1. INTRODUCTION

Recent studies on user interface have paid more attention to Kansei. Literatures show that there are many directions of Kansei approach in user interface. For example, designing intuitive interaction between a user and a product or a system by multi-modal communications in order to improve user’s efficiency and satisfaction with interface [1-3]; creating intimate connections between users and systems by anthropomorphic or animation character [4, 5]; supporting the human’s creating activity in using product or system to perform complex work [6] and so on. We consider that Kansei approaches in interface are practical designing applications to utilize all properties of interface, such as text, color, sound, image, motion, structure, tangibility, etc, to improve products or systems more attractive, amusing and colorful, and bring users more positive and affective experiences than knowledgeable using.

Kansei is commonly described as an “integrated function of mind, and various functions existing in during receiving and sending” [7]. But this description is not sufficient to differentiate Kansei from cognition in the study of user interface. In our study, we propose that, Kansei is an intuitive information processing system that mainly produces affective appreciation or emotional experience on external information, while cognition is an active information processing system to recognize the information and perform acts by series of thinking.

Even though the former study [8] suggested that Kansei is paralleling with cognition, it is still fuzzy on the mechanism of Kansei. Especially in the study field of Kansei interface, it is very important to understand how Kansei works in the process of using a product or a system as while as Kansei factors are actually induced to interface designing. The process of using a product or a system can be seen as the process that cognitive information processing is performed consciously when a user is motivated by acting purposes. In the situation, how does the user’s Kansei interact with interface properties; how to lead the user’s affection or emotion to more positive state so that products or systems become more attractive; how Kansei influences using behaviors in short term or long term. Holding these basic thoughts, we expect to clarify the actions of a user’s Kansei in the interaction between the user and a product or a system.

2. OBJECTIVE OF THE RESEARCH

In our former studies, we investigated the possibility of measuring driver’s comfortable feeling by Yashida “basic affection vector model” (details seen in section 3), and analyzed the correlations between the indicators of comfortable feeling and vehicular motional characteristics. The significant correlations between indicators of comfortable feeling and motion characteristics were clarified both in linear motion [9] and curvilinear motion [10]. The results also showed the possibility of that a drivers’ comfortable feeling could be excited by the vehicular motion information.

Based on the possibility, in the research we continued to investigate if user’s emotional reactions could be elicited positively by information of interface properties, and its effects on operating activities and user’s subjective evaluations on interface, in order to observe effects of Kansei in user interface and prospect the possible directions of Kansei supporting interface.
3. HOW TO EVALUATE Kansei

Kansei evaluation is an important issue in Kansei researches. There are much information extracted from physical, verbal, and behavior, which can be used to evaluate Kansei. Ozaki el [11] proposed a possible approach to objective evaluation of subject’s feeling by physiological responses. In Kakiyama’s research [12] the availabilities of evaluating methods, including thoracic movement and expressional icons, were investigated through remote controlling system and network communication. Sensory Evaluation was widely used in many researches, such as Kansei simulation in automobile industry [13], motion of interactive robot [14], and so on. The literature researches show that user’s Kansei can be examined from two aspects of subjective evaluation and physiological evaluation.

3.1 Subjective evaluation

Subjective evaluation is normally considered as the most direct way to investigate physiological reactions of users by recording the descriptions of their self-emotional experience on product and operation based on subjective understanding. It is usually recorded as verbal expressions during operation by thinking aloud, or conducted after users finished operation by questionnaire or Semantic Differential (SD) Method.

3.2 Physiological evaluation

Many expressions of human bodily changes co-occurring with affect and emotion can be the indicators of Kansei, such as body posture, hand perspiring, increase in heartbeat, and brain waves. Because of the complexity of Kansei in mechanism and expressions, it is not appropriate to expect that currently researchers can find a sufficient and efficient way to distinguish Kansei states and evaluate them from full expressions. Therefore, in our research, we only chose comfortableness, one of emotional reactions inspired by Kansei, as the evaluation indicator.

From the dictionary, comfort is defined as ‘a feeling physically relaxed and satisfied’. In recent years, many researches have been done on how products or environments could elicit user’s comfortable feeling, such as comfortableness of clothes, automobiles or interior environment. It is also important to select certain physiological indices to measure the comfortable feeling. The past research [15] has shown that comfortableness was obtained by “1/f fluctuation” of air current periodical changes in automobile industry field. Musha [16] succeeded to objectively measure the relationship between comfortableness and fluctuation in EEG (electroencephalogram), and clarified the frequency fluctuation of the alpha wave of the brain influences on human’s feelings. Moreover, Yoshida [17] proposed “basic affection vector model”, in which comfortableness is evaluated by two-dimension references known as valence (positive mood – negative mood) and arousal (calm/low arousal – excited/high arousal) separately, and 1/f-like frequency fluctuation in left/ right frontal lobe. In the model, alpha waves in frontal lobe accompanying with comfortable feeling can be measured objectively as indicators of the two dimensions. The left frontal frequency fluctuations of alpha express valence, while the right frontal frequency fluctuations of alpha express arousal. When both left and right absolute values of slope coefficients of frontal frequency fluctuations of alpha near the rhythm degree 1 of ”1/f fluctuation”, it means that human is in the state of “calm pleasure”. Moreover, the degree of comfortableness is calculated by valence and arousal. Corresponding to the model, Yoshida further developed a non-invasive measuring apparatus called HSK-Centered Rhythm Monitor Slim (as see from Figure 1) to measure person’s comfortable feeling chronologically in real time series. Using the HSK-Centered Rhythm Monitor Slim, brain waves were detected through a headband sensor equipped with two electrodes (left and right) placed on the forehead of human subject. The detected brain waves are transmitted to a notebook computer by a small EEG amplifier and digitally filtered to extract alpha wave components (8-13Hz) [17]. The alpha waves of left forehead and right forehead are calculated into degree of valence and degree of arousal in real time; furthermore, degree of comfortableness is calculated by degree of valence and degree of arousal.

In our researches, we employed the HSK-Centered Rhythm Monitor Slim to measure user’s comfortable feeling as one sort of physiological responses with Kansei.

4. EXPERIMENTAL STUDY

In the experimental study, a program was developed to realize the ‘mental-rotation’ in PC virtual 3-dimension...
environment, in which the interface background color could change according to design beforehand or by user’s favorable choose. We intended to see if user’s comfortable feeling can be excited by the background color, and have an effect on cognitional activities when a user operates the program.

4.1 Introduction of the experiment

4.1.1 PC Program used in the experiment

We referenced Shepard’s famous psychological experiment of Mental Rotation of Three-Dimension Objects [18] to build our platform of the experiment. According to Shepard’s experiment, when subjects were asked to judge whether two portrayed 3-dimensional objects were same or not, there was a tendency that the reaction time was a linearly increasing function of the angular difference in the portrayed orientations of the two objects. The experiment gave the evidence that mental process of rotating objects in 3-dimension was analogy with the process of rotating objects in reality space.

Considering the mental rotation as a typical cognitive process, we made a PC program realized the mental rotation in virtual 3D space, in which user could click the buttons of the program by mouse to rotate 3-dimensional objects to match with the designated images. In the program we designed simpler 3-dimensional object than the original object in Shepard’s experiment to reduce difficulty of operation (as see from Figure 2).

The interface of the program, shown as Figure 3, was designed with left image area, right image area and right side of buttons area. In the buttons area, six buttons shown as the icon with axis and rotating direction were to rotate the object in right image area around the three axes to match up with left image. The ENTER button was to confirm the operation and enter next step after one task had been finished.

The program sequence is shown in Figure 4. Each subject was provided once practice to know about the operational method, then required to finish the 3 tasks. The task was
‘click the buttons on the right side of interface to rotate the right image and match up with the left image’. The left image was fixed, and the initial angle of the right image was changed in specified degrees around 3 axes in each task. The 3 tasks taken as one operating stage repeated 5 times. There was a short time rest break before each stage began.

4.1.2 Setting of the background colors of the program’s interface

The background colors of the interface were used as stimuli to elicit subject’s comfortable feeling. We decided 4 types of colors for 4 comparing groups, red, blue, gray and favored colors selected by subjects, as see from Figure 5. According to the color psychology [19], red was typically viewed as warm and exciting, blue was typically viewed as cool and relaxing, gray was viewed as boring and lower exciting. Favored colors were expected to elicit subjects’ pleasure feeling. Meanwhile, in order to avoid eyestrain after long-watch at high saturation color, the background colors in red and blue were designed as 3 graded saturations, from bright low saturation to dark high saturation, shifting with the background of 3 tasks. And in favored color group, each subject was asked to select 3 favorite colors before formal tasks, and the selected colors were used as background color of 3 tasks separately.

4.1.3 Subjects in the experiment

According to the 4 types of background colors, 4 groups, each group 5 persons, totally 20 students of the University of Tsukuba took part into the experiment.

4.1.4 Setting of the experimental environment

To exclude the influence of environmental light on the colors of the interface, a black box intercepting the environmental light was set on a table. A 21-inch liquid crystal screen, on which the program was presented, was set in

![Figure 5: 4 kinds of background colors of the program's interface and experiment sequence](image)

The colors were decided by RGB color mode. The colors of the red group are set 3 graded colors as RGB(253, 218, 231), RGB(249, 129, 162) and RGB(242, 0, 0); the colors of the blue group are set 3 graded colors as RGB(217, 240, 223), RGB(153, 216, 212) and RGB(104, 159, 202); the gray is RGB(217, 217, 217). In favor color group the 16 colors, formed with 4 color sequences of red, blue, yellow and green, were provided to subjects for selection. Each color sequence is divided into 4 graded colors from bright low saturation to dark high saturation.
one inner side of the box, and on the opposite side of the box, there was a viewing hole opened. Subjects were asked to view at the screen from the viewing hole to operate the program, as shown in Figure 6.

4.1.5 Measured indicators in the experiment

During the operation, the following indicators were recorded, shown in Table 1.

We used the device HSK-Center Rhythm Monitor Slim to measure the indicators of subjects’ comfort feelings dynamically when they operated the program. By frontal alpha wave components (8-13Hz) extracted from the EEG amplifier, we obtained values for valence, arousal and degree of comfortableness through the notebook computer in real time.

After the operation, Semantic Differential Method (SD Method) was used to let subjects subjectively evaluate their emotional impressions on operation. In the questionnaire, ten pairs of adjective were listed, including interesting-boring, amusing-laboring, favorable-detestable, smooth-jerky, energetic-tired, easy-difficult, simple-complex, calm-upset, relax-stress and satisfied-dissatisfied. There were 5 evaluating points in each pair of adjective.

The language used in experiment was Japanese, including the introductions to subjects in the program and SD survey.

Subjects’ operating log data of mouse, including operating time and operating clicks on the buttons, were recorded as indicators of operation.

4.2 Analysis and Results of the Experiment

4.2.1 Effects of the background colors

In order to compare effects of the background colors on subjects from full aspects, One-Way ANOVA was used to verify if there were differences among the 4 groups in subjective evaluation (points of SD Method), indicators of comfortable feeling (valence, arousal and degree of comfortableness) and operation data (operating time and operating clicks on the buttons).

The result showed that subjects in the favored color group had more “positive and calm” comfortable state than other groups. Subjects in the red color groups had more “negative and excited” emotional state than other groups, shown in Figure 7.

However, no differences in subjective evaluation or operational data were detected directly among the 4 color groups.

4.2.2 Relationship between subjective evaluations and operating behaviors

The relationship between subjective evaluations and operations were investigated in the following steps.

Firstly, Hierarchical Clustering was used to investigate the subjects’ similarity of operation changing tendency in stages. When Hierarchical Clustering was performed in standardized operating time of stages, the subjects were clustered into 4 groups of time-changing types. When Hierarchical Clustering was performed in standardized operating clicks of stages, the subjects were clustered into other 4 groups of clicks-changing types. The result of Hierarchical Clustering in standardized operating clicks of stages is shown as Figure 8, and 4 groups of clicks-changing types are shown as Figure 9.

Next, Discriminant Analysis was used to investigate if there were relations between subjective evaluations and the operating clicks or time changing types divided in the first step.

The results showed that the subjective evaluations could not be separated in groups of time-changing types. No relationship between them was detected.

The results of Discriminant Analysis between subjective evaluations and groups of clicks-changing types were shown in Table 2, Figure 10 and table 3. Table 2 showed that the first 2 functions are efficiently related to the groups, and explained 96.7% of the total between-groups; moreover the mean values of subjective evaluations for the functions were different among the 4 groups at a statistical signifi-
The results showed that the subjective evaluations could be separated in groups of clicks-changing types by function 1 and 2. According to the Groups Plotting of Figure 9, Group 2 was completely separated from other groups in the function 1, and Group 4 was completely discriminated from other groups in the function 2. Reviewing the standardized discriminant function coefficients in Table 3, the items of ‘amusing’ and ‘satisfied’ had large values for Group 2 plotting in positive value of the function.
Compairing Effects of User’s Kansei Excited by Color in Process of Cognitive Operation

1, and the items of ‘interesting’ ‘smooth’ and ‘satisfied’ had large values for Group 4 plotting in positive value of the function 2. It showed that the subjects in Group 2 of clicks-changing type were more tendencies to evaluate ‘amusing’ and ‘satisfied’, and the subjects in Group 4 mostly tend to evaluate ‘interesting’, ‘smooth’ and ‘satisfied’.

According to the results, it can be said that there were relationships between subjective evaluations and operating behaviors.

4.2.3 No correlation between operating behaviors and comfort feeling

Correlation analysis between the subjects’ operations (time or clicks) and comfort feelings (valence, arousal or degree of comfortableness) showed that there was no obvious correlation between them.

Discriminant Analysis was also used to investigate if there were relations between indicators of comfortable feeling (valence or arousal or degree of comfortableness) and the clicks-changing types or time-changing types. No relation was clearly showed between comfortable feeling and operating changing types.

4.2.4 No relation between comfortable feeling and subjective evaluation

By line-Regression analysis, no significant relation was detected between subjects’ comfortable feelings (mean of valence, or mean of arousal, or mean of degree of comfortableness) and subjective evaluations.

5. DISCUSSIONS

From the analysis, the difference of valence, arousal and degree of comfortableness among the color groups were detected. The favored color of background led users to more “positive and calm” state. It is possible that user’s Kansei elicited by user’s personal preference information

![Figure 9: Clicks-changing types in stages of 4 groups according to the result of Hierarchical Cluster Group 1 has the tendency that operating clicks decrease among the stages; In Group 2, operating clicks get a peak in the stage 3; and in Group 3, operating clicks get a peak in the stage 4; Group 4 has the tendency that operating clicks obviously increase in the last stage.]

![Figure 10: Result of Discriminant Analysis between groups of clicks-changing types and subjective evaluation (Groups Plotting)]
can induce user into positive emotional state. But no evidence showed that the colors or the color effects on physiological responses influenced operating behaviors and subjective evaluation. We consider that even though emotional reaction aroused by the colors could be observed from physiological response of brain waves, the colors and the color effects did not influence operation directly in short term of operating, and the user’s Kansei excited by the colors did not enter the conscious emotions in these situation.

There was a relationship between the operating behaviors and subjective evaluations. The subjects whose operating clicks got a peak in the stage 3 tended to evaluate the operation more ‘amusing’ and ‘satisfied’ than other subjects, and the subjects whose operating clicks increased among stages tended to evaluate the operation more ‘interesting’, ‘smooth’ and ‘satisfied’ than other subjects. Although the relationship between subjective evaluation and operating behaviors had not shown more regular patterns for us to understand the evaluating basis in subjects’ mind, we considered that Kansei also worked while operation and produced emotional impressions on the operation. This effect of Kansei was memorized subconsciously during the operation and could be recalled consciously by subjective evaluation.

Certainly, it is very difficult to record user’s subjective evaluations dynamically at the same time of operation. Therefore, we could not verify whether the emotional impressions on former operation would influence the latter operation or not in the experiment. One point that can be confirmed is, cognitive activities are also the stimuli information effecting on Kansei to produce the emotional experiences memorized unconsciously, and these emotional experiences can be recalled consciously by subjective reviewing evaluation after operation.

6. CONCLUSIONS

In this study, we developed the PC program of ‘mental-rotation’ in virtual 3-dimensional environment as the research platform, in which the background colors of interface could be changed according to design beforehand or by user’s favorable choice. The subjects were asked to complete the designated task by using the program. Both physiological responses by EEG and subjective evaluations were measured as indicators of Kansei expressions. Log data of mouse were recorded as indicators of operating behaviors. The relationships among the indicators were quantitatively analyzed to compare effects of user’s Kansei among the different color environments.

The study indicates that Kansei would be performed independently responding to the information of interface dynamically even in the state that cognitive processing is mainly performed. It is possible that user’s preference information can be utilized to improve user’s emotional physiological reactions to positive states. On the other hand, Kansei also show connections with cognitive activities. Even if the emotional impressions on operations do not be reflected on some physiological changes, they can be memorized implicitly, and aroused consciously by subjective evaluation after operation.

From this study, even though no evidence showed that user’s Kansei elicited by color could influence cognitive activities directly in short-term operating, we consider that the Kansei reactions on information from interface would quite possibly influence on some cognitive activities, such as operating strategy making, or product long-term usage. This needs to be studied by new ways in future research. Meanwhile, how to utilize properties of interface, besides color, to lead user’s Kansei into positive direction, and how to organize user’s cognitive operation through interface design in order to give user positive emotional experiences, are very challenging tasks in our future research.

REFERENCES


Lei SHI
Lei Shi received the B.S. degree and the M.S. degree in industrial design from Beijing Institute of Technology, China in 1994 and 1997 respectively. In 2007 she received Ph.D. degree in Kansei Science from University of Tsukuba, Japan. She joined the department of Industrial Design, Design and Art School in Beijing Institute of Technology in 1997, and has been a lecturer from 1999 to present. She engaged in researches in the fields of consumer product design, semiotics in product and user psychology. Her current research interests include Kansei interface design, emotional communication, and interaction design employing multimedia technology. She is a member of Japanese Society of the Science of Design and Japanese Society of Kansei Engineering.

Shiho NAKAMORI
Shiho Nakamori received the B.S. degree in industrial design from School of Art and Design, University of Tsukuba in 2005. She has been attending Graduate School of Comprehensive Human Sciences, University of Tsukuba from 2005, and received M.S. in Kansei Science in 2007. She began to work as research fellow of the Japan Society for the Promotion of Science from 2009. Her current research interest is the measurement of “users’ interest”.

Toshimasa YAMANAKA