Relationships between Robots' Self-Disclosures and Humans' Anxiety toward Robots

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***Abstract*— The research aimed at investigating how self-disclosure of robots affects humans' anxiety and behaviors toward the robots. A psychological experiment (*N* = 39), comparing between the conditions of no-self-disclosure, positive self-disclosure, and negative self-disclosure from a small-sized humanoid robot, found that the subjects' anxiety toward communication capacity of robots was stable before/after positive self-disclosure from the robot although this anxiety increased under the other conditions. On the other hand, self-disclosure from the subjects was independent to the conditions of the robot's self-disclosure, and the subjects originally having hither anxiety toward discourse with robots before the interaction performed negative self-disclosure toward the robot.**

Keywords-component; Human-robot interaction; Anxiety toward robots; Self-disclosure

I. INTRODUCTION

There is a possibility that humans feel anxiety toward robots, which prevents them from interaction with robots, as well as social anxiety prevents humans from communication with others. Nomura et al., [1] found that anxiety toward robots increased in part after interaction with a human-sized humanoid robot, and this anxiety affected humans' communication avoidance behaviors toward the robot. When robotics applications become ambient in daily life such as pedagogical and domestic uses, it is need to explore what factors in robots decrease humans' anxiety toward robots.

As one of these factors, the research focuses on self-disclosure. Social psychology has revealed that self-disclosure is an important factor which influences intimate relationships between humans, and it has been applied into virtual agents interacting with humans to construct intimate relationships between the agents and humans [2][3]. Moreover, self-disclosure has recently been applied in human-robot interaction such as a guide robot [4].

In addition to existence of self-disclosure, important is what type of self-disclosure from robots influences humans. In human-human interaction, it is estimate that effects of negative self-disclosure differ from those of positive disclosure. Thus, it is needed to investigate effects of this difference on humans' anxiety toward robots.

For the above aims, the research conducted a psychological experiment comparing three conditions of self-disclosure from a small-sized humanoid robot: non-self-disclosure, positive self-disclosure, and negative self-disclosure. Then, it was investigated which condition influences humans' anxiety toward robots.

II. METHOD

A. Date and Subjects

The experiment was conducted from November to December, 2010. A total of thirty nine persons participated to the experiment (male: 17, female: 22, natural science and technology: 13, social science: 26). They were university students in the western area of Japan, and recruited with one thousand yen.

B. The Robot Used in the Experiment

The small-sized humanoid robot used in the experiment was "Robovie-X" shown in Figure 1, which has been developed by Vstone Corporation. This robot stands 34.3 cm tall and weighs about 1.3 kg. The robot has a total of 17 Degrees of Freedom (DOFs) at its feet, arms, and head. Moreover, this robot has a function of utterance based on audio data recorded in advance such as Windows WAV files, which is limited to 300 KB.

In the experiment, the utterances from the robot were synthesized from the Japanese text data by using "Easy Speech," "Text-to-Speech Engine Japanese version," "Sound Engine Free" (free software), Microsoft SPAI 4.0, and L & H TTS 3000. The quality of the voice was artificial and neutral independent on gender.

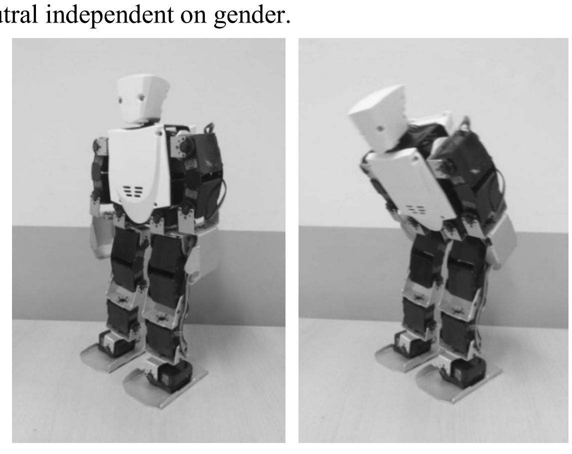


Figure 1. "Robovie-X" Used in the Experiment

C. *Self-Disclosure from the Robot*

In the condition of no-self-disclosure, the robot only uttered the greetings and a question to ask subjects to answer their recent situations. In the condition of negative self-disclosure, the robot uttered its recent negative situation (“My motors are not well, but have still not been restored.”) between the greetings and the question. In the condition of positive self-disclosure, the robot uttered its recent positive situation (“I am very fine due to the maintenance conducted a few days ago.”) between the greetings and the question.

In all the conditions, the robot performed the behavior of bowing by inclining its upper body forward at the utterance of the greetings, as shown in Figure 1. After this behavior, the robot kept standing without any motion during utterance.

D. *Procedure*

Each session was conducted based on the following procedures:

- Each subject was briefly explained about the experiment and signed the consent form about dealing with data including video-recording. In this stage, the experimenters only indicated that the task in the experiment was interaction with a robot and they planned to video-record the scene in the experiment. Moreover, the subject responded a questionnaire measuring his/her robot anxiety before facing the robot.
- The subject was led to an experiment room in which the robot was put on a desk, shown in Figure 2. The experimenters instructed him/her to sit on the chair in front of the desk, and left the room.
- Just after the subject was left alone in the room, the robot started the motion and utterances via remote control.
- When 20 seconds passed just after the robot finished the utterances, the experimenters entered the room again, and indicated that the session finished. Then, the subject responded another questionnaire measuring his/her robot anxiety after facing the robot.
- Finally, the experimenters conducted debriefing about the actual aim of the experiment and the fact that the session was video-recorded by a camera concealed from the subject.

E. *Measures*

The scenes of the experiment were recorded with a digital video camera and IC recorder to extract the subjects’ behaviors toward the robots, in particular, their utterances toward the robot. Moreover, before/after facing the robot, robot anxiety of the subjects were measured by using the Robot Anxiety Scale (RAS [1]). This scale originally consists of 11 Japanese questionnaire items classified into three subscales: “Anxiety toward communication capacity of robots”, “Anxiety toward behavioral characteristics of robots”, and “Anxiety toward discourse with robots”. The experiment adopted the first and third subscales since the second subscale was not the focus. Table 1 shows the questionnaire items of the RAS used in the experiment. The score of each subscale was calculated as a sum of the corresponding item scores.

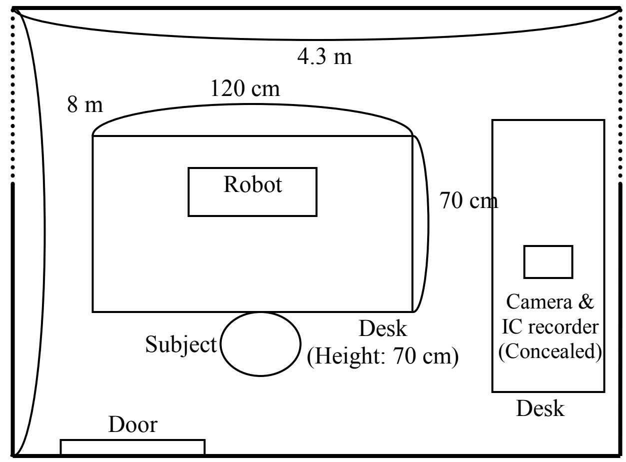


Figure 2. Overview of the room where the experiment was executed (a view from above)

III. RESULTS

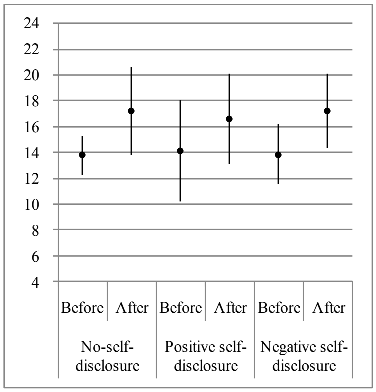
A. *Change of Robot Anxiety*

Table 2 shows the assignment of the subjects into the conditions in the experiment. Chronbach’s reliability coefficients of the RAS subscales were .709 and .729 in Anxiety toward discourse with robots and Anxiety toward communication capacity of robots, respectively.

Figure 3 shows the means and standard deviations of the RAS subscale scores before/after facing the robot, and the results of mixed ANOVAs with the conditions of self-disclosure from the robot and before/after the interaction with the robot. It was found that the scores of anxiety toward discourse with robots after facing the robots were higher than those before facing the robot at a statistically

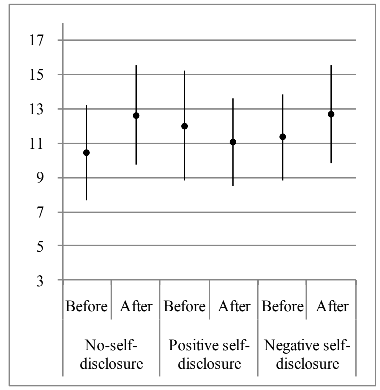
TABLE I. QUESTIONNAIRE ITEMS OF THE ROBOT ANXIETY SCALE [1] USED IN THE EXPERIMENT

Subscale	Item (6-graded answer: 1. I do not feel anxiety at all – 6. I feel very anxious)
Anxiety toward discourse with robots	How I should talk to the robot.
	How I should respond when the robot talks to me.
	Whether the robot will understand what I am talking about.
	Whether I will understand what the robot is talking about.
Anxiety toward communication capability of robots	Whether the robot might talk about irrelevant things in the middle of a conversation.
	Whether the robot might not be flexible in following the direction of our conversation.
	Whether the robot might not understand difficult conversation topics.



	Self-disclosure	Before/After	Interaction
F	.012	41.607	.464
p	.988	.000	.633
Partial η^2	.001	.543	.026

Anxiety toward Discourse with Robots



	Self-disclosure	Before/After	Interaction
F	.137	4.725	5.775
p	.872	.036	.007
Partial η^2	.008	.116	.243

Anxiety toward Communication Capacity of Robots

Figure 3. Means and Standard Deviations of the RAS Subscale Scores Before/After Facing the Robot, and Results of Mixed ANOVAs

TABLE II. ASSIGNMENT OF SUBJECTS INTO THE CONDITIONS

	Male	Female
No-self-disclosure	6	7
Positive self-disclosure	7	7
Negative self-disclosure	4	8

significant level. Moreover, the interaction effect was at a statistically significant level on the scores of anxiety toward communication capacity of robots. A simple main effect test with Bonferroni's method revealed that this anxiety scores increased after facing the robot at a statistically significant level ($p < .05$) under the non-self-disclosure condition, they increased at a statistically significant trend level ($p < .1$) under the negative self-disclosure condition.

B. *Contents of Utterances from Subjects*

Contents of the subjects' utterances after the robot's question about their recent situations were extracted from the video and audio data. Then, the subjects were classified based on the decision of two persons for their utterance contents. As a result, four classes were extracted. The first class consisted of the subjects who did not give any concrete response for the question, and the subject group was interpreted as "No response". The second were those who answered things not related to their either positive or negative situations (e.g., "I have no specific thing"), and the subject group was interpreted as "No self-disclosure". The third was those who mentioned their positive situations (e.g., "A few days ago, I enjoyed drinking"), and the subject group was interpreted as "Positive self-disclosure". Finally, the fourth was those who mentioned their negative situations (e.g., "I am too tired to follow the contents of lecture courses"), and the subject group was interpreted as "Negative self-disclosure". Table 3 shows the numbers of the subjects based on the classification. χ^2 test found no relationships between the classification and the conditions of the robot's self-disclosure.

Then, one-way ANOVAs with the classification were performed for the RAS subscale scores before and after facing the robot to explore relationships between anxiety toward robots and the subjects' utterance behaviors. The results found a statistically significant difference between the utterance classes on the scores of anxiety toward discourse with robots before facing the robot. Figure 4 shows the means and standard deviations of the scores and the result of the ANOVA. A multiple comparison with Bonferroni's method found that the subjects who mentioned their negative situations had higher anxiety toward discourse with robots before facing the robot than those who did not give any concrete response at a statistically significant level ($p < .05$), and than those who mentioned their positive situation at a statistically significant trend level ($p < .1$).

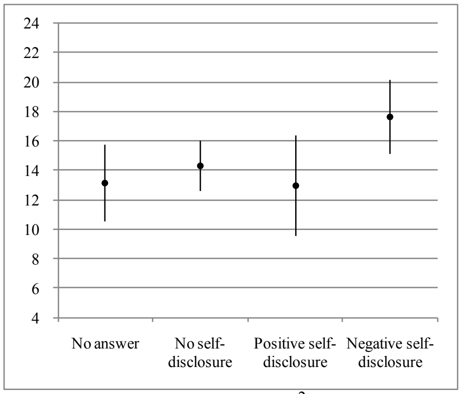
IV. DISCUSSION

The results of the experiment showed that the subjects' anxiety toward communication capacity of robots did not increase after facing the robot, only under the condition of

TABLE III. NUMBERS OF SUBJECTS BASED ON THE UTTERANCE CONTENTS FOR THE ROBOT

	Classes of the Subjects' Utterances			
Condition of the Robots	No response	No self-disclosure	Positive self-disclosure	Negative self-disclosure
No-self-disclosure	5	6	1	1
Positive self-disclosure	5	4	4	1
Negative self-disclosure	7	2	2	1
Total	17	12	7	3

($\chi^2(6) = 4.339$, *n.s.*)



($F = 3.143$, $p = .037$, $\eta^2 = .212$)

Figure 4. Means and Standard Deviations of the Scores of Anxiety toward Discourse with Robots before Facing the Robot Based on Subjects' Utterance Classes, and Results of One-Way ANOVA

the robot's positive self-disclosure. It suggests that even in a simple interaction like the experiment, positive self-disclosure from robots has an effect to inhibit humans' anxiety or apprehension toward robot's ability for communicating with humans.

However, the results of the experiment also showed that the subjects' anxiety toward discourse with robots increased after facing the robot, independent on the condition of self-disclosure from the robot. Moreover, self-disclosure from the robot did not have relationships with the subjects' utterance behaviors toward robots. These suggest that self-disclosure from robots has no influence into humans' anxiety toward discourse with robots or behaviors toward robots such as self-disclosure toward robots. Furthermore, the results suggested that higher anxious persons toward discourse with robots tend to negatively disclose about themselves, although lower anxious persons do not have this tendency. It is consistent with the results by Nomura et al. [1].

The above findings suggest that self-disclosure from the robot positively affects humans' anxiety toward factors related to communication in robots. On the other hand, it may not solve factors related to communication in humans. Although Suzuki and Yamada [3] suggested the possibility that self-disclosure from virtual agents elicits humans' self-disclosure, the experiment did not show this tendency. This suggests a difference between human-agent and human-robot interaction. It may be caused by robots' physical factors such as appearances, sizes, utterances, and motions. Thus, we need to explore robots' physical and behavioral factors for increasing humans' self-efficacy in communication with robots, including verbal feedbacks and gaze control.

Important is the trend that higher anxious persons toward discourse with robots tend to negatively disclose about themselves. Kang and Gratch [5] revealed that socially anxious people tended to disclose more about themselves toward virtual agents in comparison with real humans. In case of robot anxiety, the trend may be opposite to it. Nomura et al., [1] hypothesized that high anxiety toward communication lead persons to desire communication opportunities, and in addition, to talk with robots about things related to themselves to supplement blanks in communication. If this hypothesis is valid, interaction between robots and persons anxious toward robots may look like smoother. However, it does not mean that humans feel comfortable for the interaction. Thus, designers in HRI should not evaluate interaction states only from behavioral results.

However, the research in the paper has some limitations. We adopted single task, size, and appearance. Goetz et al. [6] proposed a "matching hypothesis" to explore relationships between robot appearances and tasks, and found that friendlier tasks matched friendlier appearances. Kidd and Breazeal [7] found that real robots were more suitable than virtual ones for tasks such as pointing at objects in real surroundings. Thus, we should consider interaction effects of task, appearance including size, and age. Moreover, we did not consider subjects' other personal traits such as age, gender, and educational backgrounds. In particular, recent studies [8][9] found effects of gender and its interaction effects with other factors. Thus, we should also consider several personal traits and their interaction effects.

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