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MEASUREMENT OF "WAKUWAKU" FEELING GENERATED BY INTERACTIVE SYSTEMS USING BIOLOGICAL SIGNALS

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ABSTRACT

To evaluate the Kansei value of artificial products, such subjective evaluation methods as questionnaires are commonly used, even though they have some demerits such as linguistic ambiguity and interfusion of experimenter and/or participant intention to the results. We began our research to objectively evaluate interactive systems by quantifying sensations using biological signals to supplement the above questionnaire demerits. We utilize biological signals to estimate participant feelings of relaxation, comfort and excitement, which are considered non-negative sensations. However, relaxation and comfort are considered static compared with such a dynamic feeling as excitement. We focus on a positive and dynamic feeling called "wakuwaku" in this article and constructed various systems to evaluate Kansei values to derive wakuwaku feeling using biological signals to clarify the relation between the wakuwaku feeling and biological signals.

Keywords: *wakuwaku feeling, excitement, biological signal, interactive system*

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1. INTRODUCTION

Recently, the Kansei value has become very important in manufacturing in Japan. Following function, reliability, and cost, the Kansei value has been determined as the fourth highest characteristic of industrial products by Japanese Ministry of Economy, Trade and Industry (METI). According to METI, it is important not only to offer new functions and competitive prices but also to create a new value to strengthen Japan's industrial competitiveness. Focusing on Kansei as such a new value axis, METI launched the "Kansei Value Creation Initiative" in 2007 [1], [2] and held a Kansei value creation fair called the "Kansei-Japan Design Exhibition," at Les Arts Decoratifs (Museum of Decorative Arts) at the Palais du Louvre, Paris in December 2008. Launched as an event of the "Kansei Value Creation Years," the exhibition had more than 10,000 visitors during its ten-day run and was received favorably [3].

Rapid progress of computers and internet has made interactive systems such as computer games, simulators and interactive arts for entertainment and/or art much more common than before. To evaluate the Kansei value of such interactive systems, subjective evaluation methods such as questionnaires are commonly used. Questionnaires are known for the established methods for subjective evaluation and have various merits. However, at the same time, they suffer from the following demerits:

- Linguistic ambiguity.
- Interfusion of experimenter and/or participant intention to the results.
- Interruption of the system's stream of information input/output.

Solving these problems is crucial to evaluate the degree of interest and/or excitement of a constructed interactive system, such as whether the system is really interesting, and to identify the moment of excitement. Evaluationg the Kansei value of an interactive system only by such subjective evaluation methods as questionnaires is almost impossible.

We began our research to objectively evaluate interactive systems by quantifying sensations using biological signals that offer the following merits and can supplement the above questionnaire demerits:

- Can be measured by physical quantities.
- Avoids influence from the intensions of experimenter and participants.
- Can be measured continuously.

Many previous researches have measured mental sensations using biological signals. Ohsuga et al. used biological signals to measure mental stress or simulator sickness [4], [5], which are considered negative sensations. On the other hand, Omori et al. measured ECG and EEG to evaluate autonomous and central nerve activities evoked by color stimuli, where they treated relaxation or comfort [6]. We previously utilized the alpha waves of EEG to estimate participant feelings of relaxation [7]. Compared with negative sensations, relaxation and comfort are considered non-negative sensations.

In this article, we focused on a feeling called "wakuwaku," which is a Japanese word for a positive sensation derived when someone feels something exciting or captivating. The word means thrilling or exhilarating in English. A wakuwaku feeling is also considered non-negative sensation, as are relaxation and comfort. However, a big difference exists between those sensations; a wakuwaku feeling is considered dynamic, especially compared to the static sensations of relaxation and comfort. Little previous research exists on such positive and dynamic sensations as the wakuwaku feeling.

The purposes of this article include to clarify the relation between the dynamic, positive sensation of the wakuwaku feeling and biological signals.

2. CONSTRUCTION OF SYSTEMS

We constructed various systems based on a treasure chest game to evaluate the degrees of wakuwaku feeling. We employed virtual treasure boxes by computer graphics instead of real treasure boxes because creating various real treasure boxes mentioned below would be costly and time consuming. These constructed systems have various complicated components to promote wakuwaku feeling, such as the appearances of figures, their combination, and the actions of the combined figures. The parameters of these systems were the design of the boxes and the sound, the BGM and the effect as shown in Table 1. The three box designs are shown in Figure 1. The constructed systems are shown in Table 2.

The procedures of the game were as follows:

1. Confirm the figures in the boxes (Figure 2 a).
2. Choose one of the boxes (Fiure 2 b).
3. Watch the figure in the chosen box (Figure 2 c).
4. Repeat the above procedures (Figure 2 d).
5. Watch the combinations of the two figures (Figure 2 e).
6. Watch the combined figure (Figure 2 f).

These procedures were designed to promote wakuwaku feeling when expecting a figure's appearance from the chosen box and combining two figures. Questionnaires and biological signals were employed to evaluate the degree of wakuwaku feeling of each system.

Figure 3 shows the system diagram. The input device was a keypad, and the output devices were a 17-inch LCD display and a pair of speakers. The biological signals were measured by sensors and BIOPAC measurement equipment (Biopac Systems Inc.). Two PCs were employed for system display and to measure the biological signals.

Table 1: System parameters

Parameters	Factor 1	Factor 2
Box design	designs*	White
Sound (BGM and effects)	With sound	Without sound

*Shown in Figure 1.

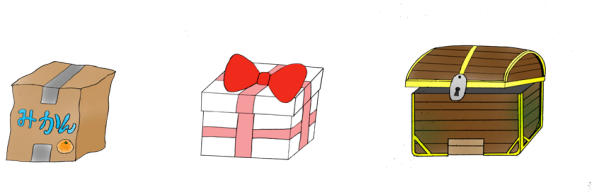

Figure 1: Three types of boxes

Table 2: Constructed systems

System	Box design	Sound
1	Decorated	With sound
2	Decorated	Without sound
3	White	With sound
4	White	Without sound

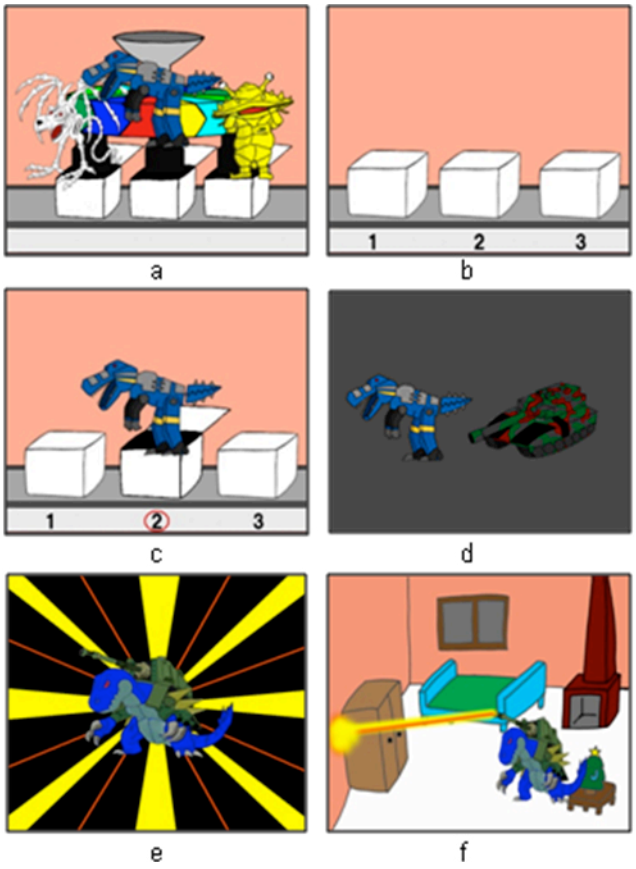

Figure 2: System flow

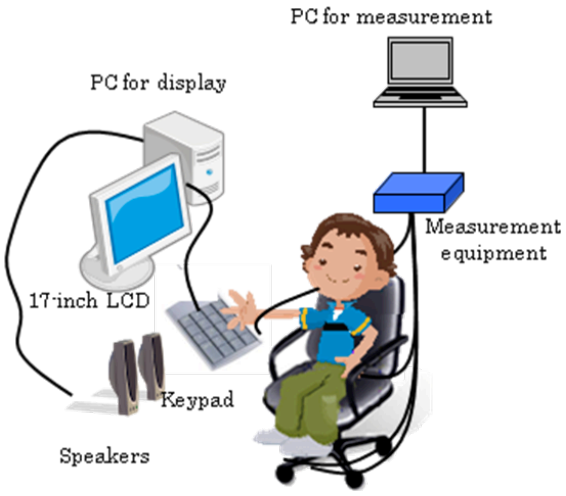

Figure 3: System setup

3. EXPERIMENTS TO EVALUATE THE SYSTEMS

3.1. Method

The participants randomly played the four games shown in Table 2 and answered questionnaires for each system.

The questionnaire about the wakuwaku feeling consisted of 23 items of paired 7-point evaluations such as "fun - boring," and five items of unpaired 5-scale evaluation such as "pounding." For the paired 7-point evaluation items, four indicates neutral, seven indicates the best, and one indicates the worst. For the unpaired 5-point evaluation items, five indicates the best and one the worst. In addition, participants were asked some free description questions after playing four games.

The following biological signals were measured constantly during the experiments to detect the degree of wakwaku feeling: Garvanic Skin Reflex (GSR), Electrocardiogram (ECG), and breathing rate. GSR, which is affected by states of emotion, was used as a physiological index to detect such emotions as anxiety and mental stress. ECG is changed not only by physical exercise but also by mental factors such as anxiety and stress. In addition, breathing rates and patterns are also indexes of stress and anxiety.

3.2. Results

Experiments were performed with twelve male students in their twenties who served as volunteers.

From the results of the analysis of variance for each questionnaire item with parameters in Table 1, the main effect of sound was significant for almost all questionnaire items including exciting and enjoyable. On the other hand, the main effect of the box design was not significant for almost all items. Table 3 shows the result of the analysis of variance for enjoyable. In the free description answers, some participants pointed out that the BGM and the sound effects were good points of the system, suggesting that sound is effective for wakuwaku feelings.

As for biological signals, we selected various physiological indexes as shown in Table 4. Since we designed the game flow with various events to promote wakuwaku feelings, we chose the following three moments for analysis:

- Moment I: When the first box opened.
- Moment II: When the second box opened.
- Moment III: Just after combining the two figures.

The first and second moments were in the first half of the game, while the third moment was in the second part. By a paired difference test, the heart rate at each moment of the first and the second choices of boxes was significantly different between the systems with different box designs. On the other hand, the heart rate at Moments I or II was not significantly different between the systems with sound and without sound. However, the averages of GSR at Moment III were significantly different only between the systems with sound and without sound. Table 5 summarizes the results of all tests.

Table 3: Analysis of variance (enjoyable)

Factor	Sum of squared deviation	DOF	Mean Square	F-value	P-value
Box design	20.02	1	20.02	14.47	0.00**
Sound	0.19	1	0.19	0.14	0.71
Error	62.27	45	1.38		
Total	82.48	47			

Table 4: Physiological indexes

Biological Signal	Physiological indexes
Galvanic Skin Reflex (GSR)	Average GSR
Electrocardiogram (ECG)	Average heart rate (the average number of heart beats per minute) Variance of heart rate Average R-R interval (Inverse of heart rate) Variance of R-R interval
Breathing rate	Number of breaths (breath per minute) Variance of number of breaths Amplitude of breathing

Table 5: Results of difference tests

Physiological Index	Parameter	Moment I	Moment II	Moment III
Average GSR	Box design	-	-	-
Average GSR	Sound	-	-	*
Average heart rate	Box design	**	**	-
Average heart rate	Sound	-	-	-
Average R-R Interval	Box design	**	**	-
Average R-R Interval	Sound	-	-	-

-: Not significant, *: Significant at 5% level, **: Significant at 1% level

4. DISCUSSION

The above experimental results suggeste that heart rate and GSR averages may show the wakuwaku feeling of the users of interactive systems. Moreover, the heart rate results are related to the system's former part, and the results of GSR averages are related to its latter part. Since the questionnaire results agreed with the results of the GSR averages and disagreed with the heart rate results, they might reflect the wakuwaku feeling of the latter part of the systems. The questionnaire may reflect the wakuwaku feeling of the system's last part because the participants can only remember it.

5. CONCLUSION

To evaluate the Kansei value of artificial products, we constructed various systems based on a treasure chest game to evaluate their Kansei values especially generated wakuwaku feeling using biological signals.

We performed experiments to measure the degree of wakuwaku feeling by using the constructed systems. From analysis of the experimental results, we obtained the following useful knowledge:

- The degree of wakuwaku feeling may vary depending on such parameters as object design and sound effects.
- The degree of wakuwaku feeling may be measured by such biological signals as GSR and ECG.

This work is the first step to measure wakuwaku feeling occurred by interactive systems. Future work will include more detailed research.

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