

Inconsistency in Behaviors of Virtual Agents and Robots: Case Studies on its Influences into Dialogues with Humans

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Introduction

Mutual interaction among contents and ways in utterances, nonverbal behaviors such as postures and gestures, and contexts is an important factor in human communication. Bateson (1972) argued, in his theory of double-bind situations, that inconsistency in human communication can cause mental illness, by combination with power relations forcing the inconsistency. Along Bateson's theory, Aoki (1993) experimentally validated influences of inconsistency between utterance contents and ways into human cognition and memorization. Krauss, Chen, and Chawla (1996) surveyed research results on relationships between hand gestures, comprehension of contents in speech, and speech production. These studies suggest the importance of consistency on agents' and robots' forms of information presentation in dialogues with humans.

However, there have been few studies that straightforwardly investigated this possibility in human-agent and human-robot interaction research. As an attempt for this investigation, some psychological experiments were conducted in Japan, by using simple animated characters (Ohnishi and Nomura, 2004; Nomura and Okuyama, 2007) and a small-sized humanoid robot (Nomura and Nakamura, 2010).

Case 1: Inconsistent Replies by Virtual Agents

This pilot study aimed at investigating influences of inconsistent replies by virtual agents under a context of quiz game (Ohnishi and Nomura, 2004). In the experiment conducted at May, 2004, human subjects interacted with animated characters having simple face image animation. The agents questioned subjects with texts on the computer screen, and then subjects answered to get their scores by clicking "yes" or "no" button with the mouse.

Two types of agents were prepared in the experiment. One provided with ten questions for which subjects could find the correct answers by thinking logically (e.g., question: "It was found that students having the habit of smoking do worse at school than those not having. Does it prove that tobacco decreases human intelligence?", correct answer: "no"). Another agent provided with ten questions related to feeling rules (Hochschild, 1983), that is, whether they are subordinated to tacit rules on emotions in specific situations (e.g., "Do you feel it strange if you did not feel sad in the funeral of your lover?"). Regardless of "yes" or "no" in subject's answers, this agent replied that subject's answer was wrong due to some reasons. The evaluation results by nine Japanese university students (males aged from 18 to 20) revealed that they had more negative impressions for the inconsistent agent.

Influences of Faces in the Inconsistent Agent

The results of the above study suggested that inconsistent replies by the virtual agent negatively affected human impression. On the other hand, Rickenberg and Reeves (2000) suggested that specific behaviors of animated characters influenced users' anxiety and task performance. The next study aimed at investigating interaction effects between human factors and physical characteristics of the agents under the inconsistent situation, while focusing on the problem on how the degrees of humans' computer anxiety affect impressions of agents dependent on the existence of face images (Nomura and Okuyama, 2007).

In the experiment conducted from August to October, 2006, two types of agents were prepared in within-subject design. One is the inconsistent agent same as the previous experiment. Another is the agent same as the inconsistent one, only except for no-existence of face image animation. Before the experiment, computer anxiety of each subject was measured by a Japanese psychological scale (Hirata, 1990). Subjects' impression evaluation of the agents after interaction was measured by a questionnaire, and then each subject's score of positive impression for the agent with face image animation was calculated. Sixteen Japanese university students (males: 11, females: 5, mean age: 18.9) participated to the experiment. The results revealed a

moderate level of negative correlation between the subjects' computer anxiety and positive impression scores for the agent with face image animation ($r = -.488, p = .055$), showing that subjects having stronger computer anxiety tended to more prefer to the agent without face image animation under inconsistency.

Case 2: Inconsistency between Phrases and Postures of a Small-Sized Humanoid Robot

Inconsistency dealt with in case study 1 was related to contents in human-agent dialogues. However, human-robot interaction can involve several types of inconsistency including influences of embodiment, such as those between tones and postures, between phrases and postures, and between phrases and appearances. This case study focused on inconsistency between phrases and postures of robots on politeness (Nomura and Nakamura, 2010).

In the experiment conducted from November to December, 2009, a small-sized humanoid robot was used. The experiment adopted a 2 x 2 between-subjects design with politeness of phrases in utterances and posture of the robot. The utterance contents of the robot consisted of six items related to self-introduction. The utterances with polite phrases were composed of "desu/masu" forms, and those with impolite phrases were composed of "dayo" forms, of which distinction is specific in the Japanese language. In the polite posture, the robot inclined its upper body forward just after greetings and thanks, and kept standing without any motion during the other utterances. In the impolite posture, the robot stayed lying on a soft pillow while waving one arm in time with the utterances.

A total of forty five Japanese university students participated to the experiment (male: 22, female: 23, mean age: 21.3). After each subject saw the robot in one of the four conditions, he/she was asked to recall the six items in the robot's self-introduction. The results of ANOVA for the recall scores revealed that 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.

Discussion

Case study 1 suggests that inconsistency in replies of virtual agents evokes human negative impressions of them. It also suggests that under inconsistency human factors such as computer anxiety influence effects of anthropomorphic agents like face images. Case study 2 suggests 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). These suggestions imply the possibility of mutual interaction between several factors in human-agent and human-robot dialogues.

Finally, it should be noted that the research in the paper has still been limited to the Japanese culture in the sense of rules of feeling emotions, expressing politeness, and so on. Future studies must tackle several problems such as exploring types of inconsistency through cross-cultural studies and investigating psychological states causing mutual interaction with inconsistency.

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