Long-term Robot Therapy in a Health Service Facility for the Aged – A Case Study for 5 Years -

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Abstract— A long-term experiment of robot therapy for elderly people has been conducted at a health service facility for the aged since Aug. 2003. Three therapeutic seal robots, Paro, were introduced there. This paper describes the results of the experiment for five year. We regularly visited the facility twice or once a month and observed their interaction with the robots. Moreover, face scales that consist of illustrations of person's faces were used to evaluate person's moods. As the results, feelings of the elderly people were improved by interaction with the seal robots. The relationship the elderly and the robots still continued over the five year.

I. INTRODUCTION

Robot therapy which uses robots as a substitute of animals in animal therapy [1][2] is attracted many robotics researchers and psychologist. The psychological and social effects of interacting with robots on the people have been investigated in several years. Robot therapy is becoming one of the fields of robotics [3]-[30].

We have proposed robot therapy since 1996 [3]-[17]. 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 [8]-[14]. 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. In addition, the neuropsychological effects of Paro on patients with dementia were assessed by analyzing their EEGs [15][16]. 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.

With regard to other research groups, Dautenhahn used mobile robots and Robins used robotic dolls for therapy with autistic children [19][20]. In addition, other animal-type robots (such as Furby, AIBO[21], NeCoRo, etc.) have been released by several companies. Robot therapy using these robots has also been attempted [22]-[26]. For example, Yokoyama used AIBO in a pediatric ward and observed the interaction between AIBO and the children [22]. He pointed

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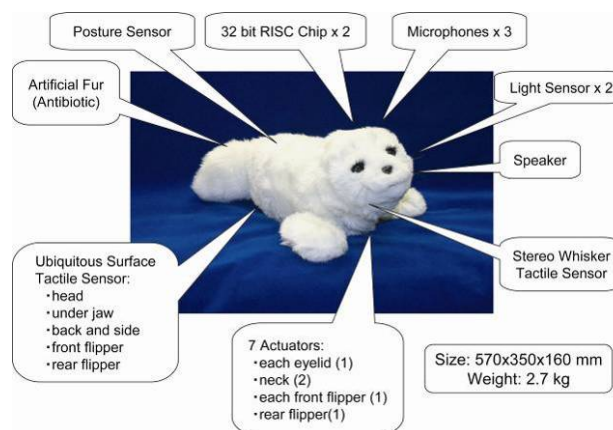
Fig.1 Paro, the Seal Robot

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 the relationship between interaction with AIBO and loneliness of the elderly in a nursing home [25]. Tamura et al. also used AIBO for 5 minutes with patients exhibiting dementia and compared its effects with those of a toy dog [26]. In addition, some research groups used Paro for therapy of elderly in nursing homes and Alzheimer disease patient [27][28]. However, the research on the influences of long-term interaction with robot is quite few.

In this paper, seal robots, Paro were introduced to mental care of the elderly people in a health service facility for the aged since 2003. We discussed the long-term interaction with robots and the elderly in care facility. Section II describes the seal robot that was used for robot therapy; section III describes the experimental methods used; Section IV describes the results; Section V discusses the current results of robot therapy and future work; and finally, section VI offers conclusions.

II. SEAL ROBOT, PARO

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 [18]. 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
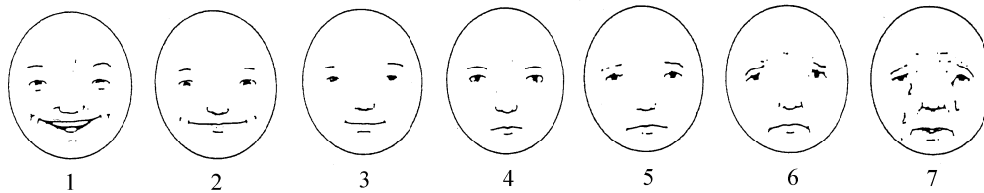
INSTRUCTIONS: The faces above range from very happy at the left to very sad at the right. Check the face which best shows the way you have felt inside now.

Figure 2 Face Scale

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 operates by using the 3 elements of its internal states, sensory information from its sensors and its own diurnal rhythm (morning, daytime, and night) to carry out various activities during its interaction with people. In addition, 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.

III. ROBOT THERAPY FOR ELDERLY IN THE FACILITY

We introduced Paro to a health service facility for the aged, (in Tsukuba City, Japan) 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.

Before starting the experiment, we explained the purpose and procedure to the people, receive their consent. The experiment was conducted under the ethical committee in AIST.

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: normal: 1 person, mild: 4 people, moderate: 5 people, and slightly severe: 3 people.

A. Method of interaction

Two seal robots were 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 arranged up around it. They interacted freely with the robots for about one hour at a time. The every interaction activity was managed by one or two caregivers. Since not all subjects could interact with the robots at the same time, we had them take turns for equal periods of time.

B. Methods of Evaluation

In order to investigate the influence on the elderly people, we visited the facility at once or twice per month and observed their interaction and corrected the caregivers' comments. In addition, questionnaire for investigate their moods, face scale, was used (Fig.2).

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 [31]. 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 the subjects are confused by the original face scale because it contains too many similar images. Thus, the scale was simplified by using seven images #1, 4, 7, 10, 13, 16, and 19 from the original set. 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."

IV. RESULTS OF ROBOT THERAPY

The elderly interacted with Paro willingly from the first day, speaking to it, stroking and hugging it. Sometimes, they kissed it with smile. Paro became common topics among the elderly people and caregivers. 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 came to like the Paro very much and gave them new names of "Maru" and "Maro." 3 months after the initial introduction, we added one more Paro to the facility because many other elderly people had voluntarily joined in the activity. The new Paro was given the name "Hana-chan" by the elderly. Moreover, the Paro have been widely accepted by caregivers, making a home for Paro in the facility.

One year later, commercialized version of Paro was released. Its functions were same with previous version. So, we replaced one of Paro ("Maro") to new one. The Paro was quickly accepted by them and given the name "Choco-chan" on the day when it was introduced there. Because of the long-term experiment, most subjects left the facility now. However, around 5 to 10 elderly people (including volunteer) still enjoy interacting with Paro.

Caregivers commented that interaction with Paro made the people laugh and become more active. Their facial expression 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 came out and willingly joined the activity. In addition, Paro encouraged the people to communicate, both with each other and caregivers, by becoming their common topic of conversation. Thus, the general atmosphere became brighter. A caregiver said "I can't imagine the facility without Paro. Paro is necessary existence in this facility."

A. Case study

Subject-A, aged 89, slightly degree of HDS-R, was sociable and comparatively independent. On the first day of the interaction with Paro, she looked a little nervous of the experiment. However, she liked Paro soon. She treated Paro like her child or grandchild. Especially, she loved "Hana-chan" very much because it has big eyes. Unfortunately, she was hospitalized during Dec. 10 to 26, 2003. When she met Paro for the first time after her recovering, she said to Paro "I was lonely, Paro. I wanted to see you again." Then, she requested the picture of Paro with her. The existence of Paro in her seemed to became bigger.

In the next year, Paros were given collars with each name tag, because she requested them to caregivers. November in the year, new Paro, Choco-chan joined the facility. She commented "this is beautiful like Hana-chan," then, loved it. But, she missed Maro when she heard it left the facility.

In the February, 2005, Hana-chan was "hospitalized" because it lost its call suddenly. She missed it very much, and asked us when it would recover whenever we visited there. So,

she was very glad when Hana-chan recovered in the next month. She said to Hana, "Hello, I haven't seen you for a long time. Choco-chan is also glad because Hana-chan is back."

Many subjects and her friends left the facility until 2006. She still enjoyed playing with Paro (Fig.4). But, sometimes, she missed the people. She commented "I would like to show Paro to the friend…"

The early next year, her health condition got bad. Therefore, she was moved to the other room. She was discouraged and decreased her strength. However, she joined the activity to play with Paro even if her condition was bad. After interacting with Paro, she commented "My feeling became better after playing with Paro." In the May, she experienced mysterious event that the Paro in the picture moved. According to her, Paro licked her face and then it slept in her arm in the picture. She was very surprised but felt it was very cute.

Figure 3. Subject-A playing with Hana-chan (Dec. 2004)

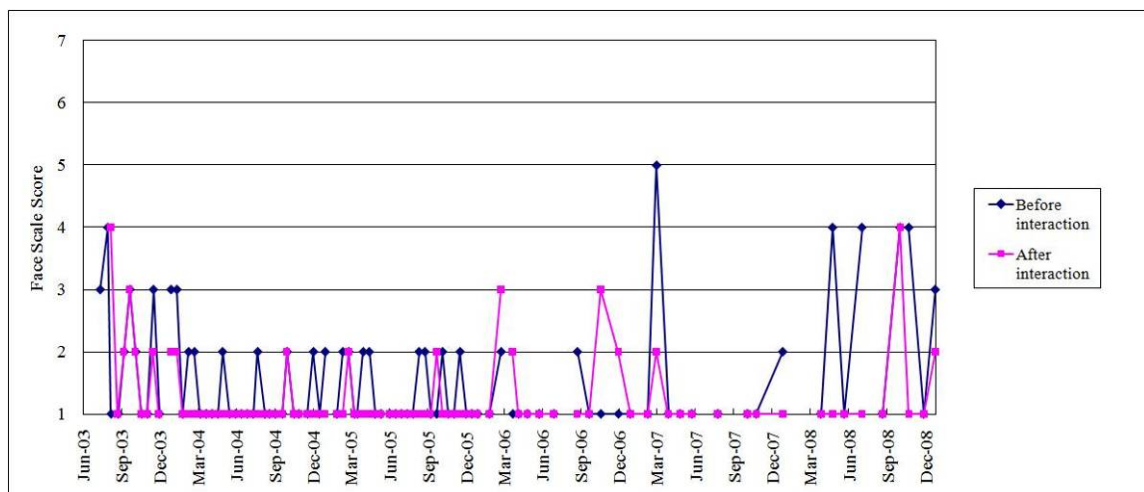Figure 4. Subject-A lifting Choco-chan up and down (Jun. 2006)

Figure 5 Result of Face Scale Score of Subject-A for 5 years

To the present, she has continued to join the activity and willingly interacted with Paro.

Figure 5 shows the results of the face scale. Her face scale scores after interaction were almost always lower than before interaction.

V. DISCUSSIONS

The interaction with Paro in the facility has continued over the five years. Of course, the strong relationship between Paro and the elderly was one of the reasons. But, being recognized by caregivers was also important. They felt Paro was necessary existence in the facility. They prepared collars, made Paro's home and turned to manage interaction with Paro. Now, Paro became a part of the facility.

From the result of case study, the effects of Paro emerged during the period. Especially, after her health condition got worse, she often refused to attend rehabilitation and other activities in the facility. The interaction with Paro was only activity she attended to. She loved Paro very much. This result showed that people could make relationship with robots over the years. (Subject-A had symptom of mild dementia, but recognized Paro was robot because she could turn it on.)

VI. CONCLUSION

We have used seal robots, Paro at a health service facility for the aged since August 2003. The results showed that interaction with Paro improved elderly people's moods, and then the effects showed up over five years.

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.

REFERENCES

[1] M. M. Baum, N. Bergstrom, N. F. Langston, L. Thoma, Physiological Effects of Human/Companion Animal Bonding, Nursing Research, Vol. 33. No. 3, pp. 126-129 (1984)

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

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

[4] T. Shibata and R. Irie, Artificial Emotional Creature for Human-Robot Interaction - A New Direction for Intelligent System, Proc. of the IEEE/ASME Int'l Conf. on AIM'97 (Jun. 1997) paper number 47 and 6 pages in CD-ROM Proc.

[5] T. Shibata, T. Tashima, and K. Tanie, Emergence of Emotional Behavior through Physical Interaction between Human and Robot, Procs. of the 1999 IEEE Int'l Conf. on Robotics and Automation (1999)

[6] T. Shibata, T. Tashima, K. Tanie, Subjective Interpretation of Emotional Behavior through Physical Interaction between Human and Robot, Procs. of Systems, Man, and Cybernetics, pp. 1024-1029 (1999)

[7] T. Shibata, K. Tanie, Influence of A-Priori Knowledge in Subjective Interpretation and Evaluation by Short-Term Interaction with Mental Commit Robot, Proc. of the IEEE Int'l Conf. On Intelligent Robot and Systems (2000)

[8] T. Shibata, et al., Mental Commit Robot and its Application to Therapy of Children, Proc. of the IEEE/ASME Int'l Conf. on AIM'01 (July. 2001) paper number 182 and 6 pages in CD-ROM Proc.

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

[10] K. Wada, T. Shibata, T. Saito, and K. Tanie., Effects of Robot Assisted Activity for Elderly People and Nurses at a Day Service Center, Proceed. the IEEE, Vol.92, No.11, pp.1780-1788, 2004.

[11] K. Wada, T. Shibata, T. Saito, K. Tanie, Analysis of Factors that Bring Mental Effects to Elderly People in Robot Assisted Activity, Proc. the IEEE Int. Conf. Intelligent Robot and Systems, 2002.

[12] T. Saito, T. Shibata, K. Wada, K. Tanie, Examination of Change of Stress Reaction by Urinary Tests of Elderly before and after Introduction of Mental Commit Robot to an Elderly Institution, Proc. of the 7th Int. Symp. on AROB Vol.1 pp.316-319, 2002.

[13] 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

[14] K. Wada and T. Shibata, Living with Seal Robots— Its Socio-psychological and Physiological Influences on the Elderly in a Care House, IEEE Transactions on Robotics, Vol.23, No.5, pp.972-980, 2007.

[15] K. Wada, T. Shibata, T. Musha and S. Kimura, Robot Therapy for Elders Affected by Dementia, IEEE Engineering in Medicine and Biology Magazine, Vol.27, No.4, pp.53-60, 2008.

[16] K. Wada, T. Shibata, T. Asada and T. Musha, Robot Therapy for Prevention of Dementia at Home - Results of Preliminary Experiment, Journal of Robotics and Mechatronics, Vol.19, No.6, pp.691-697, 2007.

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

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

[19] 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.

[20] B. Robins, et al. Robotic Assistants in Therapy and Education of Children with Autism: Can a Small Humanoid Robot Help Encourage Social Interaction Skills? Journal of Universal Access in the Information Society, Vol.4, No.2, 2005.

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

[22] 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.

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

[24] 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.

[25] 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)

[26] 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.

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

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

[29] D. Feil-Seifer, and MJ, Mataric', Defining Socially Assistive Robotics. IEEE ICORR, pp. 465-468, 2005.

[30] E. Kim, et al. Robotic tools for prosodic training for children with ASD: A case study, 2008 International Meeting for Autism Research, 2008.

[31] C. D. Lorish, R. Maisiak, The Face Scale: A Brief, Nonverbal Method for Assessing Patient Mood, Arthritis and Rheumatism, Vol.29, No.7, pp.906-909, 1986.