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Psychological and Social Effects of One Year Robot Assisted Activity on Elderly People at a Health Service Facility for the Aged

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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. Three therapeutic seal robots, Paro, were introduced there. This paper describes the results of the experiment for one year. Face scales that consist of illustrations of person's faces were used to evaluate person's moods. In addition, Geriatric Depression Scales were used to measure person's depression by questionnaires. As the results, feelings of the elderly people were improved by interaction with the seal robots.**

Index Terms- Mental Commit Robot, Human-Robot Interaction, Robot Assisted Activity, Elderly People

I. INTRODUCTION

Generally speaking, elderly people are depressed easily, as they have hard experiences such as lost their family, friends, social roles, and physical functions. Therefore, mental care of elderly is one of the important tasks for caregivers at nursing homes. However, they feel difficulty in communication with elderly because of lack of common topics among them.

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:

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 RAT&RAA. Dautenhahn has used mobile robots and robotic dolls for therapy of autistic children [18]. Besides, other animal type robots (such as Furby, AIBO [19], NeCoRo, etc.) have been released by several companies. Then, robot-assisted activity that uses those robots has been tried [20-22]. 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 *one year*.

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 it's 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.


Figure 1. Seal Robot: Paro

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: 3 people*

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

A. 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 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.

B. Methods of Evaluation

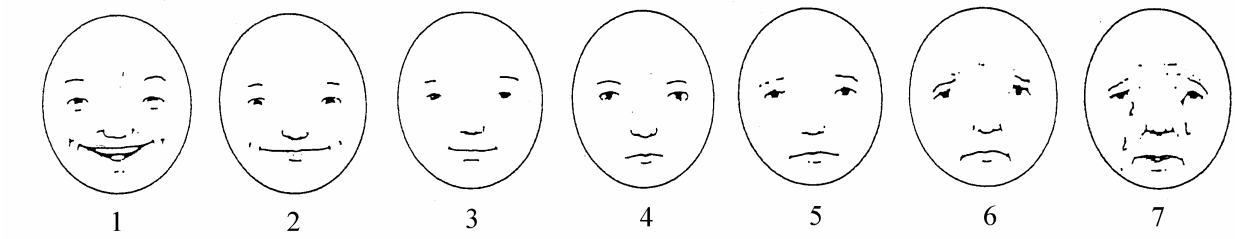
In order to investigate the effects on the elderly people before and after interaction with Paro, the following two types of data and additional information were collected.

1) *Face scale [23] (Figure 3)*
2) *Geriatric Depression Scale (GDS) [24]*
3) *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 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."

The original GDS is a 30-item instrument developed from 100 popular questions commonly used to diagnose depression. A 15-item short version has also been validated. In this research, we used the short version that was translated in Japanese by Muraoka, et al. The scale is in a yes/no format. Each answer counts one point; scores greater than 5 indicate probable depression.

The face scale and GDS were applied four weeks and one week before Paro was introduced and then in every two week thereafter. Especially, the face scale was applied



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 [23]

before and after interaction with Paro. As a statistics analysis, Wilcoxon's sign rank sum test was applied to the scores before and after interaction for each week by using SPSS 12.0 for Windows.

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). Paro became common topics among the elderly people and caregivers (Fig.5). 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 love 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 others of the elderly 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 (Fig.6).

Face scale data were obtained from 8 subjects. The average scores before interaction varied from 3.3 to 2.0 over a 5 month period (Fig.7). However, scores after interaction were almost always lower than those before interaction in each week (except Nov. 29). In particular, a statistically significant difference* was noted in Nov. 15 (Wilcoxon's test: $*p < 0.05$).

After November, many subjects couldn't attend the activity because of their hospitalization, bad health and leaving the facility. Then, it became difficult to analyze the data statistically. Therefore, we introduce several case studies.

Figure 8 and 9 shows an example of an 89 years old woman, who had a symptom of dementia (a little high degree of HDS-R), lying on her bed at her free time usually. Before the introduction, she was probably depression, as her GDS scores were about 10. After the introduction, she joined in the activity willingly, loving Paro as all around the people recognized that. And then, her Face scale and GDS scores dramatically improved. In the Sept. 20 and Feb. 21, her GDS scores rose because of her bad feelings of the day. However, the score decreased again after the days. After her hospitalization during Dec. 24 to Jan. 21, her physical strength decreased obviously. She came to doze off easily except during the interaction with Paro. Besides, her symptoms gradually got worse because of her illness. After Apr. 2004, she has not been able to answer the questionnaire.

Another example is B (aged 89, slightly degree of HDS-R) who was sociable and comparatively independent. On the first day of the interaction with Paro, she looked a little nervous of the experiment. However, she soon came to like Paro. She treated Paro like her child or grandchild. Her face scale scores after interaction were always lower than before interaction after the first day (Fig.10). Unfortunately, she was hospitalized during Dec. 10 to 26. When she met Paro for the first time after leaving hospital, she said to Paro "I was lonely, Paro. I wanted to see you again." Her GDS score then improved (Fig.11). To the

Figure 4. An Elderly Person Kissing the Seal Robot

Figure 5. Interaction between Elderly People and a Caregiver through Seal Robot

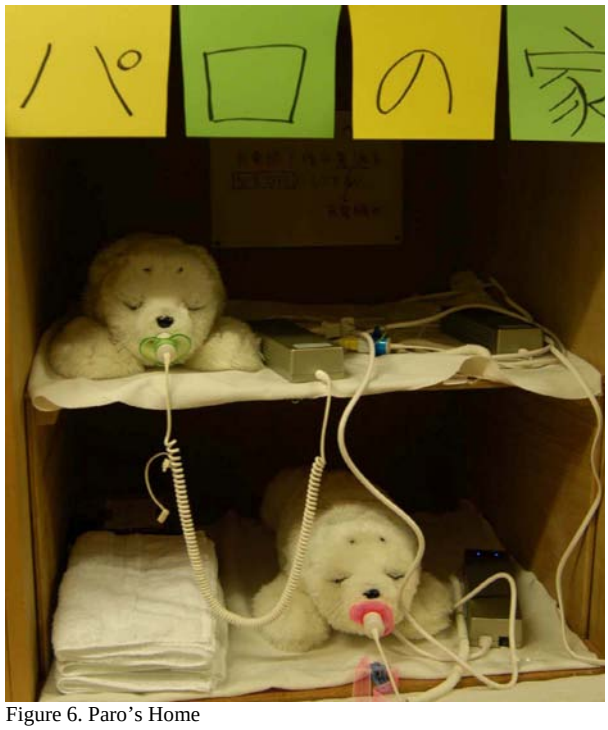


Figure 6. Paro's Home

TABLE I. BASIC ATTRIBUTE OF 8 ELDERLY PEOPLE

Sex		All women
Age (ave. ± sd)		90.3 ± 4.5
Level of dementia	***Slightly degree***	4
HDS-R	***A little high degree***	4

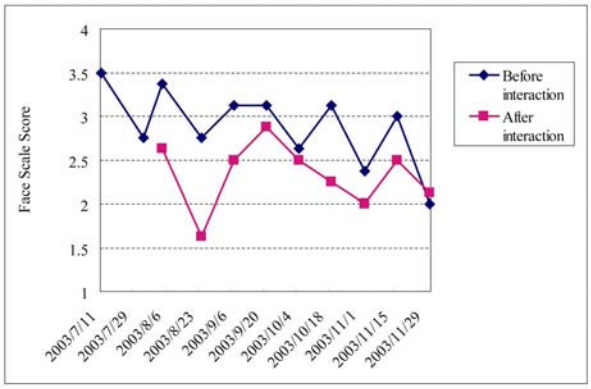


Figure 7. Change of Average Face Scale Scores of 8 Elderly People for 5 Months (Score: 1=best mood, 7=worst mood)

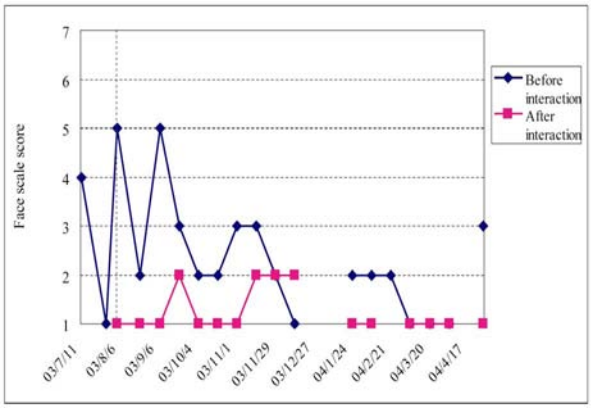


Figure 8. Change of Face Scale Scores of a Subject A for 10 Months (Score: 1=best mood, 7=worst mood)

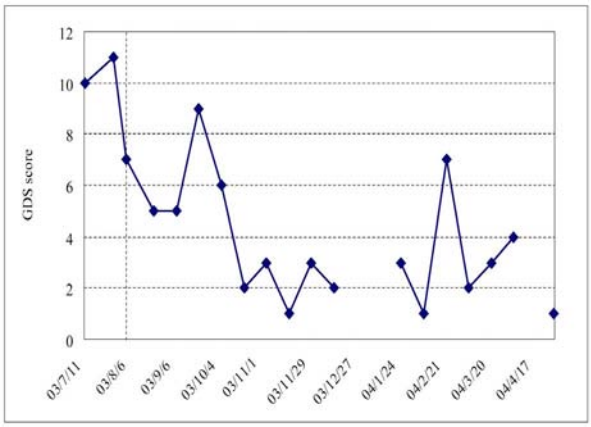


Figure 9. Change of GDS Scores of a Subject A for 10 Months (Score: healty condition <= 5 < probable depression)

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

Caregivers commented that interaction with Paro made the people laugh and become more active. For example, their facial expression changed, softened, and brightened.

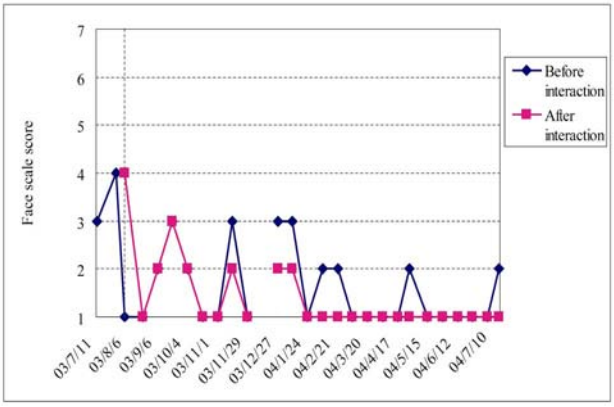


Figure 10. Change of Face Scale Scores of a Subject B for One Year (Score: 1=best mood, 7=worst mood)

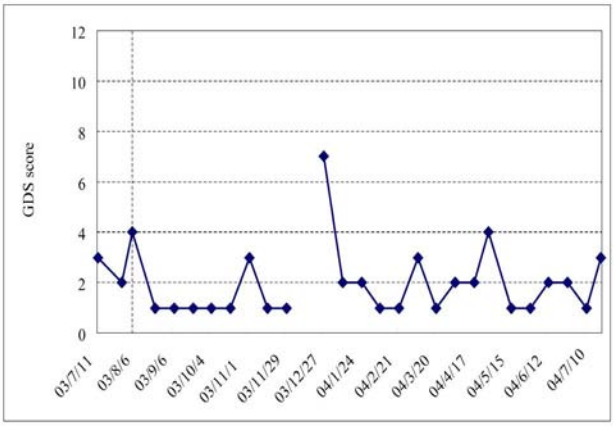


Figure 11 Change of GDS Scores of a Subject B for One Year (Score: healty condition <= 5 < probable depression)

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.

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 a report of the experiment for one year. 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 long-term. Especially, the results of case studies show that Paro keep its effects for about one year.

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 one year. In addition, no breakdown and accident occurred by now. Paro fulfill its durability and 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 results showed that interaction with Paro improved their moods and depression, and then the effects showed up through one year. Urinary tests were conducted to establish the physiological effects. The details will be described in the future.

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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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, et al., Artificial Emotional Creature for Human-Machine Interaction, Proc. of the IEEE Int'l Conf. on SMC, pp. 2269-2274 (1997)

[6] T. Tashima, S. Saito, M. Osumi, T. Kudo and T. Shibata, Interactive Pet Robot with Emotion Model, Proc. of the 16th Annual Conf. of the RSJ, Vol. 1, pp. 11, 12 (1998)

[7] 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)

[8] 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)

[9] 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)

[10] 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.

[11] K. Wada, T. Shibata, T. Saito, K. Tanie, Robot Assisted Activity for Elderly People and Nurses at a Day Service Center, Proc. of the IEEE Int'l Conf. on Robotics and Automation pp.1416-1421, 2002.

[12] K. Wada, T. Shibata, T. Saito, K. Tanie, Analysis of Factors that Bring Mental Effects to Elderly People in Robot Assisted Activity, Proc. of the IEEE Int'l Conf. On Intelligent Robot and Systems (2002)

[13] 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 Artificial Life and Robotics Vol.1 pp.316-319, 2002.

[14] K. Wada, T. Shibata, T. Saito, K. Tanie, Psychological and Social Effects to Elderly People by Robot Assisted Activity at a Health Services Facility for the Aged, Proc. of Joint 1st International Conference on Soft Computing and Intelligent Systems and 3rd International Symposium on Advanced Intelligent Systems, paper number 23Q1-3, in CD-ROM Proc., 2002.

[15] T. Saito, T. Shibata, K. Wada, K. Tanie, Change of Stress Reaction by Introduction of Mental Commit Robot to a Health Services Facility for the Aged, Proc. of Joint 1st International Conference on Soft Computing and Intelligent Systems and 3rd International Symposium on Advanced Intelligent Systems, paper number 23Q1-5, in CD-ROM Proc., 2002.

[16] T. Shibata, T. Mitsui, K. Wada, and K. Tanie, Subjective Evaluation of Seal Robot: Paro -Tabulation and Analysis of Questionnaire Results, Jour. of Robotics and Mechatronics, Vol. 14, No. 1, pp. 13-19, 2002

[17] T. Shibata, K. Wada, and K. Tanie, Tabulation and analyasi of Questionnaire Results of Subjective Evaluation of Seal Robot in Japan, U.K., Sweden and Italy, Proc. of IEEE Int'l Conf. on Robotics and Automation, 2004 (accepted).

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

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

[20] A. Yokoyama, The Possibility of the Psychiatric Treatment with a Robot as an Intervention -From the Viewpoint of Animal Therapy-, Proc. of Joint 1st International Conference on Soft Computing and Intelligent Systems and 3rd International Symposium on Advanced Intelligent Systems, paper number 23Q1-1, in CD-ROM Proc., 2002.

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

[22] E. Ohkubo, et. al. Studies on necessary condition of companion robot in the RAA application, Proc. of 2003 IEEE Int. Sympo. on Computational Intelligence in Robot and Automation, pp.101-106, 2003.

[23] 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.

[24] J. A. Yesavage, Geriatric Depression Scale, Journal of Psychopharmacology Bulletin, Vol.24, No.4, 1988.