Paper:

Examination of Practicability of Communication Robot-Assisted Activity Program for Elderly People

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[Received November 30, 2009; accepted March 24, 2010]

We have developed a Robot Assisted Activity (RAA) program for recreational use in health care facilities for elderly people. The RAA program has been evaluated in such a facility to assess its usefulness. The program applies a standard classroom model, starting with homeroom and including lessons in the Japanese language, music, gymnastics, arithmetic, and other subjects. At the end of the program, there is a graduation ceremony. We use a video camera to record each scene. Each behavior and utterance of the participants is then analyzed. In addition, immediately upon completion of the RAA program, specialists conduct a Focus Group Interview (FGI) in which they collect comments, opinions, and requests from the participants. Ten elderly people participate in the program, two men and eight women (81.0±3.7 years old). All are residents at a health care facility in Aichi Prefecture, Japan. The MMSE (Mini Mental State Examination) score indicating the level of dementia is 24.1±3.0 points. Two participants are judged to be in a moderate stage of cognitive decline (21 points or less), six are in a mild stage (22–26 points), and the remaining two are normal. On the Geriatric Depression Scale (GDS), in which a score of 13.3±4.2 points indicates a state of depression, seven participants are judged to be depressive (11 points or more). The results of our study show that all participants have a favorable impression of the robot and nearly all have a positive opinion of the RAA program. This suggests that the program can be used for emotional and recreational therapy at health care facilities for the elderly. However, in spite of the overall success of the RAA program, we seldom observe interaction between participants and the robot.

Keywords: robot assisted activity, dementia care, communication robot, Ifbot, qualitative evaluations

1. Introduction

A survey by the Ministry of Health, Labour and Welfare in 2007-2008 shows that 16.4% of 26,822,941 primary injured persons (65 years old or over) in the long-term care insurance system are certified to be in need of long-term care [1]. 58.8% (2,591,149 persons) of these elderly people are resident in or go to day service or health care facilities for the elderly who require long-term care and health and welfare facilities, such as nursing homes [2]. These facilities provide the elderly with nursing care to complement their lost functions and nursing-care prevention to suppress a decrease in their holding functions, which are called "activities." Specifically, they include recreational activities that require physical activity of an elderly person, such as doing gymnastics, taking walks, and playing games, as well as handicrafts, such as knitting and decorating. However, there are many times when residents in facilities for the elderly suffer from depression. This may be due to the stress of group living in the facility, a lack of communication between them, or various losses of abilities related to aging, as described above. The "avoidance of solitude" is needed to prevent or alleviate depression, but there are few activities for the prevention of solitude. In view of the above, it is important to consider activities for seniors at risk of depression and relieve their affliction or torment.

Animal Assisted Therapy (AAT) or Animal Assisted Activity (AAA) has been implemented with the intention of getting therapy or pleasure through contact with a pet as a countermeasure against the issue described above, with the effect of improving the social network or spiritual well-being of elderly persons [3, 4]. However, since there are many problems associated with pets for the elderly, Robot Assisted Activity (RAA) has recently been attempted using a pet robot [5–7], not an animal. A robot has much less possibility than an animal of hurting an el-

derly person requiring long-term care or causing infectious diseases, and it does not need to be taken care of, either. In addition, anyone can use the robot at any time in the same way without any need of breeding or training it. The studies on RAA have reported the following: (1) "physiological effects," such as stimulation or relaxation effects, (2) "psychological effects," such as joy or emotional expression, and (3) "social effects," such as language activation or group coherence [7].

In addition, it is possible to build relationships exceeding those with animals by not treating robots simply as pet substitutes, but by letting the robots play roles (intelligent activity support, such as a conversation partner or partner for playing cat's cradle) that can be played only by robots. This study uses a YORISOI Ifbot robot with the conversation communication function to attempt the development of an RAA program to be available as an activity in facilities for the elderly. Since this RAA program requires that an assistant be present, the costs of the robot at the facilities for the practical use of the program are higher in comparison with having a similar function performed only by the assistant. However, since the types of activity are limited at the facilities, they are often conventional, without originality or freshness. In other words, they become stereotyped. It may be possible to produce satisfactory physiological and psychological results by counting on effects of the RAA through AAA or pet robots and building relationships not obtained between persons, namely, relationships based on an elderly person's emotions of attachment or affection for a robot. In addition, a social effect can be obtained by using a highly social activity, conversation, to avoid the solitude of the elderly. From the above, the following can be expected from the implementation of this RAA: (1) improvements in the stereotyped nature of an activity, (2) improvements in the physiological and psychological aspects through attachment and affection, and (3) improvements in sociality through conversation.

Quantitative evaluation obtained by carrying out an intervention study is eventually required to verify these effects, but, prior to it, qualitative evaluation is indispensable for the robot and RAA program.[1] As the pre-stage of conducting quantitative evaluation, this study qualitatively evaluates the devised RAA program with behavior observation during the RAA and an interview after the RAA to clarify the problems inherent in the RAA program and consider what should be paid attention to in the quantitative evaluation.

2. YORISOI Ifbot

Figure 1 shows the appearance of the YORISOI (close together) Ifbot. It has a height of 44.5 cm, a weight of 8.1 kg, a depth of 35.8 cm, and a width of 43 cm. The YORISOI Ifbot is a partner robot for the elderly. It was developed for the purpose of relieving the solitary feelings or loneliness of the elderly through simple conversation [8–10]. In this study, we developed a new RAA program and installed it in the YORISOI Ifbot (Ifbot).

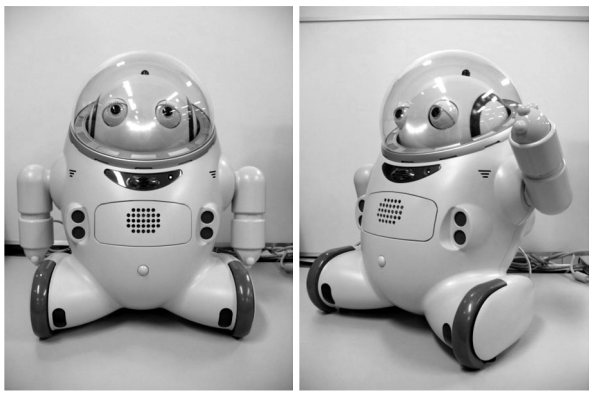

Fig. 1. Front and side views of YORISOI Ifbot.

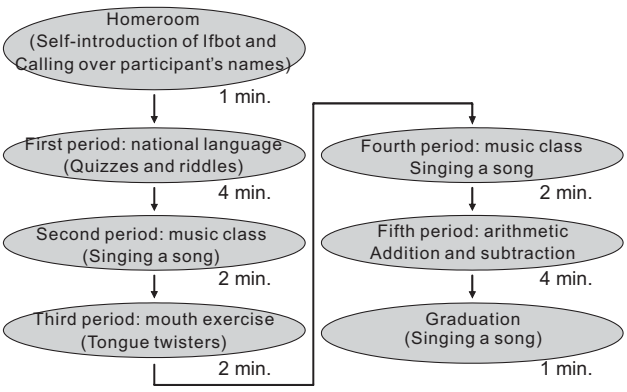

Fig. 2. RAA program.

3. RAA Program

It is necessary to have a place for the elderly to gather and share pleasure to relieve their loneliness. For this purpose, activities in health and welfare facilities are usually carried out for many residents by several staff members. Since communication robots such as the Ifbot have been developed for use in the one-to-one mode, the ability for these robots to have conversations with several persons has not been installed. This paper proposes an RAA program that allows two or more seniors to participate simultaneously.

Figure 2 shows an outline of the RAA program. This program models school lessons which enable a single teacher (staff member / robot) to engage many pupils (residents). A school is where people can re-experience their education without regard to age, which can remind them

1. In recent years, researchers have taken a growing interest in qualitative research. In particular, qualitative research has been attempted in a variety of areas as a substitute for the quantitative study method. This paper takes into account these discussions, but it does not observe strict adherence in terms of methodology. It also uses qualitative evaluation to get suggestions regarding quantitative evaluation from it.

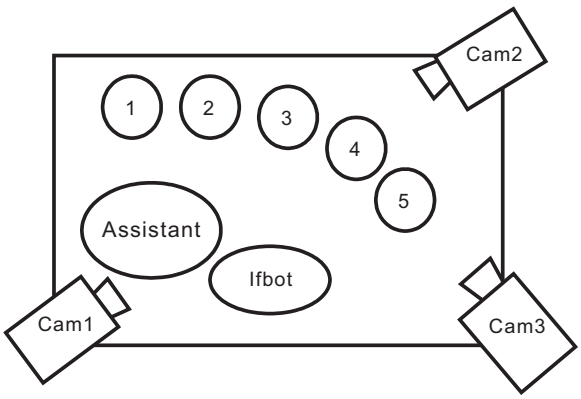

Fig. 3. Overview of RAA program.

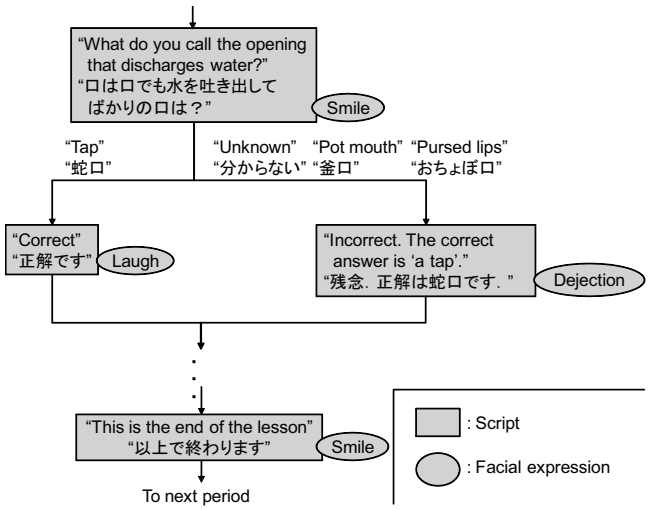

Fig. 4. An RAA program scenario. In this figure, the words in boxes are utterances by the robot and in ovals are facial expressions at the time the utterances were produced. The words alongside the arrows are words uttered by the robot while it was waiting.

of their past. This can lead to the expectation of the effect of reminiscence therapy. Learning therapy using reading aloud and arithmetic calculation has been reported to help reduce or prevent dementia [11]. This is also an advantage of the school lesson style.

The RAA program includes homeroom, Japanese language study (quizzes and riddles), music (singing songs), mouth exercise (tongue twisters), and arithmetic (calculation). Each of these is progresses in the order shown in **Fig. 2**. The RAA program allocates a lot of time to the music class because elderly people reacted positively, singing along with the robot in the preliminary stage of experiments. This has resulted in the assumption that music is suitable as an activity.

Figure 3 gives an overview of how to execute the RAA program. This program assumes one assistant, five to six participants, and one robot. One program (**Fig. 2**) was planned to last about 15 minutes after taking the following things into account: the participants should not be subjected to psychological stress caused by contact with an unfamiliar object (robot), and 15 minutes is enough time to be able to assess the RAA program. The proposed RAA program requires an assistant so that communication between the robot and two or more participants can progress smoothly. Participants require human interaction, not just communication with the robot, during robot therapy [6]. For this reason, it is desirable to allocate an assistant to this program.

The RAA program was developed on the basis of scenarios. One example of these scenarios is shown in **Fig. 4**. The scenario progresses as follows. First, the Ifbot directs an utterance (question) to the participants. While they consider their answers to the question, a turn is taken by the assistant. If the participants answer the question, the assistant tells the Ifbot the answers. The Ifbot proceeds with the scenario and asks the participants the next question.

As the scenario progresses, the Ifbot produces facial expressions appropriate to the content of the utterance. This reduces the fear or sense of incompatibility that the participants may feel toward the robot, so that they may communicate with it in a more familiar manner.

Table 1. List of participants.

No.	Sex	Age	MMSE score	GDS score
A1	Female	81	26	9
A2	Female	77	20	15
A3	Female	84	20	10
A4	Female	81	23	13
A5	Female	84	23	14
B1	Female	80	29	16
B2	Female	88	25	6
B3	Male	75	26	14
B4	Female	79	27	15
B5	Male	81	22	21
Av.		81	24.1	13.3
SD		3.7	3.0	4.2

4. Experimental Method

4.1. Participants

Table 1 lists the characteristics of the participants. They were ten elderly persons (two men and eight women with an average age of 81.0±3.7) requiring support, residents in health care facilities for seniors requiring long-term care in Aichi Prefecture. A psychological specialist used the Mini Mental State Examination (MMSE) to do a survey of the cognitive functions of these participants and the Generic Depression Scale (GDS) to do a survey of their emotional functions on an individual basis. From the MMSE score, two persons were judged to be in a moderate stage of cognitive decline and six persons were judged to be in a mild stage of cognitive decline. However, it was confirmed to be able to ensure the quality of the Focus

Group Interview (FGI) for the collection of opinions after experiments, because all of the participants could carry out a daily conversation and understand each other. The GDS score was 13.3±4.2 points, and seven persons were judged to be depressive (11 points or more).

4.2. Ethics

We informed the participants of the purpose and procedure of this study, the video and voice recording of the experimental scenes, the protection of individual information, and their refusal or withdrawal from participation. We obtained their written consent to participate in the study.

4.3. Survey and Measurement

All the conversations and behavior during the RAA program were videotaped, and the behavior of each of the participants was observed and analyzed. A timeline was created for behavior observation based on the video. It was used to mark off the behavior of a participant for each unit of time to grasp the progress of the RAA and the flow of the behavior of all participants. We used this to analyze the reactions (behaviors and utterances) of participants in the RAA, the interactions between the participants and the robot, and the interactions among participants. In this survey, we set one time unit as one minute. Soon after the end of the RAA program, a psychological specialist who can properly control the flow of discussions acted as a coordinator to implement the FGI for about 20 minutes and collected comments, opinions, and requests related to the RAA program. Note that the FGI is one of the qualitative research methodology, and a data collection method in which two or more participants are questioned about a specific theme at the same time [12, 13]. As two or more participants are questioned at the same time, they can be stimulated by group dynamics, mentioning ideas or events that were almost forgotten.

We used the following method to perform an analysis of the FGI [14]. First, we transcribed the recorded contents literally and coded (attached meaning to information) the points that might be related to the theme while confirming the intention and meaning of the speaker. Then, we classified each code according to the common or distinct points and extracted as subcategories ones that formed groups of two or more codes. In addition, we put subcategories together to extract categories. We gave each category a suitable name and created a structure model of all categories, taking into account the relationships and strengths among categories. The analytical and decision-making processes were confirmed and discussed by two or more joint researchers to secure their correctness.

We divided the ten participants into two groups at random (Group A: participants A1 to A5 and Group B: participants B1 to B5) to implement the survey and measurement discussed above, once for each group. The RAA program was executed not as a link to the activity normally carried out in the facilities, but as a substitute for another activity during the period of time specifically set up.

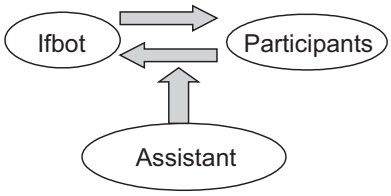

Fig. 5. Ideal interaction.

Fig. 6. RAA program with assistant (left) mediating conversation between five participants (right) and Ifbot (left).

We employed a robot (Ifbot) specialist as an assistant and instructed him to support the interaction between participants and the robot (**Fig. 5**). We conducted several pretests in advance so that no hindrances would occur.

Figure 6 shows how the experiments were carried out. The person at the left in the photo is the assistant, and the five people seated on the right are participants. This photo shows three Ifbots, but the Ifbot on the stand in front of the assistant was used for the RAA program. The Ifbot at the lowest position in the photo was located at the entrance of the meeting place to receive participants. The Ifbot positioned the background is a spare robot for experiments.

5. Results

5.1. Behavior Observation

As a result of analyzing the recorded video, the following participant behaviors were found to be characteristic[2]: (1) reaction to the robot at the time of entrance, (2) assistant mediation, (3) interaction between the robot and the participants and among participants, and (4) reaction to

2. This video analysis was primarily done by one researcher, and important scenes or those difficult to judge were analyzed in such a way that other researchers agreed with the primary researcher.

Table 2. Timeline: assistant acceptance situation (circled numbers indicate order of response).

Ifbot	Assistant	B1	B2	B3	B4	B5
"First question: What is 2 plus 5?"						
	"What is 2 plus 5?"					
			"Pardon?"			
	"2 plus 5 is?"					
		"7"③	"7"②	"7"①	"7"④	
	"7, OK?"					
		Nods yes				
	"Ifbot, 7"					
"Correct"						
"Second question, what is 3 plus 8?"						
	"3 plus 8 is?"					
		"11"②	Laughs	"11"①		

Table 3. Timeline: lesson (music class).

Ifbot	Assistant	B1	B2	B3	B4	B5
"The second lesson is music..."		Laughs				
Sings	Sings	Sings	Sings	Sings	Sings	Keeps rhythm
"This is the end of the second lesson."						
	"Let's move on to the third lesson."					

individual parts of the lessons. We paid attention to these behaviors for analysis.

1. Reaction to robot at time of entrance

   Four of ten participants noticed the existence of the robot as they entered the room where the RAA was carried out. For example, Participants A1 and A2 in Group A sat down at their specified positions without noticing the existence of the robot and then they paid attention to the Ifbot located in front of them. Three of four participants who noticed the robot had favorable reactions to the robot, saying "cute," or pointing to it.

2. Assistant mediation

   All participants accepted the existence of the assistant in a good way. They often listened not only to what the robot said during the RAA, but also to the repetitions or hints given by the assistant, and they reacted to the comments made by the assistant. **Table 2** lists an example of dialogues in Group B. Even if the Ifbot said, "First question: What is 2 plus 5?," the participants did not immediately answer, and the conversation proceeded with the assistant repeating the utterance. Apparently the participants often could not understand what the robot said and waited for the repetition by the assistant. Due to this fact, a more active relationship was observed between participants and the assistant than between participants and the robot.

3. Interaction between robot and participants and among participants

   There were few utterances from participants during the execution of the RAA. There was little talk directed to the robot, few direct answers to questions posed by the robot, and little interaction among participants. When the Ifbot malfunctioned, participants did not talk directly to it and often waited for questions from the assistant. However, there were some times when participants nodded or laughed at what the robot said.

4. Reaction to individual parts of lessons

   Participants reacted well to the songs in each lesson, and almost all of them sang along with the robot. **Table 3** shows the timeline of the musical content. Nine of ten participants actively joined in on the songs. The participant who could not join in on the songs was B5 in **Table 1**. In this table, it can be seen that the cognitive functioning of participant B5 was normal, but he had a mild speech disorder (that did not hinder understanding). B5 participated in the songs rhythmically (**Table 3**). The reaction to riddles and arithmetic calculations was good, and all participants except B5 participated actively. In these activities,

when one participant spoke, other participants also spoke in turn. This fact can be observed in **Table 2**. On the other hand, the reaction to the tongue twisters was not good. Three of ten participants spoke or moved their lips along with the robot as it spoke, but many of them did not know the words or could not follow the speed of the robot, resulting in an overall poor reaction to the activity.

5.2. FGI

As a result of structuring what was said during the course of the FGI, 17 subcategories and 4 categories were extracted. These four categories were (1) assessment of the RAA program, (2) feelings toward the robot, (3) interaction and (4) communication problems. The following are examples for explanation.

1. Assessment of RAA program

   There were many good impressions of the entire program and many opinions, such as "pleasant" and "educational." In addition to their opinions of songs, such as "pleasant" and "nostalgic," there were requests for the following: "Please let us know the title of the song before we sing it" and "Difficult to understand when to start singing." One participant offered the opinion that it was difficult to hear what was being said about arithmetic and riddles, but there were also positive reactions, such as "If I got the answer right, I was happy" or "It was educational." Regarding the tongue twisters, some participants said, "I could not follow them" or "I could not hear them."

2. Feelings toward robot

   The participants had the following opinions of the robot: "It is cute," "Pleasant if it were in my house," and "It was therapeutic and calmed me down." There were requests for additional lessons, such as lessons in foreign language and dialects as well as comic stories. In addition, there was a functional request for the movement of the robot. Participants considered the robot as a toy, saying things such as "Good as a playfellow," but they felt unsatisfied with the robot as a medical device, saying it was "Far away from medical technology" and "Difficult to ask to do something."

3. Interaction

   There were many comments on the relationship between participants and the assistant in riddles and arithmetic that suggest that participants required the mediation of the assistant. There were comments such as "I can answer a question after it is explained in a different way by the assistant" and "It is easy to use the robot because the assistant is there." On the other hand, participants offered comments such as "I answered a question while consulting other participants regarding the points that were difficult to understand" and "I answered the questions after consulting all participants." This approach was not found in behavior observation, but it was found that interaction among participants was remembered.

4. Communication problems

   There were times when participants could not hear what the robot said and the robot did not correctly hear what the participants said (recognition errors). There was a complaint of "late reaction" because the robot froze or otherwise malfunctioned, and this confused the participants. Almost all participants may have been dissatisfied with the robot's speaking and voice recognition functions.

Figure 7 shows the result (structure diagram) of structuring the relationship between categories from the results of behavior observation and the FGI based on the Glaser's coding families of theoretical codes [15].

The solid lines in **Fig. 7** qualify the relationships formed as the RAA progressed; their thicknesses indicate the strength of the relationships. For example, when the participants are doing riddles and arithmetic, the relationship can be illustrated as follows: first, a question is conveyed from the Ifbot to the assistant and then to participants (arrows A and B in **Fig. 7**); second, the participants consult each other about the answer (C); then, the answer is given to the assistant (D); finally he conveys the answer to the Ifbot (E). The broken lines show the psychological relationship not related directly to the progress of the RAA. For example, the relationship of communication problems that is formed due to the low level of Ifbot voice recognition and hearing loss on the part of the participants is illustrated.

6. Discussion

To observe the participants' frank reactions to the robot, we paid attention to their reactions to the robot as they entered. Almost all participants were accompanied by care providers or entered the meeting place in wheelchairs. They concentrated on their destination and did not look around them. This seemed to be the reason why few participants noticed the robot upon entering. Since the robot was located below the eye level of the participants, they did not notice it. When this observation was made, it seemed necessary to relocate the robot to a position where the participants could easily notice it upon entering or to prepare a way for them to see the robot prior to entering.

The reaction to each lesson was generally good. All participants except B5 (9 of 10) positively participated in riddles, did arithmetic, and sang songs. It seemed difficult for B5 to participate in the activities because of his mild speech disorder. Participants reacted poorly to tongue twisters because they were uttered too fast to hear, and most of the participants did not know these particular

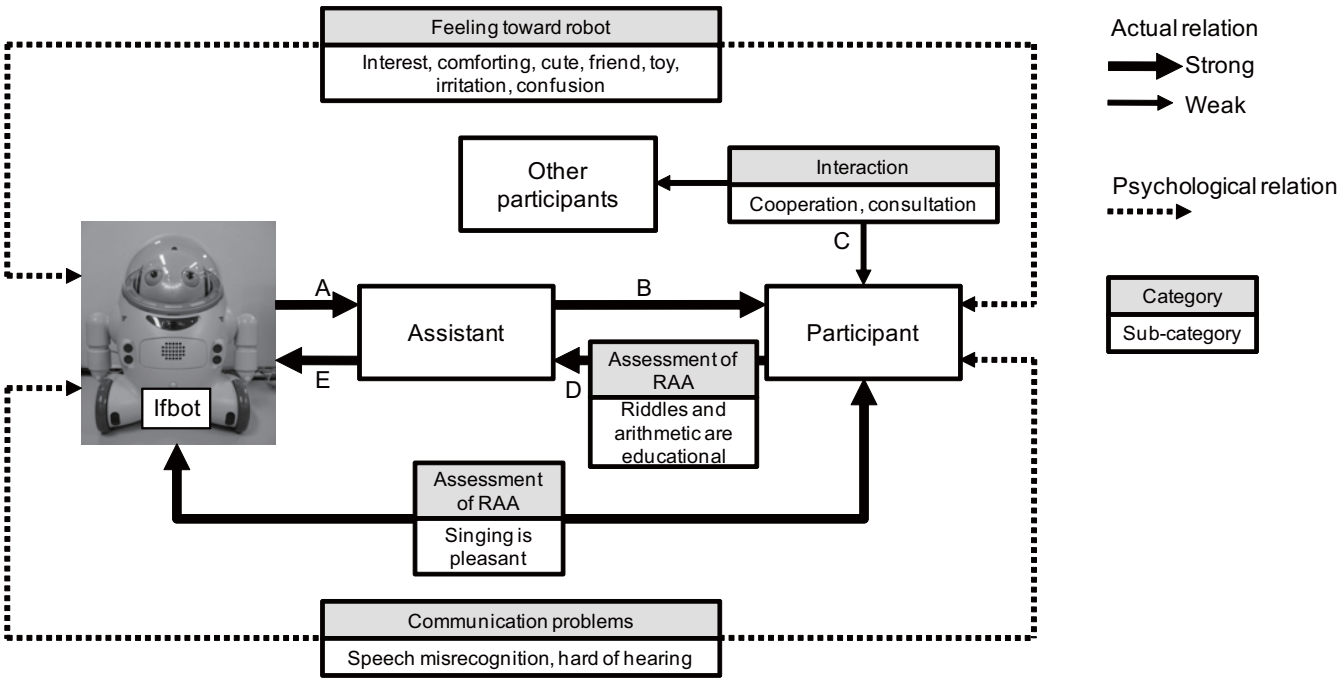

Fig. 7. Results of FGI analysis.

tongue twisters. Many elderly people suffer from hearing disorders such as hearing loss, and this often significantly hinders their ability to communicate. The hearing loss experienced by seniors is of a progressive sensorineural type. It begins with the high frequency band and gradually spreads to the middle and low frequency bands [16]. As the voice of the Ifbot is relatively high and has an unnatural, electronic quality, it seemed that there were times when it was difficult for the elderly participants to hear. Countermeasures against this include modulations in frequency, adjustments in speed, and increases in the amount of information given at one time through the lengthening of the utterances of the robot.

Regarding the relationship among the robot, participants, and the assistant, it would be ideal for the assistant to lie in the direct line of interaction between the participants and the robot, as seen in **Fig. 5**. This relationship was established in the musical contents. On the other hand, in the riddles or arithmetic lessons, there was a possibility of silence or a break in conversation because the participants could not hear what the robot was saying and they could not give answers for the questions. There were therefore many times when the assistant repeated what the robot had said to enable the participants to respond to the robot. As a result, a relation of interaction (arrows A to E in **Fig. 7**) was built up in which participants waited for the assistant's repetition, and the participants seldom spoke directly to the robot.

Behavior or cognitive therapy is now being employed as a nondrug therapy for cognition. The devised RAA program in this study is similar in part to the reminiscence therapy of the cognitive therapy. In addition, there is a report [11] that suggests that the stimulation therapy of "reading aloud" and "simple calculation" improves the cognitive functions of the elderly, and, if this program is continuously executed, it is expected to contribute to the improvement of cognitive functioning. The singing of songs, which can be considered as one type of active music therapy [17, 18], can improve functioning and help patients recover from mental and physical disorders. It is difficult to quantitatively evaluate the effects of this therapy implemented as a one-to-one interactive activity based on the existing program of the Ifbot [19], but it can be done by using the RAA program, a structured group therapy. Additionally, participants were not often observed talking with each other during the progress of the RAA, but the results of the FGI have shown links (memories of their "participation and cooperation") between participants. This RAA program will serve to provide topics for conversations between participants outside the activity, thus increasing their socialization.

The positive participation of participants in the RAA and their comments afterward that it was "pleasant" implies that it is possible to employ a robot as a new activity in welfare facilities. There were also many positive evaluations of the robot, including that it was "cute" and "therapeutic," which means that the elderly may able to feel affection toward it, as they would toward a pet. However, these evaluations remain short-term ones, and "weariness" must be evaluated when the RAA program is used for a middle to long period of time during its quantitative evaluation. In addition, since interaction was observed between participants, the RAA program can be considered to contribute to the buildup of their social networks. On the other hand, there were negative opinions of functional aspects that should be improved. The proposed

RAA program requires improvements in (1) the assistant intervention method and (2) the speaking and voice recognition functions of the robot. From the above, it is important in the quantitative evaluation to assess these improvements, weariness, and effects on MMSE and GDI scores.

When people have feelings of familiarity, they decrease their physical and mental distance. It has been confirmed that when a robot talks to a person and asks for a hug or other physical contact, it increases familiarity, and the average distance between the robot and the person gradually decreases [20]. To deepen the communication with the robot, it was presumed that familiarization with the robot used was required as well as a certain lapse of time. It has been reported that it is important that the speech function of a communication robot be at a high level, but minor recognition errors do not prevent participants from keeping up conversations based on proper mutual interpretation, and, if both of them talk smoothly, they can converse for a considerably long period of time [20]. In the future, it will also be important to develop an RAA program that can be used continuously by individuals.

7. Conclusion

In this paper, we used a robot equipped with the conversational communication function to develop a Robot Assisted Activity (RAA) program available for recreational use in health care facilities for the elderly, and we qualitatively evaluated the devised RAA program as the prestage to a quantitative evaluation. Because the participants showed good reactions to the songs, quizzes, and riddles, it was tentatively found that it might be used to contribute to the diversion and relaxation of the participants through songs and to maintain and improve their cognitive and emotional functions. The reactions of the elderly to this RAA program were mostly positive, and its practicality was judged to be verifiable by quantitatively evaluating (1) improving the speaking and voice recognition functions of the robot and the intervention method of the assistant as well as (2) the weariness and (3) the cognition and emotional functions of the participants. This paper discussed the connection between participants, but it did not survey the relationship between care provider and participant. This matter must be investigated when quantitative experiments are carried out.

Acknowledgements

This work was supported by the "2006 Linkage Model Project for Cultivation of the Health and Longevity Industry of Aichi Prefecture" and "Grant-in-Aid for Young Scientists (B) #17700160 of the Ministry of Education, Culture, Sports, Science and Technology," Japan.

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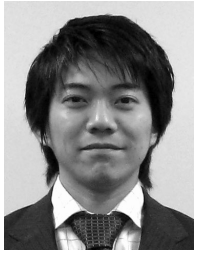

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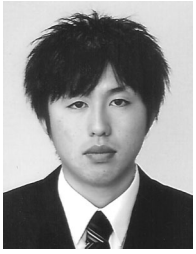

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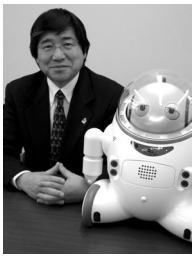

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