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Minor Study

Psychological and Physiological Effects of Robot Assisted Activity

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In this research whether a pet-type robot AIBO had psychological and physiological therapeutic effects or not was examined. In an experiment, 40 undergraduate women were assigned to either of an AIBO condition and two video conditions. After the participants engaged in a stress task, they interacted with AIBO or viewed a neutral video. Results showed that interacting with AIBO more greatly decreased the participants' loneliness and state-anxiety psychologically, reduced cardiac rate and the lowest blood pressure physiologically than video viewing. But, these effects could not be obtained for self-esteem, degree of stress and fatigue, the highest blood pressure, and task score. Results also revealed that attachment to AIBO and preference for dogs moderated those therapeutic effects. These results indicate that a pet-type robot would have the therapeutic effects like a living animal.

Key words: pet-type robots, therapeutic effects, animal assisted therapy/activity

Through advancements in science and technology, living with robots as described in the world of science fiction is no longer just a fantasy. Until now, "robots" usually meant industrial robots on the factory production line, but in recent years, compact and light-weight robots have continued to be developed and sold for use in daily life areas such as the home. Among these, pet-type robots, such as "AIBO," the dog-like robot by Sony Corporation, and "PARO," the seal-like robot by the National Institute of Advanced Industrial Science and Technology, have become very popular and are expected to be emotionally beneficial to people in the same manner as living animals.

Interaction with animals has been well known to have therapeutic effects for people and has been implemented in Animal Assisted Therapy and Activity (AAT/A) (Katcher & Beck, 1983; Gunter, 2005). AAT/A is considered to be effective in three major aspects: psychological, physiological, and social. Psychological effects are increased self-esteem and reduced loneliness, stress, and anxiety (Garrity, 1989). Physiological effects include relief of strain, and reduced blood pressure and cardiac rate (Baun, Bergstrom, Langston, & Thoma, 1984). Social effects are increased communication between humans through pets (Eddy, Hart, & Boltz, 1988). However, many problems, such as housing, infectious diseases, and pet loss (depression after the death of pets), also arise because a living creature is involved.

If a pet-type robot can have therapeutic effects just like living animals, these latter issues can be solved and the effects of AAT/A can be achieved in a simpler and more convenient way. In fact, there are reports on trial therapy activities (Robot Assisted Therapy/Activity: RAT/A) using AIBO or PARO that have been carried out. RAT/A using PARO improved patients' and elderly people's moods, making them more active and more communicative (e.g., Shibata et al., 2001; Wada et al., 2004). However, attention should be given to the fact that most of

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these few experimental studies are of a pre-test–post-test single group design that does not set a control condition. In general, the effect of treatment is not clear for an experimental design that does not set a control condition, even a difference between measured values in the pre- and post-tests is observed, because alternative explanations such as the change being due to some intervening event, natural growth, or the passage of time, and not the treatment itself, cannot be ruled out (Shadish, Cook, & Campbell, 2002). Thus, up to now, few experimental studies that evaluate whether a pet-type robot can have therapeutic effects for people have been conducted according to the appropriate methods of setting a control condition.

The purpose of this study is to examine whether a pet-type robot can have therapeutic effects by means of an experiment using AIBO. To do so, it is desirable to show that the participants experience healing by interacting with AIBO ("AIBO condition") in comparison with those who do nothing in the same time period (a control condition). However, since doing nothing for a specific amount of time can be considered to be an unusual situation in a daily routine, it was decided to let the participant view a neutral video as the control condition for this study ("video condition"). Two videos were prepared for generalization of the results.

Furthermore, the need for the therapeutic effect is assumed to be greater for a person in a stressed condition. Therefore, this study would first apply stress to the participants and then focus on recovery from the stressed condition by treatment (interaction with AIBO/video viewing).

In the experiment, after performing a stress task, half of the participants interacted with AIBO, and the other half watched and listened to a neutral video during the same time period. After treatment, psychological variables were measured by a questionnaire. Physiological variables were measured several times throughout the experiment in order to more closely examine any changes.

Both psychological and physiological aspects were examined as indicators of therapeutic effects. The psychological aspects measured were self-esteem, loneliness, degree of stress and fatigue, and state anxiety. Previous AAT/A research revealed an increase in self-esteem, and reduced loneliness and anxiety (Garrity, 1989), so we would attempt to determine if the same psychological effects could be achieved with a pet-type robot, as well. However, measures used for this study focused on a short-term and subjective evaluation since the short-term effects in the experimental situation were examined. Physiological aspects measured were blood pressure and cardiac rate. Blood pressure and cardiac rate were shown to increase during tension by the dominant activation of the sympathetic nerve and to decrease during relaxation by dominant activation of the parasympathetic nerve (Andreassi, 2000).

Hypothesis 1: The AIBO condition would increase self-esteem and reduce fatigue and state anxiety more than the video condition.

Hypothesis 2: The AIBO condition would reduce blood pressure and cardiac rate more than the video condition.

In addition, the degree of attachment to AIBO and whether the participant liked dogs or not were included as moderators. According to previous AAT/A studies, the degree of attachment to the therapy animal influenced the effect (Jenkins, 1986), so in this study we also examined if attachment felt towards AIBO or if the participant liked dogs or not influenced the effects.

Hypothesis 3: The tendency in hypotheses 1 and 2 would be more apparent in: 1) a person with a higher attachment to AIBO, than a person with a low attachment; 2) a person who liked dogs more than a person who did not.

METHOD

Participants

Forty female university students attending psychology studies were randomly assigned; 20 for the AIBO condition, 20 for the video condition (two videos, ten persons each). Ages ranged between 18 and 22 years old, with an average age of 19.4 years old.

Neutral video

"See the World by Train" (Sekai no Shasho kara) (12)—French Railway—(Video 1) and "World Journey—European Alps" (Shin Sekai Kikou) (Video 2) were used. In the analysis of the contents beforehand, three female graduate school students watched eight prospective videos based on the criteria of "no scenes of violence, and a weak plot." Afterwards, the students independently answered the degree of change in emotion on a nine-point scale from -4 to $+4$ using 35 pairs of emotive adjectives prepared based on Terasaki, Kishimoto, and Koga (1992). The two lowest scoring videos (in other words, the videos with the smallest emotional variables) based on two indices, the arithmetic mean of the rating scale values given by the three students and the average absolute value as indicated by the distance from the center, were selected as the neutral videos.

Stress load task

The task was similar to the "Uchida-Kraepelin Psychodiagnostic Test" of adding neighboring single-digit numbers (Komaki, Hiyama, Ichimura, & Maruoka, 2007; Han & Uchiyama, 2004).

Equipment

Physiological measurement device A Phinapress noninvasive electronic blood pressure gauge 2300 (Japan Electric Sanyei Corporation) was used with the cuff wrapped around the middle finger of the left hand.

Pet-type robot AIBO ERS-111 (Sony) was used. The memory card "Hello AIBO!" was used for this study to remove any influence caused by changes in the personality of AIBO during the experiment and to enable AIBO to demonstrate a consistent reaction to each participant.

Image presentation A 29-inch TV (Victor) and VCR (Victor) were used.

MEASURES

Psychological variables The following five dependent variables were measured using a nine-point scale from strongly disagree to strongly agree.

Self-esteem (19 items). In this study, it is necessary to measure short-term variations in self-esteem in the experimental situation, but existing scales do not capture this aspect. Therefore, we created a scale referring to Kurosawa (1992) to measure aspects within self-esteem that were considered to be comparatively easy to change, such as short-term and subjective evaluation and the sense of capability felt by the participant herself at the site. Internal consistency was confirmed in a preliminary survey of 83 female university students ($\alpha=.93$). Examples of the items include "I'm going to fail at whatever I do" and "I have confidence in myself."

Loneliness (16 items). A scale was created referring to Ochiai (1983) to measure loneliness based on short-term, subjective affection, so that short-term variations in the experimental situation could be measured. Internal consistency was confirmed in a preliminary survey ($\alpha=.86$). Examples of the items include "I feel like I am left alone" and "I don't think I am alone."

Stress and fatigue (20 items). A scale was created to measure short-term fatigue, somatic symptoms caused by stress, and negative feelings felt by the participant herself on site. Internal consistency was confirmed in a preliminary survey ($\alpha=.89$). Examples of the items include "My head is not clear and feels dull" and "I feel refreshed."

State-anxiety (20 items). Shimizu and Imae

(1981) was used.

Attachment to AIBO (33 items) A scale was created to measure the participants' impression of AIBO. To measure the impression after actual interaction with AIBO, only "participants of the AIBO condition," in other words those who interacted with AIBO, were allowed to answer the last part of the experiment (participants of the video condition did not answer). Examples of the items include"Cute" and "Boring."

Physiological variables Using the mean scores from data measured every 30 seconds for five minutes, the highest blood pressure (systolic blood pressure), the lowest blood pressure (diastolic blood pressure), and cardiac rate were obtained.

Physiological variables were measured several times in order to more closely identify the degree of recovery from the condition of stress. Participants were first given a stress load task, and then their physiological response under a stressed condition was measured. Next, while controlling physiological response under a stressed condition, we examined whether a difference in physiological response could be observed between the conditions immediately after treatment (T1), after treatment and rest (T2), and then when working on a stress load task (second task) (T3).

Procedure

Participants were called to the experimental room one by one and were seated on a cushion in front of a desk. After a brief explanation of the experiment, a base line was measured for five minutes. Next, a stress load task was conducted for five minutes, and the physiological response under the stress was measured at the same time. After the task was completed, participants of AIBO condition played with AIBO for 30 minutes. Those of video condition viewed a neutral video for the same period of time. After treatment, the physiological response was measured for five minutes (T1). Following that, the questionnaire measuring self-esteem, loneliness, degree of stress and fatigue, and state-anxiety was filled out. Next, the physiological response was measured for five minutes after treatment and rest (T2). Finally, a second stress load task and physiological response measurement were then performed for five minutes (T3).

For the video condition, the experiment was terminated here.

For the AIBO condition, the scale of attachment to AIBO was measured by a questionnaire, and then the participants were verbally asked if they liked dogs or not, after which the experiment was terminated.

RESULTS

Internal consistency

We conducted an item analysis for the scale of attachment to AIBO and excluded items without significant coefficients of I–T correlation. The alpha coefficient of the remaining 32 items was .97.

Verification of Hypothesis 1: Psychological variables

Analyses of variance (ANOVAs) were conducted with the condition (AIBO, video 1, video 2) as an independent variable, and the total score of each scale (self-esteem, degree of stress and fatigue, loneliness, or state-anxiety) as dependent variables. No significant difference was obtained in self-esteem and the degree of stress and fatigue. The main effect of the condition was significant for loneliness ($F(2, 37)=5.35, p<.01$) and state-anxiety ($F(2, 36)=3.40, p<.05$). A planned comparison of "AIBO vs. two video conditions" revealed that loneliness ($F(1, 37)=7.12, p<.05$) and anxiety ($F(1, 36)=4.24, p<.05$) of AIBO condition were significantly lower than those of the two video conditions. These results suggested that interacting with AIBO after receiving a stress load reduced loneliness and state-anxiety more than viewing the neutral video. In contrast, a similar effect was not observed for self-esteem and degree of stress and fatigue. Hence, Hypothesis 1 regarding loneliness and state anxiety was supported. Group

Table 1 Group means and standard deviations.

			AIBO		Video 1		Video 2	
Psychological variables	Self-esteem		112.79	(21.47)	109.20	(40.17)	98.60	(25.22)
	Loneliness		50.60	(14.31)	58.40	(24.19)	74.10	(19.93)
	Stress		84.60	(24.38)	93.10	(36.85)	106.6	(30.10)
	Anxiety		69.58	(20.96)	76.20	(24.92)	91.90	(20.65)
Physiological variables	Highest blood pressure	(T1)	−2.52	(14.03)	4.39	(9.18)	0.66	(8.33)
		(T2)	−3.84	(14.28)	4.07	(11.61)	3.62	(9.80)
		(T3)	−2.47	(14.99)	2.45	(14.23)	2.49	(10.89)
	Lowest blood pressure	(T1)	−0.47	(7.83)	1.32	(6.23)	−0.38	(7.37)
		(T2)	−1.99	(7.59)	1.70	(7.94)	2.28	(7.94)
		(T3)	−3.51	(9.07)	3.47	(9.42)	3.55	(8.18)
	Cardiac rate	(T1)	−1.64	(4.53)	3.56	(4.87)	−0.28	(3.77)
		(T2)	−0.41	(4.75)	0.91	(3.56)	−0.10	(3.83)
		(T3)	−0.13	(5.04)	1.72	(4.11)	−1.47	(3.30)
Task score			−3.52	(22.71)	1.87	(33.73)	5.17	(19.63)

NOTE: Mean scores are shown for psychological variables, and scores of residuals for physiological variables and a task score.

Table 2 Group means and standard deviations of high and low attachment, and like and not like dogs.

			High attachment		Low attachment		Like dogs		Not like dogs	
Psychological variables	Self-esteem		119.10	(24.09)	105.78	(16.72)	115.27	(23.61)	103.50	(4.36)
	Loneliness		47.70	(15.27)	53.50	(13.44)	47.47	(13.54)	60.00	(13.56)
	Stress		75.50	(27.54)	93.70	(17.70)	84.07	(25.98)	86.20	(21.39)
	Anxiety		58.80	(22.36)	81.56	(10.93)	66.36	(22.74)	78.60	(12.62)
Physiological variables	Highest blood pressure	(T1)	−4.82	(12.32)	−0.23	(15.88)	−4.12	(12.14)	2.25	(19.54)
		(T2)	−5.70	(13.41)	−1.99	(15.58)	−5.44	(13.67)	0.96	(16.60)
		(T3)	−3.95	(12.97)	−0.99	(17.36)	−4.96	(15.25)	4.99	(12.70)
	Lowest blood pressure	(T1)	−2.31	(6.23)	1.37	(9.12)	−2.04	(5.63)	4.23	(11.98)
		(T2)	−4.67	(6.69)	0.70	(7.79)	−3.99	(5.95)	4.02	(9.45)
		(T3)	−6.24	(7.78)	−0.78	(9.82)	−5.32	(8.77)	1.93	(8.51)
	Cardiac rate	(T1)	−2.87	(4.92)	−0.41	(3.97)	−2.23	(4.44)	0.14	(4.80)
		(T2)	−1.57	(4.74)	0.75	(4.71)	−1.61	(3.90)	3.22	(5.65)
		(T3)	−0.91	(4.85)	0.66	(5.36)	−0.65	(5.26)	1.44	(4.42)
Task score			−6.31	(27.61)	−0.73	(17.57)	−12.13	(9.06)	−0.65	(25.32)

NOTE: Mean scores are shown for psychological variables, and scores of residuals for physiological variables and a task

mean scores are presented in Table 1.

Verification of Hypothesis 2: Physiological variables

Analyses of covariance (ANCOVAs) were conducted with the condition as an independent variable, and blood pressure and cardiac rate at the first stress load task as covariates. Dependent variables were blood pressure and cardiac rate for each point, immediately after treatment (T1), after treatment and rest (T2), and during the second stress load task (T3). Results showed no significant difference in any measurement period for the highest blood pressure. The main effect of the condition was marginally significant for the lowest blood pressure during the second stress load task (T3) ($F(2, 36)$

$=3.02$, $p<.1$). The planned comparison of "AIBO vs. two video conditions" for the score of residuals revealed that the lowest blood pressure of AIBO condition was significantly lower than that of the two video conditions ($F(1, 38)=6.15$, $p<.05$). The main effect of the condition on the cardiac rate was significant immediately after treatment (T1) ($F(2, 36)=5.43$, $p<.05$), and the planned comparison revealed that the cardiac rate for the AIBO condition was significantly lower than that of the two video conditions ($F(1, 38)=5.43$, $p<.05$). These results suggested that interacting with AIBO after receiving a stress load lowered the temporarily increased diastolic blood pressure and cardiac rate more than viewing the neutral video. In contrast, no similar effect was observed for systolic blood pressure. Hence, Hypothesis 2 was supported for the lowest blood pressure at the second stress load and for cardiac rate after treatment.

Verification of Hypothesis 3: Moderator effects

Attachment to AIBO The participants of the AIBO condition were divided into the "AIBO condition and high attachment (high-attachment condition)" and "AIBO condition and low attachment (low-attachment condition)" based on the total score of the scale of attachment to AIBO using a median split method. ANOVAs with the condition (high-attachment, low-attachment, video 1, and video 2) as an independent variable were conducted. If the main effect of the condition was significant, three patterns of planned comparison, "high-attachment condition vs. low-attachment condition," "high-attachment condition vs. two video conditions," and "low-attachment condition vs. two video conditions" were implemented according to the hypothesis. Group mean scores are presented in Table 2.

Psychological variables. Results showed no significant differences between high-attachment and low-attachment conditions for self-esteem, degree of stress and fatigue, and loneliness. The main effect was significant ($F(3, 35)=4.49$, $p<.01$) for state-anxiety. The result of the planned comparison for the score of residuals revealed that state-anxiety of the high-attachment condition was significantly lower than that of the low-attachment condition ($F(1, 38)=5.77$, $p<.05$), and that although the high-attachment condition yielded a significantly lower anxiety than the two video conditions ($F(1, 38)=9.99$, $p<.01$), there was no significant difference between the low-attachment condition and the two video conditions. These results suggested that attachment to AIBO moderated the effect of treatment for state-anxiety and supported Hypothesis 3-1 regarding state-anxiety.

Physiological variables. No significant differences were obtained between high-attachment and low-attachment conditions in the results. Hence, Hypothesis 3-1 was not supported.

Like dogs or not Following the experiment under AIBO conditions, the participants were asked whether they liked dogs or not. Fifteen out of 20 answered that they liked dogs; five answered that they did not. Accordingly, the participants under the AIBO condition were divided into "AIBO condition and like dogs (like dogs condition)"and "AIBO condition and do not like dogs (not like dogs condition)". ANOVAs were conducted with the condition (like dogs, not like dogs, video 1, and video 2) as an independent variable. If a main effect of the condition was significant, three patterns of planned comparison, "like dogs condition vs. not like dogs condition," "like dogs condition vs. two video conditions," and "not like dogs condition vs. two video conditions" were implemented according to the hypothesis.

Psychological variables. No significant differences were obtained between like dogs and not like dogs conditions. Hence, Hypothesis 3-2 was not supported.

Physiological variables. Results indicated no significant differences for the highest blood pressure and the cardiac rate. The

main effect of the condition for the lowest blood pressure was marginally significant after treatment and rest (T2) ($F(3, 35)=2.36$, $p<.1$), and significant at the second stress load task (T3) ($F(3, 35)=2.91$, $p<.05$). In the planned comparison for the score of residuals, the lowest blood pressure after treatment and rest (T2) of the like dogs condition was significantly lower than that of the two video conditions ($F(1, 38)=5.55$, $p<.05$) and the do not like dogs condition ($F(1, 38)=4.36$, $p<.05$), but no significant difference was observed between the do not like dogs condition and the two video conditions. At the second stress load task (T3), there was no significant difference between the like and not like dogs conditions. Hence, Hypothesis 3-2 was supported for the lowest blood pressure after treatment and rest.

Stress load task

Analyses of covariance (ANCOVAs) were conducted with the condition as an independent variable, the number of correct answers in the first stress load task as covariates, and the number of correct answers in the second stress load task as a dependent variable. No significant differences were obtained in the results.

DISCUSSION

Psychology variables

The results demonstrated that a pet-type robot was effective in decreasing loneliness and state-anxiety. However, no significant difference in self-esteem or the degree of stress and fatigue was observed when compared with video viewing. Possible reasons why no effect of interacting with the pet-type robot could be achieved may be that the treatment period was too short, or the interaction occurred in the experimental room, a specific environment. If this is the case, effects such as improved self-esteem and reduced stress may be expected if the interaction with the pet-type robot occurs during daily life, at any time, or any length of time. To answer these questions, long-term consideration in a more natural setting is needed in the future.

Physiological variables

The therapeutic effect of interacting with a pet-type robot was observed in the lowest blood pressure during the second stress load task and in the cardiac rate immediately after the treatment. There is a time difference in effect appearance between two physiological responses, the lowest blood pressure and the cardiac rate. From this, the therapeutic effect induced by a pet-type robot may be immediately effective for cardiac rate. In contrast, the effect for the lowest blood pressure may arise when stress appears the next time, in dealing with stress when it is received.

The therapeutic effect was observed for the lowest blood pressure but not for the highest blood pressure. This difference is considered to be related to the function of the highest blood pressure and the lowest blood pressure. The highest blood pressure is mainly related to cardiac output, which is controlled by both the parasympathetic nerve and the sympathetic nerve. In contrast, the lowest blood pressure is related to vascular resistance. Vascular resistance changes with the length and thickness of blood vessels, their ability to expand, and the viscosity of blood, but this depends on each blood vessel and cannot be changed easily. Vascular resistance can thus only be adjusted by contracting and expanding blood vessels, which are controlled solely by the sympathetic nerve (Andreassi, 2000). The results that the highest blood pressure did not change and only the lowest blood pressure was reduced indicate that sympathetic inhibition could be achieved but not parasympathetic activation. Hence, while it cannot be clearly stated that a relaxed condition was reached, it is suggested that a reduction in the state of tension may have been achieved.

However, the reduction of diastolic blood pressure in this research was very slight. Although the effect was consistent with the positive effect observed in the reduction of

cardiac rate and psychological variables, care must be exercised not to generalize the results of this study. In the future, research must be accumulated in order to increase the reliability of the results.

Moderator effects

Persons with a stronger attachment to AIBO had a lower state-anxiety than those without such attachment. Furthermore, although the high-attachment condition yielded a significantly lower anxiety than the video condition, there was no significant difference between the low-attachment condition and video conditions. Hence, this suggests that a therapeutic effect can be obtained by persons who have an attachment to AIBO, in other words, by those who think AIBO is cute and like it, but persons who do not have such an attachment will have difficulty achieving a therapeutic effect.

Participants who liked dogs had a larger reduction in the lowest blood pressure after treatment and rest (T2) than those who did not like dogs. Furthermore, the like dogs condition yielded a lowest blood pressure that was significantly lower than the video conditions, but no significant difference was observed between the do not like dogs condition and the video conditions. This demonstrates that it is difficult for persons who do not like dogs to obtain a therapeutic effect from a pet-type robot.

Stress load task score

A therapeutic effect was not obtained for the stress load task score. This indicates that the therapeutic effect of a pet-type robot cannot improve performance through psychological and physiological effects.

Possibility of robot therapy

The study results have demonstrated that interacting with a pet-type robot reduces loneliness and state-anxiety psychologically, reduces cardiac rate physiologically, and even reduces the lowest blood pressure although not immediately. These results are similar to AAT/A research and indicate that a pet-type robot may have therapeutic effects just like real animals. However, a therapeutic effect could not be confirmed for self-esteem, degree of stress and fatigue, the highest blood pressure, and task score.

Also, with regard to the moderator effect, it was shown that the therapeutic effect through interacting with AIBO differed according to whether the participant liked dogs or had a high or low attachment to AIBO. These results are in agreement with points indicated by AAT/A.

However, care must be taken as this study has the following limitations. First, this study only examined the short-term effect under specific conditions, such as an experimental situation. If the interaction with a pet-type robot occurs in daily life, such as at home, at any time, and whenever they want, the quantity and quality of the therapeutic effect may differ from the results of this study. Second, this study targeted only female university students, but the effect may be different if participants are male, children, or elderly. Third, this study only used the pet-type robot AIBO as the stimulation material. Along with recent robot technology, various types of robots have been developed and sold, and the therapeutic effect is expected to differ depending on the features and characteristics of the individual robot. In order to clarify these points, long-term, continuous research of the daily scene, consideration of various types of robots, and targeting participants with a wider range of attributes, are needed in the future.

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