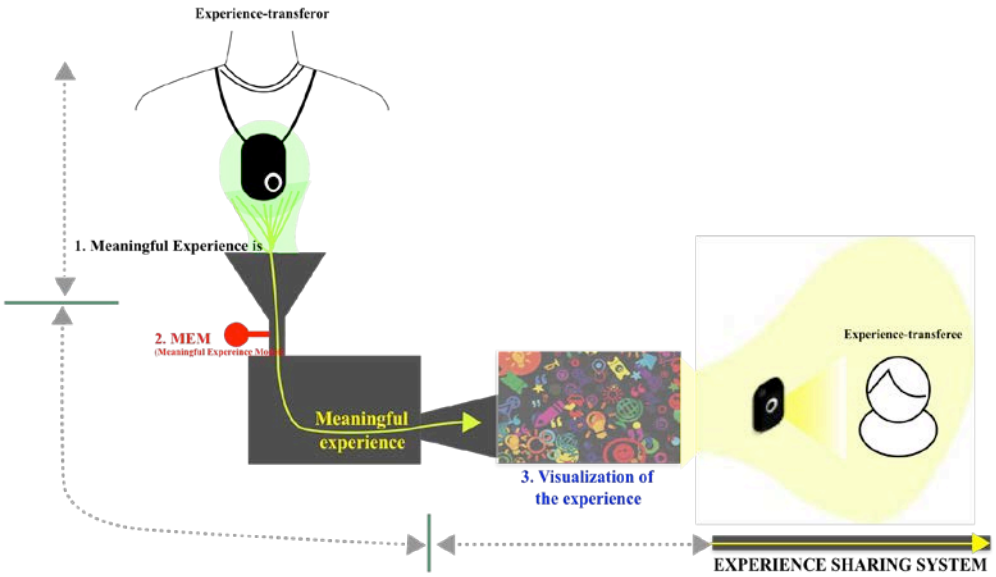

Figure 4. Future research directions to build the experience sharing system

1. What is one's meaningful experience to share with others

Defining a scene that could be meaningful and valuable for reminiscence or exchanging with others is the first thing to address in this research. Rather than the explicit traits that could determine the experiences in terms of such as location, and time, we want to focus more on the implicit meanings behind the captured moment with qualitative research methodologies. We assume that the sharable experiences are firstly meaningful for the experience owner. Based on the assumption, we would precede the open-ended interview to derive what their meaningful experience are by letting the interviewees recollect their past events (i.e., using thematic apperception test (Murray, 1943)). We would then define whether the meaningful moments are emotionally specific for either pleasant or unpleasant, or open experiences that could be interpreted in different perspectives.

2. Meaningful experience model (MEM)

To deal with the voluminous life-log data, prior studies have applied several approaches with various sensing information. However, they do not give enough implications to analyze one's valuable life-log data. Based on the previous theme (i.e., what is one's meaningful experiences that they want to share with others), we would build a computational model to filter out if the experience is meaningful. To do so, firstly, we carry out to identify the likely factors to pinpoint the value of one's meaningful experiences. We currently apply the physiological data such as Heart rate variability (HRV), Galvanic Skin Response (GSR) and Functional Near-Infrared Spectroscopy (fNIR). In addition to this quantitative data, several lexical items that are able to represent the user's intentions to express and convey their experience would be also considered at the verbal protocol sessions. We want to denote the factors that have an influence on generating one's meaningful experiences regarding both explicit and implicit components.

3. How to convey the meaningful experience to others

In retrieving and building the meaningful experience model from an experience-transferor perspective, we would extend our research to consider the 3rd persons, (i.e., the experience-transferee) who would like to share other's experiences through the experience-sharing system. The way to convey the experience to others would significantly affect on empathy and active interaction between the experience-transferor and experience-transferee when they exchange and share the experience. We would suggest a way to deliver the experience with two different perspectives, one is with different combinations of media (e.g., images, verbal, emotion) to present the moment (see Figure 5(a)), and the other is with different types of storytelling (e.g., images as an attention unit (Cohn, 2013), point of view, four steps in composition) to recompose the episodes to share (see Figure 5(b)). Depending on what the experience-transferor wants to share with the others, the way to visualize the events should be differentiated. If the experience-transferor wants to share their experience the same as what they felt at that moment, showing the images with additional information (e.g., sound or emotion) would be of greater value. On the other hand, if they want to get empathy with the meaningful happenings (episode), composing a story with the images would be worthwhile to deliver the experience to the transferee. To verify if the characteristics of the experience contents influences on the experience-transferee's empathy with the experience-transferor, we will measure their physiological data such as fNIR, GSR, which are affected on the stimulus in terms of prefrontal cortex brain activity and emotions to be dimensionally determined, respectively.

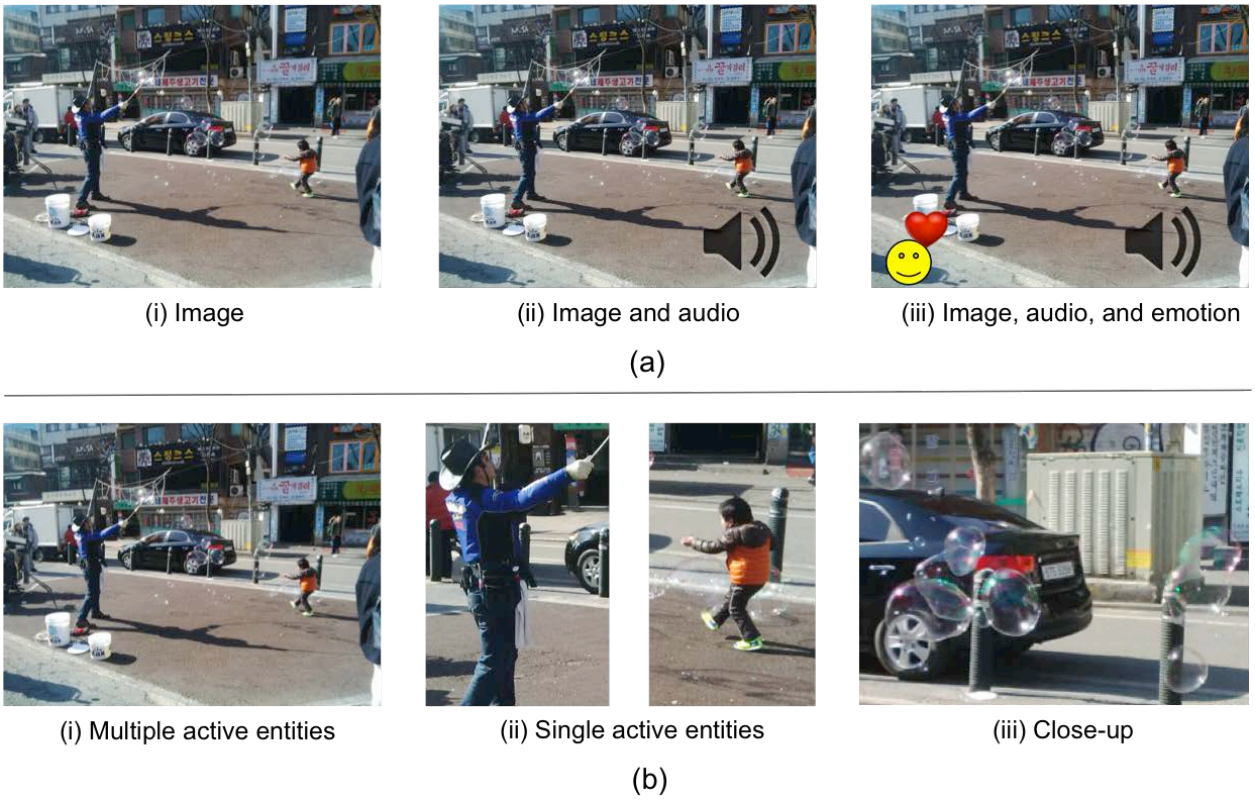

Figure 5. Examples of the way to convey one's meaningful experience; (a) different types of media; (b) storytelling with attention units

CONCLUSION

Although life-log data are suggestively used for the various fields, they are not properly utilized for the potential of experience sharing. We believe that life-log data should be a valuable resource to build an experience-sharing system, not just a memory repository, but for like more on social activity. That benefit is the only way to compensate privacy issue, so the experience holder can voluntarily give their private information for sharing experiences. Life-log itself is one's personal episodes which is worthwhile to share and exchange with others. It would give opportunities to the others to do mimesis of others' experiences and interpret it for their own experiential references.

Hence, the implicit meanings behind the life-log data should be regarded to do reminiscences of the meaningful moments and convey the moments to the others with empathy. In this regard, in this position paper, we address our research directions rather than empirical outcomes. Indeed, we are running an experiment on this research direction, and it is very likely to present what we have from this empirical study at the conference.

ACKNOWLEDGEMENTS

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A SWOT Analysis of the Gamification Practices: Challenges, Open Issues and Future Perspectives

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ABSTRACT

In this paper, we present a SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis for the gamification field. The analysis will begin with a review of the topics frequently discussed in relation to gamification strengths and weaknesses, by reporting existing works in the field. The work will continue by outlining an analysis of opportunities and threats, that require an examination of marketing and design trends, with the aim to provide a strategy for guessing what lies ahead in the future. We are not aiming at a complete review of all the relevant works in this field; we want to identify a useful tool to spot both positive and negative aspects of gamification, as well as its perspectives of development and its risks of decline, describing some elements through which imagine its future, showing limits, challenges, ethical issues, expectations and possible evolutions of this phenomenon.

Keywords: Gamification, SWOT Analysis

INTRODUCTION

In this paper, we present a SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis for the gamification field. SWOT analysis is a commonly employed framework in marketing researches, for analyzing the elements that can influence a firm's competitive position in the market, considering present and future issues. Strengths are internal resources and abilities that an entity has and that can help it to achieve its goals; weaknesses are the entity's internal limitations, that could interfere with the achievement of its goals; opportunities are the favorable trends in the environment that the entity could play on; threats are unfavorable trends in said environment that could limit development and impede progress towards its goals.

Generally, the aim of a SWOT analysis is to discover a way for matching the entity's strengths with the opportunities, overtaking its weaknesses and minimizing the threats (Kotler and Armstrong, 2010). However, SWOT analysis has been used outside the business world too, when analyzing promising technologies, such as Near Field Communication technology (Jandebeur et al., 2013) and Virtual Reality technology (Rizzo and Kim, 2005), and "it can be usefully applied to guide any organized human endeavor designed to accomplish a mission" (Rizzo and Kim, 2005: 120). This model can be a useful tool in structuring an analysis that aims at providing an overview of the gamification phenomenon, highlighting the key issues that are essential in interpreting this new area of HCI studies.

The analysis will begin with a review of the topics frequently discussed in relation to gamification strengths and weaknesses, by reporting existing works in the field. The work will continue by outlining an analysis of opportunities and threats, that require an examination of marketing and design trends, with the aim to provide a strategy for guessing what lies ahead in the future. We primarily drew on research literature in important conferences, such as Gamification Conference, ACM SIGCHI Conference on Human Factors in Computing Systems (including the gamification workshop at CHI 2011 and CHI 2013) and Mindtrek Conference. Then, we made searches in the ACM Digital Library, with the terms *gamification* and *gamified*. We further investigated the references of the initially found relevant papers and, with a snowball sample method, we discovered other relevant works. Finally, we drew on our own research experience to spot pertinent studies in the game design literature. However, we have to notice that gamification literature is rapidly expanding, not only in HCI conferences and journals; significant works can be found scattered amongst marketing, health, learning and other journals.

We also considered non-scientific writings such as blog posts, magazine articles, technical reports, white papers, designer interviews and mainstream books, starting from searches in Google with the terms *gamification* along other terms such as *motivation*, *engagement* and *behavior change*. Our aim is not to provide a complete review of all the relevant works in this field; we want to provide a useful tool for identifying both positive and negative aspects of gamification, as well as its perspectives of development and its risks of decline, describing some elements through which figure out its future, showing limits, challenges, ethical issues, expectations and possible evolutions of this phenomenon. The inclusion criteria for the works discussed in this analysis included papers related to: i) motivation and engagement; ii) effects on human behavior; ii) specific game elements, such as points, badges and leaderboards.

Strengths

Availability of a shared minimal language

Gamification is an effective design strategy to insert game mechanics in existing contexts. Differently from past solutions aimed at using games for serious purposes (e.g. serious games), gamification does not require the design of a full fledged game. In fact, serious games, during the years, evolved into powerful simulation environments, able to provide sophisticated models to emulate complex behaviors, but requiring high development investments: these simulations are more apt to be point-in-time works in separate environments and are not integrated with existing processes and contexts (Deloitte, 2013). Gamification, as is conceptualized, does not show these high entry barriers: it relieves the designer, who doesn't have to create complex game worlds from scratch, but can count on a set of limited elements that can be applied through different situations.

In the (video)game design field there is an ongoing effort to formalize and enumerate the central building elements of a game, aiming at providing a grammar or a Unified Modeling Language (Deterding, 2013). Cook (2007), for example, introduces a game grammar, starting from a behavioral model of the player, based on the idea of skill atom: a skill atom is a "self contained atomic feedback loop" between player and game and is organized around a challenge that the player is trying to master. Brathwaite and Schreiber's game design atoms (2008) are a set of game design elements: game state, game view, player avatar, game mechanics (i.e. the game rules), game dynamics (i.e. the game rules set in motion by the player), game theme and goals. Instead, Järvinen (2008) lists forty game mechanics including in his enumeration many concrete elements as building, choosing, conquering, jumping, storytelling, trading, while Schell (2008) individuates more abstract mechanics, as space, objects, attributes and states, actions, rules, skills, chance. Most of these elements are built on the MDA framework (Mechanics, Dynamics, Aesthetics) that distinguishes three macro-categories for the game components: mechanics are the various actions, behaviors and controls afforded to the player, describing the particular components of the game, at the level of data representation and algorithms; dynamics are the run time behavior of the mechanics; aesthetics are the desirable emotional responses evoked in the player (Hunicke et al., 2004).

Many of these organizations of game elements have been considered for gamification, since they have been seen as useful for orienting its practices. However, the spreading of shared techniques, focused mainly on three main game components, points, badges and leaderboards, soon overcame the grammatical complexity of game design, focusing on simplicity and convenience. Points are commonly used for i) keeping score, ii) providing feedback, iii) showing a status, iv) creating a connection between a progression in the game and an extrinsic reward, v) determining a win state and vi) providing data for the designer (Werbach and Hunter, 2012). Stackoverflow (http://stackoverflow.com/), for example, uses reputation points to signal the authority of its contributors. Badges, instead, are virtual goods, which are awarded to users for completing specific achievements. They can have different functions: i) presenting goals to achieve, ii) providing instructions about what types of actions are available in the system, iii) determining the trustworthiness of people or reliability of contents, iv) providing personal affirmation through the communication of one's past accomplishments and v) identifying the user in a group (Antin and

Churchill, 2011). Foursquare (https://foursquare.com/) shows how the possibility to gain badges can promote location-sharing through check-ins. Leaderboards are a list of users in a challenge, ordered according to a parameter (e.g. the score), showing their performances to the public and promoting the competitiveness (Costa et al., 2013). Samsung implemented leaderboards in Samsung Nation, for supporting loyalty of its customers (http://www.samsung.com/us/samsungnation/).

This is the so-called PBL triad (Points, Badges, Leaderboards), a set of game design elements used in the majority of commercial gamified applications (Werbach and Hunter, 2012) and academic researches (Hamari et al., 2014). The common acceptance of usage of these three elements provides the designers with a shared minimal language: the simplicity and the speed of implementation of these elements represent a primary gamification strength, facilitating its widespread adoption by services and systems far away from the entertainment world. Users, recognizing common features in different applications, can immediately gain a clear perception of the actions required by them, shortening the learning curve and favoring a quick user engagement.

Availability of ready-to-use solutions

The efficiency of gamification practices, made possible by rapid and simple implementation techniques, is manifested even more clearly in the services provided by the gamification platforms, nowadays spreading on the market. Badgeville (http://badgeville.com/) offers portable reputation systems, enabling companies to track and reward user behaviors across different digital touch points. Big Door Media (http://bigdoor.com/) provides small websites code that can be embedded in web pages, enabling features based on rewards, while offering gamified loyalty programs for larger websites, tailoring services to their specific needs. Bunchball's Nitro platform (http://www.bunchball.com/) allows companies to track user behaviors, supporting points, levels, leaderboards, challenges and social features. Gigya (http://www.gigya.com/) delivers interoperable plug-ins, supporting leaderboards, feedback, achievements and rewards.

The availability of these ready-to-use services promoted the spreading of gamification. To date, any website, application or social network can add game elements, by simply embedding codes in their systems or integrating prepackaged software modules. The simplification of technology allowed designers to create gamified applications without spending time in cumbersome development activities. Besides, the current platforms often include, in their offers, analytics services, delivering integrated solutions that both incentivize and track users' behavior. So, companies also have, through these third-part services, powerful tools to gather information about their customers, such as engagement and retention rate, and offer them customized advertising and recommendations.

Enhancement of user engagement and motivation

Gamification generally aims at leveraging the most involving aspects of games for enhancing motivation and engagement of users and, thus, increasing their productivity and performances. The big hype in the marketing sector (Gartner, 2011a; 2011b) led to a shared enthusiasm: gamification platforms often push amazing results, in terms of increased user participation, in a variety of contexts, simply obtained through the addition of game elements to existing applications and services.

Academic researches provided successful examples of gamification too. Barata et al. (2013a) show that introducing experience points, levels, badges, leaderboards and challenges in a course in Information Systems can improve student engagement, online participation and proactivity. Cechanowicz et al. (2013) suggest that game elements have additive effects in increasing participation and motivation: it is possible to obtain greater motivational effects combining a game mechanic with additional game elements. Flatla et al. (2011) propose the usage of gamification to make calibration tasks, required by interactive systems to ensure the optimal configuration of input and output, more engaging and entertaining. Results of their user study show that it is possible to introduce the pleasurable experiences of games like enjoyability and fun to serious activities, even without drastically changing the nature of these tasks. Thom et al. (2012) highlight how the removal of a points-based incentive system from an enterprise social network has a significant negative impact on the user activity of the site, reducing the amount of contributions and decreasing the overall participation.

Furthermore, Hamari et al. (2014) show, in a review of empirical studies on gamification, that this design technique has positive effects on performances and participation of the users, as well as on their motivation and engagement, as highlighted by the majority of the paper revised. However, as we will see in the next session on gamification weaknesses, HCI researchers have not obtained univocal results on its efficacy yet: lots of failures in enhancing user motivation and performance through these directives are also available.

Weaknesses

Unclear effects on user attitudes and behaviors

Despite Hamari et al. (2014) showed that the majority of the researches they revised found a positive effect of gamification on user behaviors and attitudes, doubts still persist on its real efficacy. On one side, authors identify several shortcomings in the quantitative studies examined, such as small sample sizes, lack of a control groups, presentation of descriptive statistics only with no inferring relationship between constructs and short experiment timeframes, in which novelty might have skewed the participants' experiences; on the other side, the qualitative researches reviewed, in which the findings consisted of both positive and negative perceptions regarding the studied applications, revealed that gamification is a varied phenomenon, where some underlying confounding factors may exist.

Montola et al. (2009) apply a game achievement system in a photo sharing service, discovering, through interviews, that users' reactions to the achievements were mild and somewhat irrelevant. However, since the achievements are relatively cheap to implement, authors suggest that introducing them might be a viable option to add some mildly hedonic value to existing applications. Li et al. (2012), evaluating GamiCAD, a gamified tutorial system for first time AutoCAD users, show that points, levels and feedback determine higher engagement levels and faster performances. However, qualitative data seem to highlight that some users want to challenge themselves, repeating tasks to achieve higher scores and levels, while others disliked the stress and the pressure of the game.

We can find ambivalent data and open issues in some quantitative studies too. Fitz-Walter et al. (2011) report the evaluation results of Orientation Passport, a gamified orientation event application for smart phone. Although the added achievements were generally well received by the users, as a welcome addition to the system, the data gathered highlight that once the achievement had been unlocked the majority of users stopped using the application features. Farzan et al. (2008), in their evaluation of a feature that rewards contributions with points in a social networking site, found that, even though users were initially motivated to add more content to the site, the impact of the point system quickly decayed after its introduction.

A study by Hamari (2013) shows that an important factor that could determine the success or failure of a gamification process is represented by the context in which it is applied. Hamari (2013) states that in utilitarian contexts (e.g. e-commerce and trading websites) badges do not have effects in incrementing the performance and in triggering psychological effects, such as social comparison and goal setting, for the majority of users. The author concludes that the effectiveness of game elements depends on the nature of the service in which they are used: in hedonic contexts, as games, badges seem to be a valid vessel for players' goal-oriented and social behaviors, while in utilitarian services their effects seem to vanish. In this kind of contexts, gamification should add hedonic emphasis, using narrative and combining different game mechanics or shaping the core activity within the service as a game. Highlighting that gamification, as deployed at the moment, is not as effective as it could be in utilitarian contexts has to bring us to consider how to better implement it effectively in non hedonic environments.

Simplification and limitation of the game elements employed

Despite the simplicity of its language represents a strength, it is surprising to observe that the game elements commonly used in gamified applications rarely go beyond the basic alphabet represented by points, badges and leaderboards. Werbach and Hunter (2012), analyzing more than one hundred implementations of gamification, found that the majority of them start with these elements, highlighting that PBLs are so common that they are often described as though they were gamification itself.

Zichermann and Cunningham (2011) add levels to this triad. In videogames, level design is one of the most important and complex activity, since the designer has to balance the challenges present in the game in ways that must be fun and interesting, paying attention to the right amount of difficulties, rewards and meaningful choices that the player will encounter during her journey in the game (Schell, 2008). In gamification, levels are commonly implemented as completion affordances, for signaling the percentage of accomplishment of a task (e.g. the progression bar in Linkedin: https://www.linkedin.com/), or as reputation systems, for clustering users in groups with different privileges (e.g. the levels in Yahoo Answers: http://answers.yahoo.com/), taking into account only the superficial layer of the level design techniques.

If the convenience of gamification represents one of its strengths, reducing the complexity of games and replacing their essence with few elementary design elements could be one of its central weaknesses. Some designers believe that limiting its perspective to the use of points, badges and leaderboards is the main problem of gamification.

Margaret Robertson calls this phenomenon *pointification*, stating that "what we're currently terming gamification is in fact the process of taking the thing that is least essential to games and representing it as the core of the experience" (Robertson, 2010). Ian Bogost suggests to call it *exploitationware*, since "it confuses the magical magnetism of games for simplistic compulsion meted out toward extrinsic incentives" (Bogost, 2011). Gamification makes believe that points, badges, levels and rewards are key game mechanics: instead, key game mechanics should be only those operational parts of games that produce emotional experiences, while points and levels are only gestures that provide structure and measure progress within a game (Bogost, 2011). Simplifying and reducing could cut costs, time and efforts, but at the same time impoverish and pervert the experiences that games commonly generate in their players.

One-size-fits-all

The spreading of third-part services on the one hand has promoted the adoption of gamification, on the other hand has highlighted the problem of the one-size-fits-all approach currently applied to many gamification interventions. This design technique is mainly actualized as a cut and paste methodology, lacking originality not only for the scarce variety of the elements commonly employed, but also for a perspective that is inclined to consider different contexts and different users in the same way.

First of all, the one-size-fits-all approach conflicts with one of the most peculiar characteristic of games, the sense of discovery and novelty that they elicit in players. Second, delivering a set of features that does not change during the interaction with the system does not match with the game experience, which usually evolves during the player journey, adapting itself to the variation of the player's skills and emotions. Finally, using the same game elements indifferently for all contexts may deteriorate the contents to which they are applied. Gamification often does not modify the user experience of the service by moving it towards a more engaging and enjoyable experience, but overlaps the existing contents, covering them with a glaze of "already seen". This approach makes it a prepackaged solution, instead of a design process able to gather user needs and desires, to which adapting and delivering useful services.

In order to solve these issues, Jacobs (2013) suggests to move from a perspective aimed at adding atomic game elements to existing situations to a solution centered on the creation of new experiences, making gamification a technique for developing new environments from the combination of mechanics and the existing contexts. Ami Jo Kim (2012) proposes to consider different motivational patterns in designing for gamification. Starting from Bartle's (1996) player types, Kim catalogues four different Social Engagement Verbs (compete, collaborate, explore and express), for identifying what motivates users in gamified systems and tailoring different design solution for different types of users. Dixon (2011) suggests to exploit Bartle's typology to create play-personas, fictional characters by which to orient gamification towards a design process that takes into account the differences among users and their related motivations and needs. Designing gamification features is not so far from the user-centered design process: the game elements applied to existing contexts must be means to create experiences that can satisfy the addressed users. The one-size-fits-all approach, instead, could cause damages, since it is known that designing for specific users is better than designing vaguely for everyone (Cooper, 1999).

Side effects

In order for gamification to become a useful tool in motivating and engaging users, we need to consider the adverse side effects. First of all, using extrinsic rewards, such as points and leaderboards, until now has no clear effects on user intrinsic motivation. Although Mekler (2013) shows that points, levels and leaderboards neither makes nor breaks user intrinsic motivation in non-game environments, many researches highlighted that different forms of extrinsic rewards could determine, in specific contexts, a detrimental effect on the users' intrinsic motivation (e.g. Deci et al., 1999; Newby and Alter, 1989). This may happen especially in those contexts where people are already intrinsically motivated to perform a task, before the introduction of the extrinsic rewards (Osterloh and Frey, 2000). Using exclusively extrinsic rewards should be carefully considered, because of the risk of impoverishing the overall experience the system could provide, since intrinsic motivation is positively associated to well-being (Decy and Ryan, 2000).

A second problem is represented by *mandatory fun*: the absence of consent to the gamified task (Mollick and Rothbard, 2012). It is critical to consider to what extent users voluntarily consent to perform a gamified task, or see it as an imposition of the designer. Gamification could be a useful technique only if its application is addressed also to achieve consent of users: to achieve this, users have to recognize that the game is being played, understand the rules of the game and see it as fair (Mollick and Rothbard, 2012).

Furthermore, even when such technique produces an enhancement of the user performance and motivation, we have to consider that this improvement might not proceed towards the intended goal. For example, leaderboards can promote competition among users for the highest rank, generating higher participation and rates of retention. However, users could target their motivation only towards being the best, performing repetitive and mechanical actions and ignoring the service that the application has to offer: even if this issue may seem irrelevant at first sight, since users are still spending time on the system, gamification in this case is not leading to a true engagement like the developer is likely hoping to achieve (Smith, 2012).

Moreover, social relationship triggered by gamification features should be evaluated carefully in respect to the possible side effects that they may generate. Leaderboards, for example, are often employed in motivating users to compete with the entire community which they belong to, pushing them to improve their skills for standing out, enhancing their overall engagement with the system. However, leaderboards alone can dampen the levels of interest and engagement of users, if numbers associated to the leaderboard positions are perceived as meaningless (Costa et al., 2013). Leaderboards also seem to favor the division of users in smaller groups, instead of bringing them together in a larger group that competes as a whole (Costa et al., 2013). Another consideration is that implementing leaderboards that do not allow users to choose who they compete with could have negative effects on the majority of them, since competition among leaders is productive, but it also demotivates those who are not in the leading group (Massung et al., 2013). A last note, leaderboards should be addressed to the contexts in which they are implemented: if leaderboards enhance user engagement through competition, where the main goal of the environment is to improve cooperation, they may not have the end result of increased engagement (Jacobs, 2013).

Opportunities

Increasing acceptance by the market

Gamification is having such a great success in the business world that many financial analysts see a rapid increase of its adoption in the next future. Gartner in 2011 predicted that "by 2015, more than 50 percent of organizations that manage innovation processes will gamify those processes" (Gartner, 2011a) and that "by 2014, more than 70 percent of Global 2000 organizations will have at least one 'gamified' application" (Gartner, 2011b). M2 Research (2012) forecasted that gamification market will reach $2,8 billion by 2016.

Nowadays, very popular applications, such as Nike+ and GetGlue, use game mechanics for increasing user performances and participation. The spreading of these applications made the use of PBL familiar. The result is a growing number of systems and services that apply game elements to drive user motivation and engagement in a variety of field (Deterding, 2012), such as tutorials (RibbonHero), forums (StackOverflow) and crowdsourcing platforms (FoldIt). Gamification of processes is also propagating in work (Reeves and Read, 2009) and education (Huang and Soman, 2013).

An example for this trend can also be seen in the growing number of articles about gamification in mainstream media (i.e. the New York Times, Wired, The Washington Post). This positive mood could anticipate a widespread acceptance of future applications able to leverage all the potentialities of this design technique.

Push of Videogame Industry

There is no doubt that the success of gamification is also driven by the recent growth in the gaming industry and the mass appeal that videogames actually have in the entertainment arena. In 2012 the worldwide video game marketplace, which includes hardware and software, online, mobile and PC games, has reached a revenue of $78,872 billion; the market is forecast to reach $111 billion by 2015 (Gartner, 2013b). Game industry has now surpassed the film industry in the entertainment market share. For example, *Call of Duty: Modern Warfare 3*, launched in November, 2011, was the most successful product launch in history, grossing more than $1 billion in its first 16 days of sales, while the most successful movie of 2011, *Harry Potter and the Deathly Hallows Part 2*, earned $381 million (M2 Research, 2012). Besides, the so called casual gaming phenomenon has reached a wide range of consumers, extending the popularity of video games to females and to age groups that traditionally were not associated to them.

The result is that nowadays 58% of Americans play videogames, the average age of game players is 30 and women represent the 45% of the total gamer population (Esa, 2013). Even in Europe, 45% of video gamers is represented by female gender, while the 49% of players is more than 35 years old (Ipsos Media CT, 2012). These data show how the video game world is not anymore of hardcore gamers, 18-24 year old male population commonly seen as core users of gaming applications, but is becoming a part of the home environment and of everyday live of a majority of

people. This familiarity with interactive games has opened new opportunities for gamification: the integration of games in daily life is an element that could facilitate its spreading in contexts usually associated with serious tasks and meanings.

Increasing interest of the academic world

Gamification is receiving an increasing attention by the academic world. Researches aimed at investigating the effects of game elements on users are more and more, for example in sport and physical activity (Mueller et al., 2011), design methodologies (Rapp et al., 2012), education (Barata et al., 2013b), citizen science (Bowser et al., 2013), health care (Parendes et al., 2013). This interest is showing even in the organization of workshops (CHI 2011 and CHI 2013 Gamification Workshops; GamifIR '14 Workshop), track dedicated to the topic in international conferences (HCII 2013; CHI Play 2014; Personal Learning Environment Conference 2013), conferences that have gamification as their central theme (Gamification 2013; Persuasive 2014) and special issues of international journals (Journal of Gaming and Virtual Worlds; Creativity and Innovation Management; Computers in Human Behavior). Searching the term "gamification" in Google Scholar we have 4690 results (as of 29th January, 2014); at the same time a growing number of researchers with a shared interest in gamification are coming together in online communities, such as the Gamification Research Network (http://gamification-research.org/).

We see now a shift in the attitudes towards gamification, a legitimization of a phenomenon that until a short time ago was only ascribed to the marketing field and industry debates, discussed only in relation to its supposed efficacy in attracting and retaining customers. Now, gamification practices are gradually consolidating as design techniques that may provide new opportunities in increasing motivation and engagement and for changing behavior.

Changing behavior

Using game elements for changing people behavior towards healthier lifestyles and more sustainable consumption practices seems to be the great promise of gamification practices. In comparison of serious games, exergames and games for improving psychological and physical states, such as SuperBetter, a game for developing resilience, and Lumosity, a suite of games aimed at enhancing brain performance, all these practices can intervene on existing contexts, without the necessity of developing full fledged games.

Even if the behavior changing aspect is still at an early stage of development, some authors seem to prefigure new opportunities. Rao (2013) states that it is necessary to reconsider current popular gamification strategies based on competition and victory, leaderboards and points, when focusing on changing people behavior. The author suggests to conceive alternative design techniques, as altruism and cooperative social interactions, using emphatic feedback and features aimed at stimulating social responsibility and intrinsic motivation. Laschke and Hassenzahl (2011) propose to go beyond reward mechanisms that reminisce the Token Economy of behaviorism and embrace a vision that embeds meanings in gamification, shaping novel behavior into a meaningful story, for promoting goals such as being happier or being more socially active. Sakamoto et al. (2012) introduce a value-based gamification design framework, suggesting to go beyond common game mechanics: a design based on values (informative, empathetic, persuasive, economic, ideological) could develop services for behavior change, improving user intrinsic motivation and self-efficacy. Jylhä et al. (2013) combine a self-tracking application with a gamified system with personalized challenges based on the data tracked, in order to promote sustainable mobility.

The relationship between game elements and self-tracking applications is probably the field that better exemplifies the challenges that gamification should face in connection to behavioral change. Using game mechanics for motivating users in self-monitoring activities and engaging them in the exploration of their personal data could be a way to conceptualize a new form of gamification: points, badges and leaderboards do not suffice in this context, opening the possibility to imagine a new role for game elements in serious situations (Rapp, 2013).

Inclusion of new game elements

Although points, badges and leaderboards are the most common game elements used in gamification, game designers have a huge quantity of components at their disposal, almost unexplored in the gamification practices until now. Zichermann and Cunningham (2011) propose a taxonomy of game mechanics that should be applied in gamification. They categorize twelve classes of game mechanics, which can be combined and mapped into the Bartle's four player types, to create complex gamified systems. For example, in the collecting category, key game mechanics are collecting objects such as stamps and badges, scarcity and returns and trading mechanisms with others. Werbach and Hunter (2012) note that points, badges and leaderboards are not suitable to all contexts. Starting from the MDA framework (Hunicke et al., 2004), authors list among the mechanics suitable to be used in

gamification interventions challenges, chance, competition, cooperation, feedback, resource acquisition, rewards, transactions, turns and win states. Finally, Robinson and Bellotti (2013) codify a large taxonomy of game elements, differentiating them by Low, Medium, High and Variable, depending on the minimum level of engagement requested for a specific element to become effective: for example, in the class of intrinsic incentives, the authors list curiosity, challenge, entertainment, social reward/peer pressure, personal returns, societal returns.

The main problem with these taxonomies lies in the lack of examples apt to show, on the one hand, the implementation of these new game elements and, on the other hand, to prefigure how a complex gamified system could be. Zichermann and Cunningham (2011), for example, cite GetGlue to illustrate the mechanic of scarcity, since it offers its users badges in limited edition for the new season of Dr. Who. ClubPsych (http://clubpsych.usanetwork.com/) is signaled by Werbach and Hunter (2012) in relation to the mechanic of challenge, since the website allows users to answer questions and watch videos gaining points and climbing leaderboards. It is clear that even if these applications incorporate some elements not commonly used in gamification practices, their logic is based on the PBL triad.

Recently, among designers an awareness is spreading: new ways must be explored in designing journeys that evolve and creating experiences of fun. Ferrara (2012a), for example, notes that it is more and more necessary for UX designers to expand their competencies in game design, in order to create high-quality player experience. Nicholson (2012) highlights the need of introducing meaningful game elements for developing a meaningful gamification: deeper integrating of game mechanisms into non game contexts; taking inspiration from player-generated contents in order to allow users to set their own goals, create their own tools and their own leveling system; looking to Alternate Reality Games for community-based aspects so that participants can find meaning through group engagement. All of these are only some of the suggestions that the author proposes.

We do not know whether the inclusion of new game elements could lead to a radically transformation of gamification: but it is clear that game design and video game worlds have much more to offer to the design of interactive systems than what we have seen until now.

Threats

Failure by poor design

In 2012, Gartner predicted that "by 2014, 80 percent of current gamified applications will fail to meet business objectives primarily because of poor design" (Gartner, 2012). For Gartner, the main problems lie in the lack of game design talents to apply to gamification projects and the focus on obvious game mechanics, "such as points, badges and leader boards, rather than the more subtle and more important game design elements, such as balancing competition and collaboration, or defining a meaningful game economy" (Gartner, 2012). Gamification designers often confound the creation of an enjoyable experience with the implementation of a reward system. Besides, rewards themselves often fail their aim, not resulting rewarding for their users. Points, badges and leaderboards, in fact, in most cases are not rewarding per se, but represent feedback to the player actions or tokens that refer to further valuable elements. Users accumulate points for exchanging them for preferred items, activities and privileges that represent a set of backup reinforcers (Cooper et al., 2007); otherwise points could simply indicate a progression towards mastery or belonging: what is rewarding, however, is not points but the elements they represent (Pihl, 2013). By not recognizing what is really rewarding for users and the meaningful aspects of gamification has recently generated a sense of skepticism: if these practices will continue to implement poor design application and services, it is easy to imagine that the sort of fame achieved up until now will soon be fading.

Behavior manipulation and ethical issues

Gamification applied to behavior change is not exempt from the worries, as well as ethical doubts, that always come with new technologies. First of all, it bumps into the same dilemmas that afflicted the mass communication means in the 1950s. As a new form of hidden persuasion (Packard, 1957), leveraging the power of games for attracting unaware customers pushing them to buy more and more, gamification could be seen as merely an expedient for promoting mechanical behaviors and increasing customer relationship metrics, without any improvement of the user experience. Heather Chaplin states that "in a gamified world, corporations don't have to reward us for our business by offering better service or lower prices. Rather, they can just set up a game structure that makes us feel as if we're being rewarded. McGonigal goes even further. She talks about an 'engagement economy … that works by motivating and rewarding participants with intrinsic rewards, and not more lucrative compensation.' This economy doesn't rely on cash—rather, it pays participants with points, peer recognition, and their names on leader boards. It's hard to tell if this is fairy-tale thinking or an evil plot" (Chaplin, 2011).

Warnings related to the manipulative power of gamification are arising from many parts. For Danah Boyd, gamification "will seep into many aspects of life without us even acknowledging it. It'll become a central part of neoliberal ideology without folks even noticing it. Why? Because it's a modern-day form of manipulation. And like all cognitive manipulation, it can help people and it can hurt people. And we will see both"; while for Viktor Suter "gaming itself can be a terrible addiction—I'm not sure what the proliferation of gaming interfaces in non-game settings will mean to those with the addiction" (Anderson and Rainie, 2012). The risk of creating addiction and driving behaviors of unaware customers are dreaded by researchers and common users.

Another element to consider is related to the expansion of the game logic to the contexts of everyday life and its consequent devaluation in the eyes of the users. As David Cohn highlighted, "If everything is a game, then no game is fun"; Susan Crawford on the same notes: "If everything was a game, no one would have a reason to invent; any metric corrupts, as people shape their behavior to ensure that they come out on top" (Anderson and Rainie, 2012). A widespread competition triggered by game mechanics could favor repetitive behaviors, emptying experiences and creative processes. This threat calls to mind the dystopia presented at DICE 2010 by Jesse Schell, where extrinsic motivators permeated a future world, covering every actions of people with a patina of meaningless mechanics connected to fame.

Unrealistic expectations

The spread of gamification in work process, educational dynamics and interactive systems generated a series of expectation, among companies, designers and researchers, related to the power of games in driving human behavior: now the risk of disappointment is more concrete than ever. The idea that gamification should represent a panacea is surely unrealistic. Nor every contexts is suitable of being addressed with it, neither the game elements are able to engage all type of users. Gamification limits such as poor designs, repetitiveness and meaningless rewards, risk to soon betray the expectations: hanging in the balance between being considered a panacea or a buzzword, this design technique is far from being a grounded acquisition in the design world. In Gartner's hype cycle for emerging technology (2013) gamification is now positioned in the peak of Inflated Expectations. A reduction of expectations and interests in the next years is somehow physiological, since many applications are failing in reaching their goals. This is indeed a desirable reshaping: history of technology provides many examples of overexploitation of new inventions based on excessive expectations and poor scientific data. It is necessary, besides, that designers are aware of limits of what is called now gamification, focusing on investigating the motivational dynamics and behavioral processes that lie in the gaming world and could be employed even in non game contexts.

CONCLUSIONS

The picture that emerges from this SWOT analysis highlights that gamification is still in an early stage of evolution, scarcely supported by hard facts when it comes to efficacy. Designers seem to use it as a convenient design technique to increment in the short term the customer metrics, but persisting in this attitude could lead to a drop of interest both for the addressed public and for researchers that are starting to delve this phenomenon. Thus, it seems necessary to go beyond these consolidates practices to find new ways through which conceptualize and imagine the role of game elements in non game contexts.

A first step along this path is connected to the evaluation methods used to estimate the efficacy of gamification. As noted by Hamari (2013), evaluating the success of gamification only on the basis of metrics that measure the augmentation of the costumer experience leads to ignore the subjective experiences of the users: what kind of meanings do users attribute to the game elements outside their original contexts? Do the gamified applications currently on the market lighten the user experience with a sense of enjoyment and fun? Do they create a joyful experience?

Another key point is represented by the game elements involved in gamification practices. Addressing new game elements, more complex and articulated, extracted from the gaming experiences of players and not from consolidated praxis or game design manuals, is a way for contributing to moving the designer point of view into the user experience: how would it be possible to re-create the same feelings of enlightenment, interest, fascination, challenge, suspense that players experience during the phases of hard playing even in non game contexts? How to trigger the same motivational pull and behavioral commitment that lie in the video game world even in serious situations?

Trying to apply these new game elements to behavior change is one of the biggest opportunities that designers should address. The Quantified Self, as an emergent area of applications that are trying to drive user behaviors though self-knowledge and self-reflection, could be an optimal testing ground for a new use of game elements in non game contexts, since we could imagine to overcome many of the issues related to the self-monitoring activities using suggestions derived from the video game worlds (Rapp, 2013).

From this perspective, however, it seems necessary to start moving towards a qualitative inspection of the user experience in using gamified applications, investigating their effects on motivation and engagement from the point of view of the users. For this reason, as the next step of our research, we aim at discovering, through a series of focus group sessions, how users perceive the actual implementations of gamification, pointing out its potentialities and lacks through the eyes of the users.

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Content Evaluation of Exciting Feeling by Using Biosignals

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ABSTRACT

Entertainment markets continue to expand, and Interactive systems are becoming more and more common, fueled by the dramatic progress in the fields of computer graphics and hardware (Tetsuro Aoto, 2007). In the content of such interactive systems, important factors include increasing excitement. Thus, we use young adult males in their twenties and assess their opinions of *"exciting"* by questionnaires and employed it as a keyword to clarify their exciting scene. Based on our questionnaire results, we created two game contents and evaluated whether they elicited exciting feeling using biological signals.

Keywords: Effective engineering, Biological signal, Exciting feeling

INTRODUCTION

Entertainment markets continue to expand, and interactive systems are becoming more and more common, fueled by the dramatic progress in the fields of computer graphics and hardware (Tetsuro Aoto, 2007). In the content of such interactive systems, increasing excitement is critical. Previous research measured excitement or mental workload by biological signals (Michiko Ohkura, 2011, Nobumichi Takahashi, 2013). Thus, we assess a game content's excitement by biological signals on young people in their twenties to whom we gave questionnaires in which "exciting" was employed as a keyword to clarify their exciting scene. Based on questionnaire results, we created two game contents and evaluated whether they elicited exciting feeling using biological signals.

EXPERIMENTAL

Experimental System

The outline of our experimental systems is shown in Fig 1. They consist of the following components:

- PC that shows exciting contents
- Speakers
- Sensors (or electrodes) and instruments to measure EEG, ECG, SPA, and Eye tracking
- PCs that control measurements of these biological signals

To measure SPA (Galvanic Skin Potential), the surface of the finger's palm is commonly used. However, since palms are involved in PC operation, we instead employed the bottom of the foot.

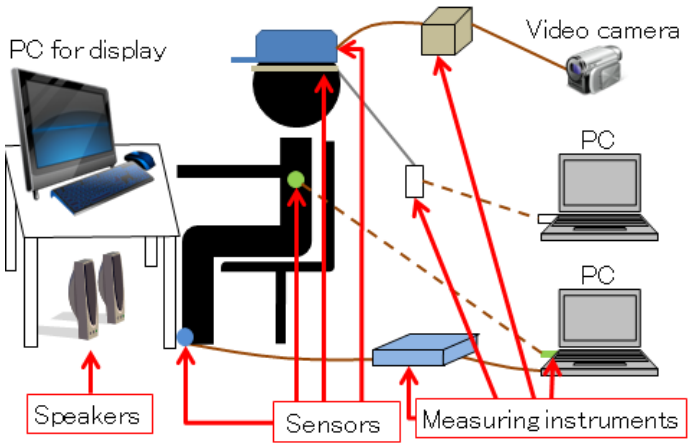

Fig. 1 Outline of experimental system

Game content

We created the following two "exciting contents":

I. Music server: exciting content

Participants select the most exciting song from a song database on the PC and listens it.

II. Treasure box: exciting content

Participants choose one of three treasure boxes and gets points when he finds treasure. He repeats this selection ten times to get more points. The six games that provide treasure are determined beforehand. Participants play six games.

Experimental procedures

We conducted the following experiments of the two game contents:

Music server experiment

(i). The experimenter explains the content.
(ii). Participants select the most exciting song.
(iii). They listen to it.
(iv). They answer questionnaires.

Treasure box experiment

(i). The experimenter explains the content's task.
(ii). Participants play one game.
(iii). They answer questionnaires.
(iv). Procedures (ii) and (iii) were repeated five more times.

We constantly measured the following four biological signals during the experiments:

- EEG
- ECG
- SPA
- Eye-tracking

Questionnaire and biological indexes

We employed question items of paired 7-point evaluations. The following are the question items:

- Exciting
- Thrilling
- Interesting
- Nostalgic
- Expecting

The biological indexes for our analysis are shown in Table 2. These indexes were candidates for exciting feelings and mental workload (Shinji Kajiwara, 2010 and). RRI means the interval between the R-waves of ECGs, and SPR means the change of the skin's resistance by sweating.

Table 2 Biological indexes for analysis

Biological Signals	Biological Indexes
EEG	Alpha ratio average
	Beta ratio average
	Beta/alpha average
ECG	RRI average
SPA	SPR average
Eye-tracking	Pupil diameter average

EXPERIMENT RESULTS

We performed experiments with eight male students in their twenties. We divided each biological signal time sequence into sections on which we set each content and analyzed it. The missing values of the pupil diameters were excluded due to the blinking of every participant. We calculated and standardized the biological indexes for each content for each participant's section. We used the rest states of the biological indexes for each content's section for standardization.

Music server

Questionnaires

The average of each question for all participants is shown in Fig. 2. We performed t-tests to determine whether the averages exceed 0. The following significant differences were found:

During selection: exciting, interesting, nostalgic > 0 ($p<0.01$)

During listening: exciting, interesting, nostalgic > 0 ($p<0.01$)

From this result, participants might be excited at the content.

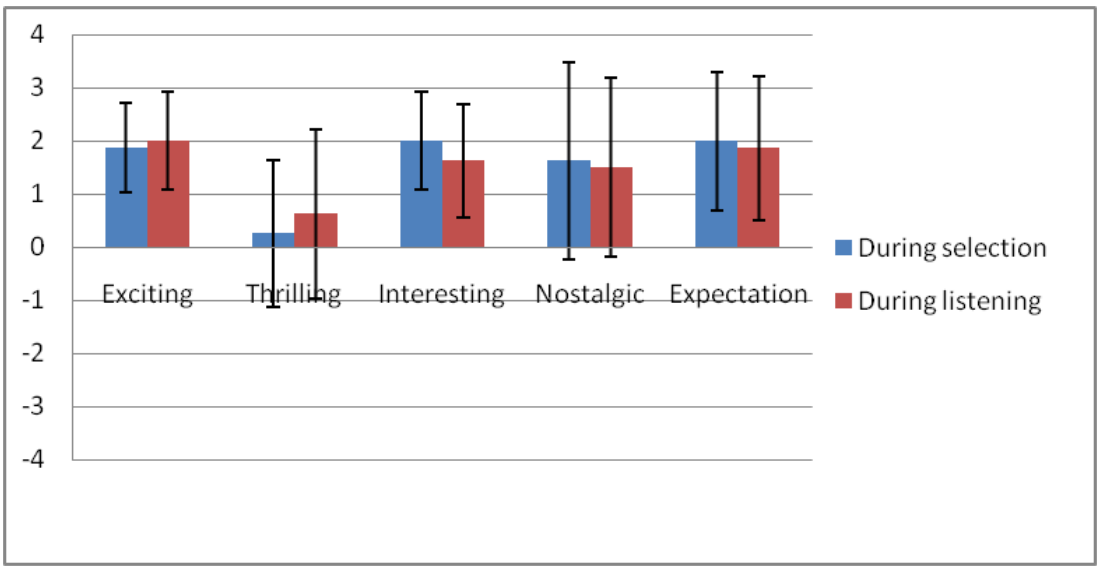

Fig. 2 Average of each question of all participants

Biological signals

Biological signals are divided into the sections as following:

- Rest state section
- During selection section
- During listening section

Figure 3 shows the RRI averages of all participants. We performed an analysis of variance between each section and found that the section's main effect was effective at a 1% level. The following are the multiple comparison results:

During selection, listening < rest state ($p<0.01$).

From this result, participants might be more excited during both the selection and listening to the song than the rest state; this agrees with the questionnaire result.

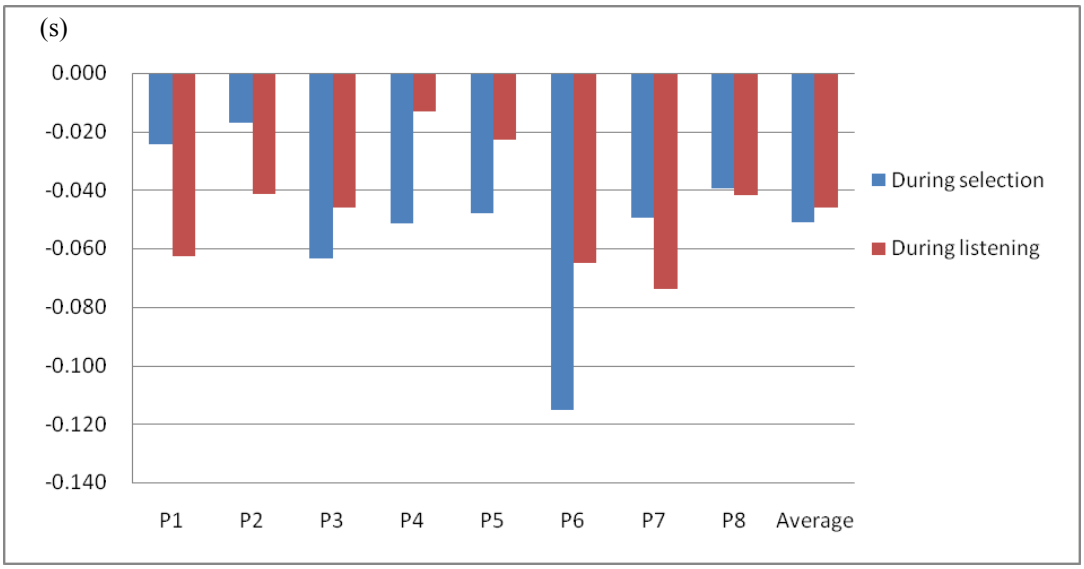

Fig. 3 RRI averages of all participants

Treasure box

Questionnaires

The questionnaire results suggest that P6 and P7 might not be excited. Therefore, these two participants were excluded from our analysis. The averages of each question of the remaining participants are shown in Fig. 4.

We performed an analysis of variance among the games. The main effects of the sections were effective at the 1% level. The following are the multiple comparison results:

$$5\text{th game} > 6\text{th game} \ (p<0.01).$$

The choices of the 5th game's patterns are all correct, and thus the participants might feel greater expectation to continue choosing the right choice.

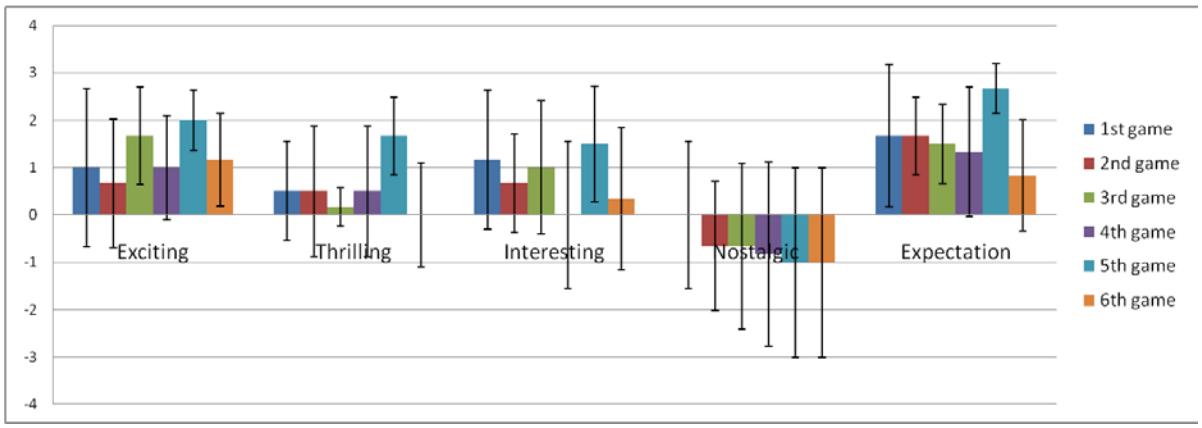

Fig. 4 Averages of each question of six participants

Biological signals

The biological signals were divided into the following seven sections:

- Rest state section
- All six individual game sections

Figure 5 shows the SPR averages of six participants. We performed an analysis of variance between each section. The main effects of the sections were effective at the 1% level. The following are the multiple comparison results:

$$1\text{st game} < 5\text{th game} \ (p<0.01).$$

The game that shows a difference is not the same as the questionnaire results. However, since the 5th game shows a high value on both sides, the participants might feel excited due to their expectations.

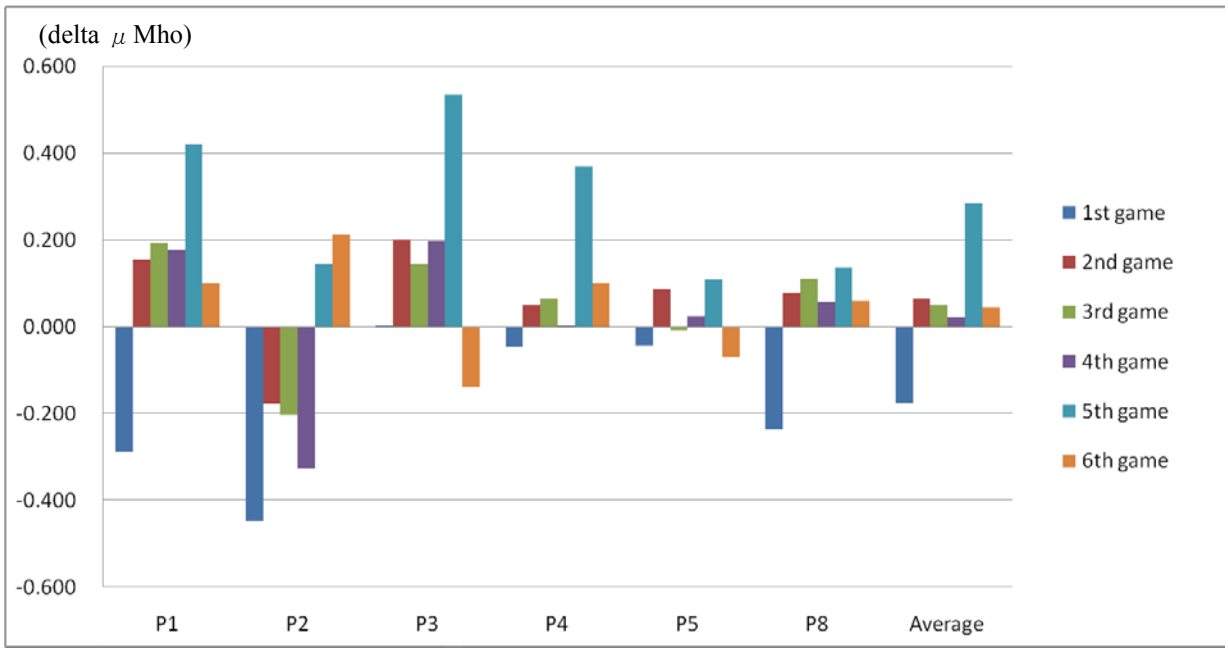

Fig. 5 SPR averages of six participants

DISCUSSION

We confirmed that the RRI and SPR averages are indexes of exciting feelings. However, since the tendencies of the RRI and SPR averages were different, their averages might show different exciting feelings.

CONCLUSIONS

We experimentally obtained the following conclusions.

- The RRI average might be an index of exciting feelings.
- The SPR average might be an index of exciting feelings.
- Perhaps the RRI and SPR averages reflect different exciting feelings.

Future work will distinguish among kinds of exciting feelings by biological indexes.

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Section 11

Emotional Design and Product Longevity

Toys and Product Longevity

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ABSTRACT

This article explores how a child's personalization of play themes is connected to the experience of play and furthermore how such creative activity can influence feelings toward toys, and subsequently how this affects the degree of pleasure elicited by play, and finally how this influences the toys' longevity. The basis for the study is an experiment performed with children from 6 to 9 years old, where situations of purchase and play, were observed. The empirical data is explored within the framework of pragmatist aesthetics and *Art as Experience* by John Dewey. This analysis brought forth the following key factors for classification: *intellectual classification, recognition, resistance, and creation of personal experience.* The analysis suggests that there is a tendency for children not to create their own play theme when a new toy is presented through associated media that proposes a theme for the play activity. Furthermore, it is suggested that the personalization of play themes enables the child to create personal experiences, a factor that contributes to a higher degree of pleasure, which can delay the child's desire to replace the toy. Implications for designers: create toys that let the child in on the process of creating and altering play themes.

Keywords: Personalization of Play Themes, Transmedia Storytelling, Product Longevity

INTRODUCTION

Today's toys often exist on multiple media platforms. Each type of media, such as games, cartoons, and tangibles, influences the experience of the toy and the manner in which children play with it. This complex toy-media platform presents a play theme through, for example, movies, cartoons, or games, and is called *transmedia storytelling* (TS). Although toys that utilize TS often demand quite a bit of learning, planning, and skills, they also prescribe how to play, which theme to play within, and consequently the child's play experience.

Children in Western society are locked into an unsustainable consumer behavior (Shove, 2003) since the constant offerings of novel must-haves, presented through TS, make a strong context of influence (Pfister & Bohm, 2008). Children cannot be expected to understand the consequences of such consumer behavior in relation to the environment, as they put pressure on their parents to purchase toys. There is plenty of evidence that attitudes or intentions influence behavior (Ajzen, 1991; Cialdini, 2009). If children and their parents understood the consequences of their consumption, and would want to become sustainable actors, these attitudes are often overrun by habits (Grankvist & Biel, 2007). Accordingly, strategies of consumer-product attachment (CPA) that can influence toward sustainable behavior without having to change attitudes and norms might be effective in order to reduce the replacement rate of toys.

As toys influence play, play enabled by a toy affects the degree of attachment toward the toy. The child connects experiences that emerge by play, throughout all stages of ownership of the toy, to the toy itself (Ball & Tasaki, 1992; Chapman, 2009; Gulden, 2013; Heljakka, 2013; H. Schifferstein & Hekkert, 2008; Hendrik N.J. Schifferstein & Zwartkruis-Pelgrim, 2008b). Thus, the toy's ability to elicit experiences is connected to how long a person hangs on to it (Gulden, 2011, 2013; Mugge, Schoormans, & Schifferstein, 2009; Hendrik N.J. Schifferstein & Zwartkruis-Pelgrim, 2008b), given that one does not replace products that are treasured. Even though people have the propensity to favor new things (Dahlen, Lange, & Smith, 2010), strong feelings of attachment toward a toy make new products offered on the market less tempting (Chapman, 2005, 2009; Nes & Cramer, 2005; Nicole van Nes, 2006).

Product personalization is a strategy recognized to elicit feelings of CPA, and it involves letting the user in on the making of a desired product before, during, or after purchase. Providing opportunities for the user to alter a product during the whole ownership has been suggested as a way of strengthening feelings of CPA (Mugge, 2007; Nicole van Nes, 2006). Toys can often be physically altered. However, the associated theme that comes with the toy, such as *Star Wars* or *Harry Potter,* is often permanently attached to the physical toy or its parts, which hinders the making of new play themes.

In order to study how associated play themes that come with TS-toys can influence the degree of CPA and consequently the durability of a toy, we (researchers in adult learning and art and design) performed a play experiment with children aged 6 to 9 years. In the experiment, the children were taken to a toy store where they got 100 NOK each to buy a toy. They rode back to school after the purchase to play with the new toy in a room with tables prepared with do-it-yourself (DIY) materials. As one would expect, the children automatically started to play with the materials on the tables when they had finished playing with the toys. As this activity proceeded, the children started to create their own play themes, a situation that did not happen while they played with the TS-toys.

The dimension of the children making their own play themes was analyzed in relation to product attachment through the research question of: How can one understand the design of toys that promote product longevity within the theoretical framework of pragmatist aesthetics (Dewey)?

Section 1 provides an explanation of the approach for the study. Section 2 offers a short synthesis of play theory. Section 3 describes the contemporary situation of toy design. Section 4 gives a brief overview of social aesthetics, which, along with the theory on pragmatist aesthetics in section 5, forms the basis for the analysis of play.

METHOD

The Experiment

The empirical data explored through theory is engendered by way of a play experiment. The experiment was set up to study children's behavior while planning to purchase, purchasing, and while playing with the purchased toy.

The experiment involved four groups of nine children aged 6 to 9. The children were transported in groups by bus to the local toy store where they got 100 NOK each to spend on a toy. After the purchase, the children rode back to school to play. Groups 1 and 2 had access only to the toys they purchased when they came back to school. The rooms in which groups 3 and 4 played were prearranged with extra materials such as tape, paper, plastic tubes, and ropes on the tables.

While observing, we noted instances of peer learning, initiatives toward other children, fantasizing and creation of play themes, isolation, cooperation, sounds, and movement. The observations were documented as notes, as the approval given by the parents did not include video recording. The observations were partly participatory in the sense that the children involved the observers in play and asked for help when needed. Master students in product design observed one child each, and the researchers did an overall observation. The children were observed before, during, and after the purchase of a toy and in particular when playing with toys.

In group 3, all nine children bought Lego toys. The probability of disclosing tendencies of play was therefore assumed to be higher in this group since all children had similar toys. Accordingly, this study refers mainly to the empirical data engendered from this group.

The Analysis

The analysis of the empirical data engendered by the experiment was explored through the theory on CPA and pragmatist aesthetics described in John Dewey's book *Art as Experience (Dewey, 1934).* The practical aim with this approach was to engender categories that could be used for the analysis of the empirical data. This was necessary in order to study how transmedia storytelling-toys (TS-toys) influence the degree of children's personalization of play themes and following-play experiences. The key terms explored in this study—namely intellectual classification of objects, recognition, resistance, and creation of own experience—appear in sequential order in Section 5. Besides a theoretical exploration of the empirical data, this analysis is also meant to illustrate theory.

Dewey's works describe the possible complete aesthetic experience, and real pleasure, rather than seeing experience as a diversion. This understanding of experience and pleasure can contribute to the understanding of the CPA strategy of personalization within the domain of toy design and longevity.

Longevity is, in this paper, understood as emotionally durable design, in which the emotional tie to a product elicits feelings of CPA and an urge to hang on to a product rather than replace it (Chapman, 2005; Mugge et al., 2009; Nicole van Nes, 2006; Hendrik N.J. Schifferstein & Zwartkruis-Pelgrim, 2008b).

Personalization of play themes involves the act of creative thinking and behavior. This study acknowledges Czsikszentmihalyi's definition of creativity as a "process by which a symbolic domain in the culture is changed" (Csikszentmihalyi, 1996; Gauntlett, 2011). The creative act in this context involves creation or transformation of play themes, physical objects, and rules and games. Research that describes the dimension of making performed by the common man, without the intervention of a designer, is often referred to as "do-it-yourself" (DIY) activity (Freeman; Gauntlett, 2011). Research on DIY activities involves, among others, the exploration of how people's perceptions of a product change through the actions of altering or constructing it.

In this study, a *toy* is defined as a play concept that can include an object and/or cartoons, sounds, games, and other possible media. A play theme is understood as the plot in which the child plays and the context in which a toy is presented. Observations in this study show that play themes presented through TS-toys are linked to the experience of them and the content of play. Therefore, there is an emphasis on TS-toys in this paper.

Play is defined in various disciplines and is often seen, from evolutionary and psychological perspectives, as a way of preparing for life (Sutton-Smith, 1997, p. 231). These perspectives are typically oriented toward the consequences of play and the purposes play serves, such as the obtaining of skills, and not what "play is in itself" (Huizinga, 1955, p. 3). This research is oriented toward the content of playing and how this activity can stimulate the making of personal experiences. Therefore, Huizinga's definition of play as a voluntary and "free activity standing quite consciously outside ordinary life as being not serious" and "fun" (Huizinga, 1955, p. 13) is recognized. Free, in this context, is understood as voluntary but not free from influence.

The fact that play is not "serious" in this setting does not mean that play is not perceived as serious by the participant; on the contrary, a player can engage "intensely and utterly" (Huizinga, 1955, p. 13)**.** Within the boundaries of play, a player would indeed ruin the game without serious intentions (Gadamer, 2004). A high degree of seriousness involves the participants taking risks. Moreover, "it is the risk that makes play attractive" (Gadamer, 2004, p. 137).

TRANSMEDIA STORYTELLING

Huizinga points out that play does not depend on material equipment. Nevertheless, it can be triggered, encouraged, or sustained because of equipment such as toys, or related themes presented with or in addition to equipment (Huizinga, 1955). This view is in line with Gadamer, who stated that conscious aesthetics can elicit activation (Gadamer, 2004). Furthermore, partaking in rituals and games often involves, or even depends on, products or toys (Heljakka, 2013; Huizinga, 1955).

Toy manufacturers have found that toys linked to media are often the bestselling ones (Heljakka, 2013, p. 28; Levin, 2010, p. 16). Early mass-produced toys typically emerged out of children's interests in firefighters, motherhood, war, or fairy tales, but they also came from popular culture, such as comic books like *Superman* (Heljakka, 2013, p.

19). *Superman* comics or cartoons can offer children suggestions for how to play *with* the action figure while also serving as market channels *for* the action figure. The success achieved by presenting a toy connected to a narrative, as in this example, has led to a development strategy that starts with the creation of a narrative followed by the development of tangible toys. The movie *Toy Story* is an example of such a process, in which the movie "actors" are in fact toys, which are, in turn, sold as real toys. The development of such toys that perform across multiple media platforms has led to the creation of *supersystems*, in which a toy merely forms one part of the whole concept (Kinder, 1991, p. 123). As Kinder explains:

> In order to be a supersystem, the network must cut across several modes of image productions; must appeal to diverse generations, classes, and ethnic subcultures… must foster 'collectability' through a proliferation of related products; and must undergo a sudden increase in commodification, the success of which reflexively becomes a 'media event' (Kinder, 1991, p. 123).

The advertisement of toys has, in other words, shifted from the announcement of information on different media platforms to toys being a part of games, cartoons, the Internet, tangible objects, and movies. Each type of media represents different sets of challenges and ways to play and, therefore, often reveals different pieces of information about the narrative to form the whole plot. Marsha Kinder coined the term *transmedia intertextuality* to explain this division between the supplementary dimensions of a toy that enlarge the experience and the toy's market potential (Kinder, 1991, p. 38). Henry Jenkins later uses the term *transmedia storytelling* (Heljakka, 2013; Jenkins, 2003).

Gadamer argued that formations or contexts brought about by conscious aesthetics place something *"into play"* (Davey, 2011; Gadamer, 2004; Huizinga, 1955, p. 1). Accordingly, TS-toys can lead to new understandings or experiences enabled by the broad structure of the toy, associated play theme, and possibilities as well as limitations. Moreover, a toy can give a child a "guided reinvention" (Frisch, 2008) that can stimulate or push the child toward action, creation, or the formation of solutions and games (Gadamer, 2004, p. 138)**.**

DESIGNING FOR PRODUCT ATTACHMENT

People purchase out of the urge to generate positive emotions (Chapman, 2005; Hendrik N. J. Schifferstein & Desmet, 2010). The degree of CPA can be understood as the strength of emotions toward products (Hendrik N.J. Schifferstein & Zwartkruis-Pelgrim, 2008a), and emotions elicited by products are referred to as product emotions (Desmet, 2008). Research on CPA has engendered several strategies on how to strengthen product emotion beyond the aforementioned strategy of product personalization (Mugge et al., 2009; Nicole van Nes, 2006) such as "do-it-yourself" processes (DIY) (Freeman; Mugge et al., 2009), "do it with others" (DIWO) (Freeman), products that surprise (Ludden, Schifferstein, & Hekkert, 2008), products serving as objects of transition (Freeman), products perceived to be scarce (Cialdini, 2009; Gulden, Moestue, & Berg, 2010), products that are owned together with other people (Mugge et al., 2009; Hendrik N.J. Schifferstein & Zwartkruis-Pelgrim, 2008a), and products that enable different levels of activation (LoA). Many of these strategies urge designers to facilitate processes in which users take part in the creation of personal experiences motivated by the product, in order for them to cherish the product more.

The strategy of the LoA describes how a user will become more attached to products that stimulate on a cognitive, emotional, relational, perceptive, and imaginative level (Gulden, 2013). The activation serves to facilitate the user to produce personal experiences and therefore memories. Moreover, the product will serve to convey memories about prior salient happenings and therefore represent meaning for the user or owner, and accordingly represent a higher degree of CPA. Thus the product and its role in the elicitation of experiences is not the most important aspect when it comes to the degree of CPA; the significance of the experience for the user is the most important factor (Gulden, 2013; Hendrik N.J. Schifferstein & Zwartkruis-Pelgrim, 2008b).

The importance of designing for the various phases of ownership in order to achieve CPA is well known (Ball & Tasaki, 1992) and a method for doing this is described in *Contexts of Experience* (Gulden, 2011), among others. Similar approaches are seen in the marketing of TS-toys in order to influence consumers at the point of purchase. In order for this to happen, the product is marketed through TS. This serves to prime the potential customers. Such priming will again stimulate functions of recognition at the point of purchase, and motivate the buyer either to consider a purchase different than the established habit or to sustain the existing habit (Bhamra, Lilley, & Tang, 2011; Dahlstrand & Biel, 1997; Grankvist & Biel, 2007; Kahneman, 1992; Verplanken, Walker, Davis, & Jurasek,

2008). For example, a Pokémon figure can be recognized in the store because of the cartoon shown on TV or by a digital game; consequently, it will stimulate purchases among children who have many of these figures already and those who are reminded about the cartoons or games because of the new experience in the shop (Grankvist & Biel, 2007). Thus, the marketing strategy involves the designing of an experience related to the product for the *pre-purchase* phase and the *point of purchase* phase of product ownership (Ball & Tasaki, 1992; Dahlen et al., 2010; Gulden, 2013).

Accordingly, manufacturers influence consumer behavior before and at the point of purchase through the acquired attention and activation through transmedia storytelling.

PRAGMATIST AESTHETICS

Dewey emphasizes the ability of aesthetics to elicit experiences. Moreover, he finds the process of creating experiences to be a central dimension in aesthetic practice, which he describes as "the privilege of the dynamic aesthetic experience over the fixed material object" (Shusterman, 2000), a privilege that implies that both the artist (or designer) and the audience are the creators of the experience. This understanding implies that there are no aesthetic truths or essences that a creation can comprise that can lead to a common definition of quality. The emphasis is rather on the "relation between thoughts and actions" (James, 1907).

Dewey stresses the importance of *resistance* as part of an experience that can work as an "invitation to reflection" (Dewey, 1934, p. 46) and further lead to "a higher complexity of thinking" (Shusterman, 2000). In a situation influenced by resistance and conflict, aspects and elements of the self, and the world that is involved in this reciprocal influence, imprint the experience with feelings and ideas in such a way that a conscious intention emerges (Dewey, 1934, p. 36). He even states that there is "an element of undergoing, of suffering in its large sense, in every complete experience" (Dewey, 1934, p. 42). By this, Dewey implies that the perceiver must go through processes similar to those of the creator, such as the act of abstracting what is significant for the creation. Thus, in order to perceive, a *"beholder must create his own experience*" (Dewey, 1934, p. 56); otherwise, the perceiver will not hear or see, and the experience will merely be shaped by norms and conventions, rather than emotional excitations (Dewey, 1934, p. 56).

Dewey claims that *recognition* hinders the creation of a personalized experience, namely: "recognition is perception arrested before it has a chance to develop freely. In recognition there is a beginning of an act of perception" (Dewey, 1934, p. 54).

The *intellectual classification* of an object influences our perception and understanding of it. Dewey gives an example of this through an anecdote. He describes a situation where an object is first recognized as a fine artwork and believed to be created by indigenous people. When it is discovered only to be a piece coincidentally and curiously shaped by nature, all of a sudden, it would seem more appropriate to have the object in a museum of natural history than an art museum (Dewey, 1934).

PLAY EXPERIMENT IN LIGHT OF PRAGMATIST AESTHETICS

Observations from the Experiment

The observations from group 3 are divided into two charts. Chart 1 (Figure 1) provides observations of the children while they played with Legos, and chart 2 (Figure 2) provides observations of play with the DIY materials. The observations of activities are classified within the categories outlined in the theory (Section 5), which are: intellectual classification of objects, recognition, the degree of creation of personal experience and premade experience, and high and low resistance. Objects which were created with the DIY material, with the associated play themes that occurred, included signs with hearts, a hotel shower-toilet, a plane, four fantasy toys (which were played with, but for which the observers were uncertain about theme and function), TV2 News show, a heliport, skis, and a unit for keeping spare Lego parts in order.

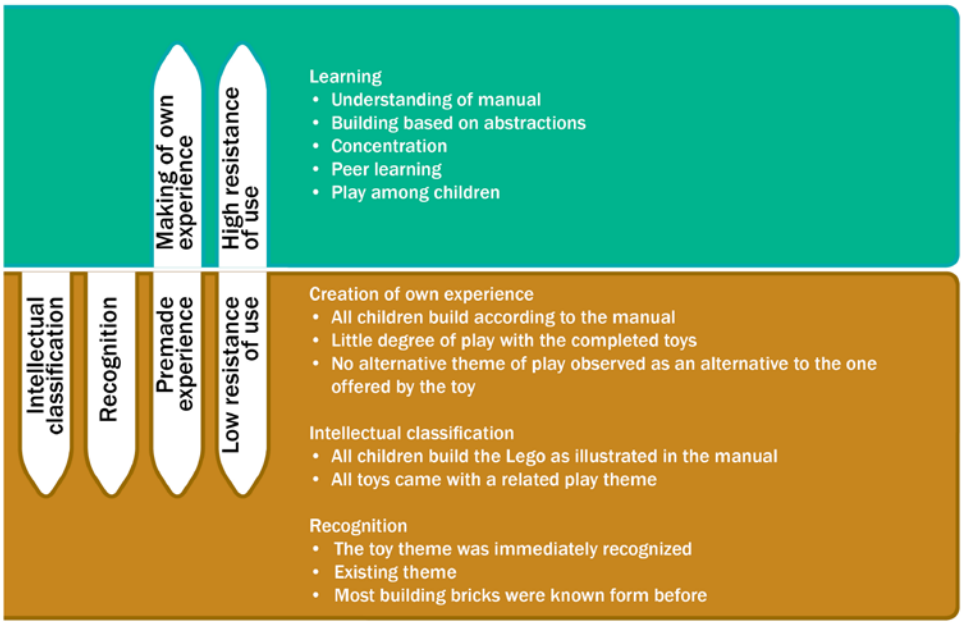

Figure 1. Observations from play with Legos, placed within categories of pragmatist aesthetics

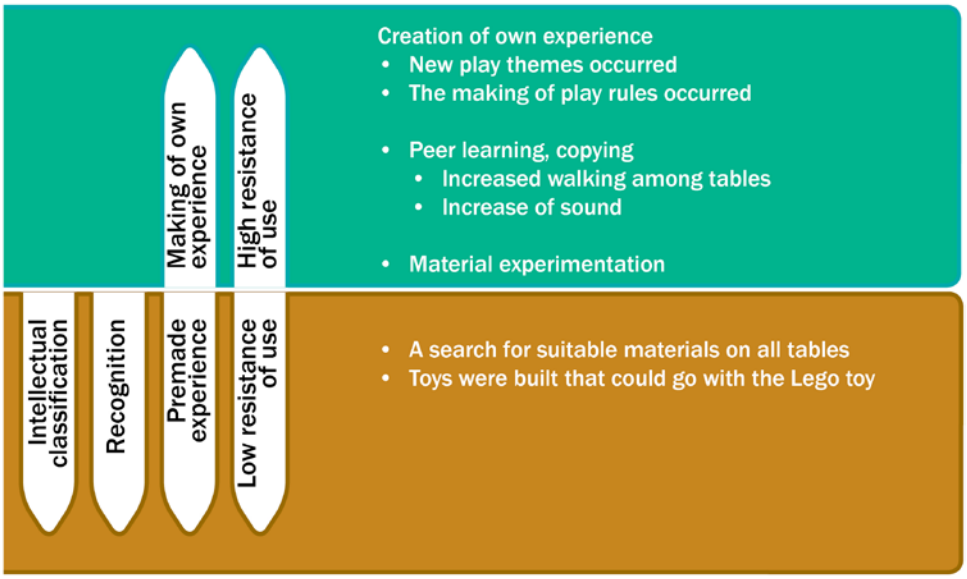

Figure 2. Observations from play with DIY materials, placed within categories of pragmatist aesthetics

Intellectual Classification of Objects

TS-toys are connected to a larger system that includes cartoons or films produced by the toy company (such as Pokémon or Chima) or existing successful films (such as *Star Wars* or *Lord of the Rings*). Such systems serve to place a product within an intellectual classification. The aim of establishing systems like this is to meet with the themes in which children are already engaged and to achieve "recognition" (see next chapter) at the point of purchase. Cartoon narratives, created in order to establish play themes in which to present toys (which are viewed on, for example, cartoon TV channels) and to intellectually classify are, with the obvious exceptions, often cognitively easy to grasp, unchallenging, and have an easy-to-foresee ending. Typically, the play themes describe a "good against evil" plot in which the good prevails in the end. The characters in these cartoons often clearly describe who is good or evil through appearance and behavior.

Observations from the play experiment in this study show behaviors inspired by the themes conveyed by the toys. For example, the children dueled with swords and spun a Beyblade (whirligig game). In relation to the latter, one child coupled the play with the Beyblade to the characters in the pertinent TV cartoons. As one observer noted: *"The oldest boy referred to what they were saying in the cartoon when spinning the Beyblade."* Another example is from playing with Lego Friends. From the observation:

> *The Lego building set was built around the theme of karate … she also started to play karate with a friend, using some of the equipment from the Lego set. We asked her why she did it; she said, "Because they do it in the set." She also said that she wouldn't be bored of this karate set because she could do it over and over again …*

The children in the other groups that played with toys that had no associated play theme personalized the theme of play. One example is playing with the slime lump "SSS," as described by an observer:

> *They started to do difficult things with it such as to put the hand through it, using it like a bracelet. "Doesn't that hurt?" they said when different children tried it. They had a good tone. Using the area. Walking, running around cheerfully. They also started to play with other groups; they started a game, trying to hit each other's faces when standing behind a board with holes in it. At the end, four kids were playing this game with children constituted from different groups.*

These examples show that the combination of toy and play theme offered by a toy is linked to how children play with it. These few examples may, therefore, illustrate the theory of how intellectual classification by the representation of a play theme influences behavior and experience.

Indeed, the Lego toys were connected to play themes, but they only stimulated a small degree of play in this experiment. This might be because the children did not think of Legos as toys. As one girl who had been constructing an object with Legos said, *"There, now I can play!"* When an observer asked, *"What have you been doing so far?"* the girl replied, *"Building of course."* Furthermore, the children might have felt that they should build the Legos first to show their gratefulness for receiving the toys.

Recognition

Some children put aside the toys that they bought during the experiment after only a short while. This might have to do with the fact that the children found it difficult to buy something they liked within the limited amount of money and time they had in the store. It might also have to do with purchases made on impulse due to recognition, which, in some situations, might have arrested the children's attentions before they had a chance to develop freely (Dewey, 1934). Furthermore, the toys that became uninteresting after a short while (such as swords and a coin flip battle game) did not seem to challenge the children in any way. They knew how to use them and did use them, but the play lacked any kind of creation of new themes. As one observer put it, "Now I know that children are not able to buy what they like in a toy store." Recognition is obviously valuable for sales, but it offers only "a beginning of an act of perception" (Dewey, 1934, p. 54). Therefore, according to Dewey, recognition does not stimulate a full experience. Recognition is a process comparable to the methods used in brand development today, built around the effort to build positive associations (Aaker & Joachimsthaler, 2009, p. 121; Kotler & Pfoertsch, 2010).

Resistance

Within the works of Dewey, aesthetic experience has to do with the recipient having to make some sort of effort or partake in the experience for it to be whole or meaningful rather than incomplete or false (Dewey, 1934; Moszkowicz, 2013; Shusterman, 2000). Play themes presented by a TS-toy do not necessarily hinder the imagination or fantasy, as mentioned earlier. Children love repetition and predictability. For example, they often want to listen to the same book hundreds of times, perhaps out of feelings of safety and stability or as a starting point for imagination. It is likely that this is the same for toys. Lego and fire engine toys have been a success for decades, possibly because they motivate the creation of personal experiences. What the observations from the experiment indicate, however, is that when the play theme is *strong*, such that the child knows the story by heart and learns how to play with the toy through associated plots, cartoons, games, and movies, it is more likely that the toy will influence play. Accordingly, the accessibility of TS-toys seems to reduce the resistance to use by offering a play theme that the child, unconsciously and with ease, can lapse into.

The observations of play showed that when children played with the extra provided materials, there was a sudden occurrence of new play themes. This implies that when a toy does not have a prescribed use, it offers a dimension of resistance within play that stimulates the creation of personal experiences, and subsequently personalization of new play themes emerges.

Creation of Personal Experience

Observations from the experiment show that the children built the Legos in accordance with their manuals. Logically, the toys were purchased through recognition of pictures on the packaging. The children were familiar with the toys from cartoons and games, and, naturally, they would want to build the toys to match the world presented by the play theme.

Presumably, when a Lego object slowly fragments into pieces, it becomes natural to use the bricks for novel creations in spite of prior rules for assembly. Thus, if a toy is possible to deconstruct, parts of a prescribed toy can somewhat turn into building materials liberated from a given theme. Hence, the theme is weakened but can still be mediated through form, color, and function of the pieces. Such a weakened play theme can serve as a guided reinvention (Frisch, 2008). For first-time assembly, however, the associated play themes seem to have more influence. The Lego designs chosen by the children in the experiment only offered a few themes of experience, and they were either identical or had similar forms. All the children could, with a mere glance, identify which parts belonged to which themes. Accordingly, the space within which to experience them was confined, and the children were not called upon to create their own play themes.

It is reasonable to think that the assembly of Lego sets according to their manuals promotes learning of new ways to assemble standard and new objects. This skill can enable children to create novel objects in the future. Nevertheless, manuals for assembly do not motivate the personalization of play in terms of fantasizing and imagining while exploring through construction. They provide an easy way out in comparison to the resistance demanded by planning, experimenting, and failing when building self-initiated creations. Dewey pointed out that it is "the integration of parts and the conscious handling of these that make the perception of a complete experience." (Dewey, 1934, p. 57) The final result—the completed Lego set—is not necessarily the most significant experience by itself, just as a "drama or novel is not the final sentence, even if the characters are disposed of as living happily ever after" (Dewey, 1934, p. 57). Rather, the most significant experience is the process of creation.

The act of building Legos did certainly include dimensions of resistance in this experiment. Many children found the assembly difficult and needed to concentrate or get help from fellow pupils. Yet, the children followed a formula of creation, and their end results were identical to the results of millions of others and to those prescribed on the package, and the toys assembled suggested a play theme.

PERSONALIZATION OF PLAY THEMES/IMPLICATIONS FOR DESIGN PRACTICE

During the experiment, the children invented new themes of play while using the DIY materials. All children made objects and personalized the play themes. Thus, in the absence of a given play theme and related fixed-form vernacular, the children created these factors themselves.

The theoretical study of these observations indicates that the degree of personalization of play themes relates to resistance, recognition, creation of personal experiences, and a toy's intellectual classification as factors of play (Figure 3). Furthermore, the analysis indicates that when a toy comes without a play theme, it stimulates cognitive, imaginative, and creative thinking. This is attained by designing the toy so that it demands a high degree of play resistance and encourages children to create their own experiences. Furthermore, when functions of recognition and intellectual classification conveyed by the toy have little influence on the play experiences, this seems to further stimulate the personalization of play themes (Figure 3).

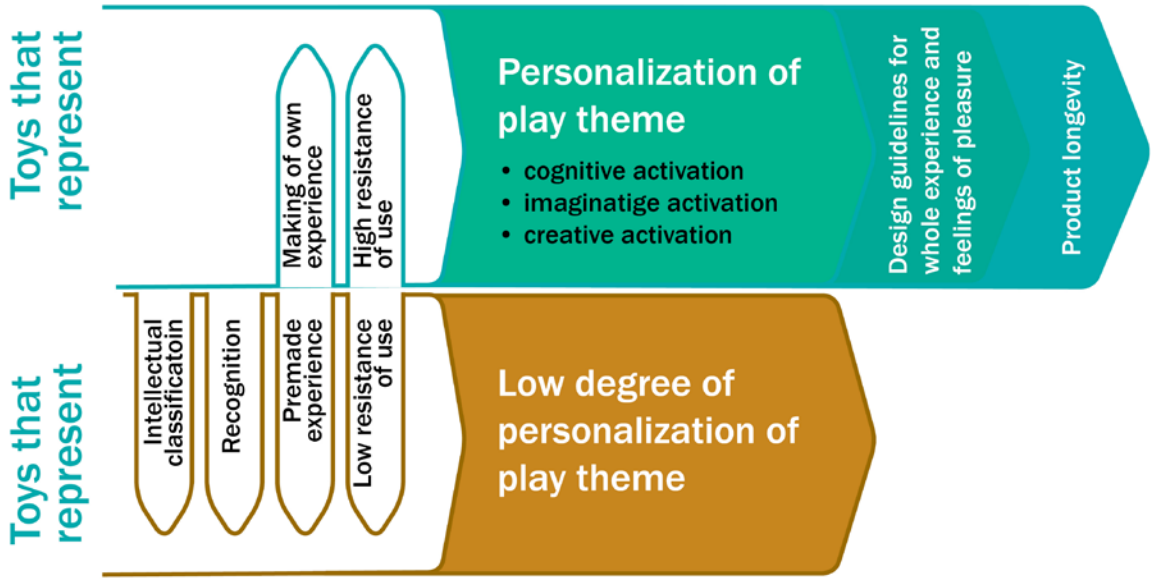

Figure 3. Toys as part of play contexts

Although transmedia storytelling acquires attention and activates children through the available different platforms of play, it seems to hinder the personalization of play themes, presumably because the strength of the theme goes beyond guidance (Frisch, 2008). Letting the child in on "similar processes as the ones of the creator" (Dewey, 1934) however, namely to partly transform, alter or create both the play themes and the bodily structure of the toy, seems therefore to be a primary function for designers to infuse, in order to create toys that stimulate the personalization of play themes.

The observations that this paper builds on are conducted during the first hour of play with a new toy. Obviously, a toys function will change over time. Lego sets do represent a challenge and demands concentration by the assembly of a concrete structure based on the learning from an abstraction presented in a manual. Nevertheless, it seems that the low resistance that these toys represent thematically, prevent own thinking in relation to which theme to play within. When a Lego set slowly turns into DIY materials however and the prescribed toy is fragmented, the toy opens up for the making of own play themes.

Avoiding or reducing factors of intellectual classification and recognition, is in a traditional sense, in conflict with market value. The study of the data in relation to pragmatist aesthetics, however, suggests that TS-toys adversely affect the play experience because they do not elicit whole experiences or lead to feelings of real (Dewey, 1934). Accordingly, toys that sell through market mechanisms often considered to inspire people to like something, such as *wow* effects, convenience, and easy accessibility, do not elicit real pleasure. Hence, unsatisfactory experiences caused by boredom or short-term interest are negative dimensions for the brand value. In order for toys to be treasured in the long run, however, it seems that the toy concept should balance factors of possible personalization of play themes and guided reinvention. Accordingly, toy longevity can contribute to market success over time, as it can contribute to sustainable consumption.

It is reasonable to suggest that toys designed for personalization of play themes, as proposed, will hold the child's interest longer due to the potential for continuous transformation, change, and uniqueness as well as the thinking it requires. A toy theme that has been personalized will possibly serve to elicit memories through the individual and social happenings that are linked to it, factors known to attach people to products.

For the continuance of this work, further research is suggested to explore the effect of the key findings (Figure 3) as design parameters for toys. Toys designed using these parameters could serve as the foundation for a new play experiment.

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Design Algorithm for Empathy

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ABSTRACT

Emotional design is a design theory that takes the emotional values/effects of users into consideration in the design process. This theory has been devoted to the appearance of the final product with integration of an emotion and/or interactivity. Emotional design is closely related to user behavior research as it often incorporates physical interactions with the users. However, the study of the user behavior is often limited to the instant interaction with the users without consideration of cultural and social behavior. The article, Design Algorithm for Empathy, emphasizes a more systemic approach within the emotional design process, which should involve strategies created from service design research and that of sociology. The paper argues that the execution of emotional design should involve a significantly more comprehensive research on cultural and social sources. The article is also concerned with the focus merely on the appearance of the design, which may result in superficial and temporary problem solving tactics rather than a more sustainable strategy.

Keywords: Emotional Design, User Behavior, Empathy, Systemic Perspective, System Design, Service Design, Sustainable Design

INTRODUCTION

Emotional design is a design theory that takes the emotional values/effects of users into consideration in the design process. This theory has been devoted to the appearance of the final product with integration of emotion (such as a sense of humor) and/or interactivity. Emotional design is closely related to user behavior research as it often incorporates physical interactions with the users. However, the study of the user behavior is often limited to the instant interaction with the users without consideration of cultural and social behavior.

In his article, *Design for (Emotional) Durability*, Jonathan Chapman states, “the sustainability crisis is a behavioral issue, and not one simply of technology, production, and volume. The behavioral conditions that both drive and influence patterns of material consumption are complex, yet fundamental to effective engagement with a contemporary sustainable design agenda”(Chapman, 2009).

In order to maximize the usability of emotional design, a more systemic approach within the emotional design process is necessary. This systemic approach should involve strategies created from service design research and that of sociology. Otherwise, emotional design—which focuses merely on the appearance of the design—may be perceived as superficial or a temporary problem solving tactic rather than a sustainable strategy.

AN UNCOMFORTABLE POTATO PEELER

During my graduate studies at York University in Toronto, I took a product development course in the university's MBA program. As part of the course assignments, each student in the class was required to present an example of a successfully designed product. One of the MBA students presented the OXO Good Grips potato peeler, designed by Smart Design. OXO Good Grips product lines are popular because of their oversized rubber handles, which provide comfort and a non-slip grip. This potato peeler is known as one of the most significant designs for both OXO and Smart Design. The concept of designing more comfortable kitchen tools came from Sam Farber, the founder and design entrepreneur of OXO International, when he realized that his wife, who had mild arthritis in her hands, was having difficulty gripping uncomfortable kitchen tools to cook ("Our Roots," 2014). After thorough research and prototyping, the ergonomically designed kitchen tools were offered in the U.S. market with a huge success.

A Q&A session followed the MBA student's presentation on how well the OXO's potato peeler was designed to the class. The first question the presenter received was "If Sam Farber loved his wife that much, why didn't he peel the potato by himself, for his wife?" The question was received as a joke, and many people in the class laughed. However, the question allowed me to realize that Farber, as a designer, should have started with an investigation of the real problem instead of instantly jumping to solve the pre-perceived problem: an uncomfortable potato peeler. Farber's approach to fulfilling the instant need of making a more comfortable potato peeler may not tackle the real potential problems that his wife might face.

The fundamental step for emotional design should focus on diagnosing the problems from a systemic perspective. With reputation for being 'problem solvers,' many designers often focus on the solution without evaluating and validating the problem. Before a designer starts conceiving emotional design solutions for a problem, he/she must investigate and define the problem through thorough research from systemic perspectives. Otherwise, the final execution of the design may merely be a temporary solution that only empathizes the superficial level of the targeted users' emotions.

DIFFERENT MESSAGE FOR EACH STAKEHOLDER

After a designer defines the most significant problem, he/she should start initiating ideas to resolve the problem. In order to arouse empathy from the targeted users, the solution may involve a system and/ or service design. In May 2013, Aid to Children and Adolescents at Risk Foundation (ANAR), a Spanish charity, released a public service announcement campaign to help abused children. The campaign was designed by an advertising agency, Grey Spain, and posters were installed on bus shelters (Lu, 2013). A unique aspect of the poster was its interactivity of the various targeted user groups using lenticular printing technique. According to The Visual dictionary of Graphic Design, "lenticular printing technique alternates strips of several images onto the back of a transparent plastic sheet, which contains a series of curved ridges called lenticules. The strips are aligned so that those forming a specific image are reflected to the same point" (Ambrose and Harris, 2006).

This method enabled the users to view different image and text depending on their height. People with a height of 1.35 meters, who are usually children, were able to view an image of a boy with bruises and read the message, "If somebody hurts you, phone us and we'll help you," as well as the European child helpline phone number (Lu, 2013). On the other hand, the people who were taller than 1.35 meters were not able to view the same image or text. Instead, they were able to see an image of the same boy without bruises alongside with a message, "Sometimes, child abuse is only visible to the child suffering it" (Lu, 2013). Within the advertisement concept of "Only for Children," the designer executed the product in a way that could bring different emotional effects for each stakeholder (Lu, 2013). While the poster gave peace of mind and a sense of security to children and communicated that they could get help if they were abused, it also brought adults' attention to the problem of child abuse. Designers must understand how the final execution of design may be interpreted in different ways and it has the potential to evoke different types of emotions from the users.

The final execution of the product, the awareness campaign poster, was designed based on its supportive existing systems.

1. Existing bus stations that were accessible to both children and adults.

2. Average height difference between children and adults.

3. Existing organization's supporting service for the abused children

Comprehensive social and cultural research was accomplished in order to integrate these existing systems. Emotional design should integrate a systemic infrastructure, which supports the final execution of product in order to derive its maximum effectiveness. Many current emotional designs often focus merely on the appearance. However, without a proper incorporation of appropriated systems, the design outcomes may not be sustainable.

CONCLUSIONS

Conventionally, emotional design was more focused on aesthetically pleasing appearances to provide affective experience to the targeted users (Desmet et al., 2007). In his book, *Emotional Design: Why We Love (or Hate) Everyday Things*, Donald A. Norman (2004) argues "that the emotional side of design may be more critical to a product's success than its practical elements" (p. 5). However, awareness of social responsibility and sustainable design is increasing amongst designers. Designers must continue to seek for ways to maximize the effectiveness of their work. Investigation of the tactical relevance with the social, economic, and ecological environment and integration of the research results into the emotional design will provide more than a 'wow-experience' for users (Desmet et al., 2007).

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Invisible Boundary in Design, Emotional Safety Net

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ABSTRACT

As our society gets complicated and faster than ever, we have much relied on technologies in order to keep our lives intact. Moreover, new technologies are introduced every day and every month, and it is hard for the users to keep up with the technologies. This phenomenon contradicts between the users and trends, the users seek out better technologies, simultaneously, and the users tend to keep their old habits and are harder to be swayed to get into a new system than times with fewer technologies involved in because the users tend to stay in their comfort zones in scope of artifact. Nowadays, interconnected and interrelated technologies make even harder for the users to move to the new system. The comfort zone from the users plays a big role in not only design, but also marketing field, brand loyalty. Once the users create their comfort zone in scope of artifact, the users establish "emotional safety net" in scope of artifact. This paper will define, "emotional safety net in design" and explore how to incorporate to design process.

Keywords: Industrial Design, Emotional Safety Net, Pain Factor, Metaphor

WHAT IS EMOTIONAL SAFETY NET IN DESIGN?

Emotional safety net in design increases in users' confidence, sense of users' comfort, and acceptance in the event of acquiring new objects/products. It is not hard for an author to find users trying to stay in certain continuity within a brand or colors or aesthetics.

Figure 1. Same Brand and Same Color

Figure 1 is a good example of emotional safety net because it is clear for the owner of those two cars to have higher user confidence and acceptance otherwise the owner would not have purchased the car within same brand and same color.

People who bought an apple product has a higher chance to buy another apple product in the future because many features have the same way to operate as their previous products and the users have confidence to operate the products. Users' confidence can be defined that it is a psychological status that users feel comfortable with a particular products/objects and are able to operate major features of the product without referring to the users' manual. Users' acceptance is another indication for emotional safety net in design. Users tend to want to stay in their comfort zone especially of any products related to safety and products with high price tags. Brands play a significant role in terms of comfort zone. Emotional safety net could lead to brand loyalty.

Figure 2. Stuffed Animal (Old: Left and New: Right)

A little girl used to carry a stuffed animal in age of 2 and refused to have another stuffed animal. The stuffed puppy was the one that she would carry and made her feel comfortable. However, she received a different stuffed puppy in age of 4 and accepted the puppy because the new stuffed puppy had very similar color scheme and size. (Figure 2)

WHY DO WE HAVE EMOTIONAL SAFETY NET

Loss Aversion

Psychologists have long observed that repeated exposure to a stimuli results in an increase in positive affect. Emotional safety net can be explained by loss aversion, which was first demonstrated by Amos Tversky and Daniel Kahneman. Loss aversion is that a loss has more influence on choices than a gain of the same magnitude (Kahneman & Tversky, 1979). What it means that a loss is more painful than gain. People make a lot of efforts to prevent from losing and keep what they currently own and feel secure. Explanations for the endowment effect commonly draw on prospect theory and suggest that possession of a product causes consumers to become loss adverse (Kahneman, Knetsch, and Thaler, 1990)

Emotion-Understanding Ability

Emotion-understanding ability is one of the core dimensions in Mayer and Salovey's (1997) ability model of emotional intelligence. It pertains to the skill of analyzing the cause-and effect relations between "vents and emotions forward" (predicting future emotions based on current events) and "backward" (identifying which past events elicited current emotions; MacCann & Roberts, 2008; Mayer et al., 2008; Mayer & Salovey, 1997).

Zaltman, author of "How customers think", stated in his book that a perfume's fragrance - a product attribute - evoke a particular memory and an associated emotions in a potential buyer. If a painful memory triggers a painful emotion, then the person probably won't buy the perfume, even if the fragrance, price, packaging, brand label, and other qualities meet her criteria (Zaltman G., 2003). Zaltman continues to state that decision making hinges on the simultaneous functioning of reason and emotions.

Because of skill of analyzing emotions forward in emotion-understanding ability, higher users' confidence and familiarity will make stronger emotional safety net. The female buyer in Zaltman's example would have bought a perfumes if she would have had a positive emotions triggered by a positive memory, which means that emotions backward would have to be positive.

Perceptual Familiarity Breeds Liking

As Zajonc and Markus (1982) observe, "When objects are presented to the individual on repeated occasions, the mere exposure is capable of making the individual's attitude toward these objects more positive". This experiment has been done numerous times in advertising and marketing field. The positive effect could be interpreted various way and covered wide in daily life. Therefore, it is possible to influence users' confidence and comfort. In advertising and marketing, the positive effect is eventually converted to action of purchase, which means that advertisers and marketers achieve their goal. However, it is more important for industrial designers to give more careful consideration after purchasing when the product and the user interact. While users interact with a product, the users gain users' confidence, comfortability, and knowledge toward the product.

Familiarity Become Knowledge

Familiarity and memory are significant elements for emotional safety net in design because familiarity has direct correlation to users' confidence and is grounded in memory. Conover summarizes familiarity and permanent memory.

> *The information that a consumer gains from using or learning about a product is stored in a permanent memory which maintains that knowledge for future use. A basic characteristic of the consumer's permanent memory is that the information contained therein is highly organized for efficient retrieval. The structure of this organized product knowledge is subject to change as the consumer acquires new information to be integrated with the old. The effect of familiarity, then, is to modify the structure of the consumer's product knowledge. Marks and Olson (1981) reported evidence consistent with a "unitization" theory of knowledge development proposed by Hayes-Roth (1977). According to this theory, knowledge structures begin with the development and strengthening of lower-order knowledge units (concepts), each of which is activated in an all-or-none fashion*. (Conover, 1982)

For example, at the earliest stages of familiarity with a product, a consumer learns isolated pieces of information about it and information would carry various feelings toward information that the consumer obtained. The emotions can be generated by active or inactive way. In an active way, the feeling by active way tends to be first impression based on previous experience. Feeling by inactive way tends to generate by feedback from peers. As the consumer experiences with a product further, these isolated information with corresponding specific feeling become correlated and identify as overall feeling. However, the feeling can be changed depending on context. In terms of gathered isolated information, the whole information becomes a unit and Hayes-Roth called it "unitized". An appropriate stimulus evokes both overall product information and feeling toward the product. Conover stated in the same article that after a period of increasing complexity of product knowledge (in the sense of comprising multiple separate concepts), further increments in familiarity lead to knowledge structures that are actually simpler (i.e., they contain relatively few, higher-order units, each of which comprises numerous related pieces of information) (Conover, 1982).

HOW DO WE ACHIEVE EMOTIONAL SAFETY NET IN DESIGN THROUGH DESIGN PROCESS

Emotions have been a critical component in many disciplines – business, advertising, cognitive science, and design - trying to engage emotional aspects with customers in every possible way because emotions have been a vital aspect in decision making process. There are two components - validating users' feeling and analyzing a metaphor - to achieve emotional safety net in design throughout design process.

Validating Users' Feeling

Emotions are intangible, but they derive tangible outcome. Also, emotions are invisible, but they are visible by reactions. There are three activities – story engagement, analyzing pain factor, and writing a break up letter - that can be applied in order to elicit users' true emotions

Story Engagement

Stories that feel meaningful will ultimately lead you to meaningful outcome (Simmons, 2006). We even find stories from TV commercial in 45 seconds. Grandfather reads fairy tale books to his granddaughters and grandsons and those books have lessons to learn. Stories are indirect communication, easy approaching and soft unfolding format. However, stories can deliver a lot of details, insights, and lifetime lessons. Literally, one inspired story can change people's lives. Good stories are tremendously powerful and extremely delicate. Also, stories are contagious and epidemic. Something goes on in the world that infects people with certain memes and those memes eventually influence their hosts' behavior in such a way that the something gets repeated and/or spread (Brodie, 2009). We all got connected by stories. Because the stories are tremendously powerful tool it must be created an experience that your audience will relate to but one that ultimately presents your ideas and your sincere intentions (Belsky, 2010). The psychic lever that opens us to the power of stories is the ability to form mental representations of our experience (Guber, 2011). More people in the story mean the bigger audiences. Washington University neuroscientist Jeffrey Zacks has found that vividly narrated stories activate the same brain areas that process the various component of real-life experience (Guber, 2011).

Listening to other's stories is a way to find out your own story. Simmons said, "Genuine listening gives you permission to wonder aloud about your uncertainties. Influence is much easier when you gain access to the place where people hide their uncertainties" (Simmons, 2006) and suggested seven techniques for finding story (Simmons, 2006).

1. Look for patterns: How they tie together, what they mean to you, the moment of glory in your life

2. Look for consequences: Consider good or bad results that have influenced the way you develop relationships.

3. Look for lessons: Recall the biggest mistake you ever made, a turning point in your career and the lesson you learned

4. Look for utilities: Remember that story that changed you

5. Look for vulnerability: Tell me about your soft spot; the last time you cried, so happy, and touching family stories about those you love deeply

6. Look for the future experience: Develop your day-dreams of "how it could be" into a full story with real-life.

7. Look for story recollections: Find a story that stuck with you and mine it for meaning – favorite movie or book: there should be reasons for it.

Many people express that finding the stories are difficult and hard, and it is true if they don't listen. As a matter of fact, these seven rules for finding story are how to listen to others.

Break-up Letter

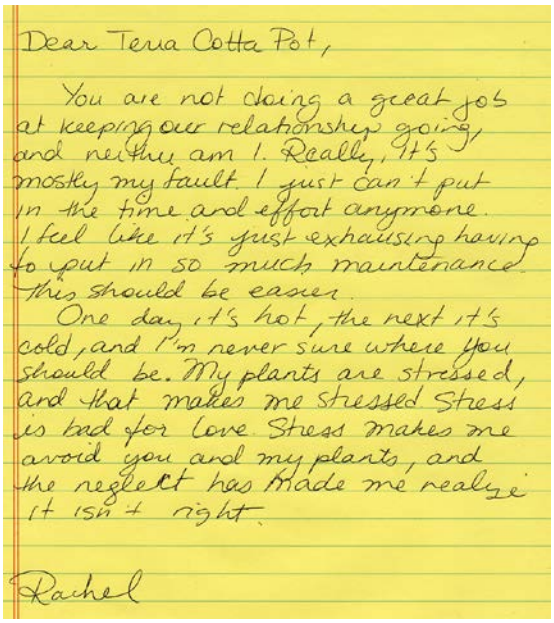

Figure 3. Break up letter (Student's Example)

In 2009, Smart Design created this method based on a familiar format in which to express thoughts and feelings about a product or service in an informal, accessible way. (Marin, B., Huntington, B. 2012) It is widely used in both product developments and marketing field. Also, break up letter can compensate the criticism of focus group interview (FGI). John R. Hauser, Kirin professor of Marketing at MIT's Sloan School of Management, recently noted, "If you have two hours to cover five to ten topics with eight people, then you have about one or two minutes on each topic with each person. You can't possibly get much beyond the surface given those constraints (Zaltman G., 2003)."

Although break up letter can take more time than conducting focus group interview, it can deliver deeper customers' insights and identify pain factors. The biggest advantage of writing break up letter is that people who write break up letter don't have to think about what other people's opinions are and worry about not being a part of a majority. Each person only focuses on their own problems and feeling toward products (Figure 3.). Therefore, they only think about describing their problems and feelings, which can lead of higher chances of applying metaphor in their break up letter. This paper will cover with pain factor and metaphor.

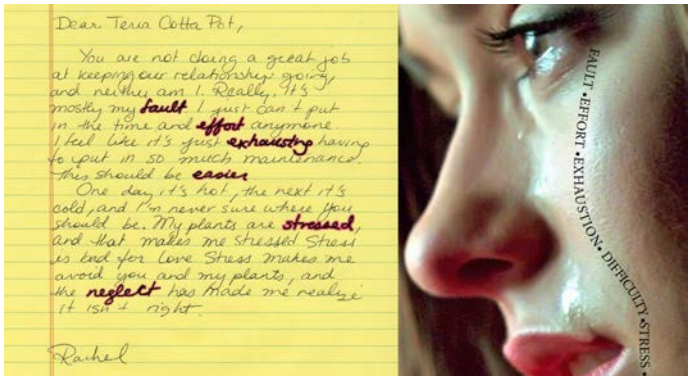

Figure 4. Analysis of Break up letter (Student's Example)

It is important to analyze the break up letter because the letter contains much valuable information such as metaphors and specific feeling toward specific problems (Figure 4.) It is hard for interviewers to identify problems and feelings because interviewees tend not to share their deep feeling toward a certain problem. Therefore, break up letter is an effective method to identify problem, which can lead to a possible solution.

Pain Factor

Diagnosing users' pain is an essential step to designing products. "Combining your expert knowledge with their own understanding of current situation and their desired outcome will lead to an accurate diagnostic of your customers' pain (Renvoise, P & Morin, C 2007)." The role of interviewers is not just to ask a series of questions and record answers. They need to be proactive and involved as completely as possible in generating the questionnaires and researching in depth for the target buyers or users because the users' pain won't be unveiled by just recording the answers from the users. We can categorize the pain we usually have in three types – personal, financial, and strategy (Renvoise, P & Morin, C 2007) – and we often can't recognize what they are.

1. Personal pain: composed of the feelings and emotions affecting those who are involved in deciding how and when to resolve the prospect's primary pain.

2. Financial pain: covers your prospect's economic performance or lack thereof.

3. Strategy pain: includes issues that affect the business process used to develop, manufacture, and sell products or services.

Personal and financial pain -- emotion, feeling, and money -- can be main issues from the users' point of view. It seems to be little obvious that money is one of the main issues, however, feeling and emotions are something we need to look into further. One subtle problem – smell, texture, temperature, color, sound, physical weight, visual weight, tightness - can cause a major shift in decision making. Strategy pain tends to be in the business side and won't go detail further in this article. Pain factor can be simplified as shown in table 2, which helps to visualize pain source, intensity, timing and awareness.

Table 2. Pain Factor in Product Development

Source	Intensity	Timing	Awareness
Mainly Financial	High	Immediate	High
Loss of Money	Prospect is allocating multiple resources to eliminate the PAIN	Prospect's life or business will endure instant deterioration if no action is taken	Prospect is highly conscious and actively seeking a solution

Now, we can establish the "Pain Factor" for the Domino's Pizza's case: "Actually, the number one pain customers expressed was the anxiety of not knowing when the pizza would arrive. Armed with this vital information, Domino's pizza established a very successful slogan: Thirty minutes or less (or it's free)" (Renvoise, P & Morin, C 2007)

Table 3. Pain Factor of Domino's Pizza

Source	Intensity	Timing	Awareness
Personal Pain	High	Immediate	High
#1 pain customers expressed was the anxiety of not knowing when pizza would arrive.	Because of customers' anxiety, sales revenue did not improve.	Domino's needed to take action right away.	Because of Domino's campaign, customers' anxiety was removed and sales revenue increased.

Once we establish the pain factor, which allows us to easier see the pain, it helps us to make the clear direction and diagnose the pain accurately.

Analyzing Metaphor

"Cognitive linguistics treats metaphor as a key to understanding the conceptual processes of the human mind." (Nehaniv, 1998) Metaphors are powerful tools. Stemming from the biological, bodily aspect of the human existence, they underwrite most human thoughts. Metaphors are tools for meaning, representation, understanding, science and education (Louridas, 1999). Metaphors stimulate the workings of the human mind. By one estimate, we use almost six metaphors per minute of spoken language (Zaltman G. , 2003). The current theory, "The Contemporary Theory of Metaphor" by George Lakoff, must be addressed in order to valid of investigating metaphors in everyday language because metaphor was seen as a matter of language not thought in classical theories of language. (Lakoff G. , 1992). However, Lakoff argued traditional assumptions that "all everyday conventional language is literal, and none is metaphorical" and "All subject matter can be comprehended literally, without metaphor." (Lakoff G. , 1992). However, Lakoff stated in his theory that the reason for the difference is that, in the intervening years, a huge system of everyday, conventional al, conceptual metaphors has been discovered and it is a system of metaphor that structures our everyday conceptual system, including most abstract concepts, and that lies behind much of everyday language. (Lakoff G. , 1992)

It indicates that we might not be able to communicate with other without having metaphors in their expression. Such metaphors are capable of giving us a new understanding of our experience (Lakoff M. J., 2003). As designers' point of view, the metaphors can deliver valuable insight that would not be able to find out from conventional survey question. Analyzing the users' metaphors in the design process should be included and be followed by the users' interviews. Interview questions should be carefully and thoughtfully constructed before conducting the interview in order to derive the metaphors from the users. An interview question, "What is your experience when using a microwave oven?" seems to be appropriated. However, the question is failed to make the user think and use the deeper metaphors. The questions can be rephrased, "When you think about cooking in your kitchen, what thoughts and feelings come to mind?" or "Tell us about how you use your microwave oven when preparing meals." Therefore, it is vital for designers to ask the right questions to have the right answers. Many designers tend to overlook the process of creating questionnaires and focusing more on answers and conclusions. The goal of generating questions is not just to find the numbers or trends. Then, what are the proper questions? The right questions can lead to answers that indicate some vital pain factors; pain source, intensity, timing, and awareness. Therefore, the designers must involve in the processes, from brainstorming questions to analyzing answers. How can the designers construct the legitimate questions for the interview? Zaltman (Zaltman G. Z., 2008) suggests eight guidelines for formulating the series of questions.

1. Determine the generic question you want to explore. Generic questions are not about users' demographics. They are about users' generic experiences. Designers should explore users' attitudes and perceptions toward experience and environment.

2. Determine whether the basic question should be specific to brand, category, or problem. It is essential to have a clear direction whether the questions should be about the brand, the product category, or problem that users are facing. Depending on the characteristic of the project, the questions need to focus more on the situation.

3. Pose more general and more specific versions of the first question that occurs to you. Once designers establish the foundation of a questionnaire they tend to jump into specific questions they would like know directly —and thus miss vital cues from users.

4. Determine whether you need to know the direction, velocity, or both.

Sometimes, launching a new product is a high-risk project. It is like driving in busy downtown streets you have never visited before, without a GPS or even a printed map. Lately, the role of designers has expanded to include decision making about what to learn from the current market and consumers.

5. Allow for surprises. Designers need to be proactive while conducting surveys or focus group interviews. It means that users or consumers are motionless and receptive. They will only deliver the information that designers ask for. Furthermore, they will not even reveal their emotions and thoughts toward the products. That's why designers need to stimulate users to get their inside stories.

6. Convert assumptions into questions. Assumptions are the worst enemy of questionnaires. Similarly, I always tell my students that the project will face a dead end the moment you assume the answer, users' behavior, feelings, etc.

7. Employ a clairvoyant. No one can see the future. However, exercising and engaging imaginative thoughts will

help to predict better. “Will this design succeed in the market?” Expand your imagination to seek specific answer for the products, “What do users dislike when they use this product?” or “What key emotions speak with other users when users think about the products and brand?” With those types of questions, designers can concentrate on the factors affecting users’ thinking and behavior. It will dramatically help to grasp not only the forest, but also the trees in the forest.

8. Employ a wizard. It is another stage in using our imaginations. “If there were a wizard, what would the first thing he would fix to correct this problem?” This question will lead designers to identify potential issues that can occur in the near future. In this case, designers should ask themselves, “Do we have enough information or resources to respond if problems occur?” and “Is it really likely to occur?” Establishing a strong “plan of attack” will solidify not only the design concept, but also sales revenue later.

Establishing insightful questionnaires is a solid foundation for the entire research process, and it is something we can control. Extensive preparation gives accurate and useful results to the designers. In other words, constructing the interview questions should be considered as design process and does need to have a brainstorming in order to formulate the valuable questions that would reveal the customers’ insight. As a matter of fact, these eight guidelines could initiate brainstorming stages, which plays a role for narrowing down a desired direction and composing critical interview questions.

CONCLUSIONS AND FURTHER RESEARCH

Emotional safety net is a combination of strong feelings in order to stay in secure. It has been developed since babies have interacted with their parents. As babies grow, they tend to be attached a certain object such as blanket or stuffed animal. The security blanket or stuffed animal can provide emotional safety net for the kids because those simple objects can give peace of mind to the kids. Nowadays, there is the same phenomenon in among adults because they have been attached certain products and strong feeling toward those products. Therefore, it is important for design students to recognize that emotions have become an important design element and play a big role for decision making process. It is still ongoing research and there are more tasks to complete. Relevant literatures need to be revisited and hard data from interview and survey need to be collected in order to support relevant arguments and statements.

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