Can Human Performance be Improved by Break Periods with a Companion Animal or a Robotic Pet?

Iiji Ogawa* and Takumi Sakamoto**

* Department of Animal Science, Teikyo University of Science & Technology,
2525 Yatsusawa, Uenohara, Kitatsuru, Yamanashi-Ken, Japan 409-0193
e-mail:iiji@ntu.ac.jp

** Division of Management Information System, Teikyo University of Science & Technology,
2525 Yatsusawa, Uenohara, Kitatsuru, Yamanashi-Ken, Japan 409-0193
e-mail:g153008@st.ntu.ac.jp

***Abstract*-This study was undertaken to assess differences on the performance of a simple data input and a creative task using PC when break periods with free time, a friendly companion animal, and a robotic pet were given. Playing with a companion animal poodle or with the robotic pet AIBO was used as two of the possible recreational activities between the tasks. Before/after each performance, subjects' EEGs were measured to investigate their emotional states. Also, during each performance, their heart rates (R-R intervals) were measured to monitor their levels of concentration. Twelve (12) subjects were selected for this study. The results indicated that the break period with the robotic pet AIBO was beneficial for the data input task; on the other hand, in terms of performance, for the creative task, the break period with the companion animal poodle or free time was better.**

I. INTRODUCTION

Many different kinds of recreational activities are used in nursing home facilities for therapeutic purposes including Animal/Robot Assisted Therapy and Activity (AAT, RAT, AAA, and RAA). Sakamoto and Ogawa [1] conducted an experiment where balloon volleyball was used as the group recreational activity to find out whether having an individual or a group activity during a break period increased a word processing task performance. They pointed out the importance of the recreational activity and found that a group activity proved more beneficial on a word processing task performance. However, they also noted that individual recreational activities may be more suitable under real working conditions.

The latest and most highlighted type of recreation has been labeled as AAT/AAA in which several living animals are brought in the nursing home guided by medical and voluntary staff. Turner [2] reported the effectiveness of those activities in terms of the participants' physiological, psychological, and social effects. Katcher [3] and Baun et al. [4] demonstrated that petting an animal lowered people's heart rate and blood pressure. As for RAA, Yokoyama [5], Yanagi and Tomura [6] reported in a preliminary trial the effectiveness of using the robotic pet, AIBO in a pediatric ward and a primary care setting. In a detailed study of human robot behavioral interaction, Nakata et al., [7] analyzed the relationship between a robot and its human counterpart in a human-robot-interaction experiment.

However, the effectiveness of those activities for company employees has not yet been fully investigated in the literature. Those activities may also be beneficial in terms of health and performance for company employees who are engaged in data input or creative tasks using PC on the job. Therefore, this study was undertaken to assess differences on the performance of a simple data input and a creative task using a personal computer (PC) when a break period with free time, a friendly companion animal, and a robotic pet were given.

II. METHODS

A. Experimental Set-Up

The experiments were carried out in a shield room (W3.5m. × D2.6m. × H2.4m.). The following experimental units were used in the experiments:

1) PC Unit: An IBM APTIVA with a 22 inch monitor, 733MHz (CPU), 194MB (memory), and Windows Me (OS) were used to run the performance tasks.

2) EEGs (Electroencephalograms): The Emotion Spectrum Analyzer was used. Using the international 10/20 method, EEGs of 14 mono-polar signals were measured with the ear lobe as a reference. A method suggested by Musha [8] was applied to quantify four of the emotional states (anger, sadness, joy, and relaxation), based on the cross-correlations between two of the mono-polar signals in terms of θ waves (5 to 8 Hz), α waves (8 to 13 Hz), and β waves (13 to 20 Hz). In this study, the level of anger/stress was only analyzed as an index of subjects' feelings toward each task.

3) Heart Rate (HR) Measuring Unit: The 64 K byte heart rate memory unit was used to measure the heart rates (R-R intervals). Based on the data collected, subjects' Heart Rate Variability (HRV), which was the standard deviation of heart rates (R-R intervals), was calculated to find out the level of their concentration during each task. When HRV is low, the concentration level can be said to be high [9].

B. Performance Tasks

The performance tasks consisted of two kinds; one was a simple repetitive data input task, i.e., each subject was required to feed many sets of 10 digits from an original manuscript as fast and as accurately as possible, and the other was a creative task which involved designing and building a house under some constraints, using software designed for such purposes. Both of the experimental tasks lasted 20 minutes and were repeated twice. The performance measures of each task were as follows:

1) The total number of 10-digit data inputs which the subjects fed correctly into the PC for the data input task.

2) The completion rate of the house for the creative task as evaluated by an experimenter.

C. Subjects

Twelve (12) male university students, between 18 and 24 years of age, participated in the experiments. None of them disliked companion animals.

D. Companion Animal

A one-year-old male toy poodle participated in the experiments as the friendly companion animal. The poodle was in good health, well trained, and slightly bigger than the robotic pet used.

E. Robotic Pet

The SONY entertainment robot AIBO (ERS-210) was used as the robotic pet. It was programmed in advance in order to be able to play ball with the subjects.

F. Experimental Procedure

Before starting the experiments, each subject had a practice period for both performance tasks to minimize the learning effect. The two performance tasks were carried out on the same day for the convenience of the pet owner; however, sufficient rest periods of more than 30 minutes were given between the two tasks. The experimental procedure is shown in Figure 1. For each performance task, a one-minute rest period was set before and after the first and second trials, thus in total, there were four (4) one-minute rest periods in order to measure subjects' EEGs at rest. A 5-minute break period with free time, the companion animal, or the robotic pet was placed between the second and third one-minute rest periods. During the 5-minute break period with free time, each subject could do anything except eat, sleep, and engage in exercise. During each performance task, subjects' heart rates (R-R intervals) were measured.

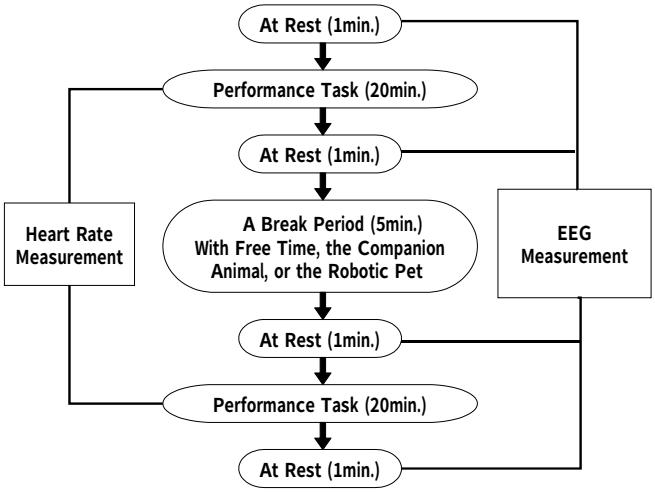

Figure 1. Experimental Procedure for each Performance Task.

III. RESULTS AND DISCUSSIONS

A. *Performance*

The following data analysis was done by the SAS system for Windows (version 6.12). The ANOVA for each task was performed separately. The results of both ANOVA indicated that individual differences were highly significant.

1) Data Input Task: The results of the data input task indicated that the break periods (BP) were found to be a significant factor on performance as shown in Table 1. However, the difference between before and after (BA) the break period was not significant. In analyzing each subject's data, eight (8) out of the twelve (12) subjects showed an increase on the data input task after the break period with the AIBO. After the break period with the poodle, eight (8) subjects also indicated an increase. The graphical presentation of the mean of the number of data inputs before/after the break period is shown in Figure 2. The break period with the robotic pet AIBO was found to be the best and statistically different from the other conditions for the data input task performance.

2) Creative Task: The results showed that BP and BA were quite significant factors on the creative task as shown in Table 2. While nine (9) subjects indicated an increase on the creative task performance after the break period with AIBO, eight (8) subjects indicated the increase after the break period with the poodle. The break period with the companion animal poodle gave the best performance and was found to be different from the period with the robotic pet AIBO as shown in Figure 3.

Table 1. ANOVA Table of the Number of Data Inputs for the Data Input Task.

Source	DF	F Value	Pr > F
Subjects (Subj)	11	66.26	0.0001**
Break Periods (BP)	2	4.02	0.0232*
Before/After (BA)	1	2.01	0.161

** indicates significance at 1% level of significance.
* indicates significance at 5% level of significance.

Table 2. ANOVA Table of the Performance Scores for the Creative Task.

Source	DF	F Value	Pr > F
Subjects (Subj)	11	2.88	0.0166*
Break Periods (BP)	2	6.86	0.0048**
Before/After (BA)	1	12	0.0022**
Subj＊BP	22	1.2	0.3346
Subj＊BA	11	0.34	0.9668
BP＊BA	2	0.02	0.9754

** indicates significance at 1% level of significance.
* indicates significance at 5% level of significance.

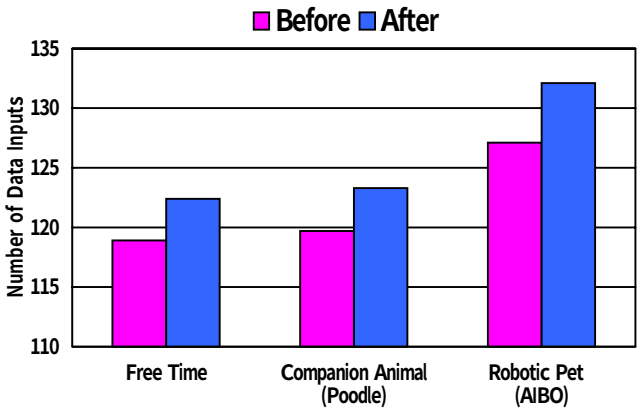

Figure 2. The Mean of the Number of Data Inputs before/after each Break Period with Free Time, Poodle, or AIBO for the Data Input Task.

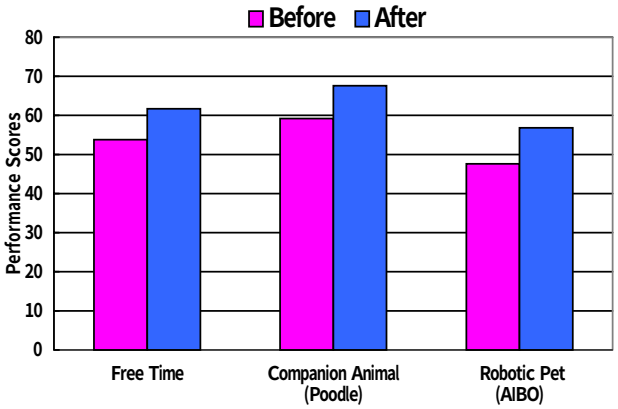

Figure 3. The Mean of the Performance Scores before/after each Break Period with Free Time, Poodle, or AIBO for the Creative Task.

B. EEGs (Electroencephalograms)

1) Data Input Task: The EEG data collected at rest were analyzed. The results of ANOVA of the anger/stress level before/after the data input task performance indicated that Subj and the interaction between Subj and BP were highly significant, and BP was significant as shown in Table 3. The factor of At Rest (AR) was not significant. The break period with free time was found to have the highest level of anger/stress; on the other hand, the break period with the poodle showed the lowest level as shown in Figure 4. Both of the conditions were found to be statistically different.

2) Creative Task: BP was highly significant. The break period with the robotic pet AIBO gave the highest anger/stress level; on the other hand, the period with the companion animal poodle was the lowest and found to be statistically different from the two other break periods for the creative task performance as shown in Figure 4.

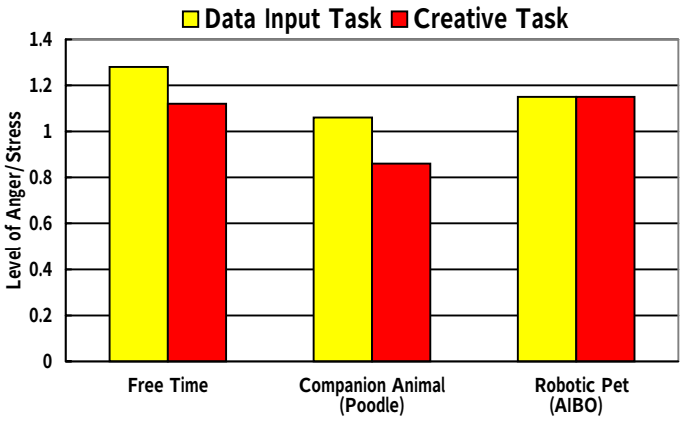

Figure 4. The Mean of the Level of Anger/Stress for each Break Period with Free time, Poodle, and AIBO for both Performance Tasks.

Table 3. ANOVA Table of the Level of Anger/Stress for the Data Input Task.

Source	DF	F Value	Pr > F
Subjects (Subj)	11	37.71	0.0001**
Break Periods (BP)	2	4.76	0.0118*
At Rest (AR)	3	2.32	0.0835
Subj∗BP	22	2.78	0.0007**
Subj∗AR	33	1.19	0.2709
BP∗AR	6	1.84	0.1044

** indicates significance at 1% level of significance.
* indicates significance at 5% level of significance.

Table 4. ANOVA Table of the Level of Anger/Stress for the Creative Task.

Source	DF	F Value	Pr > F
Subjects (Subj)	11	16.5	0.0001**
Break Periods (BP)	2	6.91	0.0019**
At Rest (AR)	3	0.29	0.8328
Subj∗BP	22	1.96	0.0192*
Subj∗AR	33	0.75	0.8168
BP∗AR	6	0.77	0.5988

** indicates significance at 1% level of significance.
* indicates significance at 5% level of significance.

C. HRV (Heart Rate Variability)

In order to find the level of subjects' concentration during each task, their HRV was calculated. The result of ANOVA for both tasks is shown in Table 5. The performance tasks (PT) and BA were found to be highly significant factors and BP was significant. HRV was found to be the highest during the break periods, including the one with the robotic pet AIBO; however, when the companion animal poodle was in the break period, HRV was the lowest as shown in Figure 5. HRV after the break period was higher than before the break and significantly different from each other.

Table 5. ANOVA Table of HRV for both Tasks.

Source	DF	F Value	Pr > F
Subjects (Subj)	11	71.71	0.0001**
Performance Tasks (PT)	1	42.7	0.0001**
Break Periods (BP)	2	3.27	0.0434*
Before/After (BA)	1	7.22	0.0088**
Subj∗PT	11	4.54	0.0001**
Subj∗BP	22	1.8	0.0303*
Subj∗BA	11	1.91	0.0501
PT*BP	2	0.21	0.8122
PT*BA	1	0.05	0.832
BP∗BA	2	0.47	0.6289

** indicates significance at 1% level of significance.
* indicates significance at 5% level of significance.

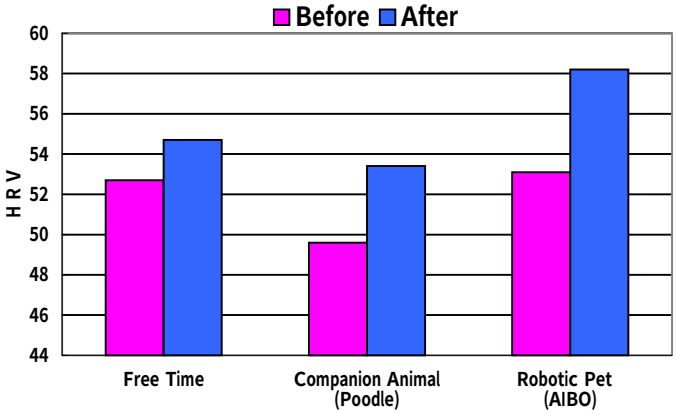

Figure 5. The Mean of HRV before/after the Break Periods for both Performance Tasks.

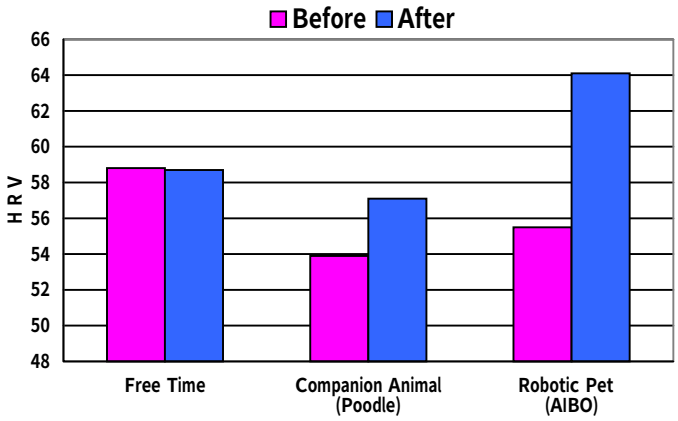

Figure 7. The Mean of HRV before/after the Break Periods for the Creative Task.

The results of each performance task are as follows:

1) Data Input Task: BA was found to be significant on HRV at 10% level of significance. HRV was found to be higher after the break periods as shown in Figure 6.

2) Creative Task: BA was found to be significant on HRV at 5% level of significance for the creative task. HRV was higher after the break periods with the companion animal poodle and the robotic pet AIBO as shown in Figure 7.

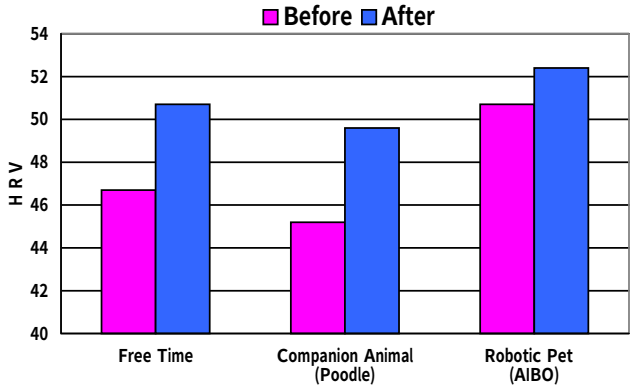

Figure 6. The Mean of HRV before/after the Break Periods for the Data Input Task.

IV. CONCLUSIONS

The following conclusions can be made within the limitation of the experiments.

A. For Data Input Task

1) The break period with the robotic pet demonstrated better performance.

2) The break period with free time gave the subjects high stress; on the contrary, the period with the companion animal poodle gave less stress.

B. For Creative Task

1) The break period with the companion animal exhibited better performance.

2) When the robotic pet AIBO was in the break period, subject's stress level was higher during the creative task performance. However, the period with the companion animal poodle demonstrated the least stress.

3) For the creative task only, the level of subjects' concentration before the break period was found to be statistically different and higher than after the break period. However, the graphical presentation as shown in Figure 7 indicated that there was not a significant difference on the level of concentration between before and after the break time with free time.

C. For Both Performance Tasks

1) The performance was better after each break period with free time, the companion animal, and the robotic pet.

2) The level of subjects' concentration during each performance task was found to be high when the subjects played with the companion animal poodle in the break periods; on the other hand, when playing with the robotic pet AIBO, the level of concentration was low during each task. The level of concentration was higher before any break period.

3) Comparing the task performance with the stress and concentration levels, the level of stress was found to be higher, the level of concentration was the lowest, and the data input task performance was the best after playing with the robotic pet AIBO. Also, for the creative task, the opposite holds true, i.e., the level of stress was the lowest, the level of concentration was the highest, and the creative task performance was the best after playing with the companion animal poodle.

Beneficial activities in the break periods were found for different types of PC works. It can be said that performance became better and the concentration level became lower after the break time with free time, the companion animal poodle, and the robotic pet AIBO. For both tasks, the stress level was the lowest when the companion animal was in the break period.

For data input tasks, playing with a robotic pet during break periods can be recommended for better performance. In creative tasks, playing with a companion animal may enhance performance with less stress and high concentration. These findings may be due to the fact that a programmed pet and a living animal evoke different responses in humans. When a subject interacts with a robotic pet, he must act consciously, plan his interaction, and think it over many times. However, with a companion animal, the interaction is natural and spontaneous.

RAA/AAA are usually conducted in a group. In this study, however, RAA/AAA were individualized; therefore, some considerations may be needed for further studies. These findings are likely to be useful in arranging break periods for company employees. The results reported here pertain to the first of a series of studies which are planned. One further study aims at investigating the same questions for people aged 65 or over. It is hoped that the results of this study increase the understanding and importance of AAT, RAT, AAA, and RAA.

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