

Conversational System Encouraging Communication of the Aged by Method of Reminiscence and Quantification of Active Participation^{*,**}

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Abstract. We developed a conversational system encouraging aged persons to have conversations. This system quantifies the degree of active participation (DAP) by analyzing attitudes of the users, and selects topic based on it. The DAP was revealed to be quantified with vertical movement of face per question for each topic. As a result of experiments, the system succeeded in keeping or raising the DAP in 75% (9 out of 12) of topic selection cases. In addition, the method of reminiscence was proposed and applied to the system. The method proved to be effective in encouraging conversations of the aged persons.

Keywords: Speech and natural language interfaces, New technology and its usefulness.

1 Introduction

In recent years many countries have been facing rapid progress in population aging. Especially in Japan, the rate of aging is 23.3% in 2011. As one result of aging, the number of aged single persons is increasing [1]. Furthermore, in Japan, 35% of aged single persons have a day with no conversation at all [2]. This shows that the shortage of conversation is serious issue in increasing aged single persons because it leads the aged persons to lose their energies to live [3]. Though supports by human are provided for solutions against this issue, these supports have temporal and geographical constraints. On the other hand, conversational robot at aged single person's home is able to support whenever she/he needs help, and geographical constraint never be involved.

In utilizing conversational systems, selection of topic is important. In this paper, we therefore developed a conversational system that quantifies the DAP of aged persons and selects topic based on the quantification. In addition, a method of

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reminiscence to encourage conversation of aged persons was proposed and applied to the system.

A definition of the DAP is “a status that one participates in a conversation by her/his own will”, and “extra information is contained in one’s answer to question of others, and she/he shows the attitude to convey the information to questioner”.

2 Proposition of Conversational System

2.1 Concept of Conversational System

Platform. PaPeRo (Fig. 1) is adopted for the interface of the system. To use conversational system in aged person’s house, interface robots require adequate function, appropriate size and friendly appearance. The PaPeRo meets these requirements.



Fig. 1. PaPeRo developed by NEC

Novelty. There are a number of advanced researches proposing techniques for conversational systems [4-6]. In addition, because of the increasing number of aged single persons, a large number of researches about conversational systems targeting aged single persons are conducted [7-11]. However, there is no technique based on real elderly caring. Accordingly, in this research, a new conversational method of reminiscence was proposed. This method is devised from reminiscence therapy conducted in practice at the field of elderly care. Recently, sentence generation techniques using contents from news or blogs on the internet are developed [12]. To utilize such techniques, selection of topic is important since vast amount of information is on the internet. However, existing systems have no proper means to select topic. Degree of interest is often used by systems as an object to quantify status of human. However in this research, the DAP is taken for an object to be quantified. To quantify these parameters, acquirement of reference value from evaluation by human is necessary. When the degree of interest is quantified, results of evaluation by human contain high dispersion [13]. This is because the degree of interest is a psychological parameter. In contrast, results of evaluation by human contain less dispersion when the DAP is quantified because the DAP is a parameter that quantify visible attitude. By taking the DAP for object, more credible reference values are expected to be acquired. Therefore we develop the system which quantifies the DAP of participant.

2.2 Methodology to Encourage Conversation

Method of Reminiscence. This method is composed of two elements. The first is “reminiscence and expression by aged person”. This is accomplished by “topic recalling autobiographical memory” and “asking question positively”. The second is

“empathic and receptive attitude of listener”. This is accomplished by “reaction based on participant’s answer” and “nodding”.

Afforded Topics and Questions. Based on the method of reminiscence, topics “Your school days” and “Plays in childhood” are prepared. These topics are able to recall autobiographical memories. Topics “Daily life” and “Your hobby” are prepared for comparison. The system provides topics in order of Table 1. Each topic includes 117 questions. An example of questions regarding “Plays in childhood” is shown in Table 2.

Table 1. Order of topics

No.	1	2	3	4
Topic	Daily life	Your school days	Your hobby	Plays in childhood

Table 2. Example of questions about topic “Plays in childhood”

No.	Question
Q. 1	Did you play a lot in your childhood?
Q. 2	What did you play the most often?
Q. 3	Do you remember playing with your friends?

2.3 Prior Examination about the DAP

Candidate for DAP Quantification. In a prior research conducted by Kobayashi in 2010, feature quantities such as time until participant started to talk, their speaking rate and inclination of their eyes were used for quantification of the degree of interest. The DAP was supposed to be quantified by larger features than what used in quantification of the degree of interest. From this viewpoint, 7 candidates (amount of utterances, frequency of chiming in, volume of voice, range of intonation, direction of face, amount of nod, posture changing) were listed for feature quantities.

Methodology of Prior Examination. The prior examination was carried out by participant observation to group reminiscence therapy at a home for aged and by analysis of experiment video recorded in prior conversation experiment with robot and aged person. A group of healthy aged persons (7 females, 2 males) had reminiscence therapy. The group activity was held once a week for about an hour, six times altogether.

Result. An amount of utterance, a change of posture and the number of nod were concluded to be suitable for quantification of the DAP qualitatively by observing the participants as well as analyzing the video. Regarding the change of posture and the number of nod were difficult to quantify because of individual difference, a movement of face was decided to be quantified instead of both.

3 Development of the Conversational System

3.1 Experimental Design

Basically, a conversational system requires accurate voice recognizing and natural language processing as shown in left side of Fig. 2. However, these technologies are still at an early stage of development and not yet being met with requirement of our system. Despite of such situation, the Wizard of Oz technique enables to simulate the future complete system behavior by replacing these undeveloped technologies with human judgment [14]. The experimental design based on the Wizard of Oz technique is shown in right side of Fig. 2. In this paper, the processes of “Voice Recognition” and “Natural Language Processing” were performed by manipulation of experimenter.

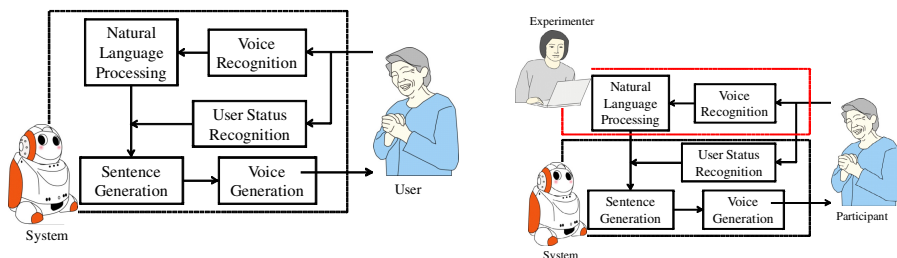


Fig. 2. Functions required in conversational systems and experimental design in this paper

3.2 Conversational System

Conversational Process. This system has two modes. At first, system gets into topic proposing mode. In this mode, system selects topic out of yet unused topics, and ask a question about the topic two times. If a keyword which is natively registered with the system is included in a participant’s answer for the question, the system chimes in with the keyword in it. By this, the system shows her/him that it recognizes the answer from person. If there is no keyword in the answer, the system chimes in with a generic phrase. After asking questions two times, the system asks for permission to continue the topic. If the system gets positive reply from the participant, the system gets into topic continuing mode. In this mode, the system continues to ask questions about the topic until there is no unused question in the system. If the system gets negative reply in permission asking, the system returns to the beginning of the topic proposing mode and changes topic.

Detection System. The conversational system detects face position and amount of utterance of participants. To detect face position, a camera is attached to the PaPeRo as shown in left side of Fig. 3. To detect faces out of images from the camera, we process face detection using OpenCV in 3 frames per second. In this research, we define an amount of utterance as the number of letters obtained by writing utterances out. Voice of participants is obtained through a super directive desktop microphone and is converted to text by Microsoft Japanese Recognizer v5.1.

3.3 Experiments to Establish Quantification Method of DAP

Experimental Object. The object of these experiments was to establish a method of quantifying the DAP from the status of a participant. To achieve this object, conversation experiments in which aged persons talked with the system and evaluation experiments in which evaluators observed the conversations and evaluated the DAP of aged persons were conducted.

Methodology of Experiment. An experimental room was arranged as shown in right side of Fig. 3. The PaPeRo with camera was put on the table, and a participant had a seat in front of it. An experimenter sat at a distance from them. A video camera was placed behind the PaPeRo. A video recorded with this video camera was used in evaluation experiment. Participants for the conversation experiment were 6 aged persons (labeled A-F, 3 females and 3 males, 67-79 years old). Explanations we made to participants are shown below.

- Answer to questions from the robot and follow a flow of a conversation.
- Robot will react to your answer, and you can ask the same question robot asks you.

After the conversation with the robot, participants filled out a questionnaire about the conversation. The questionnaire items are shown in Table 3. Multiple answers were allowed from the topics in Table 1.

In evaluation experiments, evaluators watched the videos recorded in the conversation experiments, and evaluated the participants by the DAP for each topic according to a six grade system. Median of the results was taken for the reference value of the DAP. Evaluators were 10 young persons (3 females and 7 males, 18-22 years old).

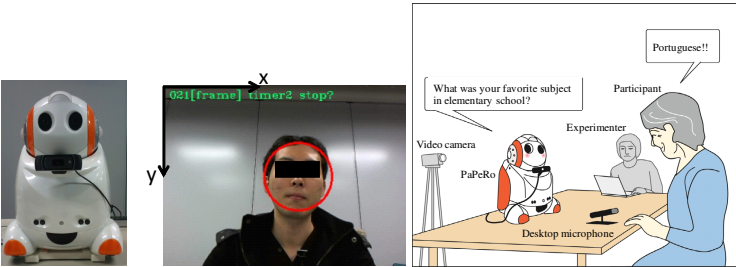


Fig. 3. PaPeRo with the camera, face detection and Arrangement of experimental room

Table 3. Questionnaire about the conversation

No.	Questionnaire
Q. 1 (2)	Were there any topics you felt were easy (hard) to talk about in the conversation?
Q. 3 (4)	Were there any topics you felt you (didn't) talked a lot about in the conversation?
Q. 5 (6)	Were there any topics you felt you (didn't) wanted to talk more about in the conversation?

Result of Experiment. Correlation coefficients between the results of conversation experiments and the reference value of the DAP acquired from evaluation experiments were calculated for each participant. In results of calculations, the correlation

coefficients between the y-direction movement of face per question and the reference value of the DAP were over 0.7 in 67% (4 out of 6) of the participants as shown in Table 4. According to this result, it was concluded that the vertical movement of face per question quantifies the DAP of aged persons. An equation to quantify the DAP was defined in (1). Delta y is calculated for each frame from the result of face detection. By summing up absolute values of it for each topic, movement of face is calculated. Dividing the total by N (the number of questions) gives the DAP of a topic.

Table 4. Correlation coefficients between the reference value and the vertical face movement

Participant	A	B	C	D	E	F
Correlation coefficient	-0.003	0.678	0.946	0.728	0.770	0.861

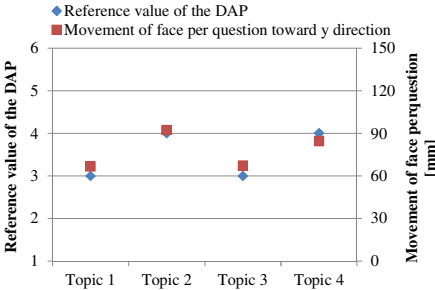


Fig. 4. Movement of face toward y direction and reference value of the DAP (participant C)

$$DAP = \frac{\sum_{Topic} |\Delta y_i|}{N} \tag{1}$$

4 Evaluation of Effectiveness

4.1 Experiments to Evaluate Effectiveness

Experimental Object. The object of these experiments was to evaluate the effectiveness of the conversational system. To achieve this object, conversation experiments and evaluation experiments were conducted.

Methodology of Experiment. A function of selecting topic based on quantification of the DAP was added to the conversational system. The system provided 4 topics in the same way as previous conversation experiments. After providing 4 topics, the system chose the 2nd highest of 4 topics in the DAP for 5th topic. For 6th topic, the system chose the highest of 4 topics in the DAP. Both experiments were the same as previous ones mentioned in 3.3 in a respect of experimental method. Participants and evaluators differed from those. Participants of conversation experiments were 6 aged persons (labeled G-L, 3 females and 3 males, 68-79 years old). Evaluators were 8 young persons (6 females and 2 males, 18-22 years old).

4.2 Result

Effectiveness of Topic Selection Based on the DAP. Reference values of the DAP are shown in Fig. 5. There were 12 cases (2 topics for each participant) of topic selection made by the system. The reference values kept relatively high in 75% (9 out of 12) of these cases. Seeing the results individually, the reference values stayed high or increased by selecting high DAP topics in participant G, I and K. On the other hand, one reference value decreased in participant H and J. Both decreased in participant L, but this was believed to be not an effect of topic selections because the reference values continued decreasing through the whole experiment. In all participants, the reference values of 6th topic were lower than the 5th topic although the highest DAP topic was selected in 6th topic. This was because the numbers of questions for 5th and 6th topics were half of topics 1-4, and participants were not able to adapt to the frequent changes of topics.

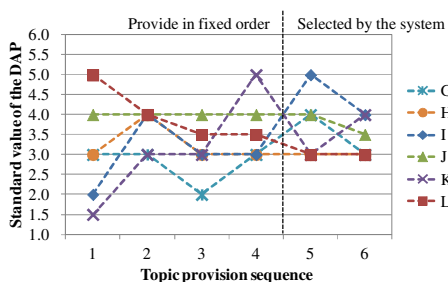


Fig. 5. Reference values of the DAP for each participant

Effectiveness of the Method of Reminiscence. Reactions of participants against nodding performed by the system while the participants were speaking were summarized in Table 5. Numbers within brackets indicate the number of cases in which participants returned nodding to the nodding made by the system. In this table, 27% (14 out of 51) of nodding induced the nodding of participants. The nodding performed by the system didn't disturb the participants speaking. In addition, the nodding performed while participants were silent induced smiling faces of them. This revealed that the nodding performed by the system made the participants feel at ease. According to these results, nodding strengthened an affinity of the system.

Reactions of participants against chiming in by the system with a keyword in it were summarized in Table 6. 57% (33 out of 58) of chiming in performed just after the utterance of participants induced only reactions such as "Yes.". On the other hand, in 28% (16 out of 58) of the cases, participants resumed speaking after chiming in made by the system. 8 cases out of these 16 were observed in the conversation experiment with participant K. According to the results, chiming in by the system encouraged a conversation of some aged persons.

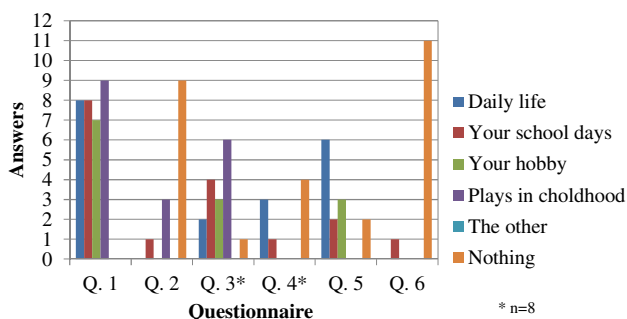
Table 5. Timing and result of nodding

N=51	In speaking	In interjection	Just after speaking	In silence
Continue speaking	23 (6)	3 (0)	8 (1)	-
Pause	4 (2)	1 (1)	-	-
Discontinue speaking	0 (0)	0 (0)	-	-
Finish speaking	-	-	8 (2)	3 (1)
Reply short term	0 (0)	0 (0)	0 (0)	1 (1)

Table 6. Timing and result of chiming in

N=63	In speaking	In interjection	Just after speaking	In silence
Continue speaking	2	0	16	-
Pause	0	0	-	-
Discontinue speaking	2	0	-	-
Finish speaking	-	-	9	0
Reply short term	0	0	33	1

The results of questionnaire are shown in Fig. 6. There were more answers of topics recalling autobiographical memory to Q. 2 than the other topics. The reason for this result was that the autobiographical memories, that are almost equal to long term memories for aged persons and recalling these memories were difficult for them. The difference arising from the difference of recalling their memories were believed to activate their brains and this was one of the effectiveness of the method of reminiscence.

**Fig. 6.** Result of questionnaire (n=12)

Topics recalling autobiographical memory also acquired more answers than the others in Q. 3, although the numbers of questions were the same between topics. This result showed the effectiveness of the method of the reminiscence. Topics provided earlier got more answers in Q. 4. Familiarity with the system was supposed to have had effect on this result. Topics provided earlier also got more answers in Q. 5. A reason for this was related to the answers to Q. 4, because one tends to desire to talk more about a topic that she/he couldn't talk about a lot.

From the above, conversation of aged persons was encouraged by the topics based on the method of reminiscence, and their brains were believed to be activated by difficulty of recalling their memories.

5 Conclusion

We developed the conversational system that quantified the DAP of aged persons in order to select and provide proper topics to the aged single persons. Additionally, we applied the method of reminiscence to the system. According to the results of experiments to establish a method to quantify the DAP, vertical movement of face per question was revealed to quantify the DAP.

The results of experiments to evaluate the effectiveness of the system with DAP quantification showed the DAP stayed high or increased in 75% (9 out of 12) cases in which the system selected and provided the high DAP topics. Owing to this result, the topic selection based on the DAP was concluded to be effective. By summarizing the results of the questionnaire, the effectiveness of the method of reminiscence was demonstrated. Nodding gave participants the feeling of affinity, and chiming in encouraged conversations of some aged persons. The topic recalling the biographical memories also encouraged conversations of them and was believed to activate their brains at the same time.

In the future, more work is necessary in determination of the quantification method of the DAP. Although vertical movement of face per question was adopted for quantification method at our research, there is still a possibility that the DAP is quantified better with other feature values or with a combination of feature values.

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** This paper is available only in Japanese. In this paper, authors tried to quantify “degree of interest”. In the conclusion, they mentioned that evaluations of the degree of interest by human, which are necessary to obtain true value, contained wide dispersion.