Robot Therapy in a Care House

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Abstract – Robot Therapy for elderly residents in a care house has been conducted from June, 2005. Two therapeutic seal robots were introduced, and activated for over 9 hours every day to interact with the residents. This paper presents a progress report of this experiment. In order to investigate psychological and social influences of the robots, each subject was interviewed, and their social network was analysed. In addition, activities of the residents in the public areas were recorded by video cameras during daytime (8:30-18:00) over two months. The results indicate that the density of the social networks was increased through interaction with the seal robots. Furthermore, their social interaction was increased through interaction with the seal robots.

Index Terms – Mental Commit Robot, Robot Therapy, Human-Robot Interaction, Elderly Care, Social Network

I. INTRODUCTION

Over the last several decades, social psychologists have investigated the relationship between social ties and the health of elderly people [1]-[5]. They found that lacking in social and community ties will lead to loss of health in people. For example, Berkman & Syme assessed the relationship between social and community ties and mortality, using the 1965 Human Population Laboratory survey of a random sample of 6928 adults in Alameda County, California and a subsequent nine-year mortality follow-up [1]. They found that people who lacked social and community ties were more likely to die in the follow-up period than those with more extensive contacts. Zunzunegui et al. examined the influence of social networks and social engagement on the cognitive decline of elderly people [2]. They found that poor social connections, infrequent participation in social activities, and social disengagement predict the risk of cognitive decline in elderly individuals.

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 [6][7]. 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 proposed robot therapy, using robots as the substitute of animals in animal therapy [8]-[24]. We proposed a mental commit robot that provides mental value to the subject, such as joy, happiness, relaxation, etc., through the physical interaction. We developed a seal type mental commit robot, named Paro, especially for robot therapy, and used it at pediatric hospitals and several facilities for the elderly, such as a day service center, and health service facility for the aged [14]-[18]. The results showed that interaction with Paro improved patients’ and elderly people’s moods, making them more active and communicative with each other and their caregivers. Results of urinary tests showed interaction with Paro reduced stress amongst the elderly [18]. In addition, we have investigated the long-term interaction between Paro and the elderly, and found Paro maintained its effects on the subjects for more than one year [19]. Furthermore, the neuro-psychological effects of Paro on patients with dementia were assessed by analysing their EEG [20]. The results showed that the activity of their cortical neurons was improved by interaction with Paro, especially for those patients who liked Paro.

Meanwhile, other studies have been conducted using questionnaires given out at exhibitions held in six countries; Japan, U.K., Sweden, Italy, Korea and Brunei, in order to investigate how people evaluate the robot. The results showed that the seal robot widely accepted beyond the culture [22]-[24].

As for other research groups, Dautenhahn has used mobile robots and robotic dolls for therapy of autistic children [25]. Additionally, other animal type robots (such as Furby, AIBO [26], NeCoRo, etc.) have been released by several companies. Robot therapy using these robots has also been tried [27]-[31]. For example, Yokoyama used AIBO in a pediatric ward, and observed the interaction between children and AIBO [27]. He pointed out that, 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. Kanamori et al. examined effects of AIBO on elderly in a nursing home [30]. They found that stress of elderly decreased after one hour interaction with AIBO by measuring hormone in saliva, and their loneliness improved after 20 times sessions during seven weeks. Tamura et al. also used AIBO to dementia
II. SEAL ROBOT: PARO

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. Ubiquitous surface tactile sensors are 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 [21]. 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 2.7 kg. Its operating time with the installed battery is about 1 hour. However, Paro can keep operating during use by employing a charger which mimicked a pacifier.

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

A. Proactive Behavior

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

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 a numerical level, which is changed by stimulation. The state also decays in time. Interaction changes the internal states and creates the character of Paro. Each basic behavior is selected stochastically based on the status of the state transition network. The behavior-planning layer sends basic behavioral patterns to the behavior-generation layer. The basic behavioral patterns include several postures 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 the 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 variation in parameters. This creates life-like behavior. In addition, to gain attention, the behavior-generation layer adjusts parameters of the priority of reactive and proactive behaviors based on the magnitude of the internal states. This function contributes to the behavioral situation of Paro, and sometimes generates unpredictable behaviors for the subject. For example, the reactive behavior, to look in the direction of the sound, is a comparatively predictable behavior but does not always emerge whenever Paro detects a sudden sound.

3) Learning functions

Paro has a function of reinforcement learning. This has a positive value on preferred stimulation such as stroking and a negative value on undesired stimulation such as beating. Paro assigns values to the relationship between stimulation and behavior. This changes the choice probability of basic behavior at the state of the state transition network.
Gradually, Paro can be tuned to the preferred behaviors of its owner. In addition, Paro can memorize a frequently articulated word as its new name. The users can give their preferred name during natural interaction.

B. Reactive behavior

Paro reacts to sudden stimulation. For example, when it suddenly hears a loud sound, it becomes alert and looks in the direction of the sound. There are several patterns for combining of stimulation and reaction and are assumed as conditioned and unconscious behavior.

C. Physiological behavior

Paro has a diurnal rhythm. Physiological behaviors (those that emerge through the proactive process) mean several spontaneous behaviors, such as sleep, based on this rhythm.

III. ROBOT THERAPY IN A CARE HOUSE

A. Care House

The experiment has been conducted in the care house, “Mori-no-Ie” in Tsukuba city, Ibaraki prefecture, Japan. A care house is a type of communal housing in which basic daily care; is provided to residents, such as meals, bathing etc. Basically, the residents of care houses are aged over 60 years. They have physical difficulties in preparing their own meals and living alone. At the beginning of this experiment, 28 residents lived in the care house. We explained the purpose and procedure of this experiment to the residents and received their consent from 12 people. Regarding the video cameras, all the residents agreed their installation in a public area of the house.

B. Subjects

Table I shows basic attributes of 12 subjects, including one male, aged from 67 to 89 years. Their mental cognitive states were assessed by MMSE [33]. An individual whose MMSE score is over 23 is diagnosed as mentally healthy.

C. Methods of Interaction with Paro

The care house was on 3 floors. A dining room, hall, and office were on the first floor. A Paro was introduced in the care house at 18:00. The residents could play with Paro whenever they wished during the time. Before introduction of Paro, we explained that Paro is a robot and described its operation to them.

D. Methods of Evaluation

1) Interview

A free pile sort method was used to investigate social ties among the residents [32]. It uses a deck of cards representing each of the residents in the care house and has several blank cards. The users are asked to fill in those people on the blank cards. They can sort these cards using their own classification system and during that time they should be sorted.

The resident had more than one interaction with Paro and other people during the time. But, no interaction with other people.

TABLE I. BASIC ATTRIBUTES OF 12 SUBJECTS

<table>
<thead>
<tr>
<th>Sex</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (ave. ± sd)</td>
<td>77.5 ± 7.3</td>
<td>80.6 ± 6.1</td>
</tr>
<tr>
<td>MMSE (ave. ± sd)</td>
<td>25.3 ± 3.9</td>
<td>26.0 ± 3.7</td>
</tr>
</tbody>
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Regarding the relationship with Paro, people were interviewed along the lines of the following questions:

a) How is your daily life after introduction of the robots?
   i) Do you speak to and touch the robot?
   ii) When do you play with the robot?
   iii) How often do you play with the robot?
   iv) What do you call the robot?
   v) Is the robot necessary/unnecessary in this house?
   vi) What is the robot to you?
   b) Are there any changes in your daily life?

At the beginning of interview, a respondent was asked the first question, “How is your daily life after introduction of the robots?” During his/her answering the question freely, interviewer asked him/her the rest of items interactively.

The subjects were interviewed, one by one, using these methods before and then one month after the introduction of Paro. Each interview took from approximately 30 minutes to 1 hour.

2) Video Recording System

In order to objectively investigate changes in their social interaction with each other and with Paro, the activities of the residents in the public areas were recorded by each video camera during daytime (8:30-18:00) over the three weeks before the introduction of Paro. As the video data obtained was too huge to record on video tapes, each video camera was connected to a HDD video recorder (HDD: 250GB, maximum recording time: approximately 460 hours) to store the data automatically (Fig.2).

Figure 3 shows a map of the residential floor. Each video camera was located at a corner of public areas in 2nd and 3rd floors. The area that the video camera recorded was shown as gray color. An example of recorded image is shown in Fig.4. We measured how long the resident staying in the public area. We classified the time spent following categories:

a) Time spent including interaction with Paro and people

The resident had more than one interaction with Paro and other people during the time.

b) Time spent including interaction with Paro

The resident had more than one interaction with Paro during the time. But, no interaction with other people.

c) Time spent including interaction with people
The resident had more than one interaction with other people. But, no interaction with Paro.

c) No interaction

The resident had no interaction with Paro and other people during the time.

In this research, we analyzed video data of June 1-6, 2025, and July 20-25 (in total 342 hours).

IV. RESULTS OF ROBOT THERAPY

A. Results of Interviews

We were able interview only 11 subjects because one subject’s health condition deteriorated. We extracted their social interaction with the residents and with Paro from the video data. Then, we classified them and defined the strength of social ties with other residents/Paro as follows:

1) Interaction with other residents

No tie:

a) Don’t know the resident.

Weak tie:

b) Knowing his/her name. But greetings and small talk only.

Moderate ties:

d) Having meal at a same table.

c) Belonging to the same club activity

Strong ties:

e) Playing cards together.

f) Meeting voluntarily and talking in public areas.

g) Visiting his/her room.

h) Going for a walk, dining room, shopping together.

i) Cooking a small dish and exchanging it.

2) Interaction with Paro

No tie:

a) Disregard

Weak ties:

b) Greeting when passing by.

c) Joining the interaction only when somebody was playing with it.

Moderate ties:

d) Talking to it when passing by.

e) Stroking and petting it.

f) Naming it.

Strong ties:

g) Voluntarily leaving own room to play with it.

h) Grumbling and sharing own feelings with it.

i) Grooming it

j) Inviting somebody to play with it together.

For example, a resident visited resident-B’s room and his/her only interaction with Paro was a greeting; in such a case, the resident was defined as having a strong tie to resident-B and a weak tie to Paro. Before the introduction, all the residents knew each others name.

B. Social Network of the subjects

As the next step, we investigated changes in the social networks of the subjects. Fig.5 (a) and (b) show sociograms of the strength of ties of 10 subjects before and after the introduction of Paro. (We excluded a subject from the analysis because she had a problem with other residents after the introduction of Paro, which was unrelated Paro, and changed her social interaction.) For instance, solid arrow A to B means subject-A had strong tie with subject-B and a weak tie to Paro. Before the introduction, all the residents knew each others name.

The density formula for these directed graphs is:

\[ \text{Density} = \frac{l}{n(n-1)} \]  (1)

Where \( l \) is the number of lines present. And \( n \) is the number of points. (e.g. \( l = 24, n = 10 \) in Fig.5(b)) From the results, the density in Fig.5 (a) was 0.23 and that in (b) was 0.27.
The density was increased after the introduction of Paro. This result applies particularly to the changes in subject-H. She avoided other residents and usually stayed her room before introduction of Paro; after the introduction, whenever she found someone playing with Paro, she voluntarily joined the interaction and talked with other people. However, most subjects commented that there were no changes in their social relationships. We consider that one month might be too short for the most subjects to detect these changes subjectively.

As for the relationship between Paro, subjects C and G had no ties with Paro. Subject-C, who was a male aged 89, said “I’m too old to be relaxed by (playing with) such a thing.” Comments from subject-G, female, aged 71, were “I never interact with the robot, without a thought. *snip* I might be heartless.” However, most subjects had moderate to strong ties with Paro. They greeted Paro whenever they passed by, and called it by the name that they had given it: Paro, Shi-shi maru, Mori-kun, Mori-chan, and Shiro. They commented that the atmosphere was brighter, and that abuse from others had decreased.

C. Results of video analysis

Figure 6 (a) and (b) show the change of their total time spent in public area on 2nd and 3rd floor. Total 2145 subjects spent time there during the period. Maximum time spent at a time was 1:47:25. And minimum time spent was 1 sec.

Before introduction of Paro, subjects on 2nd floor stayed at the public area much longer time than subjects on 3rd floor. The subjects on 2nd floor were relatively communicative. They talked about weather, disease, gossips of other residents and etc. Moreover, 4 subjects played cards at the area. In contrast, most subjects on 3rd floor had only passed the corridor. In usual, only two of them spent few minutes before meal to wait their friends.

The 1st week (June 20 - 25) of introduction of Paro, total time spent on 3rd floor was dramatically increased from about 7 hours to over 16 hours. Especially, the time spent including interaction with Paro and people was about 10.5 hours.
the other hand, the time spent on 2nd floor was decreased from about 31 hours to 29 hours. The reason was that subjects who were excluded from the analysis couldn’t spend time at the public area.

4 weeks after (July 20 - 25), the total time spent on the 3rd floor was decreased about 4 hours. Especially, its time spent including interaction with Paro and people was decreased. On the other hand, the time spent including interaction with people was increased. This means that the subjects became accustomed to existence of Paro. As for the 2nd floor, its total time spent was increased to about 37.5 hours. The total time spent at both public areas became to be longer than those of before the introduction of Paro.

V. CONCLUSIONS

We have used seal robots, Paro, for elderly residents in a care house since June, 2005. They freely interacted with Paro for over 9 hours every day. The current results show that Paro strengthened their social ties, and their social interaction was increased through interaction with the seal robots. In this research, urinary tests were conducted to establish the physiological effects. The details will be described in the future. This experiment is still on-going. We will report more long-term influences on the residents of the care house in the future.

REFERENCES