Influences of Inconsistency between Phrases and Postures of Robots: A Psychological Experiment in Japan

Tatsuya Nomura, *Member, IEEE* and Kaori Nakamura

***Abstract*—To investigate influences of inconsistency on forms of information presentation by robots, a psychological experiment was conducted in Japan, with between-subject design for forty five university students. In the experiment, a small-sized humanoid robot performed self-introduction with polite/impolite postures and polite/impolite phrases in the utterances, in the Japanese cultural sense. The results revealed that: 1) the subjects under the inconsistent conditions (polite posture – impolite phrase condition or impolite posture – polite phrase condition) recalled less on the contents uttered by the robot than did those under the consistent conditions (polite posture – polite phrase condition or impolite posture – impolite phrase condition), and 2) there was only a low level of correlations between the recall scores of uttered contents and impressions of the robot. The paper discusses about implications from the results for future robotics design.**

I. Introduction

CONSISTENCY among contents, ways and attitudes in utterances, and contexts is an important factor in human communication. Bateson [1] argued, in his theory of double-bind situations, that inconsistency in communication can cause mental illness, by combination with power relations forcing the inconsistency. A famous example in his theory is a mother who kindly accepts her children in her utterances and at the same time refuses them in her body postures.

Referring to Bateson's theory, Aoki, a Japanese psychologist, experimentally validated influences of inconsistency between utterance contents and ways into human cognition and memorization [2]. In her experiment, Japanese sentences with positive and negative contents were prepared independently, and an actress uttered these sentences with both positive and negative tones. Under this 2 x 2 between-subject design with content and tone, it was measured how subjects recalled the uttered contents, how they understood the contents, and how they felt consistency for them. The results revealed that subjects under the inconsistent conditions recalled less than did those under the consistent conditions. In particular, it was revealed that feeling of consistency was the lowest in the condition of the negative tone and positive content. Moreover, Aoki hypothesized that influences of this particular inconsistent condition were specific in Japan, where inhibition of affective expression tends to be evaluated positively.

Aoki's study suggests the importance of consistency on forms of information presentation in human-robot interaction (HRI). For example, when guidance robots provide visitors with information on facilities in inconsistent manners, they may cause the visitors' confusion on cognition and memory, and as a result the visitors may not receive important information.

However, there have been few studies that straightforwardly investigated this possibility in HRI research. Goetz, et al., [3] suggested the importance of consistency between robots' appearances (humanlikeness) and tasks performed by them (serious vs. playful). Walters, et al., [4] investigated human preferences to different robots having consistent appearances with their behaviors. In case of HRI, several types of inconsistency can exist including influences of embodiment, such as that between tones and contents as dealt with by Aoki, that between tones and postures mentioned in Bateson's example, that between phrases and postures, that between phrases and appearances, and that between appearances and tasks suggested by Goetz, et al. Moreover, as mentioned by Aoki, influences of inconsistency may depend on cultures. In order to consider design of robots' information presentation, it needs to explore influences of several types of inconsistency based on user evaluation in several countries.

As an attempt for the above aim, a psychological experiment was conducted in Japan, by using a small-sized humanoid robot. This experiment had a simple design similar to Aoki's original study, focusing on inconsistency between phrases and postures of the robot. The paper reports results of the experiment to discuss about the possibility of influences of inconsistency on ways of information presentation by robots.

II. Research Question

Although Aoki's study [2] dealt with inconsistency between contents and tones of human utterances, the study focuses on phrases and postures of robots on information presentation. The reason is hardness of producing human-like utterances with positive or negative tone by speech synthesis systems generally usable in the current stage. Phrases can be controlled easily even in case of robots.

Moreover, phrases are an important factor in the Japanese, which has an explicit distinction between polite phrases ("desu/masu" form) and non-polite ones ("dearu/da" form).

The research was supported in part by "High-Tech Research Center" project for private universities: matching fund subsidy from MEXT (Ministry of Education, Culture, Sports, Science and Technology), 2002–2006, and by the Japan Society for the Promotion of Science, Grants–in–Aid for Scientific Research No. 21118006.

Tatsuya Nomura is with Department of Media Informatics, Ryukoku University, Otsu, Shiga 520-2194, Japan, and ATR Intelligent Robotics and Communication Laboratories, Japan. (phone: +81-77-544-7136; fax: +81-77-544-7150; e-mail: nomura@rins.ryukoku.ac.jp).

Kaori Nakamura is with Department of Media Informatics, Ryukoku University, Otsu, Shiga 520-2194, Japan.

Although this distinction causes a difficulty for non-Japanese people to learn the Japanese [5], politeness of uttered phrases can strongly influence impressions of conversation partners, as well as that of postures. Thus, inconsistency between phrases and postures may influence humans in interaction with both humans and robots.

Based on the above consideration, the study focuses on the following research question: "***Can inconsistency between phrases and postures of robots on politeness influence human cognition and impression?***"

III. METHOD

A. Date and Subjects

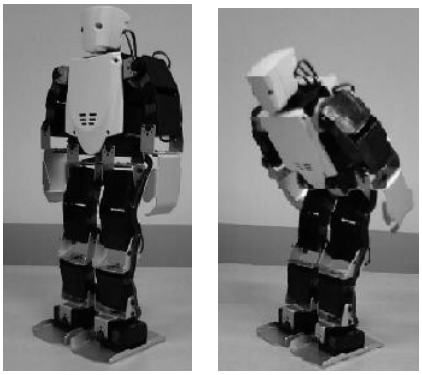
The experiment was conducted from November to December, 2009. A total of forty five Japanese persons participated to the experiment (male: 22, female: 23, mean age: 21.3 (*SD* = 2.9)). They were university students in the western area of Japan, and recruited with one thousand yen.

B. Robot Used in the Experiment

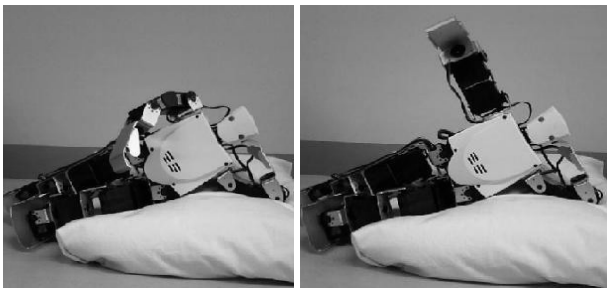
In the experiment, a small-sized humanoid robot shown in Fig. 1 was used. This robots "Robovie-X," which has been developed by Vstone Corporation, stands 34.3 cm tall and weighs about 1.3 kg. The robot has a total of 17 DOFs at its feet, arms, and head. This large number of DOF allows it to execute various 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.

C. Phrases and Postures of the Robot

Barraquand and Crowley [6] described in their study on social robots as follows; Social common sense refers to the shared rules for polite, social interaction that implicitly rule behavior within a social group. Based on this description, the experimenters prepared two types of phrases and postures different on the level of politeness respectively, referring to the common sense assumed to be shared within the Japanese community.



Polite Posture



Impolite Posture

Fig.1 Robovie-X and its Postures in the Experiment

Speech data of the robot was synthesized from 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.

TABLE 1. CONTENTS UTTERED BY THE ROBOT

Greeting:	"Hello."
Japanese polite	"**Hajime-mashite**"
Japanese impolite	"**Kon-nichiwa**"
Name:	"I am Robota."
Japanese polite	"**Watashi** / no / namae / wa / Robota / **to / moushi-masu**"
Japanese impolite	"**Boku** / no / namae / wa / Robota / **tte / yuun-dayo**"
Birthday:	"My birthday is September 8."
Japanese polite	"Tanjo-bi / wa / kugatsu / youka / **desu**"
Japanese impolite	"Tanjo-bi / wa / kugatsu / youka / **dayo**"
Hometown:	"I am from Osaka."
Japanese polite	"Shusshin / wa / Osaka-**fu** / **desu**"
Japanese impolite	"Shusshin / wa / Osaka / **dayo**"
Workplace:	"I am currently working at the cafeteria in Ryukoku University."
Japanese polite	"**Genzai** / **Ryukoku / daigaku** / no / **gakusei-shokudo** / de / hataraite / **imasu**"
Japanese impolite	"**Ima / ha** / **Ryudai** / no / **gakushoku** / de / hataraite / **iruyo**"
Hobby and specialty:	"My hobby is playing a guitar, and specialty is football."
Japanese polite	"Shumi / ha / gita / wo / hikukoto / de / tokugi / ha / sakka / **desu**"
Japanese impolite	"Shumi / ha / gita / wo / hikukoto / de / tokugi / ha / sakka / **nan-dayo**"
Thanks:	"Thank you very much for your listening to my introduction."
Japanese polite	"**Watashi** / no / jiko-shokai / **wo** / kiite / **itadaki** / arigato / **gozaimashita**"
Japanese impolite	"**Boku** / no / jiko-shokai / kiite / **kurete** / arigato"

(Italic: target words for the recall task, bold: different parts in polite and impolite phrases)

The utterance contents of the voice data consisted of six items related to self-introduction. The utterances with polite phrases were composed of "desu/masu" forms at the ending of the words and polite expression of subject and predicate. The utterances with impolite phrases were composed of "dayo" forms at the ending of the words, impolite expression of subject and predicate, and abbreviations of nouns. Table 1 shows these uttered contents. The underlined words are targets used for a recall task performed by subjects in the experiment (explained in section III-E).

In the polite posture (upper in Fig.1), the robot inclined its upper body forward just after greetings and thanks, and kept standing without any motion during the other utterances, regardless of polite and impolite phrases. In the impolite posture (lower in Fig.1), the robot stayed lying on a soft pillow while waving one arm in time with the utterances, regardless of polite and impolite phrases. These types of postures have been validated in the existing study on politeness of robots [7].

D. Procedures

The experiment adopted a 2 x 2 between-subjects design with politeness of phrases in utterances and posture of the robot. One of the four experiment conditions was randomly assigned to one session. Each session was conducted based on the following procedures:

1) Each subject was explained about the experiment and signed the consent form. In this stage, the experimenters only indicated that the task in the experiment was to look at a robot moving and speaking.

2) The subject was led to an experiment room, in which the robot was put on a desk, as shown in Fig.2. 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.

3) Just after the subject was left alone in the room, the robot was remotely controlled by the experimenters out of the room, and started its motion and utterances described in the previous section.

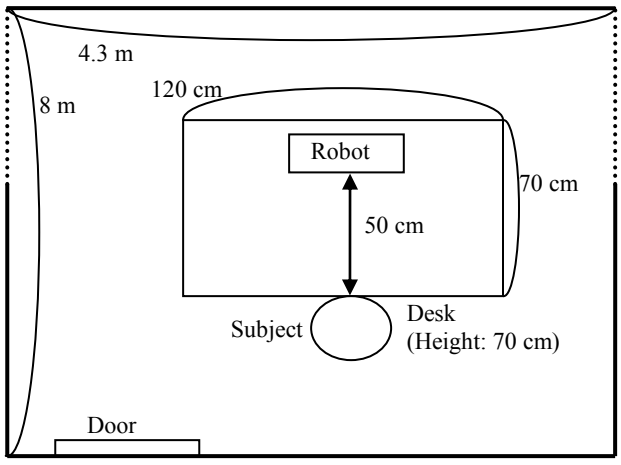


Fig. 2. Overview of the room where the experiment was executed (a view from above)

TABLE 2. PAIRS OF ADJECTIVES FOR MEASURING SUBJECTS' IMPRESSIONS OF THE ROBOT

Positive		Negative
Polite	---	Impolite
Mild	---	Terrible
Fine	---	Ill
Familiar	---	Unfamiliar
Safe	---	Dangerous
Warm	---	Cold
Cheerful	---	Gloomy
Chatty	---	Formal
Comprehensible	---	Not comprehensible
Approachable	---	Unapproachable
Light	---	Dark
Funny	---	Boring
Pleasant	---	Unpleasant
Favorite	---	Disfavorite
Interesting	---	Tedious
Fast	---	Slow
Aggressive	---	Negative
Showy	---	Plain
Cheerful	---	Gloomy
Clever	---	Foolish

TABLE 3. ASSIGNMENT OF SUBJECTS TO THE EXPERIMENT CONDITIONS

		Phrase			
		Polite		Impolite	
		Male	Female	Male	Female
Posture	Polite	5	5	6	6
	Impolite	6	6	5	6

4) Ten seconds later just after the robot finished its utterances, the experimenters entered the room again, and indicated that the session finished. Then, the subject responded a questionnaire for a task of recalling contents uttered by the robot and measurement of his/her impression of the robot. Finally, the experimenters conducted interview with the subject about the robot and the experiment, and debriefing about the actual aim of the experiment.

E. Measures

The measures in the experiment were based on self-reports by using a questionnaire consisting of two parts.

The first part asked subjects to recall contents uttered by the robot, related to six items shown in Table 1: name, birthday, hometown, workplace, hobby, and specialty of the robot. This recall task was similar with that conducted by Aoki's original study [2].

The second part consisted of twenty pairs of adjectives to measure subjects' impression of the robots, shown in Table 2. 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. These adjectives were selected from the ones used for measurement of subjects' impression in an experiment of interaction with a humanoid robot [8]. Moreover, the pair of "polite"--"impolite" was added. Each questionnaire item had a score for rating with seven intervals (1-7). On the questionnaire, it was randomized at each item which side the positive or negative adjective appeared at.

IV. RESULTS

A total of forty five subjects were assigned to four types of the experiment conditions as shown in Table 3. The following analyses were performed to investigate influences of polite/impolite phrase and posture of the robot into the subjects' cognition and memory through the recall task and impressions toward the robot.

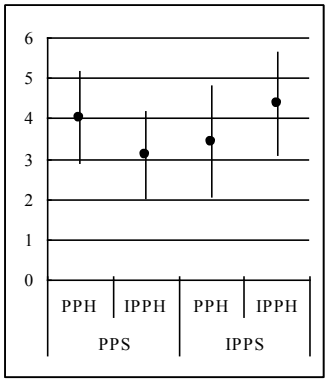
A. Recall Task

The recall task score in each subject was defined as the total number of items which he/she recalled among the six items of the contents the robot uttered (0~6). First, a three-way ANOVA with gender x phrase x posture was performed for the recall task scores. It found neither main effect of gender nor its interaction effect with other two factors. Thus, a two-way ANOVA with posture x phrase was performed again.

Fig.3 shows the means and standard deviations of the recall task scores and the results of the ANOVA. The analysis found no main effect of posture or phrase. The interaction effect was statistically significant. Post-hoc analysis with Bonferroni's method revealed a statistically significant difference between the polite and impolite posture conditions at the impolite phrase condition (p = .017). Moreover, it found differences at statistically significant trend levels between the polite and impolite phrase conditions at both the polite and impolite posture conditions (p = .090 and p = .073 respectively).

B. Impressions of the Robot

For each item of adjectives pair, the score of the seven-graded answer was coded from 1 to 7 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. The result of scree plot revealed that the three-factor structure was valid. Then, item analysis using factor loading, Chronbach's α-coefficients and I-T correlations was performed for each of these three factors to select items in the corresponding subscale. Table 4 shows the results of these analyses.



(PPS: Polite posture, IPPS: Impolite posture, PPH: Polite phrase, IPPH: Impolite phrase)

	Posture	Phrase	Interaction
F:	.893	.002	6.384
P:	.350	.967	.015

Fig.3 Means and Standard Deviations of the Recall Task Scores and Results of ANOVA

TABLE 4. RESULTS OF FACTOR ANALYSIS AND ITEM ANALYSIS FOR IMPRESSION ITEMS

Adjective (Positive)	Factor loading I	II	III	Item Analysis
Favorite	**.891**	-.192	.032	
Safe	**.819**	-.288	-.079	Removed
Cheerful	**.800**	.153	-.054	
Interesting	**.786**	-.056	-.026	
Pleasant	**.745**	-.067	.297	
Clever	**.722**	.235	-.199	
Fine	**.630**	.272	.005	
Funny	**.617**	-.046	.399	
Polite	**.551**	.332	-.212	Removed
Familiar	**.487**	.346	.031	
Warm	-.233	**.854**	.384	
Aggressive	-.147	**-.581**	.261	Removed
Mild	.168	**.552**	.096	
Approachable	.357	**.441**	-.044	
Showy	-.036	**.250**	.189	Removed
Fast	-.135	**.215**	.034	Removed
Light	.197	-.037	**.820**	
Chatty	-.016	.234	**.618**	
Comprehensible	-.293	.050	**.492**	Removed
Cheerful	.226	-.138	**.451**	

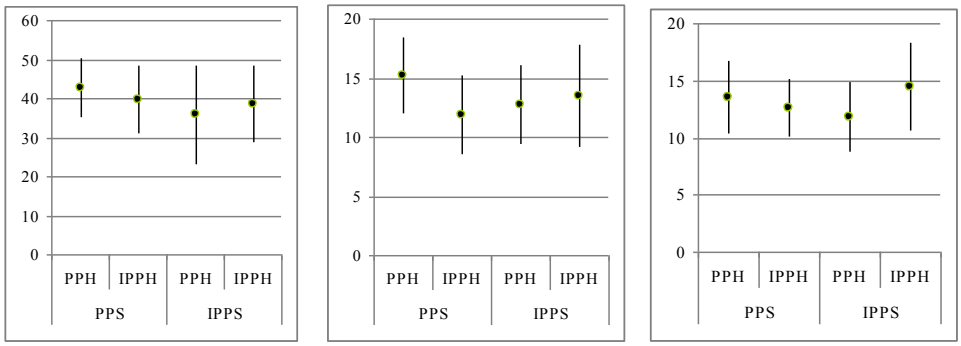
Subscale	#. Item	Chronbach's α
I. Pleasantness	8	.928
II. Warmness	3	.801
III. Cheer	3	.741

Correlations	II. Warmness	III. Cheer
I. Pleasantness	.710**	.658**
II. Warmness	-	.625**

(**p < .01)

The first factor consisted of ten items and the item analysis found two items to be removed. Based on the contents of the eight items, the corresponding subscale was interpreted as "pleasantness". The second factor consisted of six items and item analysis found three items to be removed. Based on the contents of the three items, the corresponding subscale was interpreted as "warmness". The third factor consisted of four items and item analysis found one item to be removed. Based on the contents of the three items, the corresponding subscale was interpreted as "cheer". Chronbach's reliability coefficients of these subscales showed their sufficient internal consistency. There was a high level of correlations between the impression subscale scores.

The score of each impression subscale was calculated as the sum of the scores of the corresponding items. Thus, the maximum and minimum scores are 56 and 8 for "pleasantness" subscale, 21 and 3 for "extroversion" subscale, and 21 and 3 for "cheer" subscale, respectively. First, three-way ANOVAs with gender x phrase x posture were performed for these three impression subscale scores. They



Pleasantness Warmness Cheer

(PPS: Polite posture, IPPS: Impolite posture, PPH: Polite phrase, IPPH: Impolite phrase)

		Posture	Phrase	Interaction
Pleasantness	*F*:	1.848	.001	.958
	P:	.181	.969	.333
Warmness	*F*:	.150	1.544	3.611
	P:	.701	.221	.064
Cheer	*F*:	.012	.821	3.537
	P:	.914	.370	.067

Fig.4 Means and Standard Deviations of the Impression Subscale Scores and Results of ANOVAs

found neither main effect of gender nor its interaction effect with other two factors. Thus, two-way ANOVAs with posture x phrase were performed again.

Fig.4 shows the means and standard deviations of these subscale scores and results of the ANOVAs. The analyses found no main effect of posture or phrase for the scores. The interaction effects were at statistically significant trend levels in the "warmness" and "cheer" impression scores.

Table 5 shows Pearson's correlation coefficients between the recall task scores and impression subscale scores. Except for a moderate level of correlation with the "cheer" impression, the recall task scores had almost no correlation with the impression subscale scores.

TABLE 5. PEARSON'S CORRELATION COEFFICIENTS BETWEEN THE RECALL TASK SCORES AND IMPRESSION SUBSCALE SCORES.

Pleasantness	Warmness	Cheer
.172	.130	.300*

(*$p < .05$)

V. DISCUSSION

A. Findings

The analysis results of the recall task scores revealed the following facts:

1) The subjects under the polite posture – impolite phrase condition recalled less on the contents uttered by the robot than did those under the polite posture – polite phrase condition, and those under the impolite posture – impolite phrase condition.

2) The subjects under the impolite posture – polite phrase condition also recalled less on the contents uttered by the robot than did those under the impolite posture – impolite phrase condition.

These results suggest that inconsistency on politeness between postures and phrases of robots can influence human cognition and memory, in particular, in a specific combination of posture and phrase (polite posture and impolite phrase). It is consistent with Aoki's results on inconsistency on positivity/negativity between tones and contents of human utterances [2]. Aoki argued that inconsistency between tones and contents caused dilemma in human cognition, and as a result, interfered with memorization processing. It is estimated that inconsistency between postures and phrases of robots caused the same kind of dilemma in human cognition.

Moreover, the analysis results of the impression subscale scores revealed the following facts:

3) The conditions on politeness in the robot's posture and phrase had neither main effect nor interaction effect on the subjects' impression of the robot.

4) There was only a low level of correlations between the recall scores of uttered contents and impressions of the robot.

These results suggest that the influence of inconsistency on politeness between posture and phrase into impression of robots may be weak and independent on that on cognition and memorization. Aoki's results suggest that inconsistency between tones and contents of human utterances causes negative impression of uttering persons [2]. In this sense, the results on impression of the robot are inconsistent with Aoki's results. It is estimated that impressions of robots can be more affected by other factors such as size and appearance, than by phrase and posture.

B. Implications

The above results have some important implications on robotics design for information presentation toward humans.

If there is an inconsistency between modes of robots' information presentation, such as postures and phrases dealt with in this study, it may cause dilemma in human cognition, and as a result, contents of information may not be memorized by humans. It can become a drawback in case of guidance robots.

On the other hand, inconsistency may be useful for an incentive to human attention to robots, for example, in public spaces. There is a possibility that inconsistency between some forms of robots such as appearance and utterance leads to human positive impressions of the robots. However, if human impressions of robots are independent on human information processing such as cognition and memorization, as suggested in the study, introduction of inconsistency to robotics design may cause dilemma between different objectives of robotics applications. To avoid this dilemma, robotics designers should take into account what type of inconsistency exists in forms of information presentation by robots.

Moreover, influences of inconsistency may depend on cultures in both cases of humans and robots. In both cases of Aoki's inconsistency between tones and contents of human utterances and that between postures and phrases of robots in the study, a specific type inconsistency had a strong influence. Aoki argued that uttering positive contents with negative tones was not familiar in the Japanese culture, and this unfamiliarity more strongly caused dilemma in human cognition [2]. Uttering impolite phrases with polite postures is also unfamiliar in the Japanese culture, and it is considered as a cause of the similar results in the experiment. However, this phenomenon may be specific in the Japanese culture which has high context dependency. Robotics designers should sufficiently care rules of emotion expression and politeness in cultures where robots are going to be introduced.

C. Limitations

The experiment in the study has some problems. First, sampling of subjects was limited to a small number of the Japanese university students. There is a possibility of difference on cognition of politeness in postures and phrases of robots between different generations and cultures [9]. In this sense, the generality of our findings is limited.

Second, some demographics of subjects were not controlled. Although gender had no effect in the experiment results, other factors, in particular, educational backgrounds and experiences of robots may affect the results.

Third, psychological traits of subjects were not taken into account. Aoki's study suggested that inconsistency between tones and contents more strongly influenced on subjects having higher trait anxiety. In case of robots, Nomura, et al. [10] suggested that negative attitudes and anxiety toward robots influenced communication behaviors of humans with robots. Walters, et al. [4] suggested that human preferences for robots depend on their personal traits such as emotional stability. Nomura and Okuyama [11] suggested that computer anxiety affects human impression of artificial agents having inconsistency. In this sense, there is a possibility that inconsistency of robots has interaction effects with human factors such as anxiety toward robots.

The aforementioned problems must be tackled in future experiments by extending the experimental design, for example, by sampling from more groups and using several types of demographic variables and psychological scales, and by taking into account other factors such as robots' appearances and tasks to be performed.

REFERENCES

[1] G. Bateson, *Steps to an Ecology of Mind*. Harper & Row, 1972. (Japanese translation: Y. Sato, Shisaku-Sha, 1990.).

[2] M. Aoki, "Influences of double-bind communication on human information processing system and emotion", *Japanese J. Educational Psychology*, vol.41, pp.31–39, 1993. (in Japanese).

[3] J. Goetz, S. Kiesler, and A. Powers, "Matching robot appearance and behavior to tasks to improve human-robot cooperation", in *Proc. 12th IEEE Ws. Robot and Human Interactive Communication*, 2003, pp.55-60.

[4] M. I. Walters, D. S. Syrdal, K. Dautenhahn, R. te Boekhorst, and K. L. Koay, "Avoiding the uncanny valley: robot appearance, personality and consistency of behavior in an attention-seeking home scenario for a robot companion", *Autonomous Robotics*, Vol.24, No.2, pp.159-178, 2008.

[5] S. Miyashita, "The Mastering of the Da and Desu/Masu Forms in Spoken Japanese by Singaporean Learners of Japanese: Cultural Attitudes Toward Level of Politeness and Their Effect on Language", *Science of Linguistics (Kotoba-No-Kagaku)*, vol.15, pp.135–158, 2002. (http://www.lang.nagoya-u.ac.jp/~kosakak/kotoba/Swissdy15.pdf).

[6] R. Barraquand and J. L. Crowley, "Learning Polite Behavior with Situation Models," in *Proc. 3th ACM/IEEE Int. Conf. Human-Robot Interaction,* Amsterdam, 2008, pp.209–216.

[7] T. Nomura and K. Saeki, "Effects of Polite Behaviors Expressed by Robots: A Case Study in Japan", in *Proc. IEEE/WIC/ACM Int. Conf. Intelligent Agent Technology*, Milan, 2009, pp.108–114.

[8] T. Kanda, H. Ishiguro, and T. Ishida, "Psychological Evaluation on Interactions between People and Robot," *J. Robotics Society of Japan*, vol.19, no.3, pp.362–371, 2001. (in Japanese).

[9] Y. Taki, "Culture and Politeness: Differences of Apology Strategies of the British and Japanese People: Comparison of Young and Older Subjects," *Studies in Language and Literature*, vol.22, no.2, pp.27–63, 2003.

[10] T. Nomura, T. Kanda, T. Suzuki, and K. Kato, "Prediction of Human Behavior in Human–Robot Interaction Using Psychological Scales for Anxiety and Negative Attitudes toward Robots," *IEEE Trans. Robotics*, vol.24, no.2, pp.442–451, 2008.

[11] T. Nomura and N. Okuyama, "Psychological Influence of Double-Bind Situations in Human-Agent Interaction", in *Proc. IEEE/WIC/ACM Int. Conf. Intelligent Agent Technologies*, San Diego, 2007, pp.102-108.