ORIGINAL ARTICLES

MEASUREMENT OF USER'S EMOTIONS (KANSEI) EXPRESSED WHILE INTERACTING WITH A PRODUCT

with Emphasis on Development of a Tool for Measuring User's Emotions (KANSEI)

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Abstract: In general, the methods for measuring human emotion are divided in two, one is the psychological way based on user's subjective evaluation and the other is the physiological way based on physiological signals. However, these methods have some limitations. Therefore, in this study we suggested the methods for measuring user's emotion in the natural and accessible environment for the design field. In order to observe user's emotional changes while they interact with a product, we have extracted some emotional words and representative emotions, and made a set of subjective evaluation scales. With these scales, emotion logging program "VideoTAME" was developed as an effective measurement tool for complementing the current psychological methods. In the Testing Module of VideoTAME, subjects evaluate their emotional changes through playing and watching the video clips of their performing tasks in the experiment room. In the Analyzing Module, the researchers replay the results created by subjects during the experiment and analyze the results using Microsoft Excel. It is hoped that this study will be of great help for designers for effective measurement of user's emotions naturally expressed while using a product.

Keywords: Usability, User's emotions, Emotional words, Subjective evaluation scale, Methods for measuring user's emotions

1. INTRODUCTION

Contemporary emotion-related researches have focused mainly on the relationship between product aesthetics and the emotional responses elicited by the product appearance (e.g., Desmet's study [1]). However, the researches on emotion and product usability merely show that human emotion affects product usability. Furthermore, in studies related to usability testing, objective issues such as a user's performance are emphasized and issues such as a user's emotion when using a product are feeble. This can be due to the fact that there is no suitable system to measure a user's emotion.

A user's emotion, derived from personal experience, can be defined as an intuitive and reflective feeling, about the outside world. It has characteristics that are ambiguous to express since it is complex, comprehensive, personal and dynamic [2]. Human emotion is the issue which is subjective, difficult to define and even more difficult to measure because it is personal. Cacioppo and Gardner concluded that "the measurement of emotion is a bustling research area" [3]. Generally, the methods for measuring human emotion are divided in two, one is the psychological way based on user's subjective evaluation and the other is the physiological way based on physiological signals. Since the former has limitation that is it has to be tested after experiencing the emotion, the physiological method,

measuring physiological signals to use them as an objective index of human emotion, has been tried to measure the emotion more objectively. However, equipments for measuring physiological signals to grasp the emotion are usually expensive and burdensome. Moreover, it is not easy to approach the area from the design field because of difficulties with analyzing data output from tests.

Therefore, it is necessary to research on the methods for measuring user's emotion in the natural and accessible environment for the design field and for measuring user's emotion naturally expressed while using a product. The aim of this study is to suggest a most effective method for measuring user's emotion expressed while using a product, and to solve problems of the two existing methods.

2. USABILITY AND EMOTION

Since the application of computer technology in products, usability that concerns the ease and efficiency of use has become the key factor of success rather than its appearance. However, most definitions of usability and contemporary usability-related researches, have focused on the performance-oriented functional aspects of usability (i.e., how well users perform tasks using a product). Now users want more than simply a product's usability. Today, user expectations are higher than ever; they want products that bring not only functional benefits but also

emotional satisfaction [4]. So to speak, users not only want to be satisfied on a product's functional abilities but they also want to be satisfied emotionally from using a product.

Usability is defined in various ways according to the discipline and context, and it can be found that user's emotions are included in the context of this definition. Jakob Nielsen suggested that usability is the question of how well users can use the functionality of the system. Usability has multiple components and is traditionally associated with these five usability attributes: learnability, efficiency of use, memorability, few and noncatastrophic errors, and subjective satisfaction [5]. What is more is that studies on emotion and product usability show that human emotions do have an effect on a product's usability. According to Jeffrey Rubin's research, there are five reasons for hard-to-use products and systems. As Jeffrey Rubin concluded, while developing a product, if emphasis is not on user-centered design but on product functions, or if failure to systematically apply user's rapidly changing tastes on product development, a "hard to use" product and system will eventually be developed [6]. According to studies of Nielsen and Levy, there are products that users have low preferences in even though with good objective functional performance and there are products with high preferences with low functional performance [7]. Brave and Nass noted that the psychology and technology of emotion can be mostly relevant to the design and assessment of interactive systems. They described emotion as "a fundamental component of being human" and defined it as "reactions to situations deemed relevant to the needs and goals of the individual" [8]. Donald A. Norman uses the term, "affect" to explain how emotion can effect human behaviors. He claimed that negative emotions can make a simple task difficult, and that positive emotions can make a difficult task easier [9].

As mentioned above, in spite of the close relationship between product usability and emotion, the emphasis is mainly only on the objective part of product usability and the user's emotional part is being neglected. According to Nielsen and Levy's analysis on contemporary researches done on usability, the number of studies done on the emotional side (43 cases) are comparatively low than studies on the objective side (305 cases) [7]. This could be due to the fact that although an objective evaluation scale has been developed to some extent, an emotion-measuring evaluation scale has not quite yet been developed. Current methods for measuring user emotions while using products are mostly to measure indirectly by debriefing after the experiment. Hence, research on methods to figure out user's emotion while using a product, is still on the rudimentary stage.

3. METHODS FOR MEASURING THE USER'S EMOTIONS

To begin with, previous studies on methods for psychological and physiological measuring have been collected and the limitations of these two methods were outlined.

3.1 Psychological method

Traditionally, the measurement of emotion is usually dependent on the psychological method. The most commonly used psychological method requires users to report their emotions with the use of a set of adjective interval scales (7-point scale, 5-point scale, etc.) such as semantic differential or verbal protocols. Mostly these emotions are measured in the form of an interview or a self-report.

Desmet developed a product emotion measurement instrument named PrEmo; a non-verbal, self-report instrument that measures 14 emotions which are often elicited by product design. Instead of relying on the use of words, respondents can report their emotions with the use of a set of "cartoon" animations, each expressing one of the 14 product relevant emotions. This method uses cartoon animations to show emotional expressions and gestures and asks the user to choose the most closely related emotion that he/she feels [1]. This method is expected to be useful in system development in various countries since not only is it easier for the user to show his/her current emotion compared to previous methods such as to express in words and sentences, but also because facial expression is highly consistent among different cultures. However, the drawback of this method is that other than the basic emotions, there are limitations on expressing all the other various emotions that users might feel.

Lively research has been done on psychological measuring methods in areas such as psychology, linguistics, emotional engineering, etc. However, this method, based on subjective evaluation, has some limitations. When studying what users say about their emotional state, user's emotions tend to change according to time. Plus, precisely expressing emotions in words is not an easy task. And, because emotional experiences can be delicate, users sometimes (consciously or unconsciously) manipulate their reports. Most of all, since the subjective report is examined after the emotional part is experienced, the emotion expressed can be different before and after the examination. Rosenberg and Ekman showed that these kinds of self-report do get influenced from recent effects [10]. According to Scherer, self-reports are subject to distortions due to ego-defence tendencies and socially desirable effects. Moreover, relying on the subject's memory is also a significant limitation. There is always a

time-lapse between the experienced emotion and the self-report. The bigger the time-lapse between experience and report, the more the results are distorted [11].

3.2 Physiological method

The physiological method is to use physiological reaction as an objective index to measure human emotion more objectively. The physiological signals from the autonomic nervous system are blood pressure, electrocardiogram (ECG), pulse, skin temperature (SKT), electrodermal activity (EDA) and electromyogram (EMG). The signal from the central nervous system is called electroencephalogram (EEG). When studying human emotion, EEG is mostly used rather than signals from the autonomic nervous system. This is because EEG is believed to hold the most information of brain activity [12].

Many researchers on emotion have been interested in the study of emotion and specific physiological reactions since James started that particular emotions have relations with particular physiological changes [13]. Ekman et al. used the relationship between expressing facial emotion and the autonomic nervous system to suggest an emotion classification model according to physiological reaction characteristics [14]. Their model uses the autonomic nervous system's complex index (heart rate and SKT) to show the possibility of classifying basic emotions experienced subjectively. Research results showed the possibility of the existence of an emotion-specific physiological reaction that can classify the discrete emotions. The results played a decisive role in the current lively research on emotion-specific physiological activities.

The key scholar on discrete state theory, Levenson et al. did a study on emotion-specific expressions and physiological reactions that can classify emotion [15]. Most of the research results on emotion-specific physiological reaction that continuously turned out consistent were all reconfirmed from Levenson. By bringing out emotions through facial expressions and measuring reactions of the autonomic nervous system, it was found out that emotions can be classified by heart rate and SKT [16]. Emotion and specific physiological reaction research findings reported by many emotion scholars were examined by Cacioppo et al. [17]. Collet et al. too, used six physiological variables in SKT, EDA and respiration, to establish the reaction pattern of the autonomic nervous system. While every emotion is related to different patterns of physiological reactions, it was discovered that the activities of the autonomic nervous system can be partially variegated depending upon diverse emotions when measuring emotion as a physiological index of the autonomic nervous system. They concluded that conductance variations alone cannot fully describe the subject's emotional response;

thus it must be combined with one or two other autonomic nervous system parameters [18].

Lee et al. selected stimuli that can bring about the six basic emotions (happiness, sadness, anger, fear, disgust, surprise) from the visual stimuli from the International Affective Picture System and developed a psycho-physiological emotion classifying model that can classify the six basic emotions according to the EEG and autonomic nervous systems aroused from these stimuli. The first classification of basic emotions could be done with the change in the heart rate, and the classification of the next stage was possible with the change in respiration. To summarize, four emotions, anger, fear, sadness and disgust, could be classified by EEG and the autonomic nervous systems but the remaining two emotions, happiness and surprise could not be classified in a concrete matter [19]. Among the autonomic nervous systems measuring physiological reactions, Jang et al. measured the ECG, EDA, photoplethysmography (PPG) and SKT. This research was to examine the consistency of the autonomic nervous system reaction and the pattern of emotion autonomic nervous system through many repetitions of experiments of the same experiment subjects. According to the research findings, emotion-patterns of the autonomic nervous system turned out to be consistent by sessions, and an emotion-specific autonomic nervous system reaction pattern was revealed. Skin conductance response (SCR), skin conductance response magnitude (SCRM) and heart rate (HR) which showed distinctive physiological reactive patterns according to emotions show that they are a more reliable measurement tool for emotion reactions than other physiological indexes [20].

However, the method using the physiological signals also has problems. First, it is very burdensome and unnatural with recent technology. For example, a subject has to have sensors on his fingers to monitor the pulse and the EDA, and also has to have equipments on his head to measure an EEG coming from the occipital and parietal lobe. Secondly, there are limitations in the stimulus to make subjects express their emotion. The stimulus is limited to one that makes subjects not need to move, such as visual or hearing equipments. Especially, to measure an EEG, the control of other waves has to be severe. It is still difficult to detect a pure EEG generated from emotion because eye blinking or tiny movements can make considerable noise. The third problem is an economic issue. High-priced equipments are required to sensor physiological signals and there are a lot of troublesome matters to furnish the testing environment. Fourth problem is the lack of consistency in the results of emotion research by measuring physiological signals. Even though it has consistent results about ECG or EDA, it still requires an objective index

about other signals. Since the stimulus and the physiological variables are different by researches, the research results by measuring methods are inconsistent [17]. The problems on these research methodologies are the difficulties of setting the framework for the emotion- specific reaction pattern and the relationship between emotion and autonomic nervous system reaction [21]. Therefore, it can be said that it is not easy to grasp human emotion just by physiological signals. Lastly, there are also difficulties in data analysis. It is not easy to approach the area from the design field since it requires propound knowledge of human physiological signals to analyze data from the tests.

3.3 Methods for measuring the user's emotions expressed while using a product

If taking into consideration that the stimulus is not big, and the user has to keep moving while using the product, to measure the user's emotions, the psychological measuring method can be seen as more effective than the physiological measuring method. Because it is very difficult to overcome the limitations of the physiological measuring method listed above and to detect accurate physiological signals in these situations. The most common method in the psychological measuring method is to indirectly measure the user's emotion by using adjectives, hence to measure the user's emotion by drawing out a set of emotional words. Therefore, in this research, using a set of derived emotional words, we have made a subjective evaluation scale for measuring a user's emotions. Through this, we suggest a more effective emotion measuring method that can complement the limitations of the psychological measuring method.

4. A SET OF SUBJECTIVE EVALUATION SCALE FOR MEASURING THE USER'S EMOTIONS EXPRESSED WHILE USING A PRODUCT

In our previous research, we extracted a set of emotional words and representative emotions that can show changes in emotions of users while using a product and not words that were derived simply from the product's appearance [22]. Using factor analysis, we categorized the emotional words to form the following 6 representative emotions;

- Aesthetics: Emotions expressed by product's appearance and by various visual information while using a product.
- Satisfaction in Usability: Emotions that are conceived satisfying in usability or practicality of product.
- Novelty: Emotions expressed by something that is novel and new that has never been experienced.
- Uncomfortableness: Uncomfortable or unpleasant emotions expressed while using a product.

- Pleasure: Pleasant emotions expressed while using a product.
- Excellence: Emotions expressed by something notably excellent.

Through this, we have come up with a suitable set of subjective evaluation scale for measuring user's emotions expressed while using a product. We have finalized 32 words to be used as emotional words in the subjective evaluation scale. The emotional words that fell into this category were words that were above 0.550 for factor loading and under 0.400 for factor loading of other factors (See Figure 1).

Figure 1: Emotional words to for making a subjective evaluation scale

(* [] shows the factor loading of emotional words)

5. DEVELOPMENT OF TOOL FOR MEASURING USER'S EMOTIONS EXPRESSED WHILE USING A PRODUCT

After having reviewed the limits that the psychological measuring method has and using the psychological evaluation scale, a tool that can effectively measure a user's emotion expressed while using a product was developed. The developed software named VideoTAME (Video Think Aloud for Measuring Emotion), basically asks the subject to watch a recorded video clip of the user performing a specific task and to examine the emotional changes that had occurred.

5.1 Objectives of development and structure of user emotion evaluation tool

To make up for the limitations of the previous emotion evaluation methods and taking into consideration the circumstances where the product would be used, the following objectives for development were derived to effectively measure user's emotions.

- Since emotion has to be measured after the emotion has been felt and experienced, emotion distortion should be minimized.
- The environment where the product is used should be as realistic as possible.
- User's emotion should be able to be measured in a natural environment where product is used.
- Environment should be easily accessible for the design field and should be able to sufficiently gather enough opinions from subjects.
- Collected data should be able to be transferred and utilized to other commonly used programs.
- Collected results should be databased and able to be taken out again to be used effectively.
- Suitable emotional words should be suggested to suit the various words users might come up with while using product.

The emotion evaluation tool developed based on the objectives listed above is composed largely of a Testing Module and an Analyzing Module (See Figure 2). The Testing Module is composed of one part where the subject actually performs the experiment and the other part where the data is collected and recorded. The Analyzing Module is composed of a database part which can classify, store, and manage each experiment, and an analyzing part that plays and analyzes the collected data in various ways.

Figure 2: Structure of user emotion evaluation tool

VideoTAME was developed using Microsoft Visual-Basic 6.0. A distinct characteristic is that it comes with 2 Windows Media Player engines. It is also compatible with various video clip formats such as AVI, MPG, WMV, MOV, etc. When the subject ends the session, the details of the experiment is recorded and saved in a text file format (*.txt). The saved file is then reworked as database in the Analyzing Module. The biggest characteristics of the Analyzing Module are that specific scenes can be captured from the video clip, and that all sorts of analyzed data can be directly converted into Microsoft Excel files by Excel Object 9.0. In addition to this, the subject can stop the video clip and then the selected emotional words automatically go into the sound folder. The designer

designs it so that when it plays, the emotional words can come out as voice recording so that when the subject performs the task it can give a "think aloud" effect. The following is a rough overview of the development environment of VideoTAME:

- Development Language: Microsoft Visual-Basic 6.0
- Used Engine: Microsoft Windows Media Player 9.0, Excel Object 9.0
- Development Environment: CPU Intel® Pentium® 4 CPU 2.80GHz, 512MB, XP Service Pack2
- Operating Environment: CPU Intel® Pentium® 2 CPU 600Mhz, 128MB, WIN98 and above
- Size of Program: Testing Module (228KB), Analyzing Module(1.25MB)
- Program Structure: Testing Module (VideoTAME.exe), Analyzing Module (VideoTAME-Analyzer.exe), guide.wav, Sound Folder

5.2 Testing Module

This is the Testing Module where the subject performs the experiment by following the guiding message. The Testing Module starts as the subject selects the folder where the recorded file of the subject performing the task in the experiment room is located. The Testing Module is composed of four screens. An initial screen that shows basic information on general performance of experiment, a screen that shows the movie clip that the subject can see and evaluate emotional changes, a screen used after the experiment for emotion evaluation using the subjective evaluation scale and a screen with a brief survey.

Figure 3: Emotion evaluation screen and selected emotional words

In the part where the emotion is tested, the experiment subject examines his/her own emotional change by watching the video clip that was recorded in the experiment room when the task was performed. The video clip is composed of a part where the subject's facial expression

can be seen and a part where the actual product can be seen. First of all, a task that can examine emotion should be selected, and then while playing the video clip, when there is visible emotional change the clip should be paused, then the subject should select all the emotions he/she felt from the list of the 32 emotional words. Color is added to the selected emotional words so that it can be easily distinguished (See Figure 3).

Multiple answers can be selected for the emotional words, and after selected, subjects are guided to express how strong they felt in the selected emotional words by 5-point scale. The items of the scale are automatically changed according to the emotional word selected. At the end, the subject gets to briefly write down why emotional change had occurred (See Figure 4).

Figure 4: Screen showing emotional state and reason for selecting the specific state

Additional words can be selected while the clip is paused, and if there are none, the video clip can be resumed and the emotion evaluation test can be proceeded in the same method as above. Evaluations can be added for previous screens by rewinding the video clip, and revisions can be made for the previously selected emotional words. If all emotion evaluation of the performed task is completed, the screen goes to the next screen. In the survey that is shown at the end of the experiment, a general evaluation is given about the product applied by the subjective evaluation scale made in the previous section (See Figure 5).

Figure 5: Subjective evaluation scale

Finally, the experiment ends with some basic questions related to the subject (gender, age, academic background, occupation) and some questions related to the used product. For example, if the experiment was to evaluate emotion expressed while using a cellular phone, the following questions could be asked.

- How long have you been using a cellular phone?
- What previous types of cellular phone have you used?
Please list all the company names.
- What type of cellular phone are you currently using?
Please write down company name, model type, and purchased date.

5.3 Analyzing Module

The Analyzing Module is where the designer or the researcher can play or analyze the collected data in various ways. The Analyzing Module starts as the designer selects the folder that contains the evaluation results of the Testing Module (See Figure 6).

Figure 6: Screen of selecting folder to be analyzed

The Analyzing Module is composed of two screens: A screen that allows the designer to examine the experiment results by playing the recorded video clip by each task, and a screen that variously analyzes the results that are exported to Microsoft Excel.

In the screen where the experiment results can be seen by each task, the designer can check the evaluated emotional change (See Figure 7). The designer can easily recognize the part where the subject selected an emotional word by stopping the video clip because it automatically indicates it. Plus, the selected emotional words and the degree of it gets displayed at the bottom of the screen and lets the designer know through voice recording so that the designer can have a "think aloud" effect of the performed experiment. Other than this, the selected emotional words, the score given for the selected degree, the reason for choosing the specific word, and the average of the repre-

sentative emotions can be identified through the selected emotional words. Lastly, when the analyzer finds something particular while playing the video clip, the situation can be input by clicking the "Description of Situation" button. The information that was input can be re-checked through the exported Microsoft Excel file.

Figure 7: Experiment results per task

Through the exported Microsoft Excel file, variously analyzed information can be seen as follows.

• **Analyzed information per scene:** User's emotional change per situation can be analyzed by the following – the subject's task division, time that video clip was stopped to select emotional word, scene, information on explaining situation, emotional words and degree selected from subjects, reason for selecting those specific words, and the average of the representative emotions can be identified through the selected emotional words (See Figure 8).

Task	Time	Scene	Situation Description	Selected Words (Score)	Total	Reason for Selecting	Representative Emotion	Average
1	00:00:27		The user is now using the main menu scene.	Satisfactory(2)	2	It is similar to the interface of the current phone I am using.	Satisfaction in usability	2
2	00:00:52		The user is now using the main menu scene.	Difficult(2)	2	It is very difficult to perform the task.	Uncomfortableness	2
3	00:01:17		The user is now using the main menu scene.		0		Pleasure	0
4	00:01:42		The user is now using the main menu scene.		0		Excellence	0
5	00:02:07		The user is now using the main menu scene.		0		Aesthetics	0
6	00:02:32		The user is now using the main menu scene.		0		Satisfaction in usability	0
7	00:02:57		The user is now using the main menu scene.		0		Novelty	0

Figure 8: Analyzing screen per scene

• **Analyzed Information per task:** User's emotions for

each task can be analyzed by checking the average score of emotional words, number of times of emotional words selected, and the average score of representative emotions. The information on analysis per task applies not only to the subject but also to the whole group of subjects (See Figure 9).

Task	Representative Emotion	Emotional Word	Number of Times Emotional Word Selected	Average	Average of Representative Emotion
1	Aesthetics	pretty	0	0	0
2	Aesthetics	refined	0	0	0
3	Aesthetics	elegant	0	0	0
4	Aesthetics	clean	0	0	0
5	Aesthetics	lovable	0	0	0
6	Aesthetics	cute	0	0	0
7	Aesthetics	sweet	0	0	0
8	Aesthetics	harmonious	0	0	0
9	Satisfaction in usability	satisfactory	2	2	2
10	Satisfaction in usability	careful	0	0	0
11	Satisfaction in usability	natural	0	0	0
12	Satisfaction in usability	reliable	0	0	0
13	Satisfaction in usability	efficient	0	0	0

Figure 9: Analysis screen per task (each subject)

• **Information analyzing the whole experiment:** The emotional change occurred from the user using the product can be analyzed through the whole task, the number of times emotional words selected, its average score and the average of the representative emotions can be identified through the selected emotional words. After the experiment, the results while using the product and after using the product can be compared showing the average scores of representative emotions and emotional words selected from the subjective evaluation scale. For analysis of the entire experiment, not only can the subject be analyzed but the whole group of subjects can be analyzed too (See Figure 10).

Task	Representative Emotion	Emotional Word	Number of Times Emotional Word Selected	Average	Average of Representative Emotion	Subjective Evaluation Scale	Average of Representative Emotion
1	Aesthetics	pretty	0	0	0	1.8	0
2	Aesthetics	refined	0	0	0	2	0
3	Aesthetics	elegant	0	0	0	0	0
4	Aesthetics	clean	0	0	0	3	0
5	Aesthetics	lovable	0	0	0	0	0
6	Aesthetics	cute	0	0	0	2	0
7	Aesthetics	sweet	0	0	0	1	0
8	Aesthetics	harmonious	0	0	0	2	0
9	Satisfaction in usability	satisfactory	10	2.7	2	2.5	2
10	Satisfaction in usability	careful	0	0	0	2	0
11	Satisfaction in usability	natural	5	3.2	2	2	0
12	Satisfaction in usability	reliable	1	3	3	3	0
13	Satisfaction in usability	efficient	3	2.33333333	3	4	0

Figure 10: Analysis of whole experiment (all subjects)

• **Analysis of subject's basic information:** Information on subject's serial number, gender, age, academic background, occupation, etc. and answers to questions related to the experiment is displayed. These data can be used in various ways to analyze the results of experiment through cross-tabulation analysis.

6. CASE EXPERIMENT FOR MEASURING THE USER'S EMOTIONS EXPRESSED WHILE USING A PRODUCT

6.1 Experiment Overview

The main goal of our study is to reveal the influence of usability on human emotions by analyzing the user's emotional changes while using a product. Therefore, in this experiment, we measured a user's emotions expressed while using a product using emotion logging software VideoTAME. In this research, we have asked users to examine their emotional changes while watching the recorded video clip of them in the experiment room performing a series of tasks using a cellular phone (SCH-V300, "S" Electronics Company). The subjects were 8 undergraduate and graduate students (4 males, 4 females) in their 20s (average age 23.5 years old) who have never used the phone used in the experiment and never used a phone from the same manufacturer ("S" Electronics Company) before. The length of time of using cellular phones were from 4 (minimum) to 8 (maximum) years and the average of the length of time of using cellular phones was 6 years. The experiment was carried out for 2 months from February to March, 2006.

6.2 Experiment Method

1) Material

The cellular phone used in the experiment was the model SCH-V300 from "S" Electronics Company. Usability problems of the cellular phone were already identified in previous usability testing.

2) Experiment Room Setting

The setting of the experiment room was set for the subject was able to watch the recorded clip of him/her performing tasks using the cellular phone in the experiment room through the Testing Module of VideoTAME. Two digital camcorders were used for the recording: One recorded the face of the subject so that the subject's facial expressions could be examined and the second one recorded the screen of the cellular phone so that the information on the subject performing the task could be recorded. The video clip recorded with the two digital camcorders were saved real time as a video clip file (*.wmv) through Windows Movie Maker. Two test monitors controlled the digital camcorders with one taking control of the overall experiment, and one recording any unusual situations. After the subject performed all the tasks, the main experiment where the subject gets to measure her/his own emotional changes through VideoTAME, began on the PC.

3) Tasks

By analyzing the objective usability testing results of the cellular phone, the tasks to be performed were decided. Among the selected tasks, 2 tasks were quite easy to perform with no such problems in usability, and 2 tasks were quite hard to perform because of problems in usability. The tasks given to the subject were as follows:

- Task 1. Searching and changing the phonebook
- Task 2. Entering schedule
- Task 3. Taking and saving pictures using the camera
- Task 4. Setting ring tones separately

Task 1 and Task 3 are tasks that have not so many problems in usability but Task 2 does by failing to give visible hints on how to go to the next step after performing a task and whether if information can be input or changed in a specific scene or not. Task 4 also has many problems in usability because the name of the menus fail to convey their actual functions and fail to give the actual task performing procedure a user might think of.

4) Experiment Procedure

When the subject arrives at the experiment room, instructions on the overall experiment is given so that the subject can have some time to settle down. Especially, in order to carry out a successful experiment using VideoTAME, explanation on the 32 emotional words that users can express are given beforehand.

In the first experiment the subject is given four tasks regarding the cellular phone, and this scene is recorded. Tasks that are hard to perform because of problems with usability, and tasks that are quite easy to perform because of good usability are given in turns. Recording is done with 2 tapes, one records the subject's facial expression by capturing the user's face, and the other records the scene of the cellular phone used in the experiment so that information on the task performed can be recorded. In the main experiment, which measures emotions expressed while using a product, the video recorded right before is played through VideoTAME's Testing Module and the subject, while watching the video, gets to choose among the 32 emotional words displayed at the bottom of the screen. The results to this get analyzed in various ways in VideoTAME's Analyzing Module.

6.3 Experiment Results and Discussions

1) Comparison of time required for performing task

There were some differences in the time required for performing tasks for those that did have usability problems and for those that did not have any. Task 2 and 4 which did have usability problems took more time compared to Task 1 and 3 which did not have many usability problems.

Especially for Task 3, with the exception of subject number 8, distinct difference in time could be seen with an average of 46 seconds for 7 people. Table 1 shows and compares the time required for each task.

Table 1: Comparison of time required for performing task (Sec.)

Subject	Task 1	Task 2	Task 3	Task 4
1	133	168	75	484
2	57	109	23	200
3	136	94	52	136
4	72	133	26	354
5	169	160	63	309
6	69	156	36	340
7	72	84	47	300
8	60	82	148	319
Total	768	986	470	2442
Average	96	123.25	58.75	305.25
Standard Deviation	43.08795	35.4995	40.17729	103.8471

2) Comparison of the average score of representative emotions per task

The total score of the selected emotional words in each representative emotion (See Table 2) and the average score of the representative emotions (See Table 3) in each task have been compared.

Table 2: Comparison of the total scores of the selected emotional words in each task

	Aesthetics	Satisfaction in Usability	Novelty	Uncomfortableness	Pleasure	Excellence
Task 1	0	14	3	38	1	0
Task 2	0	17	0	123	12	0
Task 3	0	17	2	47	7	3
Task 4	0	8	17	188	23	0
Total	0	56	22	396	43	3
Average	0	14	5.5	99	10.75	0.75
Standard Deviation	0	4.242641	7.767453	70.52659	9.322911	1.5

The average score of the representative emotion in each task can be solved by “dividing the total added score of the selected emotional words in each representative emotion by the total number of emotional words in the representative emotion, and then again dividing the result by the number of subjects”. By dividing Table 2’s selected emotional word score, 14, by the number of emotional words included in this category of ‘Satisfaction in Usability’, 6, and then by dividing this number with the number of subjects, 8, the average score of ‘Satisfaction in Usability’ when performing Task 1, comes down to 0.291667 as shown in Table 3.

Table 3: Comparison of average score of representative emotion in each task

	Aesthetics	Satisfaction in Usability	Novelty	Uncomfortableness	Pleasure	Excellence
Task 1	0	0.291667	0.075	0.791667	0.03125	0
Task 2	0	0.354167	0	2.5625	0.375	0
Task 3	0	0.354167	0.05	0.979167	0.21875	0.125
Task 4	0	0.166667	0.425	3.916667	0.71875	0
Total	0	1.166667	0.55	8.25	1.34375	0.125
Average	0	0.291667	0.1375	2.0625	0.335938	0.03125
Standard Deviation	0	0.088388	0.194186	1.469304	0.291341	0.0625

As shown in Table 3, small difference was shown in the average score of the representative emotional words in each task. Overall, the average score of Uncomfortableness was the highest, and then in descending order, ‘Pleasure’, ‘Satisfaction in Usability’, and ‘Novelty’. On the other hand, it was shown that there were not so much difference in the average score per task of each representative emotion. In other words, there were no big differences in the representative emotions expressed for each characteristics of task. Merely, when comparing the average score of ‘Uncomfortableness’ for each task, Task 2 and Task 4 which have problems in usability turned out to have higher average scores than Task 1 and Task 3 which have no problems in usability. The reason for this can be assumed it is because of the emotional changes occurred while facing specific situations when performing a task rather than the task itself. For example, although overall there are no problems with usability, users could face some slight difficulties when performing tasks, and thus can bring about emotions such as ‘Uncomfortableness’.

Moreover Task 2 and Task 4 which have problems in usability had results with very high average scores in ‘Uncomfortableness’. As also shown in Table 1’s required time to perform task, since there were many difficulties in performing the task it makes sense that there were many uncomfortable and unpleasant emotions expressed while using the product. On the other hand reasons for Task 2 and Task 4, which has high ‘Uncomfortableness’ scores, showing higher average scores in ‘Pleasure’ than Task 1 and Task 3 could be said it’s because of the pleasure expressed when successfully finishing a hard task. Generally ‘Aesthetics’ and ‘Excellence’ were hardly expressed and this could be due to the fact that users tend to focus mainly on how to perform the task, and not notice the products appearances or various visual information that can bring about aesthetical emotions or notice any distinct excellence.

The average score of the representative emotions shown in Table 3 is an output that took into care of both the

number of times the emotional words were selected in each representative emotion and the score given to the emotional words. That is to say, when considering both the number of times of selection and the score, the average score given to the emotional word included in each task can be verified. Therefore, it is vague to say whether the difference in the average score is due to the number of times of selection, or because of the score given to each emotional word. To solidify the ranking of the representative emotion's average scores, there is the need to separately compare the score and the number of times the words were selected.

Since this research was based only on data coming from 8 subjects, statistical analysis could not be done. If more data is collected and concrete statistical analysis is done, it is expected that a more meaningful analysis result will come out in the future.

7. CONCLUSION AND FURTHER WORK

In this study, we have suggested methods for measuring a user's emotions in the natural and accessible environment of the design field. First, by extracting emotional words and representative emotions that show changes of user's emotions while using a product, we came up with a subjective evaluation scale for measuring the user's emotion. Through this we developed a tool that effectively measures the user's emotions expressed while using a product and that can complement the limitations of the psychological measuring method. In the Testing Module of the developed software, the subject can view the recorded video clip of he/she performing some specific task, and examine the emotional changes occurred. In the Analyzing Module, results can be verified by running the total experiment clip by each task, and then the data can be sent to Microsoft Excel and be analyzed in various ways. The tool developed through this research, can be used to effectively measure a user's naturally expressed emotion while using a product. To summarize the significance of the development of this tool would be as follows:

- Firstly, a more realistic product-using environment is suggested by letting the subject to examine his/her own emotional changes occurred while performing the task by actually watching the video clip that was recorded. Distortion on emotional measurement that Scherer had once pointed out as the limitations of psychological measurement [11] can also be minimized.
- Second, the emotions naturally expressed by users in a natural environment can be evaluated effectively by complementing the previously burdensome and unnatural equipments needed for the physiological measuring method.
- Thirdly, by easily analyzing and collecting various data on facial expressions and reasons on why the emotion was felt, it has become easier to be approached from the design field.
- Fourth, by comparing the situation while using the product and the emotional words selected in that situation, it suggests the possibility of analyzing the emotional change occurred from user, and the usability of the product.

Through this research we expect to clarify what effect a product's usability has on user's emotions with the help of a tool developed for measuring user's emotions while using a product. Through the basis of this research, further works would be as follows:

- Experiment on using VideoTAME to measure emotional changes expressed by users using cellular phones.
- Experiment on using VideoTAME to measure emotional changes expressed by users using other products to compare the emotional data obtained in the different product.
- Analysis of correlation between product usability and user's emotions.
- Analysis of effects of product usability on user's emotions.

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