The Elderly and Robots: From Experiments based on Comparison with Younger People

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Abstract

Robot factors such as motions and utterances have a possibility of interaction effects with generation and other human factors, and these effects influence robotics design in elder care. Some psychological experiments conducted in our research group found these interaction effects between generation and other factors based on directly comparison between younger and elder persons in interaction with a small-sized humanoid robot. The paper firstly reviews the previous two studies, reports results of the current experiment, and then discusses about their implications from the perspective of robotics design for elder care.

Introduction

Robots are expected as one of assistive technologies for the elderly, in particular, in industrialized countries including Japan, due to the decrease in rates of childbirth and the increase in the elderly population (Scopelliti, et al., 2005; Broadbent, et al., 2009). On the other hand, it is estimated that there are several differences between elder and younger people on cognitive and behavioral characteristics toward anthropomorphized artifacts such as robots and animation characters on screens. Thus, it is necessary to clarify these age differences on cognitive and behavioral characteristics toward robots on considering the designs of robots for caring the elderly.

However, there are only a few studies on direct comparison between elder and younger people focusing on robots. In an international study in several countries (Japan, United Kingdom, Sweden, Italy, and Korea), Shibata, et al. (2004) developed and reported on participants' subjective evaluations of a seal-type robot called "Palo". Their results suggested that younger people had more favorable impressions of the robot than older people. Dautenhahn, et al., (2005) reported results of a human-robot interaction experiment conducted in the United Kingdom which suggested that in the future, younger people compared to older people would like to have a home robot companion. Scopelliti, et al., (2005) conducted a social research study in Rome and reported that younger people had more familiarity with robots than older adults.

The above existing studies measured participants' impressions and attitudes toward robots after interaction with some specific types of robots or instruction about scenes of using robots. However, they lack a comparison on concrete behaviors and cognitions in interaction with robots between elder and younger subjects.

Our research group has conducted some psychological experiments to directly compare between younger and elder persons in interaction with a small-sized humanoid robot. The paper firstly reviews the previous two studies (Nomura and Sasa, 2009; Nomura and Nakao, 2010), reports results of the current experiment, and then discusses about implications from these experiment results.

Previous Experiments: Review

Figure 1 shows the robot commonly used in the following experiments. The robot "Robovie-X", which has been developed by Vstone Corporation, stands 34.3 cm tall,

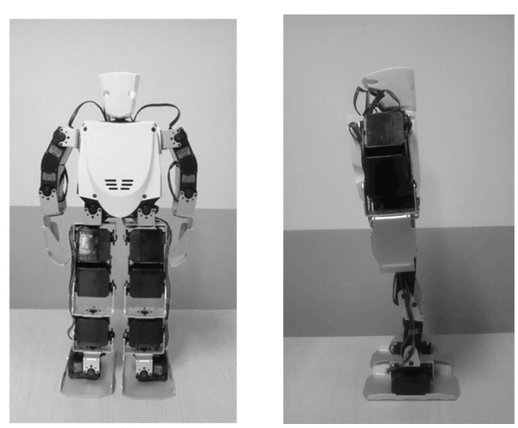


Figure 1. "Robovie-X" Used in the Experiment

weighs about 1.3 kg, and has a total of 17 Degrees of Freedom (DOFs) at its feet, arms, and head. This large number of DOF allows it to execute various gestures such as walking, bowing, and a handstand. 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.

Impressions of and Behaviors toward Real and Virtual Robots

Kidd and Breazeal (2004) found that the difference on robot appearance (really existing robots or virtual CG animation robots) affects human cognition toward robots. When considering the introduction of robots from the perspective of cost and benefit, we should take into account the problem on which we should select virtual robots that can be implemented on the existing computers, or real robots that need other physical structures. The experiment aimed at investigating differences on impressions of and behaviors toward two types of artificial agents, the humanoid robot shown in Figure 1 and a CG animation robot similar to this humanoid robot, between elder and younger people (Nomura and Sasa, 2009).

The experiment was conducted with 2 x 2 between-subject design of real v.s. CG robots and elder v.s younger persons, from October to December, 2008. A total of thirty seven persons participated to the experiment. The number of the elder subjects was twenty (male: 10, female: 10, age: min 59, max 79, mean 68.7). They were inhabitants at a local city in the western area of Japan. The number of the younger subjects was seventeen (male: 7, female: 10, age: min 19, max 22, mean 20.6). They were university students in the western area of Japan.

The task to be requested for subjects in the experiment was manipulation of physical objects on a desk, similar with Kidd and Breazeal (2004). In the experiment, it was instructed by the robots with voice. The scenes of the experiment were recorded with a digital video camera to extract the subjects' concrete behaviors toward the robots. Moreover, a questionnaire consisting of twenty eight pairs of adjectives was used for measuring the subjects' impressions of the robots after the experiment sessions.

Behavioral indices extracted from the video data revealed that more elderly subjects performed utterance or greeting behaviors toward the real robot than the student subjects, although most of both subjects followed the instructions from the robots. Moreover, impression scores extracted from the questionnaire results found that the elderly subjects felt more positive impressions of the robots than the student subjects, the student subjects felt less attachment to the virtual robot than the real robot, and the student subjects felt less attachment to the virtual robot in comparison with the elderly subjects.

Identification of Affective Behaviors Expressed by a Robot

Expressive behaviors based on body motions are one of channels for communication between humans, and has a possibility of contribution to human-robot interaction, in particular, affective information from sociable robots to humans. However, it is also assumed that effects of affective body motions expressed by robots depend on age. In fact, Wong, et al. (2005) suggested in their experiment on facial expression identification that older participants were at a distinct disadvantage on identifying fearful, angry, and sad faces by fixating their eye movement on the lower halves of faces. The experiment aimed at investigating differences on emotion identification of affective behaviors expressed by the humanoid robot showin in Figure 1, between elder and younger people (Nomura and Nakao, 2010).

The experiment was conducted from October to December, 2008. A total of thirty two persons participated to the experiment. The number of the elder subjects was fifteen (male: 9, female: 6, age: min 64, max 79, mean 69.1). They were inhabitants at a local city in the western area of Japan. The number of the younger subjects was seventeen (male: 8, female: 9, age: min 18, max 23, mean 20.8). They were university students in the western area of Japan.

The experiment focused on three basic emotions, anger, sadness, and pleasure to simplify the experimental design. Based on the existing studies on affective body motions and a literature on modern dances, motions corresponding to these emotions were defined and implemented on the humanoid robot. Each subject watched these three motions in randomized order, and then responded a questionnaire measuring degrees to which she/he felt the expressed motion looked like the specified emotions, degrees to which she/he paid their attentions to some of body or motion parts, and degrees to which she/he felt the speed of the expressed motion was fast or slow, and the magnitude of the expressed motion was large or small.

The accuracies of emotion identification, rates of attention to body and motion parts, impression of motion speed and magnitude, and correlations between them revealed that almost all the student subjects identified the three types of affective body motion as the ones intended by the motions, and many of them identified the anger and sadness motions of the robot as hate, in comparison that many of the elder subjects did not identify these motions as either the intended ones or the proximate one. Moreover, in comparison with the student subjects, more of the elder subjects paid their attentions to the upper body in the anger motion of the robot, the legs and feet in the sadness motion, which were not important on the affective expression implemented in the experiment. Furthermore, it was found that identification for the anger motion of the robot was more correct as the upper body was less paid attention to, and identification for the anger motion of the robot was more correct as the magnitude impression was stronger, and identification of the sadness motion was more correct as the speed impression was weaker.

Current Experiment: Exploration of Interaction Effects

The results of the first experiment suggest that elder people may more positively accept robots as social entities and be less sensitive for the differences between robots with real bodies and virtual robots on computer screens than younger people. It means an interaction effect between age and embodiment of robots. Moreover, the results of the second experiment suggest that effects of emotional expression by robots may depend on age, relating with individual cognitive characteristics. Thus, we should consider further interaction effects between robot factors and human factors including not only age and but also other personal traits.

The current experiment aimed at exploring this interaction effect focusing on gender. The current experiment also adopted the same small-sized humanoid robot as the previous experiment. The interviews for the elder subjects in the previous experiment suggested that elder people assumed the robot as a child. Thus, the experiment aimed at exploring effects of child-likeness in motions and ways of utterances as a robot factor, and its interaction effects with generation and gender.

Date and Subjects

The experiment was conducted from November to December, 2010. The number of the elder subjects was twenty (male: 10, female: 10, age: min 60, max 78, mean 66.8), and they were recruited with five hundreds yen from the western area in Japan. The number of the younger subjects was eighteen (male: 8, female: 10, age: min 19, max 22, mean 20.9), and they were recruited with one hundred yen from the same university as the previous experiments.

Child-Likeness in Motions and Utterances of the Robot

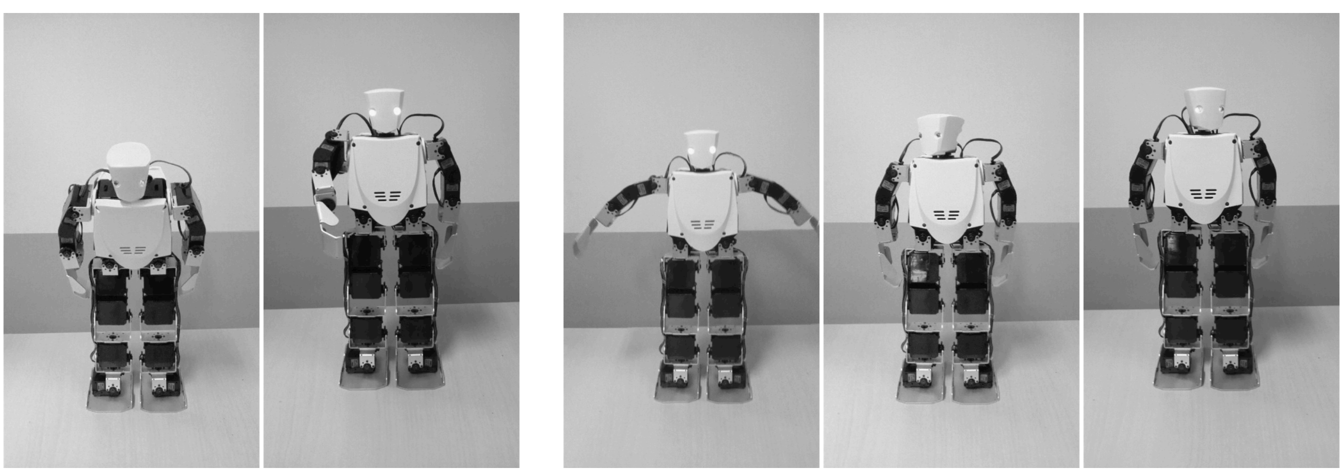
We could not find literatures formally defining child-likeness in human motions and utterances. Thus, the following two conditions of utterances and motions were temporally implemented into the robot:

<Child-like robot condition>

- Utterances:
  "Hello. I am Robovie-X. I have just recently been produced. I want to become able to do more things. I have been being familiar with my owner. Everyone feels me rare and comes up to me, so I am happy. I had a nice day. Thank you."
- Motions:
  The robot inclined its upper body forward just after the utterances of "Hello" and "Thank you" like bowing. During the other utterances, the robot opened its arms and waved its head as if it looked like restless. After bowing motion at "Thank you", it raised its right hand as if it offered its hand to subjects (shown in Figure 2).

<Adult-like robot condition>

- Utterances:
  "Hello. I am Robovie-X. Since I was charged just yesterday, I am very fine today. I appreciate my



Bowing　　Offering hand　　Motions during Utterances in the Child-Like Condition

Figure 2. Motions of the Robot in the Current Experiment

owner since he deals with me very politely. Although novel types of robots have been appearing in succession, I work harder and try not to lose. Thank you very much for your visit today."

- Motions:

  In the same way as in the child-like condition, the robot inclined its upper body forward just after the utterances of "Hello" and "Thank you" like bowing, and raised its right hand after bowing motion at "Thank you". During the other utterances, it kept standing without other motions.

The Japanese language has an explicit distinction between polite phrases ("desu/masu" form) and non-polite ones ("dearu/da" form) (Miyashita, 2002). The utterances in the adult-like robot condition were composed of "desu/masu" form at the ending of the words and polite expression of subject and predicate. The utterances in the child-like robot condition were composed of "dayo" form at the ending of the words and impolite expression of subject and predicate. The effect of this linguistic distinction in human-robot interaction has been validated in another experiment (Nomura and Nakamura, 2010). The speech data was synthesized from the Japanese text data. The quality was artificial and gender neutral.

Measures

The scenes of the experiment were recorded with a digital video camera to extract the subjects' behaviors toward the robots.

The questionnaire for measuring the subjects' impressions of the robots consists of twenty pairs of adjectives. The subjects were asked to respond to each pair of adjectives to present degrees to which they felt the impression represented by the pair of adjectives for the robots they experienced. Each questionnaire item had a score for rating with seven intervals. On the questionnaire, it was randomized at each item which side the positive or negative adjective appeared at. These adjectives were selected from a part of the items used in the previous experiment (Nomura and Sasa, 2009), and validated in the other studies (Nomura and Saeki, 2010; Nomura and Nakamura; 2010).

Procedure

The experiment was conducted with 2 x 2 x 2 between-subjects design of subjects' gender and generation (younger v.s. elder), and the robot conditions of child-likeness. Table 1 shows the numbers of subjects assigned into the conditions.

Table 1.Numbers of Subjects Assigned into Conditions

	Younger		Elder	
	Male	Female	Male	Female
Child-likerobot	4	5	5	5
Adult-like robot	4	5	5	5

Figure 3. A Scene of the Experiment

Each session was conducted based on the following procedures:

1. Each subject was 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.
2. The subject was led to an experiment room, in which the robot was put on a desk. The experimenters instructed him/her to sit on the chair in front of the desk and wait in the room for a while, and left the room (see Figure 3).
3. Just after the subject was left alone in the room, the robot started the utterances and motions. It was remotely controlled by the experimenters out of the room.
4. When the subject performed some actions toward the robot's motion of raising its right hand, or twenty seconds passed after completion of the robots' utterances, the experimenters entered the room again, and indicated that the session finished. Then, 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.
5. Then, the subject responded the questionnaire for measuring his/her impression of the robot. Finally, the experimenters interviewed with the subject about the robot and the experiment.

Results

For each item of adjectives pair, the score of the seven-graded answer was coded from -3 to 3 so that higher score corresponded to the positive adjective of the pair. Then, exploratory factor analysis with Maximum-likelihood method and Promax rotation was performed to classify these items and extract subscales for measuring the subjects' impressions of the robots. Different from the previous studies (Nomura and Sasa, 2009; Nomura and Saeki, 2010; Nomura and Nakamura, 2010), no statistically

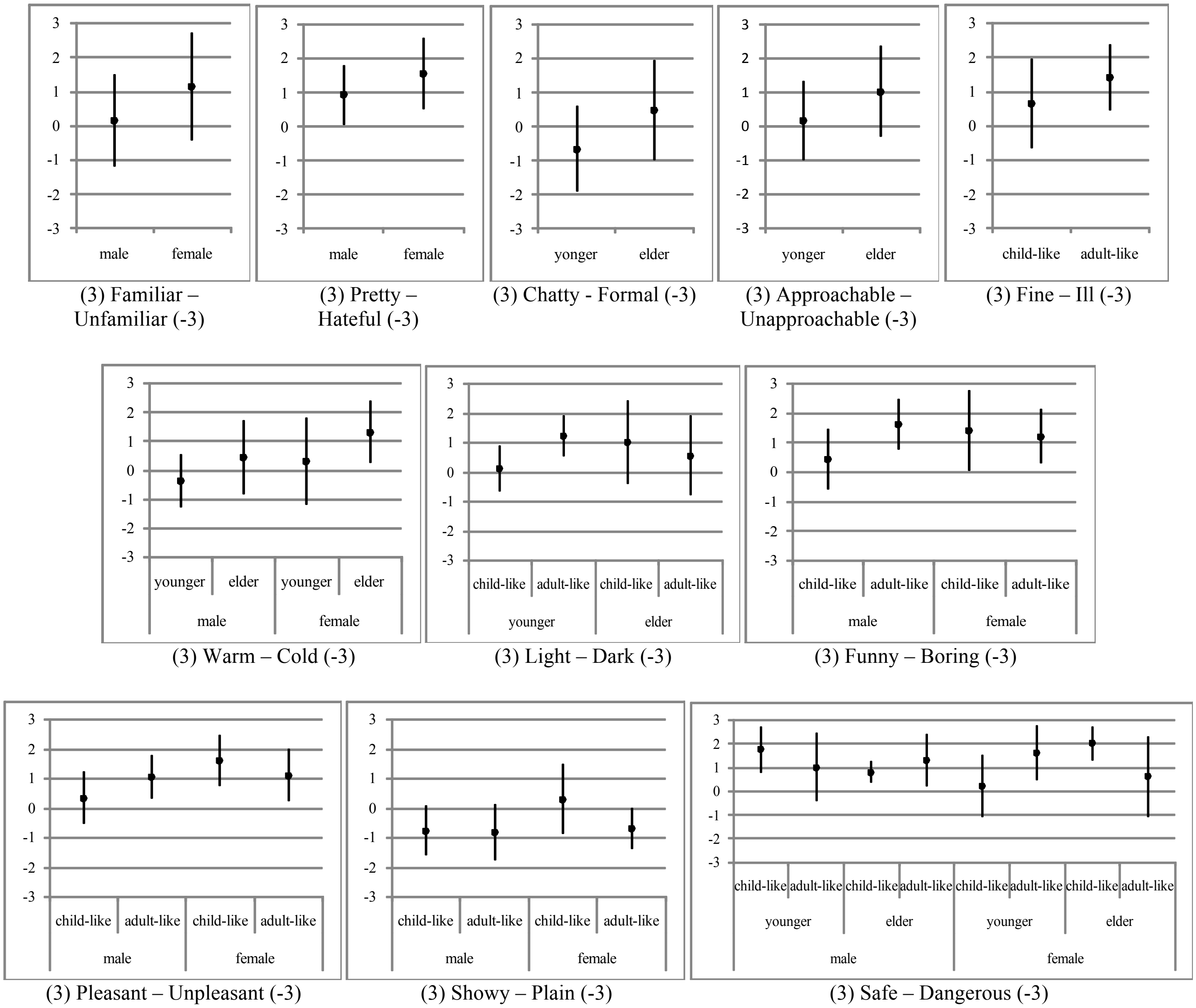


Figure 4. Means and Standard Deviations of the Impression Item Scores Showing Main or Interaction Effects

significant model was extracted. Thus, a three-ways ANOVA with generation, gender, and the robot conditions of child-likeness was conducted for each item score.

Figure 4 shows the means and standard deviations of these item scores. Moreover, Table 2 shows the results of the ANOVAs for these item scores. The results of the items showing only the main effects found that the female subjects had more positive impressions of the robot ("Familiar", "Pretty", "Warm") than did the male subjects and the elder subjects had more positive impressions ("Chatty", "Approachable", "Warm") than did the younger subjects. The main effect of the robot's child-likeness appeared at only one item and showed that the subjects had less positive impression ("Fine") of the robot with child-likeness than that with adult-likeness.

Moreover, child-likeness of the robot had some interaction effects with generation and gender at statistically significant levels or significant trend levels, showing more than moderate levels of effect sizes. The impressions of the robot with child-likeness showed inconsistent trends between the younger and elder subjects ("Light - Dark"), and between the male and female subjects ("Funny - Boring", "Pleasant - Unpleasant", "Showy – Plain"). Furthermore, the second-order interaction effect was at a statistically significant level and showed a strong level of effect size at the scores of item "Safe – Dangerous". It suggested that the trends of interaction between the robot's child-likeness and generation were inconsistent between the male and female subjects.

Table 2. Results of ANOVAs for the Impression Item Scores

		Main effect			First-order interaction			Second-order interaction
		gender	generation	robot	gender x generation	gender x robot	generation x robot	
Familiear - Unfamiliar	F	**4.526***	.631	.006	.032	.290	.411	2.608
	η^2	**.118**	.016	.000	.001	.008	.011	.068
Pretty - Hateful	F	**3.806†**	.119	2.003	.329	.247	.329	.915
	η^2	**.101**	.003	.053	.009	.007	.009	.024
Chatty - Formal	F	1.485	**7.071***	.003	1.228	1.108	.150	.371
	η^2	.036	**.174**	.000	.030	.027	.004	.009
Approachable - Unapproachable	F	.263	**3.981†**	.468	.029	.052	.013	.013
	η^2	.008	**.115**	.014	.001	.002	.000	.000
Fine - Ill	F	1.856	.487	**3.844†**	.010	.929	.584	1.203
	η^2	.047	.012	**.098**	.000	.024	.015	.031
Warm - Cold	F	**3.467†**	**4.965***	.269	.046	.210	1.141	.157
	η^2	**.087**	**.124**	.007	.001	.005	.029	.004
Light - Dark	F	.422	.057	.852	2.806	.422	**4.638***	.095
	η^2	.011	.001	.022	.072	.011	**.118**	.002
Funny - Boring	F	.518	.001	1.787	.264	**3.554†**	.029	.142
	η^2	.014	.000	.050	.007	**.099**	.001	.004
Pleasant - Unpleasant	F	**5.595***	1.245	.161	.448	**4.782***	.018	.050
	η^2	**.132**	.029	.004	.011	**.113**	.000	.001
Showy - Plain	F	**4.991***	**5.821***	**3.194†**	1.349	**3.194†**	.799	.799
	η^2	**.099**	**.115**	**.063**	.027	**.063**	.016	.016
Safe - Dangerous	F	.090	.010	.028	.938	.028	1.072	**7.319***
	η^2	.002	.000	.001	.024	.001	.027	**.184**

($^{\dagger}p < .1$, $^{*}p < .05$)

In addition, the number of the subjects who performed some actions toward the robot's motion of offering its hand to them was counted based on the video data. χ^2-tests found no relationships between the performance of actions and generation, or gender (generation: $\chi^2(1) = .001$, *n.s.*, gender: $\chi^2(1) = 1.619$, *n.s.*). However, there was a statistically significant relationship between the performance of actions and the robot's child-likeness. Table 3 shows the result. The results found that more subjects performed some actions in the adult-like robot condition than in the child-like robot condition.

Discussion

The series of the experiments based on comparison between younger and elder people suggest that the elderly had more positive impressions of robot than younger people. On the other hand, robots' factors such as motions and utterances may have several interaction effects with generation and gender. In fact, our previous experiment suggested age differences on emotion identification from the robot motions, and the current experiment suggested some interaction effects between robot factors, generation, and gender. These interaction effects may lead us to the difficulty of designing behaviors of robots for caring the elderly. For solving this difficulty, we should consider careful selection of contexts in which robots are applied for caring the elderly, and understanding of elder users' expectation of robots and modification of the expectation within possible ranges of robots' behaviors, as pointed out by Broadbent, et al. (2009).

Of course, the series of the experiments have some limitations. We only tested with a particular type of robots with a limited interaction with a small number of subjects from specific groups. In particular, the interaction between the subjects and robots in the experiment was one way where the robots only performed a script and had no reaction for the subjects' behaviors. Thus, the generality of our findings is limited. Moreover, we did not measure psychological constructs such as expectation and attitudes which have a possibility of influences into impression and behaviors of the elderly toward robots. Furthermore, we should consider cultural differences on age effect into communication strategies (Taki, 2003), and a possibility of its influences into human-robot interaction. These problems must be tackled in future experiments by extending the experimental design.

Table 3. The Number of Subjects Who Performed Some Actions toward the Robot's Offering its Hand and Result of χ^2-Test

	No action	Action	Total
Child-like	12 (63%)	7 (37%)	19 (100%)
Adult-like	5 (26%)	14 (74%)	19 (100%)
Total	17 (45%)	21 (55%)	38 (100%)

($\chi^2(1) = 5.216$, $p < .05$)

Acknowledgement

The research was supported in part by the Japan Society for the Promotion of Science, Grants-in-Aid for Scientific Research No. 21118006.

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