Influence of body orientation and location of an embodied agent to a user

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Abstract

We attempted to suggest design of embodied communication of an embodied agent so that a user and the agent can establish equal social relationships in this study. To design human-agent social interaction considering the influence of human-agent embodied communication is important to construct human-agent equal social relationships. We especially focused on body orientation of the embodied agent and depth-dimensional virtual space partitioning and location of the agent in near or far side of the partition, considering gender difference in influence of body orientation and location in human-agent dyadic conversation. An experiment ($N = 48$) to examine the influence of these factors to performance of work (picture recognition task) and impression of the agent was conducted. The result of the experiment suggested tendency of facilitation of task performance in vis-à-vis arrangement between the user and the agent and agent's presence in the near side of the partition regardless of gender, and salient preference of correspondence of body orientation and location in female participants. This tendency was slightly different from the influence of body arrangement in human dyadic conversation. This result should be considered in design of human-agent embodied communication.

Keywords: embodied agent, embodiment, embodied communication, social response to communication technologies

1 Introduction

Social actors, artifacts whose behavior induces social response by human interactants such as embodied agents, humanoid robots, computers, and so on, and human interactants should be in the same standpoint to succeed communicating socially. First, there are some studies which attempted to situate a user and an embodied agent in the same standpoint with showing empathic facial expression of the agent to the user [10]. Some other studies revealed that social actors as "teammates" can interact with people smoothly [15, 11], and have potential to change attitude and behavior of interactants [5]. The social role of "teammates" enables people to recognize that they and the social actors are in the same standpoint. Such social actors which act in the same way as interactants can maintain and promote good social relationship between the interactants and themselves. Therefore, designing social relationships so that people and social actors are in the same standpoint is needed.

Among many social actors, we shed light on embodied agents. Softwares for speech interaction, navigation, presentations, in which embodied agents appear, has been increasing [3, 14]. However, few studies have paid attention to social influence of embodied agents' body expression which can change user's attitude and behavior [21, 20]. Therefore, when designing embodied agents for information navigation and learning softwares, investigating the social influence of embodied agents via their body expression is meaningful. We inspected social influence of body orientation and location of embodied agents to a user. We focused on body orientation of the agent which shows agent's back so that the gaze direction of the user matches the body orientation of the agent. Similarly, we took note to body location of the agent so that the user can perceive that he/she shares the same virtual space with the agent. we attempted to express that the embodied agent is user's peer. We conducted a psychological experiment to examine how the user pays attention to the embodied agent whose body orientation and location corresponds with the user's in order to determine how the body orientation and location of the agent influences the user's attitude and behavior. Also, the influence of agent's body orientation and location can depend on user's gender, we considered gender difference in the influence of the agent.

In this article, first, we review some studies on social influence of human body orientation and location and its difference between females and males. Second, we propose the hypothesis that the body orientation and location of embodied agents influence user's attitude and behavior. Third, based on this hypothesis, we describe the psychological experiment that we conducted to examine the influence of the body orientation and location of an embodied agent to the user's attitude and behavior from behavior of the agent. Next, the results of the experiment are described, and we then discuss the social influence of the body orientation and location of the agent and the possibility of interaction design to situate the user and the agent in the same standpoint.

2 Related work

In this section, we introduce some related work regarding to social influence of human body orientation and location, and body expression of a social actor. We mention dependence on user's gender difference in such social influence of a social actor.

2.1 Influence of human body orientation

Arranging bodies of two people in the same orientation often represents that they are in the same standpoint. For example, in some stores of jewelry and cosmetics, customers and clerks can match their body orientations by removing a counter [22]. In such an environment, the customer can regard the clerk as more familiar than when the customer and the clerk are face-to-face over the counter. Kendon [7] defined F-formation, that is, people's body location and orientation so that they can converse equally, directly with identifying who are involving in the conversation. Especially, side-by-side arrangement, one of the F-formation, appears in dyadic conversation against a wall. This evidence suggests that matching body orientation between two people means that they are close.

We predicted that correspondence of body orientation between a user and an embodied agent enables the user to share social perspective with the embodied agent, and induce the user to change his/her attitude to accept the embodied agent's opinion.

2.2 Influence of human body location

Users can perceive distance between an embodied agent and themselves not only with rules of perspective, but by partitioning virtual space depth-dimensionally and where the agent appears in the partition. According to rules of perspective, users perceive distance between themselves and human figures in a display [15]. The rules of perspective can be applied to human-agent distance. Moreover, user's criterion of perception of human-agent distance can change by partitioning space and where the agent appears in the partition. Shinozawa, et al. [16] indicated that when information recommendation in a display by the embodied agent in the display was more acceptable for human interactants than the recommendation in the display by the humanoid robot out of the display. In this case, the human interactants should perceive the display as separator of the space. The experiment indicated that if both agents appear on only one partition, users can regard them that as having similar thoughts; if one agent appears on one partition and the other agent appears on the other space, users can regard them that as having different thoughts. However, the study which discusses influence of the depth-dimensionally partitioned virtual space to the users does not still exist. This article suggests the following hypothesis: if the virtual space is partitioned depth-dimensionally, users can regard near side of the partition as users' and cannot regard far side of the space as users'. Then, if the agent appears near side of the partition, the users can regard themselves and the agent are in the same standpoint. This study attempts to examine this hypothesis.

2.3 Influence of body expression of a social actor

In one-way visual media from a sender to a recipient, directing body orientation of characters in the media to the recipient can induce recipient's strong impression about the characters. In fact, this design principle of the body orientation of the characters is applied to picture [18] and movie [1]. However, this principle refers to influence to arousal of the recipient, not valence of the recipient. In other words, this principle does not explain the influence of the body orientation of the characters to the positive or negative evaluation of the characters by the recipient. Additionally, this principle does not consider interactivity in the media.

Considering interactivity in human-agent interaction, the design of body orientation and location of embodied agent should be discussed based on the argument in Section 2.1 and 2.2. Some studies show evidence that body orientation correspondence between a person and a social actor induces positive impression on him/her. Kanda, et al. [6] implemented a humanoid robot which navigates a human guest in a place unfamiliar to the guest, and suggested that body orientation correspondence between the guest and the robot can cause positive impression about the robot to the guest. Similar tendency of body orientation correspondence between a human interactant and a social actor can also occur when a social actor is an embodied agent. Miyazaki [9] conducted an psychological experiment which a participant tried to write a story based on a picture book without text, and found that the participant tended to write a story from first-person perspective of a character when the character showed its back to the participant. Okamoto, et al. [13] implemented movie contents which embodied agents appear with corresponding body orientation between audiences and one of the agents so that the audiences can have empathic emotion to the agent. Although they implemented movie contents featuring human-agent body orientation correspondence, they did not examine whether the audiences could become empathic with the agent in the movie contents. Suzuki and Takeda [19] suggested that human-agent body orientation correspondence can induce user's attitude change by suggestion of the embodied agent in a psychological experiment. However, this experiment was conducted with the content of dyadic conversation by two embodied agents in vis-à-vis body orientation one of which always agree with participant's suggestion and the other of which always disagree with it, and such roles of the agents influenced the experimental result more strongly than the body orientation of the agent. In the experiment in this paper, only one embodied agent appeared to exclude the influence of the agent whose body orientation did not correspond with the user. In addition, to exclude the influence of perceived distance between the user and the agent based on rules of perspective, we take into account the influence of partitioning virtual space and body location of the agent.

Furthermore, one of the important factor in perceived psychological distance between a user and an embodied agent is perceived immersiveness in virtual space. In most cases, the user exists in physical space and the agent exists in virtual space. In this environment, human-agent interaction cannot be implemented with maintaining "direct manipulation" [17] and the lack of "direct manipulation" can cause trouble in human-agent interaction. Then, user's perceived immersiveness into the virtual space can overcome the lack of "direct manipulation" and situate a user and an embodied agent in the same standpoint. We focused on body location of the agent in depth-dimensionally partitioned virtual space as a visual cue to induce perceived immersiveness to the user.

2.4 Difference in influence of body arrangement between males and females

Some evidences indicate that influence of human body arrangement depends on gender. Nelson and Golant [12] pointed out the following difference in tendency of arrangement of body arrangement between females and males:

- Men tend to keep broader personal space than women. In other words, men often try to keep longer distance to others than women.

- In dyadic conversation, women try to keep vis-à-vis body orientation with others, while men tend to maintain side-by-side body orientation instead of vis-à-vis body orientation.

This tendency should appear in human-agent interaction considering the principle of media equation [15], since the style of human-agent interaction should be different between genders [2]. We take into account this gender difference in influence of body arrangement.

3 Psychological experiment

Based on the argument on influence of human body location and orientation and difference in personal space between males and females, we conducted a psychological experiment to examine the difference in influence of body location and orientation of an embodied agent between males and females.

3.1 Purpose

This experiment aimed to inspect the gender difference in influence of body location and orientation of an embodied agent.

3.2 Method

3.2.1 Participants

The participants of the experiment were forty-eight Japanese undergraduate students (25 females and 23 males; mean of age: 19.4; SD of age 1.23). They seemed to be skilled PC user since mean of length of history of their PC usage was 6.32 (SD: 2.90) years. The participants were randomly assigned one of the following experimental conditions:

- FRONT–THERE condition
  (female: $n = 5$; male: $n = 7$)

- FRONT–HERE condition
  (female: $n = 7$; male: $n = 5$)

- BACK–THERE condition
  (female: $n = 6$; male: $n = 6$)

- BACK–HERE condition
  (female: $n = 7$; male: $n = 5$)

3.2.2 Experimental design

In this experiment, the following independent variables were considered:

Body orientation of an embodied agent The agent directed its body to the participant (FRONT), or showed its back to the participant (BACK).

Body location of an embodied agent The virtual space where the agent appeared was divided in depth dimension with a fence. Then, the agent appeared near side (HERE) or far side (THERE) from the participant. The size of the agent in the display was the same between these conditions.

Participant's gender Taking the argument in Section 2.4 into account, we analyzed experimental data considering difference in participant's gender.

This experiment was $2 \times 2 \times 2$ ({FRONT, BACK} $\times$ {HERE, THERE} $\times$ {female, male}) between-participant design. Body orientation and location of the agent in this experiment are shown in Fig. 1–4.

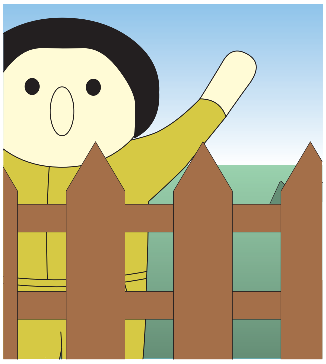

Figure 1: FRONT–THERE condition

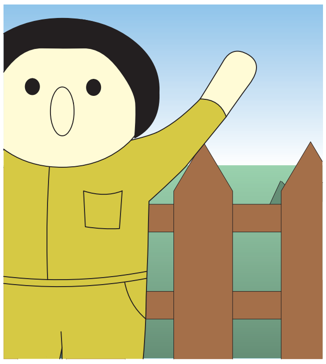

Figure 2: FRONT–HERE condition

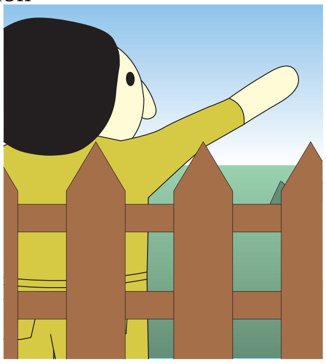

Figure 3: BACK–THERE condition

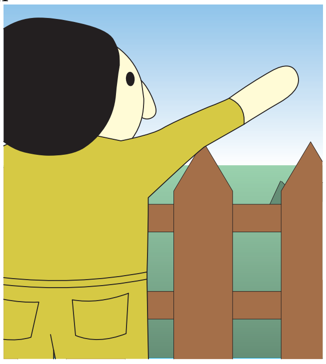

Figure 4: BACK–HERE condition

3.2.3 Hypotheses and predictions

Based on the argument in Section 2, we propose the following hypotheses:

- User's task performance becomes better when the user is female and the agent directs its body to the user; if the user is male, user's task performance becomes better when the agent directs its body corresponding with the user.

- User's impression to the agent becomes positive when the user is female and the agent directs its body to the user; if the user is male, user's impression to the agent becomes positive when the agent directs its body corresponding with the user.

- User's task performance becomes worse and impression to the agent becomes negative when the agent appears in far side of the virtual space than when the agent appears in near side of the virtual space.

Then, we predicted the following in the experiment:

P1 User's performance of a picture recognition task becomes better when the user is female and the agent directs its body to the user; if the user is male, user's performance of a picture recognition task becomes better when the agent directs its body corresponding with the user.

P2 User's evaluation on attitudinal measures about the agent becomes better when the user is female and the agent directs its body to the user; if the user is male, user's evaluation on attitudinal measures about the agent becomes better when the agent directs its body corresponding with the user.

P3 User's performance of a picture recognition task becomes worse and evaluation on attitudinal measures about the agent become worse when the agent appears beyond a fence than when the agent appears in front of the fence.

3.2.4 Procedure

Participants were told that this experiment was "evaluation of Web site navigation of zoo." First, a participant wrote age, gender, and history of PC use on a facesheet. Next, self-introduction by an embodied agent started. The agent has a role of a male zoo keeper. The self-introduction of the agent consisted of three parts: a job which *he* wanted to become when *he* was child (pharmacist), a field in which *he* majored at university (chemistry, especially about agrichemical), and an animal which *he* liked (elephant). The agent started to speak when the participant pushed the space bar for each part. After the self-introduction, the agent introduced animals according to the body orientation and location explained in Section 3.2.2 for each experimental condition. Then the participant was told that memory test for the content which the agent introduced was prepared afterward. The introduction of animals was about four different kinds of animal pairs which was bred at the same area in Japan. It takes 10 seconds to introduce each animal pair. Size of the agent was the same for each experimental condition. Speech of the agent was represented with text and speech balloons without acoustic media. The application for this experiment was implemented with Macromedia Flash (as a projector file, full-screen).

After the introduction of animals, the participant answered a questionnaire about attitudinal measures about impression of the agent. The questionnaire consisted of twenty-eight questions with 7-point scale adopted from previous studies [11, 8]. After answering the questionnaire, the participant was asked to answer the question about recognition of pictures of animals which the agent introduced with choosing 8 pictures from 32 pictures. The participant was debriefed, thanked, and dismissed after the question.

4 Results

4.1 Measures

The experimental results mainly consist of two parts: one is the results of picture recognition task (number of correct answers and number of incorrect answers) and the other is attitudinal measures about impression of the agent. The questions of attitudinal measures were categorized based on previous studies [11, 8], and eliminating some questions which decrease Cronbach's α the answers were averaged for each category. Then, the value of α was relatively low in some categories.

The categories of the questions are the following:

Teamwork This category consisted of three questions: "Did you think the agent as the partner?", "Did you think that you look at the animal with the agent?", and "Did you think you are in the same group with the agent?" (Cronbach's $\alpha = .71$).

Friendliness This category consisted of six questions: cheerful, likable, affectionate, kind, warm, and friendliness ($\alpha = .91$).

Openness This category consisted of eight questions: responsive, openness to influence, receptive, trust, acceptable, close in points aimed at, and agreeable ($\alpha = .77$).

Expertise This category consisted of two questions: knowledgeable and credible (Pearson's $r = .57$).

Information quality This category consisted of three questions: relevant, helpful and insightful ($\alpha = .51$).

4.2 Results of a picture recognition task

Table 1 shows the number of correct answers in the picture recognition task. For both male and female participants, the number in the BACK–THERE condition was relatively lower than the other conditions. Also, while the number in the FRONT–HERE condition was obviously higher than the other conditions in female participants, such tendency was not observed in male participants. Then, three-way ANOVA was conducted for the results and main effect of body orientation ($F(1,40) = 6.21$, $p < .05$), body location ($F(1,40) = 6.97$, $p < .05$) was significant and tendency of significance was observed at main effect of gender ($F(1,40) = 3.50$, $p < .10$). No significant interactions were observed in this ANOVA.

Table 1: Number of correct answers in a picture recognition task (SD in parentheses)

Female	THERE	HERE
FRONT	4.00 (2.00)	5.14 (1.21)
BACK	3.00 (1.55)	4.29 (0.95)
Male	**THERE**	**HERE**
FRONT	4.00 (1.15)	3.60 (1.14)
BACK	2.00 (1.41)	4.00 (0.71)

Table 2: Number of incorrect answers in a picture recognition task (SD in parentheses)

Female	THERE	HERE
FRONT	2.20 (1.10)	2.29 (1.38)
BACK	2.67 (2.07)	3.29 (1.26)
Male	**THERE**	**HERE**
FRONT	2.43 (0.98)	3.00 (1.00)
BACK	4.33 (2.66)	2.60 (1.14)

Table 2 shows the number of incorrect answers in the picture recognition task. In the female participants, the number in the BACK–HERE condition was relatively higher than the other conditions; in the male participants, the number in the BACK–THERE condition was relatively higher than the other conditions. In the same way, three-way ANOVA was conducted for the results, but only tendency of significance of main effect of body orientation was observed ($F(1,40) = 3.39$, $p < .10$) and no significance of other main effects and interactions were observed.

4.3 Attitudinal measures

The results of questionnaire is shown in Table 3. Three-way ANOVA was conducted for each categories.

In *Teamwork*, the value in the BACK–HERE condition and the BACK–HERE condition were higher than the other conditions in the female participants, while the value in the FRONT–HERE condition and the BACK–THERE condition was relatively higher than the other conditions in the male participants. In fact, the result of three-way ANOVA showed tendency of significance in main effect of body orientation ($F(1,40) = 3.03$, $p < .10$) and significant interaction between body orientation, body location and gender ($F(1,40) = 18.38$, $p < .001$), and multiple comparison for each gender showed the significant tendency described above. No significance of other main effects and interactions were observed.

In *Friendliness*, the value in the BACK–HERE condition was saliently higher than the other conditions in the female participants, while the value in the BACK–HERE and BACK–THERE condition was relatively higher than the other conditions in the male participants. The result of three-way ANOVA showed significant main effect of body orientation ($F(1,40) = 4.25$, $p < .05$) and tendency of significance in interaction between body orientation, body location and gender ($F(1,40) = 3.79$, $p < .10$). No significance of other main effects and interactions were observed.

In *Openness*, the value in the BACK–HERE condition was saliently higher than the other conditions in the female participants, while the value in the FRONT–HERE and BACK–THERE condition was relatively higher than the other conditions in the male participants. The result of three-way ANOVA showed significant main effect of body location ($F(1,40) = 5.23$, $p < .05$) and significant interaction between body orientation, body location and gender ($F(1,40) = 9.39$, $p < .01$). Multiple comparison for each gender showed that the value in BACK–HERE condition was significantly higher than that in the other conditions for the female participants, and tendency of significance in the difference between the value in the FRONT–THERE condition and that in the BACK–THERE condition for the male participants. No significance of other main effects and interactions were observed.

In *Expertise*, the value in the BACK–THERE condition was slightly lower than the other conditions in both female and male participants. However, the result of three-way ANOVA showed no significance of other main effects and interactions.

In *Information quality*, the value in the BACK–HERE condition was relatively higher than the other conditions in the female participants, while the value in the FRONT–HERE and BACK–THERE condition was relatively

Table 3: Mean values of 7-point-scale questionnaire for attitudinal measures (SD in parentheses)

Female		THERE	HERE
Teamwork	FRONT	3.33 (0.78)	2.19 (0.98)
	BACK	2.67 (1.53)	4.48 (0.96)
Friendliness	FRONT	3.97 (1.36)	3.45 (0.54)
	BACK	3.24 (1.26)	4.82 (0.99)
Openness	FRONT	4.90 (1.07)	5.14 (0.69)
	BACK	4.67 (1.45)	6.29 (0.59)
Expertise	FRONT	4.80 (1.04)	4.93 (1.24)
	BACK	4.33 (1.13)	5.07 (1.34)
Information quality	FRONT	3.87 (0.87)	3.95 (0.95)
	BACK	3.83 (0.98)	4.80 (0.79)
Male		**THERE**	**HERE**
Teamwork	FRONT	2.38 (0.91)	3.60 (0.86)
	BACK	3.28 (1.10)	2.40 (0.55)
Friendliness	FRONT	2.76 (1.46)	3.14 (1.04)
	BACK	3.88 (1.26)	3.80 (1.89)
Openness	FRONT	4.38 (1.10)	5.83 (0.83)
	BACK	5.47 (1.29)	4.67 (0.78)
Expertise	FRONT	4.57 (1.13)	4.70 (0.67)
	BACK	4.25 (1.44)	4.50 (1.58)
Information quality	FRONT	3.67 (1.07)	4.27 (0.43)
	BACK	4.11 (0.75)	3.60 (1.09)

higher than the other conditions in the male participants. However, the result of three-way ANOVA showed only tendency of significance in interaction between body orientation, body location and gender ($F(1,40) = 3.65$, $p < .10$) and no significance of other main effects and interactions were observed. Multiple comparison showed that the value in the BACK–HERE condition was significantly higher than the other conditions for the female participants, but no significant difference was observed for the male participants.

5 Discussion

5.1 Influence of body orientation of an embodied agent

The experimental results shown in Section 4.2 suggested that body orientation of an embodied agent can influence user's task performance and impression of the agent. When the agent directs its body to the female user the information offered by the agent can impress the user. This results partially support the prediction **P1**. Besides the influence of body orientation arrangement for female described in Section 2.4, this phenomenon can be explained from two approaches. One is vis-à-vis arrangement in F-formation [7]. In human-agent interaction between physical space and virtual space, vis-à-vis arrangement can be more appropriate than other arrangement of body orientation. However, we cannot conclude vis-à-vis arrangement is appropriate in human-agent interaction since different tendency in influence of agent's body orientation was observed in attitudinal measure of agent's impression. The other is social facilitation [23], that is, people tend to show high task performance when others see their task performance. According to the media equation [15], gaze of the agent instead of the human gaze can cause social facilitation in user's performance. However, it is known that the human gaze prevents people from better performance when they try the task at which they are poor [23]. Then, another analysis of difference in default task performance for each user should be examined.

Besides, the body orientation of the agent can influence not only the task performance but user's attitude toward the agent. According to the results described in Section 4.3, the values in indices except *Expertise* in the BACK–HERE condition for the female participants was saliently higher. However, this tendency contradicts the prediction **P2** since the female participant positively evaluated the agent's impression when agent's body orientation was corresponded with her. Although the experiment by Kanda, et al. [6] suggested that body orientation correspondence between a human interactant and a humanoid robot positively influences to his/her impression to the robot, they did not try to examine gender difference in this influence and the experimental environment in this study differs from that in their study. One of the possible explanation of the results is that perceived distance between the participant and the agent was different between the FRONT condition and the BACK condition besides the influence of body location. In this experimental environment, it depended on participant's perception that he/she located his/her body in the virtual space where the agent existed. Then, when the agent corresponded its body orientation to the participant, he/she might perceive the distance between him/her and the agent shorter than they are in vis-à-vis arrangement. This hypothesis should be examined in the future work.

5.2 Influence of body location of an embodied agent

The influence of body location was observed in the number of collect answer in Section 4.2 and the value of *Openness* in Section 4.3. In these measures, the value became lower when the agent appeared at far side of the virtual space than when the agent appeared at near side of the virtual space. This fact partially supports the prediction **P3**. It is possible that the fence in the virtual space was recognized as a separator in depth dimension of the virtual space by the participant, and he/she perceive a long psychological distance to the agent when the agent appeared at the far side of the virtual space. However, we cannot tell whether the participant recognized the function of the fence as the separator of the virtual space when the agent appeared at the near side of the space. In addition, while we used a laptop PC to display the agent, perceived distance between the user and the agent can depend on size and shape of display devices, such as an immersive display like CAVE [4], mobile devices like a PDA, a cellular phone, and so on. These issues should be addressed in future work.

6 Conclusion

In this study, we discussed gender difference in influence of body orientation and location of the embodied agent to users with conducting psychological experiment. In this experiment, we observed promotion of task performance when a participant and an embodied agent were in vis-à-vis arrangement and the agent appeared in near side of virtual space, and preference of correspondence of body orientation and location in female participants. To design embodied agents for information navigation and learning softwares considering this study should be important, with continuing the fundamental study of human-agent embodied communication.

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