2007 IEEE International Conference on
Robotics and Automation
Roma, Italy, 10-14 April 2007

Social Effects of Robot Therapy in a Care House - Change of Social Network of the Residents for Two Months -

Kazuyoshi Wada and Takanori Shibata, *Member, IEEE*

***Abstract*—Robot therapy for elderly residents in a care house has been conducted since 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 the psychological and social effects of the robots, each subject was interviewed by using the free pile sort method, and their subjective social network was analysed. In addition, the activities of the residents in public areas were recorded by video cameras during daytime hours (8:30–18:00) for over 2 months. Then, their social network was analysed from the video data objectively. The results showed that the density of the social networks was increased through interaction with the robots subjectively and objectively.**

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

I. Introduction

The lack of social and community ties leads to loss of health in people. Over the last several decades, social psychologists have investigated the relationship between social ties and the health of elderly people. For example, Berkman & Syme assessed the relationship between social and community ties and mortality [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. found that poor social connections, infrequent participation in social activities, and social disengagement predict the risk of cognitive decline in elderly individuals [2].

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. In the United States, in particular, animal therapy is beginning to be widely used in hospitals and nursing homes [3], [4]. Animal therapy is expected to have three effects:

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

However, most hospitals and nursing homes, particularly in Japan, do not accept animals, although the positive effects of animal therapy are known. The medical staffs are afraid of the negative effects of animals—such as allergies, infections, bites, and scratches—on human beings.

In recent years, robot therapy has attracted robotics researchers, psychologists, medical doctors, etc.[5]-[29]. They expect that interaction with animal-type robots will result in the mental effects of interacting with real animals. We have proposed robot therapy since 1996 [5]-[20]. We proposed a mental commit robot that provides mental value such as joy, happiness, relaxation, etc., to the subject through 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 day service centers and health service facilities for the aged [9]-[13]. 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 revealed that interaction with Paro reduced stress among the elderly [13]. In addition, we investigated the long-term interaction between Paro and the elderly and found that the effects of interaction with Paro lasted for more a year [14]. Furthermore, the neuropsychological effects of Paro on patients with dementia were assessed by analyzing their EEGs [15]. The results showed that the activity of the patients' cortical neurons improved by interaction with Paro, especially in the case of those who liked Paro. Meanwhile, the studies conducted using questionnaires handed out at exhibitions held in six countries, namely, Japan, the U.K., Sweden, Italy, Korea, and Brunei, in order to investigate how people evaluate the robot. The results showed that the seal robot was widely accepted across cultures [17].

With regard to other research groups, Dautenhahn used mobile robots and robotic dolls for therapy with autistic children [21]. In addition, other animal-type robots (such as Furby, AIBO [22], NeCoRo, etc.) have been released by several companies. Robot therapy using these robots has also been attempted [23]-[27]. For example, Yokoyama used AIBO in a pediatrics ward and observed the interaction between AIBO and the children [23]. He pointed out that when people met AIBO for the first time, they were interested in it for a brief period. However, relaxation effects such as those obtained from petting a real dog were never felt with AIBO. Kanamori et al. examined effects of AIBO on elderly in a nursing home by measuring hormone in saliva [26]. Tamura et al. also used AIBO for 5 minutes with patients exhibiting dementia and compared its effects with

K. Wada and T. Shibata work at the Intelligent Systems Research Institute, AIST, 1-1-1 Umezono, Tsukuba, Ibaraki 305-8568 Japan (e-mail: k-wada@aist.go.jp; shibata-takanori@aist.go.jp).
T. Shibata also works at SORST, JST.

those of a toy dog [27]. In addition, some research groups used Paro for therapy of elderly in nursing homes and Alzheimer disease patient [28][29]. In the above related researches, people interacted with the robot during the certain period of session which was conducted by experimenter.

In this research, we have introduced Paro to a care house since June 2005. Two Paro were activated for over 9 hours every day in public areas of the care house and recorded their interaction by video cameras, in order to investigate how people interact with Paro under the freely accessible condition and its socio-psychological and physiological effects on the residents. So far we have reported the results of this experiment in the first month [18]-[20].

In this paper, we present the socio-psychological influences of robot therapy in this experiment by analyzing the changes of their social network over *2 months*. Chapter II describes the seal robot that was used for robot therapy; chapter III describes the experimental methods used; Chapter IV describes the results; Chapter V discusses the current results of robot therapy and future work; and finally, chapter VI offers conclusions.

II. PARO, THE SEAL ROBOT

Paro, the seal robot, 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 [16]. Paro is equipped with four primary senses, i.e., 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 weighs approximately 2.8 kg. Its operating time with the installed battery is approximately 1 hour. However, Paro can continue to operate by employing a charger, which resembles a pacifier.

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.

A. Proactive Behavior

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

1) Behavior-planning layer

This has a state transition network based on Paro's internal states and desire, produced by its internal rhythm. Paro has internal states that can be described with words indicating emotions. Each state has a numerical level, which changes according to the stimulation. Moreover, each state decays with time. Interaction changes its internal states and creates the character of Paro. The behavior-planning layer sends basic behavioral patterns to the 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 programmed Paro such that its behavior is similar to that of a real seal.

Fig.1 Paro, the Seal Robot

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 variations. For example, various 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 the parameters according to 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 makes it difficult for a subject to predict Paro's actions.

3) Long-term memory

Paro has the function of reinforcement learning. It places positive value on preferred stimulation such as stroking. It also places negative value on undesired stimulation such as beating. Paro assigns values to the relationship between stimulation and behavior. The users are prevented from changing its behavior program manually; however, Paro can be gradually tuned to the preferred behavior of its owner. In addition, Paro can memorize a frequently articulated word as its new name. The users can give Paro their preferred name during natural interaction.

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 to be behavior that is conditioned and unconscious.

C. Physiological Behavior

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

III. Robot Therapy in a Care House

A. Care House

The experiment was 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 such as assistance with meals, bathing, etc., is provided to the residents. In general, the residents of care houses are aged over 60 years. They have physical difficulties with regard to 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 the experiment to the residents and received consent for participation from 12 of them; this was in accordance with the ethical committee of AIST. With regard to the video cameras, all the residents agreed to their installation in a public area of the house.

B. Subjects

The number of subjects were 12, aged 67–89 (77.5 ± 7.3) years, including one male. The subjects' mental cognitive states were assessed by the MMSE (Mini Mental Status Examination) [31]. The results revealed that their scores ranged from 15 to 29 (25.3 ± 3.9).

C. Methods of Interaction with Paro

The care house was situated on three floors. A dining room, hall, and office were on the 1st floor. In the care house, the subjects spent most of time in their rooms alone and visited the public area when they wished to communicate with other people. Spending time in another person's room was very rare. Therefore, spending time in these areas was important for their social interaction.

A Paro was introduced in the public area of the 2nd and 3rd floors, which were residential floors. We assumed that Paro would be a topic of common interest for the subjects and would encourage them to communicate with each other. In particular, those who spent much time alone would leave their rooms and communicate with others.

Caregivers activated Paro on the table in the public space of each floor at 8:30 and returned them to their office at 18:00. The residents could play with Paro whenever they wished during that time. Before introducing Paro, we explained that the latter is a robot and described its operation to the residents.

D. Methods of Evaluation

1) Interview

A free pile sort method was used to investigate social ties among the residents [30]. It uses a deck of cards representing each of the residents in the care house and has the interviewee sort them and then talk through the sort. Several blank cards are kept in hand. If the informant feels there are people missing, they 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 basically build up a network. The stack of cards is shuffled randomly and returned to a respondent with the following instructions: "Here are a set of cards representing name of residents in this care house. I'd like you to freely sort them into piles. You can use as many or as few piles as you wish. Go!" An additional instruction: "For example, you can make the piles of your friends, having meal together, etc." was given to the people who couldn't understand how they should be sorted.

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. In this research, we analyzed video data from June 1–19, July 20-26, and Aug. 20-26 (628 hours in total).

IV. Results of the Robot Therapy

A. Social Interactions among the Subjects and Paro

Before the introduction of Paro, the residents on the 2nd floor were relatively communicative compared with those on the 3rd floor. They discussed the weather, illnesses, gossiped about the other residents, etc. Moreover, 4 subjects played cards in the public area. On the contrary, most subjects on the 3rd floor only passed by the corridor. Normally, only 2 or

Fig.2 Video Recording System

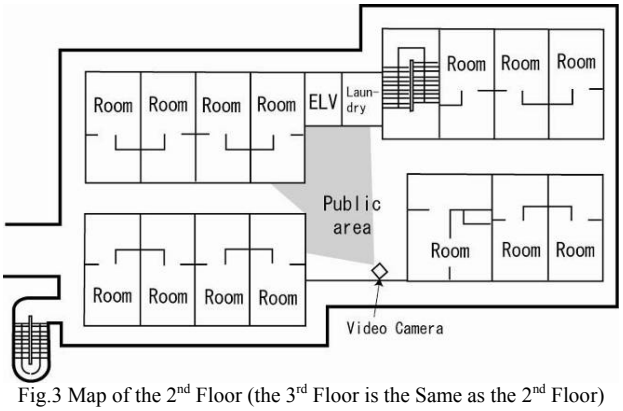


Fig.3 Map of the 2nd Floor (the 3rd Floor is the Same as the 2nd Floor)

3 subjects spent a time in the public area to wait for their friends when they went for their meals.

We extracted their social interaction with the residents and with Paro from the interviews. 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:
- c) Having meal at a same table.
- d) Going to the dining room together.
- 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, 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.

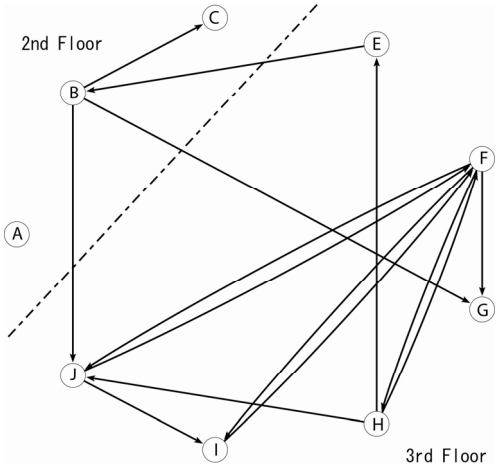
B. Subjective Social Network: Analysis of the Interviews

As the next step, we investigated changes in the social networks of the subjects. We excluded two subjects living on 2nd floor from the analyses because one's health condition deteriorated and couldn't come to the public area; and another had a problem (which was unrelated Paro) with other residents after the introduction of Paro, and changed her social interaction. In addition, we excluded the subject-D from this analysis because she showed reluctance to answer the pile sort. Fig.4 (a), (b) and (c) show sociograms of the strength of ties of 9 subjects before and after the introduction of Paro. For instance, solid arrow A to B means subject-A had strong tie with subject-B. In figure 4 (b) and (c), their moderate and strong ties to Paro are depicted by broken and bold broken arrows. We calculated the density of the each social network of the subjects [32]. The density formula for these directed graphs is:

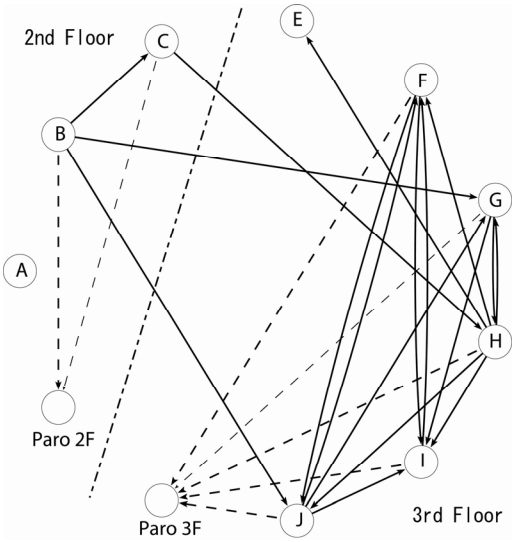
$$Density = \frac{l}{n(n-1)} \qquad (1)$$

Where l is the number of lines present. And n is the number of points. (e.g. $l = 14$, $n = 9$ in Fig.4(a)) From the results, the density in Fig.4 (a) was 0.19, that in (b) was 0.23 and that in (c) was 0.29. The density was gradually increased after the introduction of Paro. This result applies particularly to the changes in subject-G and H. Subject-G 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. As for subject-H, she had never visited 2nd floor before the introduction of Paro. However, after the introduction, she visited there to interact with Paro, and then she communicated with residents on the 2nd floor.

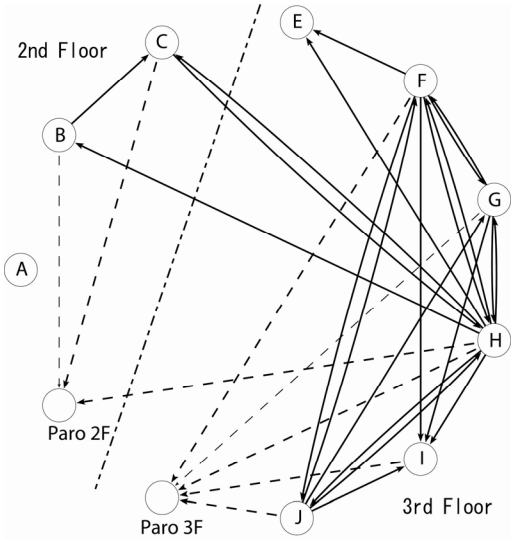
As for the relationship between Paro, subjects-A and E had no ties with Paro. Subject-A, who was a male aged 89, said "I'm too old to be relaxed by (playing with) such a thing." Comments from subject-E, female, aged 71, were "I never interact with the robot, without a thought. *snip* I might be heartless." However, most subjects had moderate to strong ties with Paro. The subjects greeted the latter whenever they passed by and addressed it by the names that they had given it: Paro, Shi-shi maru, Mori-kun, Mori-chan,



(a) Before the introduction of Paro (June, 2005)
Density of the Network = 0.19



(b) A month later (July, 2005)
Density of the Network = 0.23



(c) Two months later (August, 2005)
Density of the Network = 0.29

Fig.4 Change of Subjective Social Network

Shiro, and etc. They commented that the atmosphere was brighter, the people became talkative and that abuse from the others had decreased.

C. Objective Social Network: Analysis of the Video Data

If Paro encouraged the people to communicate with each other, people would spend the same time longer with other people at the public space. Therefore, we calculated the concordance rate of the time spent between subjects.

TABLE I CONCORDANCE RATE OF THE TIME SPENT AMONG THE 2ND FLOOR SUBJECTS

		A	B	C	D	avg. time spent/day
JUN1-19	A		0.28	0.06	0.28	0:05:22
	B	0.01		0.09	0.63	2:36:33
	C	0.01	0.38		0.29	0:38:58
	D	0.01	0.78	0.09		2:06:09
		avg. total time spent/day				5:27:02
JUL20-26	A		0.22	0.09	0.30	0:04:03
	B	0.01		0.23	0.71	2:10:41
	C	0.01	0.45		0.60	1:07:24
	D	0.01	0.52	0.23		2:57:31
		avg. total time spent/day				6:19:39
AUG20-26	A		0.22	0.24	0.38	0:04:26
	B	0.01		0.22	0.69	3:14:40
	C	0.01	0.47		0.51	1:30:50
	D	0.01	0.55	0.19		4:02:04
		avg. total time spent/day				8:52:00

TABLE II CONCORDANCE RATE OF THE TIME SPENT AMONG THE 3RD FLOOR SUBJECTS

		E	F	G	H	I	J	avg. time spent/day
JUN. 1-19	E		0.00	0.01	0.01	0.01	0.02	0:15:24
	F	0.00		0.05	0.12	0.64	0.14	0:18:42
	G	0.02	0.16		0.08	0.12	0.05	0:05:47
	H	0.02	0.22	0.05		0.17	0.17	0:09:56
	I	0.01	0.58	0.03	0.08		0.12	0:20:34
	J	0.02	0.22	0.02	0.14	0.20		0:12:24
		avg. total time spent/day						1:22:46
JUL. 20-26	E		0.01	0.03	0.01	0.01	0.01	0:31:40
	F	0.01		0.04	0.09	0.75	0.10	0:26:01
	G	0.09	0.11		0.08	0.14	0.05	0:09:23
	H	0.02	0.29	0.09		0.38	0.07	0:08:00
	I	0.01	0.50	0.03	0.08		0.18	0:38:59
	J	0.02	0.18	0.03	0.04	0.49		0:13:55
		avg. total time spent/day						2:07:58
AUG. 20-26	E		0.01	0.01	0.10	0.06	0.04	0:14:19
	F	0.01		0.19	0.36	0.56	0.12	0:23:37
	G	0.01	0.26		0.22	0.19	0.04	0:17:19
	H	0.04	0.24	0.10		0.20	0.03	0:35:40
	I	0.02	0.25	0.06	0.14		0.07	0:51:44
	J	0.06	0.34	0.07	0.12	0.42		0:08:35
		avg. total time spent/day						2:31:14

TABLE III CHANGE OF THE DENSITY OF OBJECTIVE SOCIAL NETWORK

	Before (JUN1-19)	1month later (JUL20-26)	2 months later (AUG20-26)
2nd Floor	0.26	0.28	0.29
3rd Floor	0.12	0.13	0.14

For example, the time spent concordance rate of subject-A to B, R_{AB} is total time spent of A ∩ B divided by total time spent of A. The rates were calculated among the subjects living on the same floor because they rarely visited other residential floor. Table I and II show the results. The average of total time spent of the subjects on the each floor was increased after the introduction of Paro. Especially, the time spent on the 3rd floor was increased by 83% (from 1:22:46 to 2:31:14.)

As the next step, in order to investigate the changes of the rate overall, we defined the new density of the each social network of the subjects as follows:

$$Density_{new} = \frac{\sum_i \sum_j R_{ij}}{m(m-1)} \quad (i \neq j) \qquad (2)$$

Where i and j are the name of subjects. (ex. of 2nd floor: i, j = {A, B, C, D}) R_{ij} is the time spent concordance rate of i to j. And m is the number of subjects living on the same floor. As the results, the density of 2nd floor was increased from 0.26 to 0.29, and that of 3rd floor was also increased from 0.12 to 0.14. (Table III)

V. Conclusions

We have used seal robots (Paro) for elderly residents in a care house since June 2005. The residents freely interacted with Paro for over 9 hours daily. The current results show that Paro encouraged them to communicate with each other and brought about psychological improvements in them over *2 months*. Paro became playing a stronger role as social mediator among the subjects. In this paper, we investigated social influences of Paro on the group overall by analyzing the density of their social network. More detailed analysis, influence on each person, will be done. Physiologically, Urinary tests were conducted to establish the physiological effects. The details will be described in the future. This experiment is on-going. We will report more long-term influences on the residents of the care house in the future.

References

[1] L. F. Berkman & S. L. Syme, Social Networks, Host Resistance, and Mortality: A Nine-Year Follow-up Study of Alameda County Residents, Am. J. Epidemiol. Vol.109, No.2, pp.186-204, 1979.

[2] M. Zunzunegui, et al. Social Networks, Social Integration, and Social Engagement Determine Cognitive Decline in Community-Dwelling Spanish Older Adults, J. Gerontology: Social Sciences, Vol.58B, No.2, pp.98-100, 2003.

[3] M. M. Baum, et al. Physiological Effects of Human/Companion Animal Bonding, Nurs. Res. Vol. 33. No. 3, pp. 126-129, 1984.

[4] J. Gammonley, J. Yates, Pet Projects Animal Assisted Therapy in Nursing Homes, J. Gerontological Nursing, Vol.17, No.1, pp. 12-15, 1991.

[5] T. Shibata, et al., Emotional Robot for Intelligent System - Artificial Emotional Creature Project, Proc. 5th IEEE Int'l Workshop on ROMAN, pp. 466-471, 1996.

[6] T. Shibata, et al., Artificial Emotional Creature for Human-Machine Interaction, Proc. the IEEE Int. Conf. SMC, pp. 2269-2274, 1997.

[7] T. Shibata, et al. Emergence of Emotional Behavior through Physical Interaction between Human and Robot, Proc. the IEEE ICRA, 1999.

[8] T. Shibata, K. Tanie, Influence of A-Priori Knowledge in Subjective Interpretation and Evaluation by Short-Term Interaction with Mental Commit Robot, Proc. IEEE Int. Conf. IROS, 2000.

[9] T. Shibata, et al., Mental Commit Robot and its Application to Therapy of Children, Proc. the IEEE/ASME Int. Conf. AIM 2001 paper #182

[10] T. Shibata, et al. Robot Assisted Activity for Senior People at Day Service Center, Proc. Int. Conf. ITM, pp.71-76, 2001.

[11] K. Wada, et al., Effects of Robot Assisted Activity for Elderly People and Nurses at a Day Service Center, Proc. of the IEEE, Vol.92, No.11, pp.1780-1788, 2004.

[12] K. Wada, et al. Analysis of Factors that Bring Mental Effects to Elderly People in Robot Assisted Activity, Proc. IEEE Int. Conf. IROS, 2002.

[13] T. Saito, et al. Examination of Change of Stress Reaction by Urinary Tests of Elderly before and after Introduction of Mental Commit Robot to an Elderly Institution, Proc. Int. Symp. AROB Vol.1 pp.316-319, 2002.

[14] K. Wada, et al. Psychological and Social Effects of One Year Robot Assisted Activity on Elderly People at a Health Service Facility for the Aged, Proc. IEEE ICRA, pp.2796-2801 2005

[15] K. Wada, et al. Effects of Robot Therapy for Demented Patients Evaluated by EEG, Proc. the IEEE/RSJ Int. Conf. IROS, pp.2205-2210, 2005.

[16] T. Shibata, Ubiquitous Surface Tactile Sensor, 2004 1st IEEE TExCRA Proc. pp. 5, 6, 2004.

[17] T. Shibata : An Overview of Human Interactive Robots for Psychological Enrichment, Proc. of the IEEE, Vol.92, No.11, pp.1749-1758, 2004.

[18] K. Wada & T. Shibata, Robot Therapy in a Care House - Its Sociopsychological and Physiological Effects on the Residents, Proc. IEEE ICRA, pp.3966-3971, 2006.

[19] K. Wada & T. Shibata, Robot Therapy in a Care House - Results of Case Studies -, Proc. IEEE Int. Workshop ROMAN, pp.581-586, 2006.

[20] K. Wada & T. Shibata, Living with Seal Robots in a Care House - Evaluations of Social and Physiological Influences -, Proc. the IEEE/RSJ Int. Conf. IROS, pp.4940-4945, 2006.

[21] I. Werry and K. Dautenhahn, Applying Mobile Robot Technology to the Rehabilitation of Autistic Children, Proc. of 7th Int. Symp. Intelligent Robotic Systems, pp.265-272, 1999.

[22] M. Fujita and H. Kitano, An Development of an Autonomous Quadruped Robot for Robot Entertainment, Autonomous Robots, Vol.5, pp.7-18, 1998.

[23] A. Yokoyama, The Possibility of the Psychiatric Treatment with a Robot as an Intervention -From the Viewpoint of Animal Therapy-, Proc. Joint 1st Int. Conf. SCIS and ISIS, paper #23Q1-1, 2002.

[24] E. Libin, and A. Libin, Robotherapy: Definition, Assessment, and Case Study, Proc. the 8th Int. Conf. Virtual Systems and Multimedia, pp.906-915, 2002.

[25] E. Ohkubo, et al. Studies on Necessary Condition of Companion Robot in the RAA Application, Proc. 2003 IEEE Int. Symp. CIRA, pp.101-106, 2003.

[26] M. Kanamori, et al. [Maintenance and Improvement of Quality of Life Among Elderly Patients Using a Pet-type Robot], Nippon Ronen Igakkai Zasshi. Vol.39, No.2, pp.214-218, 2002. (Japanese)

[27] T. Tamura, et al. Is an Entertainment Robot Useful in the Care of Elderly People with Severe Dementia? Journal of Gerontology: Medical Sciences, Vol.59A, No.1, pp.83-85, 2004.

[28] C. Kidd, et al. A Social Robot to Encourage Social Interaction among the Elderly, Proc. IEEE ICRA, pp.3972-3976, 2006.

[29] P. Marti, et al. Socially Assistive Robotics in the Treatment of Behavioral and Psychological Symptoms of Dementia, Proc. BioRob 2006.

[30] S. Weller & A. Romney, Systematic Data Collection. Qualitative Research Methods Series 10. California: Sage Publications Inc. 1988.

[31] M. F. Folstein, et al. Mini-Mental State: a Practical Method for Grading the Cognitive State of Patients for the Clinician, Journal of Psychiatric Research, Vol.12, pp.189-98, 1975.

[32] J. Scott, Social Network Analysis: a handbook, SAGE Publications, 1991