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Robot Therapy as for Recreation for Elderly People with Dementia – Game Recreation Using a Pet-type Robot –

Toshimitsu Hamada, Hiroki Okubo, Kazuya Inoue, Joji Maruyama, Hisashi Onari, Yoshihito Kagawa, and Tomomi Hashimoto

Abstract— Most elderly people staying in nursing homes have considerable dementia, and various kinds of recreation program have hence been executed in order to improve or prevent this problem. However the effect of recreation has not been proved quantitatively. In this paper, we show the relationship between actions of elderly people with considerable dementia during recreation and abilities of memorization, emotion control, accommodation to society, etc., and decompose their actions into basic action factors. We propose a design method for recreation programs composed of effective factor actions for improving dementia. We analyze the effect of recreation in an experiment of robot therapy recreation based on the proposed method.

1. INTRODUCTION

Most elderly people staying in a nursing home have considerable dementia, and various kinds of recreation program are hence executed there in order to improve or prevent this problem. Robot therapy is a recreation program that has recently started in some nursing homes and in which robots are replaced with real animals in animal therapy. It is said that there are 3 effects of animal therapy:

1) Physiological effects (e.g., improvement of vital functions)
2) Psychological effects (e.g., relaxation, motivation)
3) Social effects (e.g., promotion of communication among inpatients and care-givers)

However, animal therapy is executed in few hospitals and nursing homes in Japan, because there are risks such as allergies, infections, bites, and scratches even though there are these positive effects [1] –[3]. On the other hand, robot therapy is thought to be more useful than animal therapy, because robots do not carry such risks and robot actions are easily programmable for specific purposes.

Studies on robot therapy started when a seal-type robot named Paro and an entertainment robot named AIBO appeared in the world [4]. Shibata et al. developed Paro and used it at pediatric wards and facilities for elderly people [5]-[9]. However, Paro was only put on the market several yeas ago, and most researchers used commercial pet-type robots like AIBO. Kanamori et al. examined the usefulness of pet-type robot AIBO among elderly patients or those with disabilities in nursing homes or at home using biochemical markers, self-assessment, or health-related QOL questionnaires [10]. Yokoyama, a researcher on animal therapy and psychiatrist, used AIBO in a pediatrics ward and observed the interaction between AIBO and the children [11]. He said the introduction of robots into hospitals is much easier beyond expectation than the introduction of animals. And he also said robot therapy is promising. E. Ohkubo et al. discussed effective use of a wireless LAN-controlled robot, and developed a simple operating console for wireless LAN [12].

We discussed the possibility of robot therapy when AIBO appeared, and concluded that robot therapy is promising based on a questionnaire survey [13]. And through performing robot therapy at a nursing home, we analyzed the impression and the effect of robot therapy from viewpoints such as the situation of the evaluation person and the physical, mental, and living environment of the elderly people. Although there was a difference between the evaluation of care-giving staff and interveners at therapy, it was found that the effect of robot therapy was high even if the subjects had serious dementia [14]. Moreover, we discussed effective methods of robot therapy from the viewpoint of intervention and robot behaviors. We showed what type of intervention induces spontaneous actions of elderly people and what is the optimal intervention time based on experimental therapy for elderly subjects with dementia. The results of the experiment also indicated that some robot behaviors frequently induce elderly people to react to the robot spontaneously [15][16].Induction of spontaneous action is thought to be a significant factor in recreation for elderly people with dementia, and these results clearly show that robot therapy is promising.

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T. Hamada works at Tsukuba Gakuin University, 3-1 Azuma, Tsukuba, Ibaraki 305-0031 Japan (e-mail: hamada@tsukuba-g.ac.jp).

H. Okubo works at Okayama University, 3-1-1 Tsushimanaka, Okayama 700-8530 Japan (e-mail: okubo@et6500.mech.okayama-u.ac.jp).

K. Inoue, J. Maruyama, and H. Onari work at Waseda University, 3-4-1 Okubo, Shinjuku-ku, Tokyo 169-8555 Japan (e-mail: onari@waseda.jp).

Y. Kagawa works at Takushoku University, 815-1 Tachimachi, Hachioji –shi Tokyo 193-0985 Japan (e-mail: ykagawa@ms.takushoku-u.ac.jp).

T. Hashimoto works at Saitama Institute of Technology, 1690 Fusaiji, Fukaya-shi, Saitama 369-0203 Japan (e-mail: tomomi@sit.ac.jp).

However, effect evaluation of robot therapy is difficult in general. Most evaluation results are dependent on questionnaires or observation. Physiological tests, for example, testing urine and sputum, are applied to investigate the mental stress of subjects in some researches [17][18]. Evaluation by analyzing EEG signals has also been reported [19]. However, these are not necessarily thought to be optimal evaluation methods, because most therapy executors have no skill in physiological testing or using EEG. It is desired that the evaluation method be easy and acceptable to most therapy executors.

In this paper, we propose a new recreation program using robot therapy unified with the new evaluation method. The recreation program developed is games using a pet-type robot, and is designed to induce elderly people to perform specific actions. The effects of recreation are evaluated by measuring occurrence degrees of an elderly person's action. As the elderly person's actions can be expected, evaluators can judge occurrence degrees easily. Furthermore, the games are designed based on certain recreations performed in nursing homes that are useful for prevention of dementia progression. We describe the games designed and the evaluation method for game effects, and report the result of the preliminary experiment at a nursing home.

2. Design and Effect Evaluation of Games Using a Pet-type Robot

A. Actions that Occurred in Recreation and Action Factors

There are 2 types of treatment to improve or prevent dementia: treatment using drugs, and non-drug treatment [20]. As there are no full-time medical doctors at most nursing homes, various kinds of recreation program are executed there as non-drug treatment. However, the process of non-drug treatment is complicated compared with drug treatment, and it is difficult to define the effects of non-drug treatment. Even if there is improvement before and after 1 treatment, it is difficult to isolate the influence of other treatments and the subject's surroundings. Moreover, the therapist's skills are also more influential, and it makes effect evaluation difficult.

However, it is well known that recreation has the effect of improving or preventing dementia. Many attempts have been reported on recreation for elderly people with dementia [21] [22]. Examples of recreation are art therapy, music therapy, garden therapy, games, and so on. It has been reported that recreation is effective for improving elderly people's abilities weakened by dementia, but relationships between a patient's actions and improved abilities do not seem to be explained.

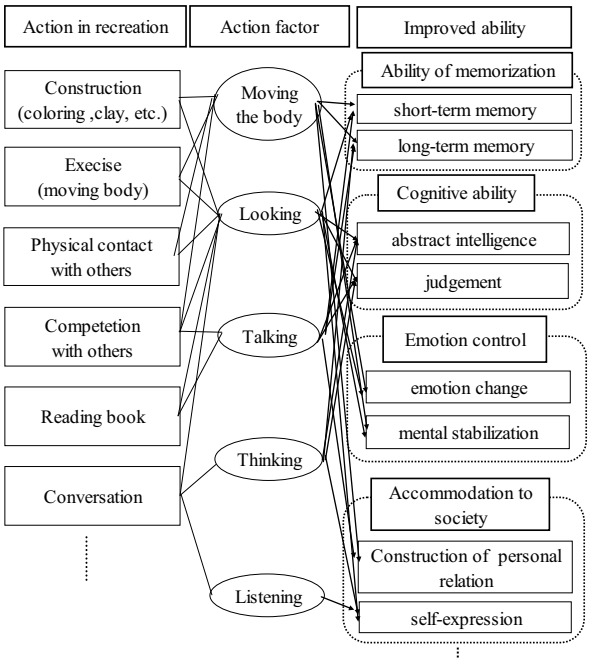


Fig. 1 Relationship between action factors and improved abilities in recreation

Table 1 Evaluation measurement of occurrence of action factors

Action factor	Measurement	How to measure		Intensity/ Frequency
		Point		
Moving the body	Degree of motion adequateness	3	move correctly and spontaneously	Intensity
		2	move correctly with staff's support	
		1	no move or move meaninglessly	
	Motion response	time to execution of purposeful action after instruction		Frequency
	Motion occurrence	(number of occurrences of purposeful action) / (total recreation time)		
Talking	Degree of rightness of talk	3	talk correctly and spontaneously	Intensity
		2	talk correctly with staff's support	
		1	no talk or talk meaninglessly	
	Talking response	time to execution of correct talk after instruction		Frequency
	Correct talking occurrence	(number of occurrences of correct talk) /(total number of occurreces of talk)		
	Talking occurrence	(number of occurrences of talk) /(total recreation time)		
Looking	Degree of rightness of eye line	3	gaze at object spontaneously	Intensity
		2	gaze at object with staff's support	
		1	no look or unstable eye line	
	Continuation of gazing	(duration time to gaze object) /(total recreation time)		Frequency

Then, we decompose actions into several action factors, and relate these factors to elderly people's abilities. And we set up the hypothesis that improvement of ability can be measured by the degree of occurrence of these factors. Five factors are derived through analysis of elderly people's actions that occurred in recreation: moving the body, looking, talking, listening, and thinking.

In elderly people, dementia causes decline of cerebral abilities: memorizing, guessing, noticing, talking, executing, cognition, and so on. Decline of cerebral abilities causes decline of mental abilities: emotion control, accommodation to society, and so on. As mentioned above, various kinds of recreation are executed at nursing homes. We investigated typical recreations, and analyzed actions occurring in them that are thought to be effective. Actions that occurred are decomposed into 5 action factors, and these factors are related to improvement of abilities. Figure 1 shows a part of the results of analysis. In this research, we evaluate the effect of recreation according to the degree of occurrence of these action factors. In the evaluation, the degree of occurrence is measured for intensity and frequency. Table 1 shows the criterion for measurement of each action factor. The factors of thinking and listening are removed from evaluation, because it is difficult to detect their occurrence by observation. In Table 1, a staff member refers to an intervener who coordinates the recreation.

B. Design Games Using a Pet-type Robot

Although there are many types of recreation executed in the nursing home, we chose games as recreation in robot therapy because of easiness of robot participation. The kind of recreation, i.e., the combination of action factors, defines what abilities are improved. We then tried to design 2 kinds of game that are thought to be effective for improving ability of memorization and ability of emotion control and accommodation to society. One is a card game, and the other is a ball game.

(1) Card game

The designed card game consists of the following 5 steps. The game is executed by 1 subject and 1 robot controlled remotely by wireless LAN. An intervener works as the game coordinator. The game involves actions which are thought to be effective for improving ability of memorization; for example selecting correct card, answering, and so on.

[Step 1] Fifty cards on which a Japanese hiragana character is written and 10 cards on which a numeral from 0 to 9 is written are placed randomly on a desk. Then, the coordinator instructs the subject to say the robot's name, present the time and room number, and indicate the robot cards on which the said character or number is written.

[Step 2] Nine cards on which a numeral from 1 to 9 is written are placed on the desk. The coordinator instructs the subject to select a favorite card and say the number. The subject pats the robot's head the number of times stated on the card, and robot takes the card on which the number is written.

[Step 3] Fifty cards on which a Japanese hiragana character is written are placed randomly on the desk. The coordinator indicates the subject fruit name that consists of 5 characters. Then, the subject indicates the robot cards on which they are written and robot takes these cards.

[Step 4] Four cards on which numerals are written are placed on the desk. The coordinator tells the subject to memorize the order of these cards. Then, cards are placed randomly, and the coordinator asks the subject to arrange the cards in the initial order. The subject indicates the cards to the robot in turn, and the robot takes the cards.

[Step 5] Fifty cards on which a Japanese hiragana character is written are placed randomly on the desk. The subject plays a word-chain game with the robot. The robot takes cards that mean a particular word, and the subject says the word following the word chain. The game is executed 3 times.

Table 2 shows actions and actions factors involved in this game. The detailed number of occurrences of action factors is omitted. The number of moving the body is 51, the number of talking is 64, and the number of looking is 45 in the design. The standard execution time of the game is 10 minutes.

Table 2 Actions and action factors in the card game

Step	Action	Action factor
1	answering the question	talking
	reading out the card	talking/looking
	selecting the card	moving the body/talking/looking
	following the object	looking
2	responding the number	talking
	reading out the card	talking/looking
	selecting the card	moving the body/talking/looking
	following the robot	looking
3	answering the question	talking
	reading out the card	talking/looking
	selecting the card	moving the body/talking/looking
	following the robot	looking
4	answering the number	talking
	reading out the number	talking/looking
	selecting the card	moving the body/talking/looking
	following the robot	looking
5	saying chained word	talking
	reading out the number	talking/looking
	selecting the card	moving the body/talking/looking
	following the robot	looking

(2) Ball game

The designed ball game consists of 4 steps. The game is executed by 6 subjects and 1 robot controlled remotely by wireless LAN. The other conditions are the same as for the card game. As the game is executed by plural subjects and involves cooperation and competition actions, it is thought to be effective for improving ability of emotion control and

accommodation to society.

[Step 1] The coordinator gives the subjects balls, and urges them to give the robot a ball. He tells them that the robot likes balls, and they recognize that the robot is pleased to take a ball.
[Step 2] The robot goes around the desk, and the subjects roll and give the ball to the robot.
[Step 3] The subjects pass the ball to one another so as not to have the ball taken by the robot.
[Step 4] The robot shouldering a basket goes around the desk. Every subject tries to shoot a ball into the basket, and competes with one another.

Table 3 shows actions and actions factors involved in this game. The detailed number of occurrences of action factors is omitted. The number of moving the body is 75, the number of talking is 45, and the number of looking is 40 in the design. The standard execution time of the game is 40 minutes.

Table 3 Actions and action factors in the ball game

Step	Action	Action factor
1	following the robot	looking
	giving the robot a ball and pleasing the robot	moving the body/talking/looking
	pating the robot	moving the body/looking
2	following the robot	looking
	rolling and giving a ball to the robot and pleasing the robot	moving thebody/talking/looking
	selecting the robot	looking
3	following the robot	looking
	passing the ball one another so as not to have the ball taken by	moving the body/talking/looking
	selecting the robot	moving the body/talking/looking
	competing with others	moving the body/talking/looking
4	following the robot	looking
	shooting a ball into the basket	moving the body/talking/looking
	competing with others	moving the body/talking/looking
	throwing the ball	moving the body

3. Experiments and Results

We applied the 2 above-mentioned games for elderly people with considerable dementia in a nursing home whose care levels in Japanese nursing care insurance system are 5. The experiment was executed continuously for 5 days. In order to investigate action factors shown in the game recreation, the activities of the elderly people were recorded by video camera. And care-givers of the nursing home evaluated abilities during and after recreation. This evaluation was dependent on the 5-point scale of several items based on the common dementia evaluation: short-term memory, episode memory, procedure memory, and meaning memory in ability of memorization; emotion change, negative emotion, and mental stability in ability of emotion control; and the will to construct personal relations and self-expression in ability of accommodation to society.

A. Card game

In the experiment, 5 elderly people participated in the game once daily. Each subject played the game as shown in Fig. 2. Figure 3 shows changes in ability of memorization over 5 recreation days. In this figure, the ability score is the average of the 5 subjects' ability points. Figure 4 shows changes in action factor occurrence over 5 days. In this figure, the degree of occurrence is the average of 5 subjects' degree changes in 3 action factors. The subjects' degree change is the average of changes in the measurement shown in Table 2, which are values relative to the first day measurement assigned 100 points. These results indicate that card game recreation is useful for improving ability of memorization of elderly people with considerable dementia. Not shown in detail is the correlation coefficient between ability change and action factor occurrence change of more than 0.8. In addition, occurrences of action factors at the first recreation were more than 80% of the designed occurrences, so the design of the game is thought to be reasonable.

Fig. 2 Card game recreation

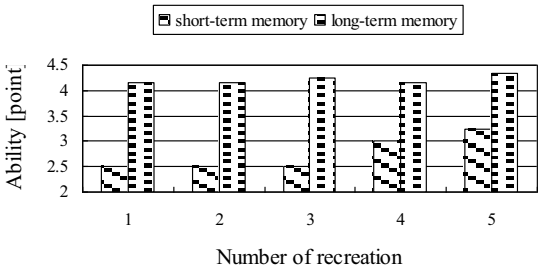
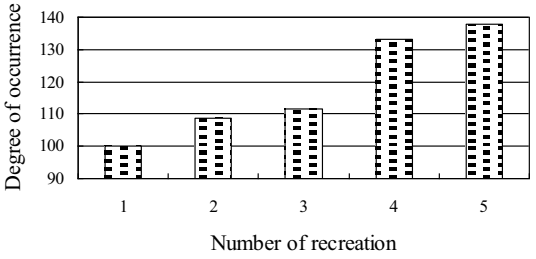
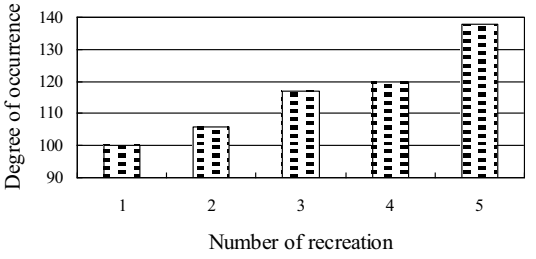


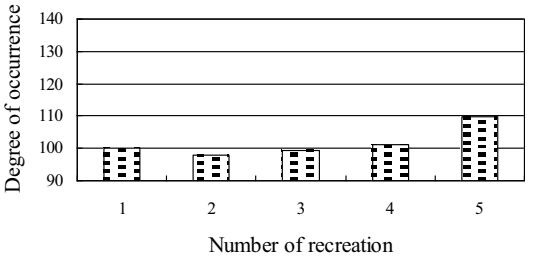
Fig. 3 Change of ability of memorization



(a) Moving the body



(b) Talking



(c) Looking

Fig. 4 Change of action factors

B. Ball games

In the experiment, 6 elderly people participated in the game once daily. The subjects played the game together as shown in Fig. 5. Figure 6 shows changes in ability of emotion control and accommodation to society over 5 recreation days. In this figure, the ability score is the average of the 6 subjects' ability points. Figure 7 shows changes in action factor occurrence over 5 days, the same as for the card game

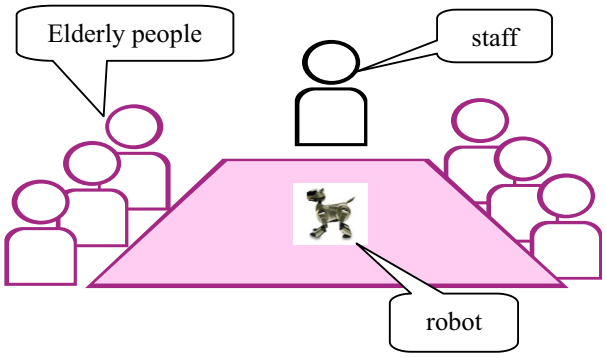


Fig. 5 Ball game recreation

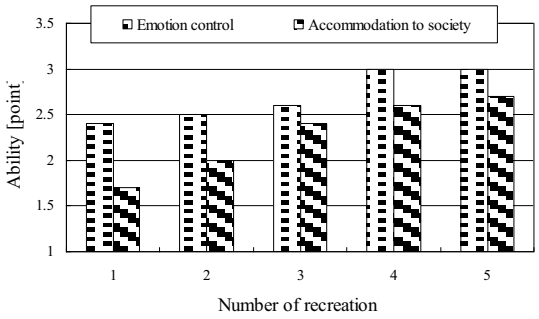
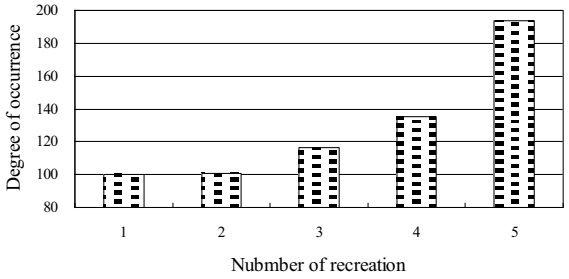


Fig. 6 Change in ability of emotion control and accommodation to society

experiment. These results indicate that ball game recreation is useful for improving ability of emotion control and accommodation to society of elderly people with considerable dementia. The correlation coefficient between ability change and action factor occurrence change is more than 0.7. In addition, occurrences of action factors at the first recreation were more than 80% of designed occurrences, the same as the card game, so the design of game is thought to be reasonable.

C. Discussion

In the experiment, the number of subjects and the frequency of recreation are small, but the result indicates that the concept of this research is promising. The coordinator of the game was not a professional care-giver but a student. This seems to mean that special skills are not necessary for recreation games using robot therapy. We consider that this viewpoint is important in an aging society in which the number of workers is declining. Anyway, in the future, we have to try more experiments to confirm these results.



(a) Moving the body

(b) Talking

(c) Looking

Fig. 7 Change of action factors

4. CONCLUSION

We developed recreation games using a pet-type robot in order to improve and prevent dementia of elderly people. There are 2 types of game. One is for improvement of ability of memorization, and the other is for improvement of ability of emotion control and accommodation to society. The results of the experiments at the nursing home that showed ability improvement of elderly people was not only proved by the evaluation of the care-giver at the home, but in the evaluation criteria of the game. Research is at the beginning stage, but a useful method of robot therapy application has been obtained.

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