Effect of Agent Appearance on People's Interpretation of Agent's Attitude

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Abstract
We conducted psychological experiments in which participants were presented with artificial sounds that were intended to convey the attitudes of three different agents: a Mindstorms robot, an AIBO, and a laptop PC. The participants were asked to select the correct attitudes based on the sounds expressed by these three agents. The results showed that the participants had higher interpretation rates when the PC presented the sounds, even though the utilized artificial sounds were the same for all three agents.

Keywords
Agent appearance, agent attitudes, human-agent interaction

ACM Classification Keywords
J.4 [Computer Applications]: Social and Behavioral Sciences–Psychology.

Introduction

One of the hottest topics in human-agent interaction studies is determining what appearance an agent should have in order to interact with people effectively. People are said to build in their minds agent behavior models based on the agent's appearance; that is, the agents' appearance significantly affects the interaction

[1]. For example, when people encounter a dog-like robot, they expect dog-like behaviors from the robot, and they would naturally speak to it using verbal commands such as "sit" and "lie down." In contrast, they would not act this way toward a cat-like robot. Several studies have focused on how an agent's appearance affects its interactions with people [2,3]. On the basis of these studies, we are focusing on the issues of what the agent's appearance should be in order to interact with people effectively and what kind of information agents should express to people. As the first step in this research, we investigated how people interpreted presented information to see if they could determine the attitudes of agents that have different appearances.

Agents' attitudes, appearances, and expressed information

We experimentally investigated the basic psychological relationship between the appearance of an agent and the information it expresses on how people interpret its attitudes.

We selected **positive and negative attitudes** corresponding to valence values as primitive attitudes for the agents to express. If agents are to interact effectively with people they should be able to convey these two values [4].

Next, we utilized artificial sounds that did not include any verbal information, but were simple and intuitive for informing people about the agents' primitive attitudes. Komatsu [5] experimentally showed that people can estimate different primitive attitudes by means of simple beep-like sounds with different durations and inflections. We selected this kind of information because of the technical ease of implementation into the agents.

We selected three agents having different appearances: a Mindstorms robot (LEGO Corporation), an AIBO robot (SONY Corporation), and a normal laptop PC (Let's note W2, Panasonic Inc.).

Preliminary Experiment

We conducted a preliminary experiment to determine artificial sounds that were effective in evoking positive or negative attitudes from people.

We prepared 44 different types of triangle wave sounds with four different durations and 11 different F0 contours (F0 average: 131 Hz). The four durations were 189, 418, 639, and 868 ms. The 11 F0 contours were set so that the transition range of F0 values between the onset and endpoint of the sound stimuli were 0, ±25, ±50, ±75, ±100, or ±125 and were linearly downward or upward. These sounds had a tone like a computer beep. The sound stimuli labeled "189u25" indicates that duration was 189 ms and the F0 transition range was 25 Hz with an upward slope (increasing intonation).

The participants were 10 Japanese university students (6 men and 4 women; 19 – 23 years old). One randomly selected sound among the 44 prepared sounds was presented to the participants. Afterwards, the participants were asked to select the correct one of three attitudes as follows: 1) Positive: the PC's internal state appeared to be good, 2) Negative: the PC's internal state appeared to be bad, and 3) Undistinguishable: it was unclear whether the PC's internal state was positive or negative. Each participant

heard all 44 prepared sounds. The order of the sounds was counterbalanced for all 10 participants. The sounds were presented on a normal laptop PC.

The results of this preliminary experiment showed that all 10 participants believed the PC had positive attitudes for four sounds: 189u125, 418u125, 639u125, and 868u125. Also, all participants believed the PC had negative attitudes for four sounds: 418d25, 418d50, 418d75, and 639d50. These eight sounds were selected for the next experiment.

Experiment

This experiment investigated the effect of an agent's appearance on how participants interpreted its attitudes. The participants were presented with the sounds that had been selected in the preliminary experiment by agents with different appearances; a Mindstorms robot, an AIBO, and a normal laptop PC (see Figure 1). They were then asked to select the correct attitudes (positive, negative, or undistinguishable) based on the sounds made by these three agents.

The participants were 20 Japanese university students (17 men and 3 woman; 19 – 24 years old); they were not familiar with robots or the toys and had not participated in the preliminary experiment. First, the participants were told that the task of this experiment was to select one of three attitudes (positive, negative, or undistinguishable) based on the sounds the agents made. All participants experienced the following three conditions.

Figure 1. AIBO robot, Mindstorms robot, and laptop PC.

1. Eight sounds expressed by the Mindstorms robot (**MS condition**): the eight sounds came from an FM radio tuner placed on the Mindstorms robot. This radio tuner received sounds transmitted from the sound-expressing PC indicated in Figure 2.

2. Eight sounds expressed by AIBO (**AIBO condition**): the sounds were presented using AIBO's "AIBO entertainment player" software that was installed in the AIBO-operating PC.

3. Eight sounds expressed by the laptop PC (**PC condition**): This laptop PC was remotely operated by the sound-expressing PC.

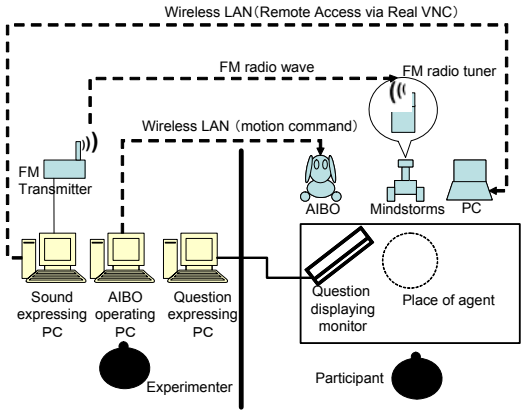

Figure 2. Experimental Setup.

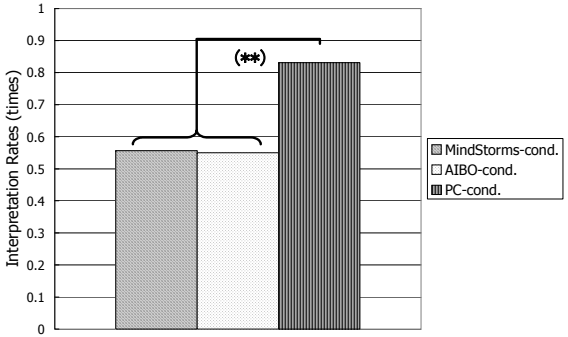

Figure 3. Participants' interpretation rates for the three experimental conditions.

The participants experienced these three experimental conditions in random order, and in all three conditions, the eight sounds were randomly presented. The order of conditions and the order of sounds were counterbalanced for the participants.

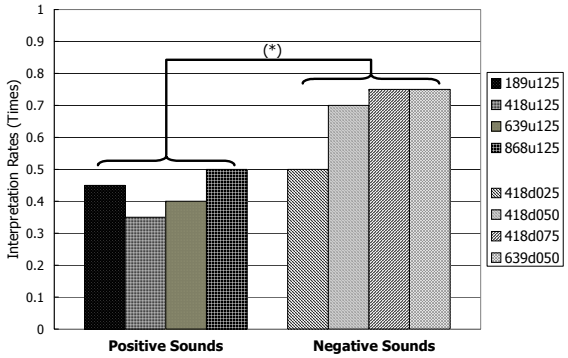

Figure 4. Interpretation rates of eight sounds for the MS condition.

We calculated the interpretation rates, which indicated how many times the participants succeeded in correctly determining the agents' attitudes among the eight sound stimuli. The participants had interpretation rates of 0.56 for the MS condition, 0.55 for the AIBO condition, and 0.83 for the PC condition (Figure 3). The results of an ANOVA showed significant differences between these conditions ($F(2,38)=15.56$, $p<.01$(**)), and a multiple comparison using an LSD test showed significant differences between the PC condition and the other two conditions (Mse=2.1219, 5% level). Thus, the participants showed **higher interpretation rates for the PC condition**, while they showed significantly **lower rates for the MS and AIBO conditions**, even though the same sounds were presented to participants in all three conditions.

Figures 4 – 6 show the interpretation rates of the eight sound stimuli for each experimental condition. For the MS condition (Figure 4), the four sounds that were

supposed to convey positive attitudes (positive sounds) had lower interpretation rates than the sounds that were supposed to convey negative attitudes (negative sounds) ($F(1,19)=7.60$, $p<.05$(**)). For the AIBO condition (Figure 5), the positive sounds showed the lower interpretation rates than the negative sounds ($F(1,19)=17.96$, $p<.01$(**)). For the PC condition (Figure 6), there were no significant differences between positive and negative sounds ($F(1,19)=0.10$, n.s.).

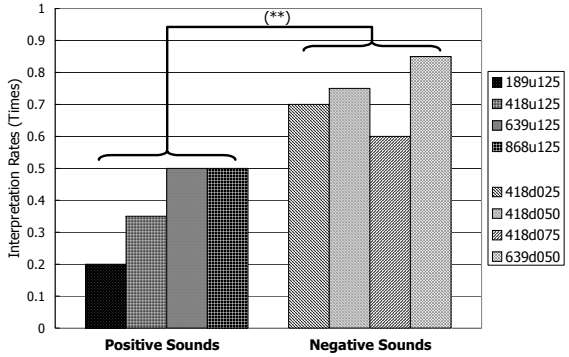

Figure 5. Interpretation rates of eight sounds for the AIBO condition.

The results of this experiment can be summarized as follows: **1)** The participants had higher interpretation rates for the PC condition than for the MS and AIBO conditions; **2)** the positive sounds showed the significantly lower rates than the ones for the negative sounds for the MS and AIBO conditions.

Discussion and Conclusions

The results of this experiment revealed that the agents' appearances affected people's interpretations of the agents' attitudes, even though the agents expressed the same information. Here, let us consider why such differences among experimental conditions were observed.

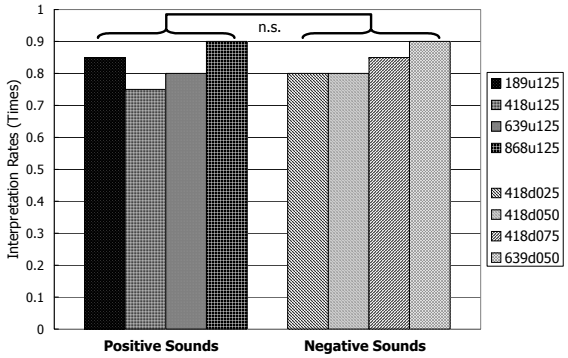

Figure 6. Interpretation rates of eight sounds for the PC condition.

For the AIBO condition (Figure 5), positive sounds had lower interpretation rates, so most sounds were interpreted as negative attitudes. The reason for this phenomenon would be rooted in the fact that the participants would expect dog-like expressions from AIBO whereas the expressed beeping sounds would be unexpected. Consequently, these sounds were interpreted as indicating that something wrong had happened, which is a normal interpretation of beeping sounds. Here, it can be said that the relationship between the AIBO's appearance and the expressed sounds were unfamiliar to the participants, and this unfamiliar relationship led to the participants' incorrect interpretations of the agent's attitudes.

For the MS condition (Figure 4), most sounds were interpreted as negative attitudes. The differences between positive and negative sounds for this condition were rather smaller than the ones for the AIBO condition. This means that the MindStorms' appearance would be suggestive of machine-like expressions, like beeping sounds. However, the interpretation rates were significantly lower than for the PC condition, even though both agents had machine-like appearances. Komatsu [6] reported that people would not expect beeping sounds from the MindStorms' appearance but rather more sophisticated machine-like expressions, such as from R2D2 in Star Wars. Therefore, the participants did not expect beeping sounds from the MindStorms robot, and these sounds were interpreted as negative attitudes. Here, it can be said that the relationship between the MindStorms' appearance and the expressed sounds were unfamiliar to the participants, and this unfamiliar relationship led them to make incorrect interpretations about the agent's attitudes.

For the PC condition (Figure 6), all eight artificial sounds received higher interpretation rates. This result would be rooted in the familiar relationship between the PC's appearance and its beeping sounds. Here, it can be said that the relationship between the PC's appearance and the expressed sounds were familiar to the participants, and this familiar relationship led the participants to make correct interpretations about the agent's attitudes.

Thus, the results of this experiment clearly indicated that the informing people of the correct attitude depend on whether the relationship between the agents' appearance and its expressed information is familiar or unfamiliar. In other words, agents should express imaginable or predictable expressions in order to inform people of their attitudes. We are planning to investigate what the most appropriate information is based on the agents' appearance. We expect that this follow-up study will contribute to establishing a design policy that can clarify the effective coupling between the appearance of an agent and the information it expresses.

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