

Psychological Effects and Change of Familiarity with Robots in Long-Term Experiment of Robot Assisted Activity

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Abstract— A long-term experiment of robot assisted activity for elderly people has been conducted at a health service facility for the aged since Aug. 2003. Two therapeutic seal robots, *Paro*, were introduced there. This paper describes an interim report of the experiment for three months. Face scales that consist of illustrations of person's faces were used to evaluate person's moods. In addition, questionnaires were used to measure person's familiarity with the robots. As the results, feelings of the elderly people were improved by interaction with the seal robots. Moreover, their familiarity with the robots gradually increased by spending the time with the robots.

Keywords- *Mental Commit Robot, Human-Robot Interaction, Robot Assisted Activity, Elderly People*

I. INTRODUCTION

Interaction with animals has long been known to be emotionally beneficial to people. The effects of animals on humans have been applied to medical treatment. Especially in the United States, animal-assisted therapy and activities (AAT&AAA) are becoming widely used in hospitals and nursing homes [1, 2]. AAT has clear goals set out in therapy programs designed by doctors, nurses or social workers, in cooperation with volunteers. In contrast, AAA refers to patients interacting with animals without particular therapeutic goals, and depends on volunteers. AAT and AAA are expected to have 3 effects:

- 1) *Psychological effect (e.g. relaxation, motivation)*
- 2) *Physiological effect (e.g. improvement of vital signs)*
- 3) *Social effect (e.g. stimulation of communication among inpatients and caregivers)*

However, most hospitals and nursing homes, especially in Japan, do not accept animals, even though they admit the positive effects of AAT and AAA. They are afraid of negative effects of animals on human beings, such as allergy, infection, bites, and scratches.

We have proposed Robot-Assisted Therapy and Activity since 1996 [3-17]. Major goals of this research are follows:



Figure 1. Seal Robot: *Paro*

- 1) *Investigation of psycho-physiological influences of Human-Robot interaction, including long-term interaction*
- 2) *Development of design theory for therapeutic robots*
- 3) *Development of methodology of RAT & RAA suitable for the subjects*

The seal robot named *Paro* have been designed for therapy (Fig.1), and used at a pediatric ward of university hospital [10]. The children's ages were from 2 to 15 years, some of them having immunity problems. During 11 days observation, the children's moods improved on interaction with *Paro*, encouraging the children to communicate with each other and caregivers. In one striking instance, a young autistic patient recovered his appetite and his speech abilities during the weeks when *Paro* was at the hospital. In another case, a long-term inpatient who felt pain when she moved her body, arms, and legs, and could not move from her bed. However, when *Paro* was given to her, she smiled and was willing to stroke *Paro*. A nurse said that *Paro* had a rehabilitative function as well as a mental effect.

Moreover, we have used *Paro* robot-assisted activity (RAA) among the elderly at a day service center for 5 weeks and at a health service facility for the age for 3 weeks [11-15]. Interaction with *Paro* improved their moods, making them more active and communicative with each

other and caregivers. Results of urinary tests showed interaction with Paro reduced stress among the elderly. In an interesting instance, at the center, an elderly woman who rarely talked with others began communicating after interacting with Paro. In another example, at the facility, an elderly man whom caregivers could hardly communicate with liked Paro very much, often laughing and sings to it, making the people around laugh. The caregivers were dumbfounded by the change.

Other studies have been conducted using questionnaires given out at exhibitions held in four countries; Japan, U.K., Sweden and Italy. The results showed that the seal robot widely accepted beyond the culture [16, 17].

Recently, other research groups have tried robot therapy using other kinds of robots. Dautenhahn has applied mobile robots to therapy of autistic children [18]. Besides, robot-assisted activity using other animal type robots (such as Furby, AIBO [19], NeCoRo, etc.) has been tried [20, 21]. For example, Yokoyama used AIBO in a pediatrics ward, and observed the interaction between children and AIBO [20]. He pointed out that the stimulus received from AIBO was strong, however, the stability was quite weak, compared with living animals. In other words, when people meet AIBO for the first time, they are interested in it for a while. However, relaxation effects such as those obtained from petting a real dog are never felt from AIBO.

In this paper, we discuss the application of the seal robots to assist elderly people at a health service facility for the aged, observing their psychological and social effects for *three month*. In addition, we also discuss change of their familiarity with the robots by using questionnaires.

Chapter II describes a seal robot that was used for robot-assisted activity (RAA). Chapter III describes ways of experiments and explains the effects of RAA on elderly people. Chapter IV discusses current results of RAA and future works. Finally, chapter V offers conclusions.

II. SPECIFICATIONS OF THE SEAL ROBOT

The seal robot, Paro, is shown in Fig.1. Its appearance is designed using a baby harp seal as a model, and its surface is covered with pure white fur. A newly-developed ubiquitous tactile sensor is inserted between the hard inner skeleton and the fur to create a soft, natural feel and to permit the measurement of human contact with Paro. Paro is equipped with the four primary senses; sight (light sensor), audition (determination of sound source direction and speech recognition), balance and the above-stated tactile sense. Its moving parts are as follows: vertical and horizontal neck movements, front and rear paddle movements and independent movement of each eyelid, which is important for creating facial expressions. Paro weighed about 2.8 kg.

Paro has a behavior generation system consisting of two hierarchical layers of processes: proactive and reactive. These two layers generate three types of behavior; proactive, reactive, and physiological behaviors:

A. Proactive Behavior

Paro has two layers to generate its proactive behavior: a behavior-planning layer and a behavior-generation layer. By addressing its internal states of stimuli, desires, and a rhythm, Paro generates proactive behavior.

1) Behavior-planning layer

This has a state transition network based on the internal states of Paro and Paro's desire, produced by its internal rhythm. Paro has internal states that can be named with words indicating emotions. Each state has numerical level which is changed by stimulation. The state also decays in time. Interaction changes the internal states and creates the character of Paro. The behavior-planning layer sends basic behavioral patterns to behavior-generation layer. The basic behavioral patterns include several poses and movements. Here, although the term "proactive" is used, the proactive behavior is very primitive compared with that of human beings. We implemented behavior in Paro similar to that of a real seal.

2) Behavior generation layer

This layer generates control references for each actuator to perform the determined behavior. The control reference depends on magnitude of the internal states and their variation. For example, parameters can change the speed of movement and the number of instances of the same behavior. Therefore, although the number of basic patterns is finite, the number of emerging behaviors is infinite because of the varying number of parameters. This creates life-like behavior. In addition, to gain attention, the behavior-generation layer adjusts parameters of priority of reactive behaviors and proactive behaviors based on the magnitude of the internal states. This function contributes to the behavioral situation of Paro, and makes it difficult for a subject to predict Paro's action.

3) Long-term memory

Paro has a function of reinforcement learning. It has positive value on preferred stimulation such as stroking. It also has negative value on undesired stimulation such as beating. Paro assigns values to the relationship between stimulation and behavior. Gradually, Paro can be tuned to preferred behaviors of its owner.

B. Reactive behavior

Paro reacts to sudden stimulation. For example, when it hears a sudden loud sound, Paro pays attention to it and looks in the direction of the sound. There are several patterns of combination of stimulation and reaction. These patterns are assumed as conditioned and unconscious behavior.

C. Physiological behavior

Paro has a diurnal rhythm. It has several spontaneous needs, such as sleep, based on this rhythm.

III. ROBOT ASSISTED ACTIVITY FOR ELDERLY PEOPLE

We have applied Paro to RAA for elderly people at a health service facility for the aged in order to investigate its long term effects on the elderly. The facility provides

services such as institutional stays, daily care, and rehabilitation to elderly people whose condition of a disease are stable, and not needing hospitalization. People who stay there receive daily care and instruction in how to live independently.

Figure 2 shows activity of the people at their free time. They communicated little and the atmosphere was gloomy. In addition, caregivers felt difficulty of communication with them because of a lack of common topics among them.

Before starting RAA, we explained the purpose and procedure to the people, receive their consent. Symptoms varied or were unclear, so we questioned the nursing staff to determine who would participate. Subjects finally numbered 14. All of them were women, aged from 77 to 98. 13 subjects presented dementia, in which case, the nursing staff judged the dementia level of each subject in terms of the revised Hasegawa's dementia scale (HDS-R). Their dementia levels were as follows:

- 1) *Non-dementia: 1 person,*
- 2) *Slightly degree: 4 people,*
- 3) *Middle degree: 5 people, and*
- 4) *A little high degree: 4 people*

B. Method of interaction

Two seal robots have been given to the elderly people at the facility on two days per week. We prepared a desk for the robots in the center of the table, and people were



Figure 2. A Scene of Usual Activity of Elderly People at a Health Service Facility for the Aged

arranged up around it. They interacted with the robots for about one hour at a time. Since not all subjects could interact with the robots at the same time, we had them take turns for equal periods of time.

C. Methods of Evaluation

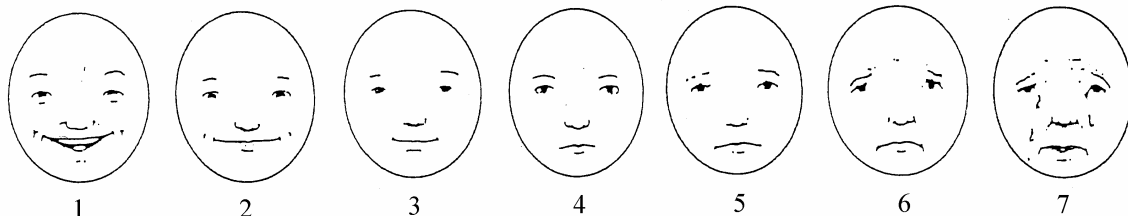
In order to investigate the effects on the elderly people before and after interaction with Paro, the following two types of data was collected.

- 1) *Face scale [22] (Figure 3)*
- 2) *Comments of nursing staff*

The original Face Scale contains 20 drawings of a single face, arranged in serial order by rows, with each face depicting a slightly different mood state. A graphic artist was consulted so that the faces would be portrayed as genderless and multi-ethnic. Subtle changes in the eyes, eyebrows, and mouth were used to represent slightly different levels of mood. They are arranged in decreasing order of mood and numbered from 1 to 20, with 1 representing the most positive mood and 20 representing the most negative mood. However, sometimes subjects are confused by original face scale because it has too many similar images. Then, we simplified it by using seven images #1, 4, 7, 10, 13, 16, and 19 in original ones. As the examiner pointed at the faces, the following instructions were given to each subject: "The faces above range from very happy at the left to very sad at the right. Check the face which best shows the way you have felt inside now."

Besides, we investigated familiarity with Paro by questionnaire. The questionnaire consisted of following 4 items: I like Paro, I speak to Paro well, Paro is like a child or grandchild for me, and I touch Paro well. Each item was evaluated by five stages: 0 = not at all, 1 = a little, 2 = moderately, 3 = quite a bit, and 4 = extremely.

The face scale was applied four weeks and one week before Paro was introduced and then in every two week thereafter. Furthermore, the face scale was applied before and after interaction with Paro. The questionnaire concerning familiarity with Paro was applied after interaction with Paro in every two week. As a statistics analysis, Wilcoxon's sign rank sum test was applied to the face scale scores before and after interaction for each week, and Friedman's test was applied to the scores of the questionnaire by using SPSS 12.0 for Windows.



INSTRUCTIONS: The faces above range from very happy at the left to very sad at the right. Check the face which best shows the way you have felt inside now.

Figure 3 Face Scale [22]



Figure 4 Interaction between Elderly People and Seal Robot



Figure 5 An Elderly Person Kissing the Seal Robot



Figure 6 Interaction between an Elderly Person and a Caregiver through Seal Robot

TABLE I. BASIC ATTRIBUTE OF 10 ELDERLY PEOPLE

Sex	All women	
Age (ave. \pm sd)	88.2 \pm 6.0	
Dementia Level HDS-R (number of people)	<i>Slightly degree</i>	4
	<i>Middle degree</i>	2
	<i>A little high degree</i>	4

IV. RESULTS OF ROBOT ASSISTED ACTIVITY

“Hello, hello.” “Come on Paro.” “You are so cute.” The elderly interacted with Paro willingly from the first day, speaking to it, stroking and hugging it. Sometimes, they kissed it with smile (Fig.4, 5). Paro became common topics among the elderly people and caregivers (Fig.6). They talked about its appearance, kinds of animals, moods, and so on. For example, “its eyes so big,” “it looks sleepy,” etc. The elderly people treated Paro like their grandchildren and gave them new name “Maru” and “Maro,” respectively.

We obtained the face scale and the questionnaire data from 10 subjects. Table I shows their basic attribute. As for face scale, the average scores before interaction varied from 3.3 to 2.5 through 14 weeks. However, scores after interaction were always lower than those before interaction in each week (figure 7). Especially, a statistically significant difference was shown in 10th week.

Figure 8(a) – (d) show average scores of four question items for 10 weeks. Average scores of all the question items were over 2.0 at the first day. Besides, the score of each question item showed a tendency to increase. Finally, the average scores reached over 3.0. Especially, the average score of the question item, “Paro is like a child or grandchild for me” increased from 2.3 to 3.4. Moreover, average score of “I like Paro” that was high value from the first day kept the value for 10 weeks. However, no statistically significant changes of these scores were shown.

As for comments of caregivers, interaction with Paro made the people more laugh and active. For example, their expression of face changed, softened, and brightened. On the day of activity, they looked forward to Paro, sitting down in their seats before starting interaction. Some people who usually stayed in their room went out, and joined the activity willingly. In addition, Paro encouraged the people to communicate with each other and caregivers by becoming their common topics. Then, the atmosphere changed to brighter.

V. DISCUSSIONS

We have studied the long term effects of interaction with Paro in the elderly people staying at a health service facility. This is an interim report of the experiment for three months. As for the results of face scale, scores of after interaction with Paro were always lower than those of before interaction. Therefore, interaction with Paro improved moods of elderly people for three months. As for the results of questionnaire concerning familiarity with Paro, the scores of all the question items showed high value from the first day, and a tendency to increase. Therefore, we can say that elderly people accepted Paro from the first day. Furthermore, their affection for Paro gradually increased through 10 weeks interaction.

Generally speaking, people often lose interest in things such as toys, after interacting with them several times. However, regarding interaction with Paro, the elderly people did not lose interest, and its effect on them showed up through three month. In addition, no breakdown and accident occurred by now. Paro fulfill its durability and

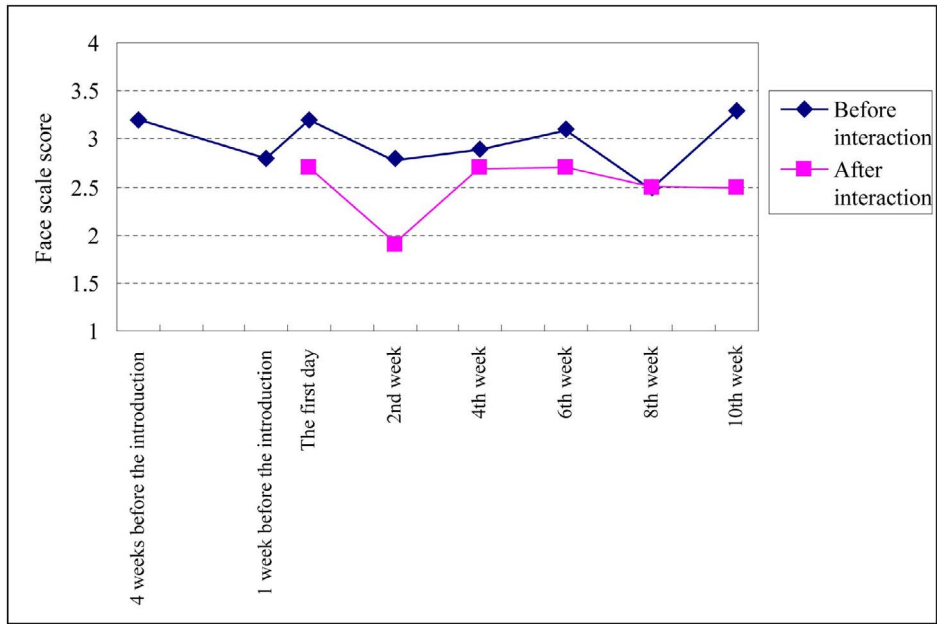
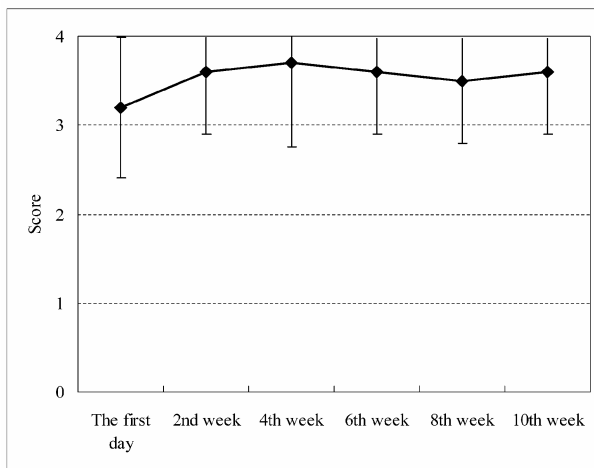
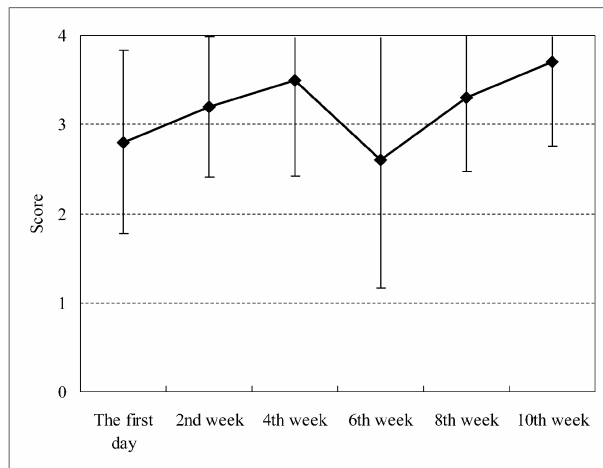


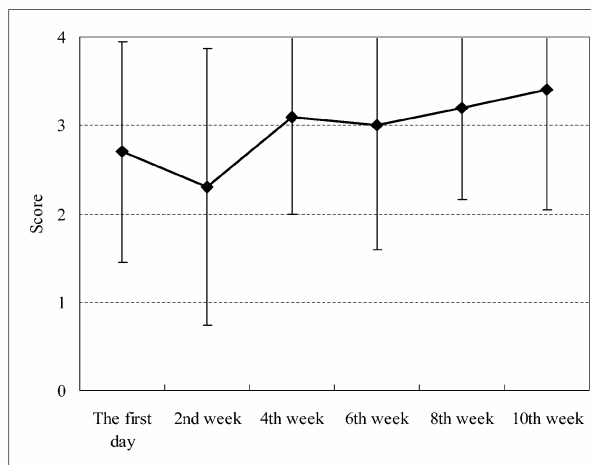
Figure 7 Change of Average Face Scale Scores of 10 Elderly People for 14 Weeks (Score: 1=best mood, 7=worst mood)



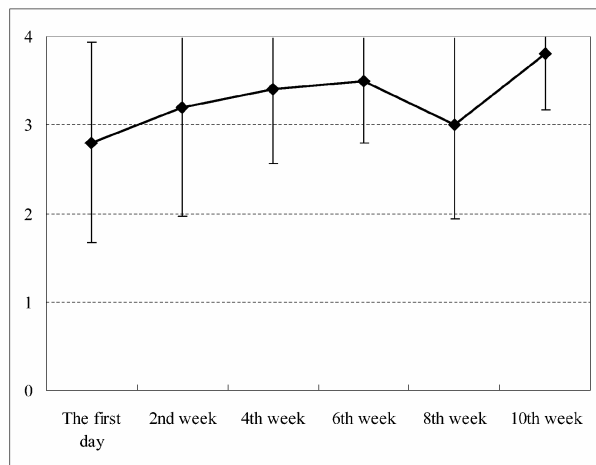
(a) I like Paro



(b) I speak to Paro well



(c) Paro is like a child or grandchild for me



(d) I touch Paro well

Figure 8 Change of Average Scores of Questionnaire Concerning Familiarity with Paro

safety of the robot, which are very important when it interacts with human beings for long-term.

VI. CONCLUSION

We have used seal robots, Paro in RAA for elderly people at a health service facility for the aged since August 2003. The interim results showed that interaction with Paro improved their moods and depression, and then the effects showed up through three months. Urinary tests were conducted to establish the physiological effects. The details will be described in the future.

Until now, we added one more Paro to the facility because many other elderly joined in the activity voluntarily. The new Paro was given new name "Hana-chan" by the elderly, soon.

This experiment is still going. We will report more long-term influences on elderly in the future. Moreover, we plan further experiments and research on different conditions and situations and the relationship between function of a mental commit robot and its effects in the elderly in RAA.

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