

The effects of the usability of products on user's emotions

- with emphasis on suggestion of methods for measuring user's emotions
expressed while using a product -

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Abstract: The main objective of our research is analyzing user's emotional changes while using a product, to reveal the influence of usability on human emotions. In this study we have extracted some emotional words that can come up during user interaction with a product and reveal emotional changes through three methods. Finally, we extracted 88 emotional words for measuring user's emotions expressed while using products. And we categorized the 88 words to form 6 groups by using factor analysis. The 6 categories that were extracted as a result of this study were found to be user's representative emotions expressed while using products. It is expected that emotional words and user's representative emotions extracted in this study will be used as subjective evaluation data that is required to measure user's emotional changes while using a product. Also, we proposed the effective methods for measuring user's emotion expressed while using a product in the environment which is natural and accessible for the field of design, by using the emotion mouse and the Eyegaze. An examinee performs several tasks with the emotion mouse through the mobile phone simulator on the computer monitor connected to the Eyegaze. While testing, the emotion mouse senses user's EDA and PPG and transmits the data to the computer. In addition, the Eyegaze can observe the change of pupil size. And a video camera records user's facial expression while testing. After each testing, a subjective evaluation on the emotional changes expressed by the user is performed by the user him/herself using the emotional words extracted from the above study. We aim to evaluate the satisfaction level of usability of the product and compare it with the actual experiment results. Through continuous studies based on these researches, we hope to supply a basic framework for the development of interface with consideration to the user's emotions.

Key words: *usability, user's emotions, using products, emotional words, user's emotions measuring methods, physiological signs*

1. Introduction

With the advent of computer technology, the fundamental nature of products has shaped from physical forms towards product interactivity. The focus is now on usability of the product rather than conversing with just the looks of the product. That is, usability that concerns the ease and efficiency of use has become the key factor of success rather than its appearance.¹ 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). Today, user expectations are higher; products that bring not only functional benefits but also emotional satisfaction.

So far, there have been many studies on human emotions and the emotional side of products in the field of emotional engineering. Contemporary emotion-related researches have focused mainly on the relationship between product aesthetics and the emotional responses elicited by the products. The researches on emotion and product usability merely show that human emotion affects product usability. In relation, Donald A. Norman (2004) claimed that negative emotions can make a simple task difficult, and that positive emotions can make a difficult task easier.² However, little is known about emotions elicited from using the products and how the usability of products has effects on human emotions. Does good usability of products elicit positive emotions? On the other hand, does bad usability of products elicit negative emotions? These questions have not been clearly answered yet.

The main objective of our research is analyzing user's emotional changes while using a product, to reveal the influence of usability on human emotions. Before proceeding into the main experiment, in this study we extracted user's representative emotions expressed from the product's use keeping aside the product's appearance. And we also proposed the methods for measuring the user's emotions expressed while using a product.

2. Research methodology

For a successful outcome, the research is composed of literature study and experimentation. First, through literature study, research on the following contents should be performed.

- Understand the concepts of usability from studies on its definitions and attributes.
- Benchmark various usability evaluation methods.
- Suggest the most effective method to measure usability of products.
- Understand the concept of user's emotions from studies on the definitions and attributes of

¹ Shackel, B. (1991). Usability-Context, Framework, Design, and Evaluation. In Shackel, B. & Richardson, S. (Ed.), *Human Factors for Informatics Usability*. Cambridge: Cambridge University Press.

² Norman, D. A. (2004). *Emotional Design-Why we love (or hate) everyday things* (pp. 17-33). New York: Basic Books.

emotions.

- Benchmark various measuring methods to measure user's emotion.
- Suggest the most effective method to measure user's emotions expressed while using a product.

The following aspects will be extracted and verified through experimentation.

- Comprehend the various types of user's emotions elicited while using a product.
- Measure the changes of user's emotions elicited while using a product.
- Analyze the relationship between task duration and emotions.
- Analyze the relationship between errors and emotions.
- Analyze the relationship between facial expression and emotions.
- Discover the relationship between product usability and the user's emotions.

3. Extraction of emotional words and user's representative emotions

In the field of emotional engineering, a measurement method that indirectly measures the user's emotions through adjectives, called emotional words, is used. However, most of the studies on emotional words are related to expressions of emotions felt from a product's appearance or studies on words that emotionally express a product's appearance itself. In relation, we have extracted some emotional words that can come up while people use a product and reveal emotional changes. First, we assembled a set of emotions that were sufficiently extensive to represent a general overview of the full repertoire of Korean emotions from various literature studies. Secondly, we found emotional words from the afternotes written by website. Lastly, emotional words were collected from verbal protocols in which the user says out loud what he/she is feeling while he/she is carrying out a task. After the collected words were deleted or integrated according to standards, they were applied on appropriateness evaluation surveys for identification of emotional expressions while using a product.

3.1. Extractions from previous research results and literature study

Researches on emotional words have been carried out actively in the fields of psychology, linguistics, emotional engineering, and etc. The following are some of the major research results. Kim et al. (1998) analyzed the human inner system in the form of 'pleasant/unpleasant' through emotion related word analysis. Through free associations, 83 human inner system words were selected from emotion related words that were frequently used when expressing experience, and were analyzed through dimensional evaluation.³ Kim (2003) organized the linguistic characteristics of Korean emotional expressions through an overall

³ Kim, Y. A., Kim, J. K., Park, S. K., Oh, K. J., & Chung, C. S. (1998). 'Dimension of the Emotion Structure through the Analyses of Emotion related terms in Korean Language', *Korean Journal of the Science of Emotion & Sensibility* 1 (1): 145-152.

examination on the characteristics of body language, and on the concept and category of emotion revealed from idioms. Idiom cases related to 'joy/happiness, sadness, anger, fear, love, and disgust/hate' were studied to examine the core meanings of each emotion.⁴ Jang and Jang (1994) categorized idioms of Korean emotion expressions into ones that reveal emotional experiences concerning the production, extinction, and continuation of emotions, and one that reveal emotion expression behaviors. 220 emotional idioms were suggested to set the category of emotions.⁵ Park et al. (1998) analyzed the overall meaning structure of Korean adjectives by using the semantic differential method. After 46 representative nouns that fall under Korean category criterion were suggested, the associated adjectives and Yonsei university Korean dictionary editors used the Korean vocabulary frequency list to collect adjectives. 115 frequently used adjectives in relation to various concepts were extracted and a group of graduate students majoring psychology extracted 40 set of main opposite word sets in Korean adjectives.⁶ Kim et al. (1993) collected adjective words that were used to express products. Applicable adjective were collected from the Korean dictionary and 265 emotional words were extracted through appropriateness evaluation survey of understanding human emotions. Out of the adjectives extracted, 40 main words excluding opposite words and similar words were organized. The 40 emotional words evaluated by scaling method were categorized into attractiveness, luxury, comfort, openness, pleasantness, intimate, and feel of use through factor analysis.⁷ Han et al. (1998) used existing research results, reference literature, association methods on product advertisements, observations on a product's interface factor groups to extract 1,700 emotional words that are related to human emotions. These words were filtered according to overlapping meanings and elimination standards to come up with 163 final emotional words.⁸

In our research, we collected 182 words by relating to these existing research results and literature studies. Psychological research result on emotional words by Kim et al. (1998) was set as the basis and other researches were added on to it. Words that clearly did not induce from the use of the product and that were induced simply from the appearance of a product was eliminated. Also, words that were derived from one word and words of similar concepts were combined in to one word group.

3.2. Extractions from product use afternotes on the website

From the afternotes, we can indirectly understand the psychological state, reactions, and opinions of

⁴ Kim, H. S. (2003). *A study on Korean emotional idioms*. Seoul: Hankookmunhwasa.

⁵ Jang, S. K., & Jang, K. H. (1994). 'A study on Korean idioms - with emphasis on emotion expressions', *Journal of Koreanology* (Institute for Koreanology, Hanyang University) 25: 295-318.

⁶ Park, M. C., Shin, S. G., Han, K. H. & Whang, S. M. (1998). 'Measuring meaning of Korean adjectives and colors', *Korean Journal of the Science of Emotion & Sensibility* 1 (2): 1-11.

⁷ Kim, C. J., Lee, N. S., Park, S. J., Park, J. H., Park, S. C., Lee, S. Y., Kwon, K. S., Park, K. S., & Jung, K. T. (1993). *Development of human sensibility measurement technology* (pp. 8-20). The 1st year report, Korea Research Institute of Standards and Science(KRISS), Ministry of Science and Technology.

⁸ Han, S. H., Yoon, M. H., Kim, K. J., Jo, S. J., et al. (1998). *Development of a Usability Evaluation Method* (pp. 9-48). Pohang University of Science and Technology (POSTECH), Ministry of Science and Technology.

users while they used the product. With the internet, we can access large numbers of afternotes from various websites. In this research, we used websites that are used by many users, such as shopping mall and mania sites, to extract emotional words from their afternotes.

◎ Shopping mall sites: 6 sites

- Daum shopping (<http://dnshop.daum.net/>)
- INTERPARK (<http://www.interpark.com/malls/>)
- Auction (<http://www.auction.co.kr/>)
- CJmall (http://www.cjmall.com/index_tab1.jsp)
- Buynjoy (<http://www.buynjoy.com/>)
- Hansol CS Club (<http://www.csclub.com/>)

◎ Mania sites: 5sites

- Cetizen.com (<http://www.cetizen.com/>)
- dcinside (<http://www.dcinside.com/>)
- nbinside (<http://nbinside.com/>)
- Clie (<http://www.clie.net/>)
- K-BENCH (<http://www.kbench.com/>)

A total of 247 emotional words were collected from 11 websites on mobile phones, camera/digital cameras, home appliances, electronic pocket books, computer peripherals, and software. The emotional words collected from each websites were eliminated and combined according to overlaps and similarities.

3.3. Extractions from Think Aloud method in experiments

The two methods above are indirect methods of extracting emotional words. Think Aloud methods was applied as a direct method to collect emotional changes expressed by users while they used a product. Users were asked to perform a set of tasks using a mobile phone (J-PHONE) and verbally express their emotion during use. The participant users were 8 graduate students (4 males, 4 females) who have never used the experimented mobile phone (See Fig.1).



Fig.1 Extractions from Think Aloud method in experiments

It took an average of 20 minutes for the 8 participants to perform 5 tasks, and a total of 85 emotional words, including overlapping words, were extracted. A total of 53 emotional words were collected after the elimination of overlapping words. From debriefs after the experiment, we found that the Think Aloud method was not easy because the users concentrated on performing the given tasks due to the pressure of having to complete the tasks.

3.4. Assortment results of emotional words that are expressed during product use

In this research, a total of 482 emotional words were collected from the following methods: 182 words from existing research results, 247 words from users' afternotes on websites, and 53 words from the Think Aloud method. After eliminating words with overlapping concepts, 363 words were used in appropriateness evaluation surveys to understand the emotions that can be expressed while using a product.

Through the first appropriateness evaluation survey on graduate students who study user interface and workers in the field of interface related work, we eliminated words that did not clearly relate to the use of a product, words that were derived simply from the product's appearance, and words that were not clearly understandable. A total of 34 users participated in the web survey. 18 users were male and 16 users were female. 18 users were in their 20s, 14 users were in their 30s, and 2 users did not mention their age.

From the survey, there were 39 words that none of the 34 participants chose, such as frustrated, disappointed, satisfied, delighted, and etc. By analogy, these words can be understood as appropriate words to express the emotions felt while using a product. In this survey, based on the average word selection frequency (average 3.887, standard deviation 4.219), the words that were selected by over 4 users were firstly eliminated. According to this, 231 emotional words were finally chosen out of the 363 words that were surveyed (See Fig.2).

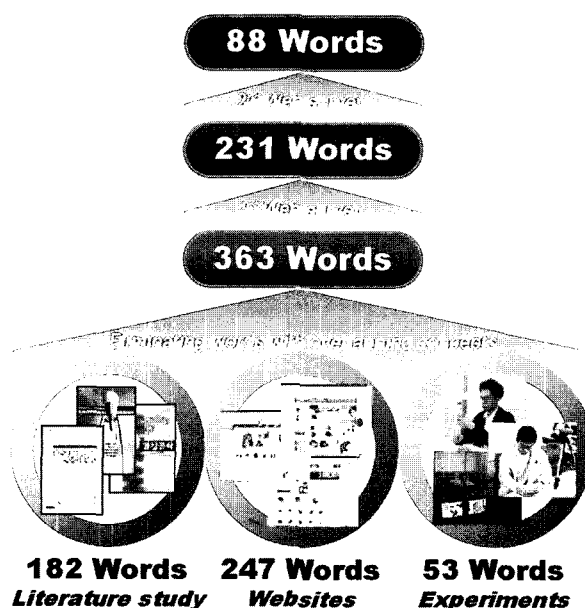


Fig.2 Extracted emotional words

The selected words were applied on the second evaluation survey for evaluating their appropriateness. This survey was conducted for identification of emotional expressions while using a product. Finally, we extracted 88 emotional words for measuring user's emotions expressed while using products. And we categorized the 88 words to form 6 groups by using factor analysis. The 6 categories that were extracted as a result of this study, such as aesthetics, satisfaction in usability, novelty, uncomfortableness, pleasure and excellence were found to be user's representative emotions expressed while using products (See Fig.3). It is expected that emotional words and user's representative emotions extracted in this study will be used as subjective evaluation data that is required to measure user's emotional changes while using a product.⁹

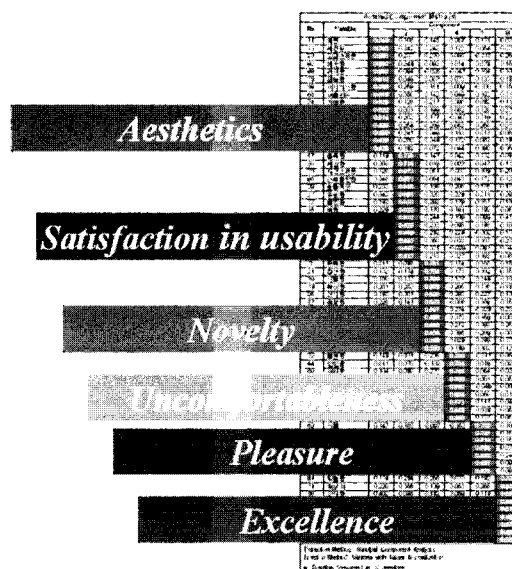


Fig.3 Extracted user's representative emotions

4. Methods for measuring the user's emotions

Human emotion is the issue which is subjective, difficult to define and even more difficult to measure because it's personal. Cacioppo and Gardner (1999) concluded that "the measurement of emotion is a bustling research area."¹⁰ Generally, the methods for measuring human emotion is divided in two, one is the psychological way based on user's subjective evaluation and another is the physiological way based on physiological signs. Since the former has limitation that is it has to be tested after experiencing the emotion, the physiological method, measuring physiological signs to use them as an objective index of human emotion, has been tried to measure the emotion more objectively. However, equipments for

⁹ Jeong, S. H., & Lee, K. P. (2005). 'Extraction of user's representative emotions expressed while using a product', *Journal of Korean Society of Design Science* 18 (1): 69-80.

¹⁰ Cacioppo, J. T., & Gardner, W. L. (1999). 'Emotion', *Annual Review of Psychology* 50: 191-214.

measuring physiological signs to grasp the emotion are usually expensive and burdensome. Moreover, it's not easy to approach in design field because of difficulty with analyzing data outputted 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 objective of this study is to suggest the most reasonable method for measuring user's emotion expressed while using a product, solving problems of two existing methods.

4.1. Comparison of methods for measuring human emotion

Traditionally, the measurement of emotion is usually dependent upon the psychological method. The most often used the psychological method requires users to report their emotions with the use of a set of rating scales or verbal protocols. However, this method, based on subjective evaluation, has two limitations. First, because emotional experiences can be delicate, users sometimes (consciously or unconsciously) manipulate their reports. According to Scherer (1986), self-reports are subject to distortions due to ego-defence tendencies and socially desirable effects. Moreover, relying on the subjects' 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

The physiological method is to use physiological reaction as an objective index to measure human emotion more objectively. The physiological signs from the autonomic nervous system are blood pressure, electrocardiogram (ECG), pulse, skin temperature (SKT), electrodermal activity (EDA) and electromyogram (EMG) and the signal from the central nervous system is electroencephalogram (EEG). However, the method using the physiological signs also has problems. First, it is very burdensome and unnatural with recent technology. For example, an examinee has to have sensors on his fingers to monitor the pulse and the EDA and have equipment on his head to measure an EEG coming from the occipital and parietal lobe. 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. Secondly, there is limit in the stimulus to make examinees express their emotion. The stimulus is limited to one that makes examinees not need to move, such as visual or hearing equipments. Third, it is about economic issue. High-priced equipments are required to sensor physiological signs and there are a lot of problems to furnish the testing environment. Forth, it is lack of consistency in the results of emotion research by measuring physiological signs. Even though it has consistent results about ECG or EDA, it still requires an objective index about other signs. Since the stimulus and the physiological variables are different by researches, the research results by measuring methods are not consistent.¹² Collet

¹¹ Scherer, K. R. (1986). Studying emotion empirically: issues and a paradigm for research, In Scherer, K. R., Wallbott, H. G., & Summerfield, A. B. (Ed.), *Experiencing emotion: a cross-cultural study* (pp. 3-27), Cambridge: Cambridge University Press.

¹² Cacioppo, J. T., Klein, D. J., Berntson, G. G., & Hatfield, E. (1993). The psychophysiology of Emotion, In Lewis, M., &

et al. (1997) concluded that conductance variations alone cannot fully describe the subjects emotional response; thus it must be combined with one or two other autonomic nervous system parameters.¹³ Lastly, data analyzing is very difficult. It is not easy to approach from the field of design since it requires propound knowledge of human physiological signs to analyze data from the tests.

4.2. Suggestion of methods for measuring user's emotion expressed while using a product

Almaden laboratory, IBM, made an emotion mouse to measure six basic emotions, such as happiness, surprise, anger, fear, sadness and disgust, by sensing ECG, skin temperature, photoplethysmographic (PPG) and EDA. 'INNO 2000', the emotion mouse by BIOPIA Co. Ltd., Korean venture, came out on the market for the first time in the world, earlier than IBM (See Fig.4).

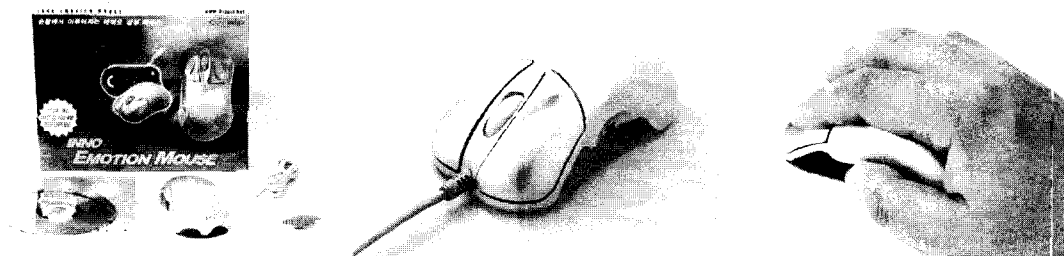


Fig.4 INNO 2000, the emotion mouse by BIOPIA Co. Ltd.

The emotion mouse of this venture senses and analyzes user's PPG and EDA, applied in a lie detector, and then transmits them to computer. A personal computer, connected with the emotion mouse, grasps the data and shows them to user real time. Moreover, the data is stored for a day or a month to trace the changing state of stress. Kim et al. (2001) who participated in the emotion mouse project, evaluated the reliability of physiological signs measured by INNO mouse. They compared EDA signs and PPG signs detected by the emotion mouse and those signs detected by MP 100 system (Biopac systems, Inc.), which is broadly used as a tool for analyzing out the physiological signs. At the result, it shows high correlation in both signs. Therefore, the physiological signs by INNO mouse have high reliability paralleled with the existing physiological signs-detecting tool and it can be used with the mediocre tools.¹⁴

Levenson et al. (1990) founded that the EDA has obvious difference between a positive emotion and a negative emotion and it increases when experiencing a negative emotion.¹⁵ The increase of a plasma

Haviland, J. M. (Ed.), *Handbook of Emotions* (pp. 119-142), New York: The Guilford Press.

¹³ Collet, C., Vernet-Maury, E., Delhomme, G., & Dittmar, A. (1997). 'Autonomic nervous system response patterns specificity to basic emotions', *Journal of the autonomic nervous system* 62 (1/2): 45-57.

¹⁴ Kim, H., Heo, C. W., & Choi, J. H. (2001). 'Evaluation of Reliability of the Emotional Function Mouse', *Journal of the Korean Society of Jungshin Science* 5 (1): 28-36.

¹⁵ Levenson, R. W., Ekman, P., & Friesen, W. V. (1990). 'Voluntary facial action generates emotion-specific autonomic

volume means the vasodilation of peripheral arterial and the decrease of a plasma volume means the vasoconstriction of peripheral arterial. It is caused by suppression and activation of the sympathetic system. PPG, recording the change of blood velocity by sensing the change of photo volume, is generally used to record plasma volume. In Levenson (1992)'s research, the emotion of sadness is able to be distinguished from other emotions because the change of plasma volume was bigger in sadness than in anger, fear and disgust.¹⁶

And the Eyegaze, which can measure examinee's eyeball movements and the change of pupil size, has potential to be applied to the research of understanding user's emotion. The examinee can move relatively free with a head set for Eyegaze, but it is still a weak point to have burdensome equipment. Thus, this study uses equipment of cornea boundary-reflecting technique, measuring the eyeball movements by reflection angle of infrared rays shot on the cornea. With this equipment, an examinee doesn't need to put burdensome tool on and an examiner can gain precise data with relatively moderate prices. However, an examinee may have a mental burden because he should not move his head in a process of calibration. This study suggests the potential of the Eyegaze to measure the change of emotion by observing user's pupil. Partala et al. (2003) showed that pupil size was significantly larger after both negative and positive than neutral stimulation. And the results showed that the pupil size was significantly larger during negative highly arousing stimuli than during moderately arousing positive stimuli. The pupil size was also significantly larger after highly arousing negative stimuli than after moderately arousing neutral and positive stimuli.¹⁷

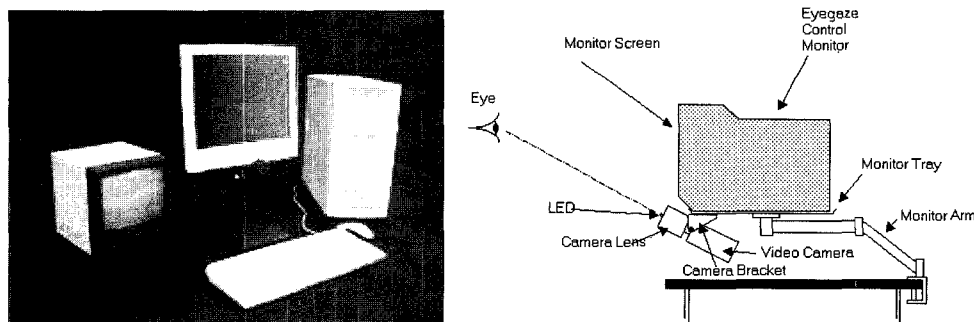


Fig.5 Eyegaze Development System by LC Technologies Inc.

This study suggests the method using the emotion mouse and the Eyegaze to measure user's emotion while using a product. An examinee performs several tasks with the emotion mouse through the mobile phone simulator on the computer monitor connected to the Eyegaze. While testing, the emotion mouse

nervous system activity', *Psychophysiology* 27 (4): 363-384.

¹⁶ Levenson, R. W. (1992). 'Autonomic nervous system differences among emotions', *Psychological Science* 3 (1): 23-27.

¹⁷ Partala, T., & Surakka, V. (2003). 'Pupil size variation as an indication of affective processing', *International Journal of Human-Computer Studies* 59: 185-198.

senses user's EDA and PPG and transmits the data to the computer. In addition, the Eyegaze can observe the change of pupil size. And a video camera records user's facial expression while testing. After each testing, a subjective evaluation on the emotional changes expressed by the user is performed by the user him/herself using the emotional words extracted from the above study. We aim to evaluate the satisfaction level of usability of the product and compare it with the actual experiment results. It suggests the potential to measure the change of emotion expressed while using a product by analyzing the physiological signs and facial expressions. INNO mouse, by Biopia Co.Ltd., measures examinee's emotion by detecting EDA and PPG while testing. Eyegaze Development System, by LC Technologies Inc., is used to observe the change of pupil size (See Fig.5). It can record examinee's eye movement by using the cornea-boundary reflecting technique with infrared ray camera and observe the change of pupil size.

5. Conclusions

In this research, the research matter and methods to be progressed were organized by presenting the conceptual framework for the study of product usability and human emotion research. Also, we extracted the emotional words and user's representative emotions that are expressed from the use of a product and not its appearance. It is expected that emotional words and user's representative emotions extracted in this study will be used as subjective evaluation data that is required to measure user's emotional changes while using a product. And we proposed the effective methods for measuring user's emotion expressed while using a product in the environment which is natural and accessible for the field of design, by using the emotion mouse and the Eyegaze. By measuring user's emotion in the concrete experiments, the result about correlation between usability of a product and user's emotion is expected. Also, through continuous studies based on these researches, we hope to supply a basic framework for the development of interface with consideration to the user's emotions.

Later process is like below;

- Concrete test plans and pilot test
- Arrangement of research result from experiments
- Analyzing the correlation between usability of a product and user's emotion
- Setting guidelines for interface design that reflect user's emotion

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