Effects on the Self-disclosure of Elderly People by Using a Robot Which Intermediates Remote Communication

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***Abstract*— The social isolation of elderly people is becoming a big problem. To solve this problem, social robots have been regarded as suitable interfaces to support these elderly people to communicate with others (e.g. family members). In such robot-mediated communication, it can be expected to elicit self-disclosure from elderly people. In this study, we explored the requirements for intermediately robots to encourage elderly people's self-disclosure. The results suggested that an intermediately robot with human-like behavior can encourage elderly people's self-disclosure about experiences of loss (e.g. health and financial issues). Additionally, we found that warmth and competence judgments to the robot are correlated to elderly people's self-disclosure. From these results, it was suggested that the influence on the self-disclosure of the intermediately robot are strengthened by being regarded as a social other.**

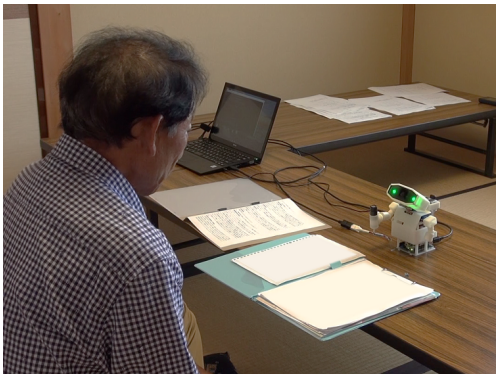

Fig. 1. A robot mediates self-disclosure of elderly people

I. INTRODUCTION

Social isolation of elderly people is a major problem. As conversation with family can improve well-being, the number of elderly people who can use e-mail and video conferencing functions is increasing. Recently, social robots have been fascinated as a remote communication interface that enhances convenience for elderly people (Fig. 1). In such remote communication systems, it is said to be enable to provide not only an asynchronous messaging function that can cope with differences in lifestyle among generations but also ease of message input by natural language dialog function [1]. It can be also expected that elderly people will be able to easily self-disclose by intermediately robot [2].

On the other hand, in social psychology, self-disclosure of elderly people is regarded as important functions to draw out social support from remote family members. Therefore, to find out the relationship between the specification of intermediary robots and elderly people's self-disclosure is very significant to design the robots which can suppress elderly people's social isolation.

The goal of our study is to explore requirements for intermediary robots to encourage self-disclosure of elderly people. To this end, we examined the following three points. First, using a self-disclosure scale, the topics that were encouraged to disclose from elderly speakers by an intermediary robot. Secondly, the difference between social attributes (robot-specific traits and characteristics) of two kinds of robotic behaviors. Last, the relationship between the robot's social attributes and self-disclosure from these two independent data.

II. RELATED WORKS

A. Self-disclosure in Old Age

In developmental psychology, developmental stages are defined as a conflict between positive emotions and negative emotions that appear most prominently for each generation [3]. The developmental stage which faced by people who aged over 65 is defined as integrity vs. despair. Integrity is a feeling when they look back on their lives and think about what they have or have not accomplished. If the people could not develop a feeling of integrity, they fall into despair.

In such a situation, self-disclosure is regarded as having extremely important functions to elicit social supports from the other person who has been received the disclosure. Social support consists of three aspects: emotional support to show understanding of the problem of the partner, substantial support such as cooperation as labor force and delivery of goods, and information support to clarify and give advice to solve the problems of the partner [4]. It is reported that looking back on their own life and sharing their own memories and values among people within same generation and inheriting to younger generation will enhance their adaptation to the situation which they are facing currently [5].

However, about the experience of loss [1], it is known to be difficult for elderly people to disclose even for close people (e.g. friends, family members) [6]. In other words, although information about the current problem based on experience of loss has high possibility to draw out social

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[1]It is known that the elderly experience four types of losses - "losing physical and mental health", "losing economic foundation", "losing connection with society", "losing purpose of living"

support from disclosure recipients, such information is hard to be shared. On the other hand, the self-disclosure can be encouraged depending on communication media. Even if he / she is hesitant to self-disclose in face to face, it is considered possible to bring a motive for self-disclosure by providing an appropriate communication method.

B. Influence of Social Robots on Human Self-disclosure

ELIZA is known to be a classical dialogue agent which elicited self-disclosure from human by asking questions interestingly [7]. ELIZA is like a chat bot and does not have a body, but there are studies that investigated the influence of physical body of robots on self-disclosure. Powers et al. compared a robot and the screen agent, and reported a robot in the real world did not affect human self-disclosure [8]. On the other hand, Martelaro et al. suggested that a robot with a high expressive behavior would draw out the user's self-disclosure [9]. It is difficult to conclude that the physical body of robots derives self-disclosure from human, but social behavior using language and body expression may influence the motive of user's self-disclosure.

In addition, it is thought that users' self-disclosure is drawn out according to the relationships with human and robot. It is reported that self-disclosure of elderly people was increased by building relationship with Paro [10]. Our pilot study also suggested when elderly people talked about experience of loss, an intermediately robot is required to be trustworthy and companionable. These two items were collected from a questionnaire investigating human-robot relationship. However, the robot was not sensing the relationship with the user. It is unlikely that the robots actively draw out self-disclosure from the user based on the relationship between human and the robot. Therefore, investigating the relationships between subjective evaluation of robotic social attributes and human self-disclosure is seen to be a more natural way.

III. HYPOTHESES

A. Topics on which Intermediary Robots Encourage Elderly People's Self-disclosure

Since self-disclosure is encouraged in computer-mediated communication (CMC) compared with face-to-face situations [11], self-disclosure of elderly people may also increase when a robot interface is used. It is also suggested that the expressive behavior of the robot encourages user's self-disclosure [9] and robots that performs social behavior are easy to accept for elderly people [12]. Therefore, human-like behavior of robots such like a socially expressive behavior is considered to increase self-disclosure. On the other hand, it is said that daily experiences and their histories are easy to talk regardless of communication media. From these points of view, the intermediary robots may have a particular impact when the users self-disclose sensitive topics such like experience of loss. Then, we made the following hypothesis.

H1: Intermediary robots with human-like behavior encourage elderly people to self-disclose their experiences of loss.

B. Perception of Social Attributes for Intermediary Robot

In social psychology, two universal dimensions of person perception has been established – warmth and competence [13]. Carpinella et.al. developed a robotic social attribute scale (RoSAS) which can measure warmth, competence and discomfort on robots [14]. With this RoSAS, it is reported that warmth and competence are perceived more on a robot with human-like face rather than a robot with mechanical face and human-machine blended face. It can be understood that warmth and competence judgements are the items which have highly relationships with anthropomorphisms. It is also said that anthropomorphization to a robot is caused not only by appearance but also by verbal and non-verbal behavior of a robot. So, we made the following hypothesis.

H2: Intermediary robots with human-like behavior are judged (a) warm (b) competent.

C. Relationship between Perception of Social Attributes and Self-disclosure

Intermediately robots with human-like behavior may encourage elderly people's self-disclosure (H1), and also the users perceived warmth and competence (H2). From these hypotheses, it is conceivable that there is a relationship between them (e.g. linear correlations). Then, we made the following hypothesis.

H3: There are correlations between user's (a) warmth (b) competence perception and user's self-disclosure.

IV. EXPERIMENT

A. Participants

In this experiment, it was very difficult to collect really isolated elderly people and their families as participants. So we assume a communication scenario between an elderly "parent" and a younger "daughter". And 21 people who aged 63 to 80 played a role of "parent" ($M = 72.04$, $SD = 5.12$, twelve females). As a "daughter", one female college student was participated (22 years old). This is because females tend to contact their parents more often than men. With this in mind, we only collected senior participants who had any adult daughters. The average of the age of participants' own daughters was 42.62 ($SD = 6.92$).

B. Communication Scenarios

The scenario for the elderly "parent" was to talk about his/her own specific episode about three contents – "pleasure recently", "an unforgettable experience", "worry about health problem". These three topics were selected from the elements of the self-disclosure scale which was used in the evaluation phase. The "daughter" was given a scene setting that a parent would contact her. Although it was a little changed according to the context, her response was controlled under all conditions of all participants. The "daughter" basically spoke according to a script except when she cannot hear what the "parent" are talking, or when parents required reply strongly.

C. Conditions

Three conditions were set in the experiment. A condition that did not use any intermediary robots was named ”telephone condition”. Telephone is the most common communication medium and usable by anyone. On ”human-like robot condition”, we used an intermediately robot with human-like behavior. On the other hand, an intermediately robot which did not have human-like behavior may occurs less anthropomorphization, so the condition used this robot was named ”machine-like robot condition”. The behaviors of the robots were implemented as below.

1) Basic Specification of the Robot: For the experiment, the robot shown in Fig. 1 was used. This robot was 145 mm in height, 130 mm in width and 105 mm in depth. This robot had two degrees of freedom on the neck two degrees of freedom on shoulder. The eyes of the robot were represented by two RGB LEDs. Speech recognition functions and speech synthesis function were implemented by several APIs (Google Speech Recognition API, NTT Docomo Text to Speech API). A microphone was mounted on the right-arm, and used it for recording user's voice. To make sounds, a small size speaker was connected to the robot. This robot was connected to the smartphone via a web server, and the interlocutor could post and get text messages on the application of the smartphone.

2) Implementation of Human-like Robot Behavior: Under this condition, natural language dialog and physical expression were implemented. This robot responded to two types of voice commands “send a message” and “check a message”. When a voice command “send message” had been input, the robot nodded with saying “What should I tell him/her?” to the user. Then it started recording with the microphone toward the user. After recording for 20 seconds, the robot got down the microphone and repeated the contents of sending message. After creating the message, robot said “I will tell him/her.” When the voice command “check a message” was input, the robot nodded, saying “I will check a message, please wait a moment.” If a new message had been received, the robot read out the message. For example, if a message “Where are you going today?” arrived, the robot said “He/she said that where are you going today?”. If none of messages had been received, the robot replied ”I do not have any new messages.”

3) Implementation of Machine-like Robot Behavior: The behavior of machine-like robot was represented by beeps and LED color. These are nonverbal information which human beings do not have. These are thought to strengthen the mechanical impression of robot. In this condition, robot responded to two types of voice commands – “send a message” and “check a message”. In response to the voice command ”send message”, the robot played a 587 Hz beep and recorded the user's voice for 20 seconds. And also the LED of the eyes changed from blue to green during recording. To notify the time of recording was finished, a 494 Hz beep was played. After recording, the voice message was converted into text and transmitted to the interlocutor's smartphone by playing a specific sound effect. When the voice command ”check a message” was input, robot read out the message if the robot had acquired the new arrival message from the server. If not, it made 493 Hz beeps twice.

D. Evaluation

1) A Self-disclosure Scale: As a self-disclosure scale, we used the same questionnaire which was used in our pilot study [2](original scale was written in Japanese [6]). This scale consisted of 16 items, and it is known that when the disclosure recipient is an intimate person such as a close friend or a family member, it has three structural factors of ”daily experience”, ”integrated life experience” and ”experience of loss”. Participants as “parent” evaluated easiness of self-disclosure to the “daughter” on a 6-points scale.

2) A Robotic Social Attribute Scale: RoSAS [14] was used for evaluation of social attributes of robots in machine-like robot condition and human-like robot condition. This scale provides psychometrically valid, standardized measure of the social attributes that people ascribe to machines. Participants were asked that ”Please evaluate the impression of the robot based on the following scale” and answered on a 6-points scale. This questionnaire was used only under conditions that are using robots, and it was not used under the telephone condition.

3) Impressions of the “daughter”: To the “parent”, we conducted two types of questionnaires on the impression of the “daughter” on 5-points scale. One was to evaluate the ease of talking of the “daughter”. The other was to evaluate how similar the “daughter” was, comparing with their own daughter. These two questionnaires were asked at the end of the experiment.

E. Procedure

The environment in which the experiment was conducted is shown in Fig. 2. The “daughter” talked with the “parent” with a smartphone from another room. Before starting the experiment, an experimenter gave an explanation about the experimental outline and made a short time meeting between “parent” and “daughter”. After that, the experimenter handed over the scenario to the “parent” and gave fifteen minutes to remember their episodes about three topics and make notes. After the “parent” finished to make notes about what to talk, three experimental conditions were carried out in random order for each participant (within-participants experiment design).

Under the telephone condition, the experimenter handed over a telephone to the “parent” and instructed them to start calling as soon as they get ready. The call was made with the flow that the “daughter” took a phone call and made greeting each other and then the “parent” started to talk about three topics. At this time, when the “daughter” confirmed that the “parent” finished talking episodes, the daughter made unified responses for each episode. Also, while the “parent's” disclosure, the reaction of the “daughter” was limited. This was because we didn't want to strengthen the impression that the telephone was easy to talk tool so much due to

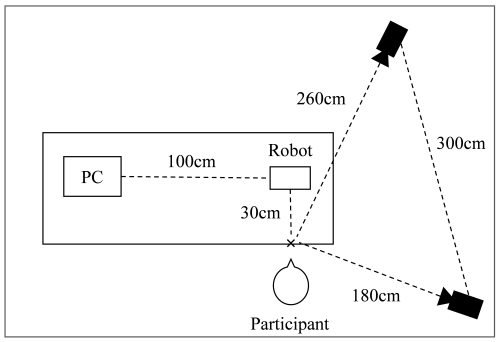

Fig. 2. Room configuration for experiments

the "daughter's" attitudes and skills. Under this condition, the experimenter went out after confirming that the "parent" started to call, and waited at outside until the call has been finished.

In the machine-like robot condition and the human-like robot condition, we explained message exchanging functions of robots based on the instruction manual to the "parent". Also, we conducted a phase for senior participants to train usage of robot. In this explanation and training phase, it was also explained that messages were sent as text message. Upon completion of this phase, the "parents" shifted to the task of self-disclosing about three topics to the "daughter". However, there was a possibility that some of the participants would be unable to understand the experimental procedure and the way of using the robot even they experienced explanation and training phase. So it was necessary to instruct the timings of sending and checking messages by the experimenter during the experiment. The experimenter instructed only the timings and waited at outside while the "parent" was sending messages. After completion of each condition, the experimenter asked the "parent" to answer some questionnaires.

V. Results

A. Self-disclosure Judgements

The average obtained from the self-disclosure scale is shown in Table I. In daily experiences and integrated life experiences, the average was more than 3.5 on average in all conditions, whereas in experience of loss, the average was less than 3.5 in all conditions, so that this topic was tended to be difficult to disclose. Also, there was no significant difference between males and females, and we decided not to consider gender difference [2].

According to results of repeated measure two-way ANOVA, there is a significant difference / a marginally significant in the disclosure contents and experimental conditions, and the interaction effect was not confirmed (disclosure contents: $F(2,40) = 28.05$, $p < .001$, $\eta_p^2 = .58$, $F(2,40) = 2.75$, $p = .076$, $\eta_p^2 = .12$, interaction: $F(4,80) = 1.70$, $p = .16$, $\eta_p^2 = .078$). Subsequently, we got a marginally significant between experimental conditions, we conducted a non-repeated measure two-way ANOVA under each disclosure contents. As a result, there was a significant difference / marginally significant between experimental conditions in daily experience, integrated life experience, and there was no significant difference in loss experience (daily experience: $F(2,40) = 2.52$, $p = .094$, $\eta_p^2 = .112$, integrated life experience: $F(2,40) = 3.49$, $p = .040$, $\eta_p^2 = .15$, loss experience: $F(2,40) = 2.00$, $p = .15$, $\eta_p^2 = .091$). As a result of the Tukey HSD method conducted in the daily experience, integrated life experience, there were marginally significances between machine-like robot condition and human-like robot condition (daily experience: $p = .077$, Integrated life experience: $p = .056$), in the integrated life experience there was a marginally significant between telephone conditions and mechanical robot conditions ($p = .087$).

[2]No significant difference was confirmed as a result of t-test ($t = 1.05$, $df = 187$, $p = .30$)

TABLE I
Self-disclosure Judgements in Each Conditions

Topics	Phone	Machine-like Robot	Human-like Robot
Daily experience	$M = 4.19$ ($SD = .77$)	$M = 3.88$ $^{+}$ ($SD = .81$)	$M = 4.44$ $^{+}$ ($SD = .84$)
Integrated life experience	$M = 4.21^{+a}$ ($SD = .78$)	$M = 3.86$ $^{+ab}$ ($SD = .86$)	$M = 4.25$ $^{+b}$ ($SD = .81$)
Experience of loss	$M = 3.12$ ($SD = .78$)	$M = 3.09$ ($SD = .87$)	$M = 3.46$ ($SD = .92$)

There were marginally significances about the self-disclosure between the machine-like robot condition and the human-like robot condition in two topics. There also be a marginally significant between the phone condition and machine-like robot condition in one topic (+: $p < .10$). However, there were no significant differences in experience of loss within experimental conditions. Therefore, the hypothesis H1 was not supported from these results.

B. Robotic Social Attributes Judgements

The average of the robotic social attributes is shown in Table II. In both the machine-like robot condition and human-like robot condition, the average of warmth and competence judgement were over 3.5, discomfort judgement was about 2.0. According to results of repeated measure two-way ANOVA, there were significant differences between social attributes and experimental conditions, and interaction effect was confirmed (social attributes: $F(1.16, 23.1) = 41.7$, $p < .001$, $\eta_p^2 = .68$, experimental conditions: $F(1,20) = 11.0$, $p = .003$, $\eta_p^2 = .36$, interaction: $F(1.51, 30.2) = 4.73$, $p = .024$, $\eta_p^2 = .19$). We conducted t-tests under each social attributes. As a result, there were significant differences between machine-like robot condition and human-like robot condition in warmth and competence, and no significant difference in discomfort (warmth: $t = 3.02$, $p = .007$, $r = .56$, competence: $t = 3.05$, $p = .006$, $r = .56$, discomfort: $t = .12$, $p = .91$, $r = .027$, $df = 20$).

TABLE II

SOCIAL ATTRIBUTES JUDGEMENTS OF EACH CONDITIONS

Social Attributes	Machine-like Robot	Human-like Robot
Warmth	$M = 3.67$ ** ($SD = 1.06$)	$M = 4.32$ ** ($SD = .90$)
Competence	$M = 3.76$ ** ($SD = 1.00$)	$M = 4.44$ ** ($SD = 1.04$)
Discomfort	$M = 2.04$ ($SD = .92$)	$M = 2.06$ ($SD = 1.03$)

There were significant differences between two types of robots. In warmth and competence judgement, participants perceived warmth / competence from a robot which has social behavior than an another type of robot (**$p < .01$). Therefore, hypothesis H2 was supported.

TABLE III

CORRELATIONS BETWEEN THE SELF-DISCLOSURE JUDGEMENTS AND THE SOCIAL ATTRIBUTES JUDGEMENTS

Topics	Warmth	Competence	Discomfort
Daily experience	$r = .54$ ***	$r = .46$ **	$r = -.19$
Integrated life experience	$r = .63$ ***	$r = .61$ ***	$r = -.18$
Experience of loss	$r = .46$ **	$r = .45$ **	$r = .20$

There were significant correlations between social attributes judgments and the self-disclosure judgements (**$p < .01$, ***$p < .001$). It was revealed that when the user perceives more warmth / competence from the intermediately robot it becomes easier to self-disclose via that robot. These results support hypothesis H3.

C. Correlations between Self-disclosure Judgements and Robotic Social Attributes Judgements

In this analysis, since we are focusing on how the social attribute judgements influence the elderly participants' self-disclosure, we did not divide the robots by conditions. There were some significant positive correlations between warmth / competence judgements and self-disclosure (Table 3). On the other hand, there were no significant correlations in discomfort judgements.

D. Impressions of the "Daughter"

The average ease of talking with "daughter" was 4.00 (SD = 0.82) out of the 5-points scale. This score indicates the "daughter" was regarded as a person who was easy to talk with. On the other hand, the average of the similarity judgment was 3.19 (SD = 1.22), and it was a result that it could not be judged whether the "daughter" and real daughter are similar or not. Moreover, these two judgements of the "daughter" had no correlations with self-disclosure judgements ($r < .04$ in all conditions).

VI. DISCUSSION

A. Considering the Order Effects Bias

Section 6.1, although there were marginally significants between the experimental conditions in self-disclose about some topics, there were no significant difference in the topic about experience of loss. To consider this reason, the transition of the standard deviation of each participant is very crucial. Table IV shows that the values of standard deviation on self-disclosure judgements are increasing as the participants experienced the experimental conditions repeatedly. For example, in the topic about experience of loss, there was a great difference of standard deviation between the groups who experienced a condition as a second order and who experienced the condition as a third order. Therefore, it is concluded that the standard deviation of self-disclosure was increased as participants experienced the conditions repeatedly and the statistical power was not enough to show significant difference using such data.

In this study, it is considered that the experimental conditions which was experienced by participants for the first time could be reflected self-disclosure judgement of each participant the most. So that, although the number of samples have to be decreased, we also analyzed self-disclosure judgement using such data (as a between participants experiment design). Of course, this is a reference result as it was calculated with fewer samples and the data was collected in another experimental design.

Table V shows the averages of self-disclosure judgements of a group which started from telephone conditions ($N = 7$, $M = 72.4$, $SD = 4.17$, 4 females) / a group started from machine-like robot conditions ($N = 7$, $M = 73.42$, $SD = 4.59$, 4 females) / a group started from the human-like robot condition ($N = 7$, $M = 71.57$, $SD = 5.12$, 4 women). As a result of repeated measure two-way ANOVA, there were significant differences between disclosure contents and experimental conditions, and no interaction was confirmed (topics: $F(2,36) = 31.1$, $p < .001$, $\eta_p^2 = .63$, experimental conditions: $F(2,18) = 9.51$, $p = .002$, $\eta_p^2 = .51$, interaction: $F(4,36) = 1.54$, $p = .21$, $\eta_p^2 = .15$). As a result of Tukey HSD on each topic, there were significant differ-

TABLE IV

TRANSITION OF STANDARD DEVIATIONS AS THE EXPERIMENTAL CONDITIONS ARE REPEATED

Topics	1st Order	2nd Order	3rd Order
Daily experience	$SD_M = .67$	$SD_M = .69$	$SD_M = .88$
Integrated life experience	$SD_M = .57$	$SD_M = .76$	$SD_M = .84$
Experience of loss	$SD_M = .61$	$SD_M = .65$	$SD_M = .93$

For each order in which each experimental condition was experienced, the average of standard deviations was calculated by (1). For example, the average of standard deviation in 1st order was calculated from SD of three conditions in which were experienced as a first condition for each participant. In other words, the participants started experiment from the phone / machine-like robot / human-like robot conditions. It was revealed that the SD_M was increased as the participants experienced the experimental conditions repeatedly.

$$SD_M = \sqrt{\frac{1}{3}({SD_{phone}}^2 + {SD_{Mrobot}}^2 + {SD_{Hrobot}}^2)} \quad (1)$$

TABLE V

SELF-DISCLOSURE JUDGEMENT OF EACH CONDITIONS BEFORE THE EXPERIMENTAL CONDITIONS ARE REPAETED

Topics	Phone	Machine-like Robot	Human-like Robot
Daily experience	$M = 4.29$ ($SD = .64$)	$M = 3.82$ * ($SD = .66$)	$M = 5.11$ * ($SD = .86$)
Integrated life experience	$M = 4.33$ ($SD = .65$)	$M = 4.00$ * ($SD = .66$)	$M = 4.86$ * ($SD = .55$)
Experience of loss	$M = 2.94$ ^{**a} ($SD = .78$)	$M = 2.86$ ^{**b} ($SD = .54$)	$M = 4.31^{**ab}$ ($SD = .62$)

There were significant differences between the machine-like robot condition and the human-like robot condition in all topics. There also be a significant difference between the phone condition and human-like robot condition in the topic of experience of loss. These results supported the hypothesis H1.

ences between the machine-like robot condition and the human-like robot condition in all the disclosure topics (daily experience: $p = .01$, integrated life experience: $p = .047$, Loss experience: $p = .002$). Also, in experience of loss, a significant difference was confirmed between the telephone condition and human-like robot condition ($p = .003$). This result supports the hypothesis H1.

In Section 6.2, there were significant differences in warmth and competence judgement between two types of robots. Elderly people perceived more warmth and competence from the robot with social behavior rather than mechanical one. This result fully supports hypothesis H2. Regarding the evaluation of robotic social attributes, it is considered that it was easy to offset the order effects by arranging the conditions at random. The number of iterations was small because this questionnaire was used only with two conditions using robots. In section 6.3, there were significant correlations between the self-disclosure and warmth/competence judgement. As mentioned above, values of the standard deviation on self-disclosure judgements were increased due to repeated experimental conditions, but social attributes are likely to be able to offset the order effects. Therefore, the relationship between these independent data is highly reliable, and hypothesis H3 is considered to be supported.

B. Requirements for the Intermediately Robots

The participants' perception of emotional aspects (warmth) and functional aspects (competence) from the robots were correlated to self-disclosure judgement. From this, it is considered that the robot was regarded as a source of social support other than a family member (human) who received the disclosure. Intermediately robots have two aspects of social support. One is emotional support aspect to convey high intimacy topics instead. The second is a substantial support aspect that helps information transmission by using its functions, such as voice input. Both of the machine-like / human-like robots which were used in the experiment had these two social support aspects, but there were significant differences in self-disclosure judgements. It was suggested that when an intermediary robot was regarded as a social other, the robot can be a source of social support. It is important for intermediary robots to be designed so that robots are recognized as a social other.

VII. CONCLUSION

We showed that an intermediately robot with human-like behavior could encourage elderly people's self-disclosure about experiences of loss (e.g. health and financial issues), as the robot was regarded as a social other. These results contribute to develop the intermediately robots that are able to suppress the social isolation of the elderly people. But there are so many limitations. For example, we just conducted a conversation task by using a role playing scenario, and we have to apply the robot into more real situation.

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