Proposal for Indices to Assess Attractiveness on Initial Use of Mobile Phones

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Abstract. It is necessary to determine the attractiveness level of using mobile phone to ensure user satisfaction. This study measured physiological indices of attractiveness during participants' initial use of a mobile phone. As physiological indices which concern autonomic nervous system activity, nasal skin temperature, pupil diameter, electroencephalography, blinking, and electrocardiography are listed. These indices were selected because preceding studies have suggested "safety and relaxing" and "feelings induced by desire and interest" as factors related to the attractiveness of mobile phones. The results obtained in these experiments that a device's attractiveness to users can be evaluated using physiological indices. Thus, the present study showed basic perspectives related to attractiveness from the point of physiological response.

Keywords: attractiveness, physiological measurement, mobile phone.

1 Introduction

Information devices are becoming increasingly advanced with progress in science and technology, making our lives more convenient. Although such advanced devices are attractive, it is difficult to satisfy users. It is necessary to determine the level of attractiveness of mobile phones to users to ensure user satisfaction. As a fundamental study, the present experiment aims to determine how to measure the level of attraction users feel toward mobile phones during their initial use by using objective indices such as physiological indices.

Studies regarding attractiveness-related *Kansei* elements have found that attractiveness may be associated with a sense of safety and relaxation induced by satisfaction or pleasantness and desire, interest, and emotion. On the basis of these findings, this study suggests that attractiveness can be assessed by indices that reflect autonomic nervous system activity [1] [2].

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Hence, the present study considered that the attractiveness level with respect to induced interest and emotion as well as a safety and relaxation can be measured by adopting nasal skin temperature, pupil diameter, electroencephalography (EEG), blinking [3], and electrocardiography (ECG) as indices related to autonomic nervous system [4]. In particular, the study emphasized ensuring usuality in the measurement situation and a non-invasive, non-contact method. The experiment examined whether physiological indices can be considered to be objective indices to measure attractiveness by adopting the method of minimized body contact or constraint.

2 Experimental Methods

2.1 Measurement of Nasal Skin Temperature and Pupil Diameter

Eleven undergraduate and graduate participants (six men and five women, mean age = 22.1 years, SD = 1.30) participated in the experiment to measure nasal skin temperature and pupil diameter.

Nasal skin temperatures were obtained using thermography (infra-eye 3000, NIHON KOHDEN Corp.). Thermal images of facial surface were recorded every minute by an infrared ray detector. From the recorded images, area ranging from under the eyes to the upper lip (vertically) and from the right to left edge of the face (horizontally) was specified. Maximum and minimum temperatures in the area were determined, and the temperature difference between them was calculated.

The pupil response was obtained using an Eyemark recorder (nac Image Technology Inc.) having a sampling rate of 60 Hz. Pupil diameters were analyzed using “dfactory”. Pupil diameters obtained here were transformed into a standardized *Z* score as an analytical indicator.

2.2 Measurement of EEG

Ten undergraduate and graduate participants (eight men and two women, mean age = 21.7 years, SD = 0.67) participated in the EEG experiment.

Exploring electrodes were placed on Fz, Cz, Pz, and Oz recording sites in accordance with the international 10/20 system [5]. Reference and ground electrodes were placed at C3 and C4 and both ear lobes, respectively. EEG was amplified using a digital EEG (Neurofax 1100, NIHON KOHDEN Corp.). The computer sampled at a rate of 1000 Hz. Fig. 1 illustrates the electrode locations in this experiment, as observed from above the head.

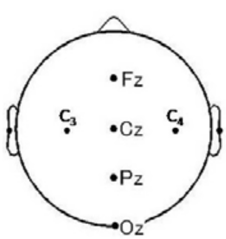

Fig. 1. Location of electrodes for EEG in this experiment

2.3 Measurement of Blinks and ECG

Ten undergraduate and graduate participants (10 men, mean age = 21.2 years, SD = 0.63) participated in the experiment to measure blinks and ECG.

Blinks were obtained by taking an eye image from a video camera per 1/30 frame. By observing images of each participant, two experimenters counted the number of blinks during each experimental operation of a mobile phone, and the average was calculated using the number of blinks obtained in both experimenters.

ECG was obtained using an RF-ECG wireless sensor (Medical Electronic Science Institute Co., Ltd.). The two electrodes were placed on the participant's left chest. The sampling rate was 204 Hz. RR intervals from an ECG signal were computed, and then spectral analysis was performed using FFT to compute the Low Frequency (LF) and High Frequency (HF) components. The LF/HF ratio was calculated as a measure of autonomic nervous system activity.

2.4 Experimental Procedure

First, participants gave their informed consent to take part in the study and the experimental procedure was explained to them in detail. They were given a scenario in which they were asked to evaluate a new phone as a possible replacement to their current mobile phone. On the basis of the preceding experimental results, three mobile phones were chosen: Models A, B, and C. The features of each are described in detail below. Model A has a touch screen and can be controlled by an onscreen software keyboard, except for a key to return to the initial screen; model B can be controlled by hardware keys (HW key) similar to some existing models and has a specific screen design; and model C has not only a touch screen but also a pointing device and some HW keys (such as an on/off hook and menu etc), unlike model A.

The participants completed three common tasks using each of these models: 1) composing a new mail, 2) setting the alarm clock for 5:00 a.m., and 3) capturing three pictures. They were handed one of the three models and asked to perform the three tasks in order. After completing all the tasks, they were handed the remaining models. The same procedure was repeated for each of the three models. Finally, the participants were asked to evaluate each model for the degree of "Attractiveness," "Desire to own," "Desire to use," and "Desire to buy" on a scale of 0 to 10 and to rank the three models. The models were randomly handed to the participants. Fig.2 shows an example of the experimental procedure.

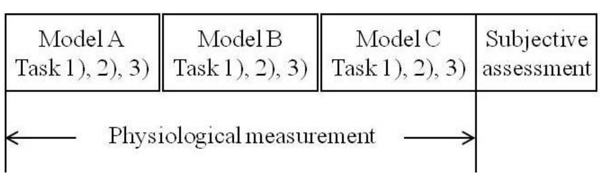

Fig. 2. Example of experimental procedure

3 Results

3.1 Nasal Skin Temperature and Pupil Diameter

For analyzing nasal skin temperature and pupil diameter, 10 participants, excluding a man whose data was incomplete, were assessed. Models A, B, and C were compared in terms of participants' physiological response while performing the task.

A one-way ANOVA was conducted for analyzing nasal skin temperature. Measurements of nasal skin temperature showed no significant differences in facial temperature between the models ($F(2,27) = 0.81$, *ns*), although facial temperature for model A is slightly higher than that for models B and C.

To examine differences between the models, a one-way ANOVA of pupil diameter was performed using standardized *Z* scores of pupil diameters. The analysis showed a significant difference among the models ($F(2,18) = 3.78$, $p < .05$). The multiple comparison by LSD method indicated that participants' pupils tended to be larger when they used model A or B than when they used model C. Fig. 3 shows the mean *Z* score of pupil diameter for each model.

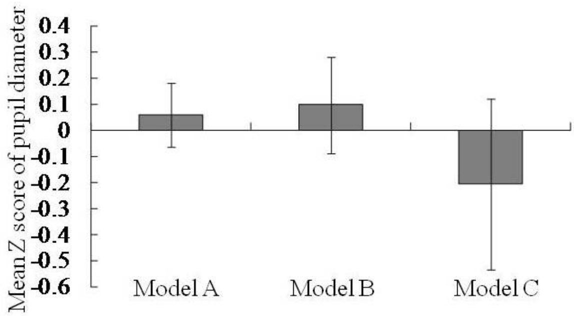

Fig. 3. Comparison of mean *Z* scores of pupil diameters of models

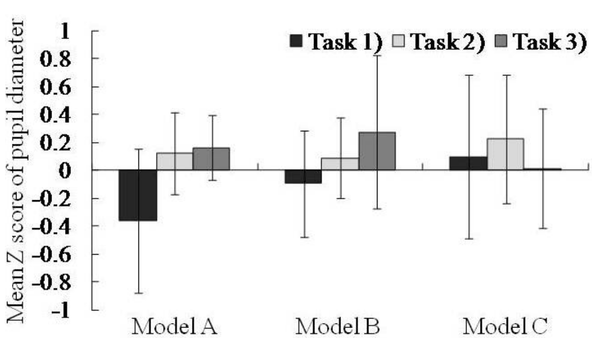

Fig. 4. Comparison of mean *Z* scores of pupil diameters

To compare the differences between tasks, the study used a two-way ANOVA for model and task. Results showed that the main effect of task is significant ($F(2,18) = 4.33$, $p < .05$). The results of multiple comparison by LSD method indicated that the pupil diameter in task 1) is smaller than in tasks 2) and 3). Fig. 4 shows the mean Z score of pupil diameter for each model.

3.2 EEG

The EEG analysis assessed nine participants, excluding a woman, because of noise in the data. The analysis examined differences between models in the amount of alpha wave (band of 8–13 Hz) associated with a state of relaxation and arousal. One-way ANOVA was performed using the amount of alpha wave for each of Fz, Cz, Pz and Oz. Results showed that there were no significant difference among the models for any the locations (Fz: $F(2,16) = 1.30$, *ns*; Cz: $F(2,16) = 1.11$, *ns*; Pz: $F(2,16) = 1.27$, *ns*; Oz: $F(2, 16) = 1.27$, *ns*).

Subsequently, two-way ANOVA for model and task was performed using the amount of alpha wave for Fz, Cz, Pz and Oz, separately. Measurements at Fz showed no difference in the amount of alpha wave among the models ($F(3,32) = 1.16$, *ns*).

For Cz, the main effect of task and the interaction of model and task are shown as follows: ($F(2,16) = 12.69$, $p<.01$; $F(4,32) = 3.37$, $p<.05$, respectively). The results of the test of simple main effect showed that for task 1), the amount of alpha wave of model A is smaller than that in of model C; for model A, the amount in task 1) is smaller than those in tasks 2) and 3); for models B and C, the amounts in tasks 1) and 3) are smaller than that in task 2).

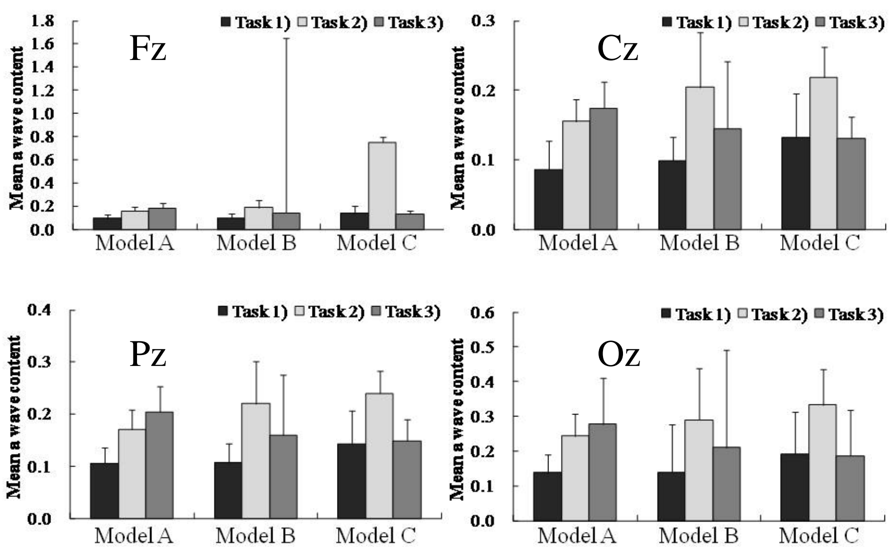

Fig. 5. Results of mean alpha wave amount for Fz, Cz, Pz, and Oz

Table 1. ANOVA tables for Fz, Cz, Pz, and Oz (**: *p*<.01, *: *p*<.05, *ns*: non-significant)

Fz

	SS	*df*	*MS*	*F*	*p*
Model	0.69	2	0.35	1.25	*ns*
Task	1.01	2	0.51	1.82	*ns*
Interaction	1.35	4	0.34	1.16	*ns*
Error	9.32	32	0.29		
Total	23.55	80			

Cz

	SS	*df*	*MS*	*F*	*p*
Model	0.00	2	0.00	0.53	*ns*
Task	0.11	2	0.05	12.69	**
Interaction	0.04	4	0.01	3.37	*
Error	0.09	32	0.00		
Total	0.40	80			

Pz

	SS	*df*	*MS*	*F*	*p*
Model	0.03	2	0.01	0.55	*ns*
Task	0.53	2	0.26	15.49	**
Interaction	0.20	4	0.05	3.52	*
Error	0.46	32	0.01		
Total	2.56	80			

Oz

	SS	*df*	*MS*	*F*	*p*
Model	0.01	2	0.00	0.29	*ns*
Task	0.24	2	0.12	8.42	**
Interaction	0.05	4	0.02	3.05	*
Error	0.22	32	0.01		
Total	2.01	80			

For Pz, analytical results indicated the main effect of task and the interaction of model and task: ($F(2,16) = 13.90$, $p < .01$; $F(4,32) = 3.24$, $p < .05$, respectively). The test of simple main effect revealed that for task1), the amount of alpha wave of model A is smaller than that of model C; for model A, the amount in at task 1) is smaller than that in tasks 2) and 3); for models B and C, the amount in tasks 1) and 3) are smaller than that in task 2).

For Oz, the main effect of task and the interaction of model and task are as follows: ($F(2,16) = 8.42$, $p < .01$; $F(4,32) = 3.05$, $p < .05$, respectively). The test of simple main effect indicated that for model A, the amount of alpha wave in task 1) is smaller than those in tasks 2) and 3); for models B and C, the amount in tasks 1) and 3) are smaller than that in task 2). Fig. 5 shows the results of amount of alpha wave for Fz, Cz, Pz, and Oz. The ANOVA results are summarized in Table 1.

3.3 Blinking and ECG

To compare the models, the study conducted an analysis of blinking and ECG by using the blink rate (blinks/second) during the performed task and the LF/HF ratio computed from the ECG data.

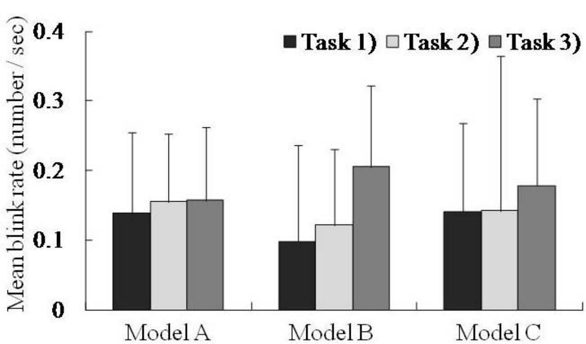

Fig. 6. Comparison of blink rate in models and tasks

A one-way ANOVA of blink rate was conducted to examine differences between models. The result showed no significant differences ($F(2,18) = 0.07$, *ns*). To examine the effects of task, two-way ANOVA for model and task was performed. According to the results of multiple comparison, the main effect of task indicated that the blink rates in tasks 1) and 2) were lower than that in task 3). The results for blink rates are shown in Fig. 6.

The LF/HF ratio was examined next using the Friedman test, which showed that there were no significant differences ($S(2) = 2.89$, *ns*). Two-way ANOVA for model and task showed the main effect of model and task ($F(2,18) = 3.00, p < .10$; $F(2,18) = 2.71, p < .10$, respectively). Multiple comparison of the effect of model indicated that the LF/HF ratio of model A was higher than that of model B. The comparison of task showed no differences among the models. The results for the LF/HF ratio are shown in Fig. 7.

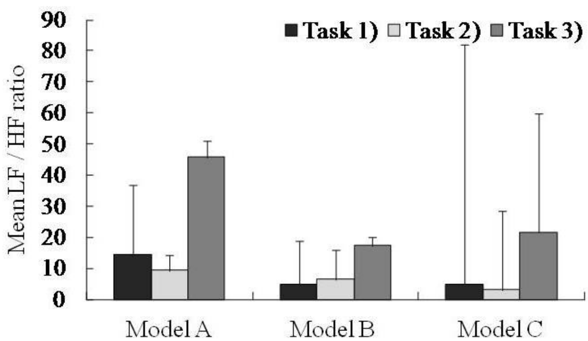

Fig. 7. Comparison of LF/HF ratio in models and tasks

3.4 Subjective Assessment and Model Ranking

The differences among models were examined in terms of the degree of "Attractiveness," "Desire to own," "Desire to use," and "Desire to buy" using separate one-way ANOVAs. It was confirmed that for all subjective assessments, model A was evaluated as significantly better than models B and C (Attractiveness: $F(2,60) = 19.74, p < .01$; Desire to own: $F(2,60) = 17.73, p < .01$; Desire to use: $F(2,60) = 14.36, p < .01$; Desire to buy: $F(2,60) = 19.55, p < .01$). The mean scores for the four subjective assessments are shown in Fig.8.

The ranks of the three models were determined using the Friedman test. The test revealed significant differences among the models ($S(2) = 24.47, p < .01$). The results of multiple comparison indicated that model A was ranked higher than models B and C.

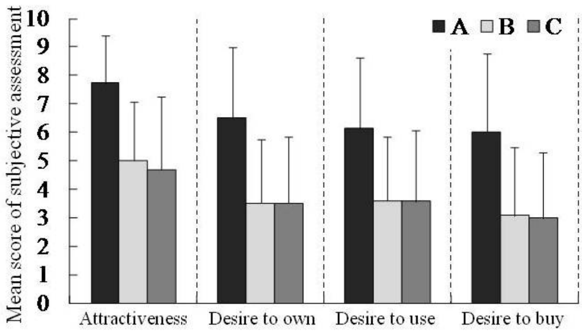

Fig. 8. Result of four subjective assessments of each model

3.5 Relationship between Physiological Indices and Subjective Assessments

To examine the relationship between physiological indices and subjective assessments, correlation coefficients were calculated. The results revealed significant correlations between pupil diameter and "Attractiveness" for models A and B. in addition, pupil diameter and "Desire to use" and "Desire to buy" tended to be correlated for model B, and blink rate and "Attractiveness" tended to be correlated for model C. Table 2 lists the correlation coefficients for physiological indices and subjective assessments.

Table 2. Relationship between physiological indices and subjective assessements

	Model A			Model B			Model C		
	Nasal skin temperature	Pupil diameter	Blink rate	Nasal skin temperature	Pupil diameter	Blink rate	Nasal skin temperature	Pupil diameter	Blink rate
Attrac-tiveness	−0.508	**0.708**	0.539	0.469	**0.675**	0.273	−0.268	0.013	−0.615
Desire to own	−0.371	0.169	0.425	0.375	0.511	0.242	−0.088	−0.16	−0.392
Desire to use	−0.182	−0.009	0.486	0.296	0.565	0.405	−0.206	−0.166	−0.092
Desire to buy	−0.393	−0.038	0.412	0.358	0.571	0.383	−0.373	−0.199	0.113

■ $p < .01$, ■ $p < .05$, ■ $p < .10$

4 Discussion

The purpose of this study is to find an objective index that expresses the attractiveness of a mobile phone during its initial use. To achive this aim, the present study carried out experiments that measured nasal skin temperature, pupil diameter, EEG, blink and ECG by considering the factors of "safety and relaxing" and "feelings induced by desire and interest" associated with attractiveness.

To examine differences in user reactions during use of mobile phones, physiological response was analyzed as participants completed three tasks: 1) composing a new mail, 2) setting the alarm clock, and 3) capturing pictures. The analysis of pupil diameter indicated a significant variation in size among participants‘ pupils as thet used the different models. The results show little evidence of substantial differences in nasal skin temperature, EEG, and blinking and ECG among the models. The changes in pupil diameter appear in response to emotional changes. Some studies have reported that because the size of the pupil is regulated by the autonomic nervous system, emotional stimuli such as interesting pictures evoke larger pupil dilation than neutral stimuli[6]. The present results showed larger pupil diameter in models A and B compared to model C. These differences may occur as a result of evoked interest and induced activity of the sympathetic nervous system for models A and B.

It was confirmed by subjective assessment that model A had higher scores in attractiveness and the other desires. In addition to the relatively larger pupil diameter, model A showed a higher LF/HF ratio. The results of the experiments suggest that physiological response and subjective assessment partially corresponded to the degree of attractiveness or desire evoked by these physiological responses, because the LF/HF ratio was associated with sympathetic nervous system activity [7] such as pupil diameter. This finding may indicate that attraction can be measured using pupil diameter and ECG.

Further studies on the combined effect of these indices are needed to establish the validity of physiological indices as measurements of attractiveness. If both indices reflect attractiveness, a similar tendency among models should be appear for pupil diameter and ECG. Therefore, it is important to measure pupil response and ECG simultaneously and to examine their association with attractiveness (subjective assessment).

Future study should focus on analysis of each task in detail. This suggestion is based on data that indicates user responses for all models tended to differ in some physiological indices depending on the task performance. This finding may indicate that the features of task and the process of operation related to task achievement might influence the measurement of attractiveness. More effort will be required to investigate task and function and to analyze the system and process of operation to expand the physiological index that expresses a products‘ attractiveness during its use.

5 Conclusion

As a fundamental study to obtain the possibility of objective indices related to a mobile phones‘ attractiveness during its initial use, the present experiment was designed using nasal skin temperature, pupil diameter, EEG, blinking and ECG. The results have shown the perceptions of different factors and physiological responses related to attractiveness.

The present study addressed mobile phone use. There is a need for further research that investigates various products to identify the relationship between a products‘ attractiveness during its use and users‘ physiological responses as objective indices. Regarding applications for engineering and high quality service, it would be valuable to develop technology for evaluating and measuring product attractiveness using a non-invasive, non-contact method and to explore practical applications of such technology.

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