Perspective sharing by body-orientation matching between a user and an embodied agent

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Abstract

People often try to discover and solve problems by accepting others' perspectives in daily life. In computer-supported environments, a user should be able to accept the perceived mental perspective of an embodied agent in the same way. In this study, mental perspective change by body-orientation correspondence between a user and an embodied agent was examined through a psychological experiment. When a participant (N=48) was solving a problem, two embodied agents, one of which always agreed with the participant's opinion, and another of which always disagreed with it, appeared face-to-face and discussed the problem in this experiment. The location of the virtual perspective of the participant depended on experimental conditions. After the problem solving, the participant evaluated each embodied agent based on his/her impression. The results of the experiment imply that the embodied agent's mental perspective that was different from the user's was acceptable to the user if the body orientation of the embodied agent corresponded with that of the user, although the abrupt body orientation correspondence of the user with the embodied agent can induce a negative social influence on the user. Considering the results of the experiment, how the design principle of human-agent body-orientation correspondence can be refined and applied in real situations is discussed.

INTRODUCTION

Considering others' thoughts to solve problems around them is an important practice for people, but some biases exist to make others' thoughts obscure in human cognitive processes. For example, in user interface design process, when developing a personal view (Norman, 1991) of a target user, a user-interface designer tends to unconsciously overlook situations around the target user. In group discussion, it is hard to compel majority's opinion since people unconsciously tend to conform to the majority's opinion (Janis, 1982). These facts imply that the human decision-making process often excessively focuses on easily available information around a person. Thus, a user interface for "persuading" (Fogg, 2003) a user to voluntarily accept a perspective from others can contribute to solving this problem. This study investigated the possibility of changing thoughts by perspective sharing with others, through designing body orientation of embodied agents.

This study attempts to reveal that an arrangement of the embodied agent's body orientation triggers the user's perspective sharing with the embodied agent. Studies on embodied agents have shown that a user regards embodied agents as voluntary thinking social entities when interacting with them. Moreover, embodied agents can visually appeal to a user's intuitive thought particularly with their body expression (Takeuchi, Watanabe, & Katagiri, 2005). However, most studies on embodied agents in a user interface have not considered body orientation of embodied agents. Embodied agents' body orientation is therefore focused on as a means to induce the user's perspective sharing with an embodied agent.

In this paper, first, the argument for focusing on perspective sharing by body-orientation matching between a user and an embodied agent is explained based on related works of perspective sharing and social response to the embodied agent's body expression. Second, a psychological experiment to examine the influence of perspective sharing with body-orientation matching between the user and the embodied agent is described based on this argument. Then, based on the results of the psychological experiment, how body-orientation matching between

the user and the embodied agent influence the user's perspective sharing and contribute to problem solving is discussed.

PERSPECTIVE SHARING BETWEEN A USER AND AN EMBODIED AGENT

In this study, two terms are introduced, *virtual perspective* (VP) and *mental perspective* (MP). These terms are necessary because the meaning of the term "perspective" changes depending on context. VP refers to a user's or an embodied agent's perspective in virtual space, while MP refers to the mental state of the user and the perceived mental state of the embodied agent.

This study intends to investigate the possibility of MP sharing between a user and an embodied agent by VP sharing. The VP sharing between them is accomplished by body-orientation matching as shown in Figure 1. Seeing the embodied agent that shows its back, the user should imagine what the agent sees and perceive the circumstance around it, and then inspect what the agent will think. This study attempts to examine the hypothesis that VP sharing by body-orientation matching between the user and the embodied agent causes MP sharing between them.

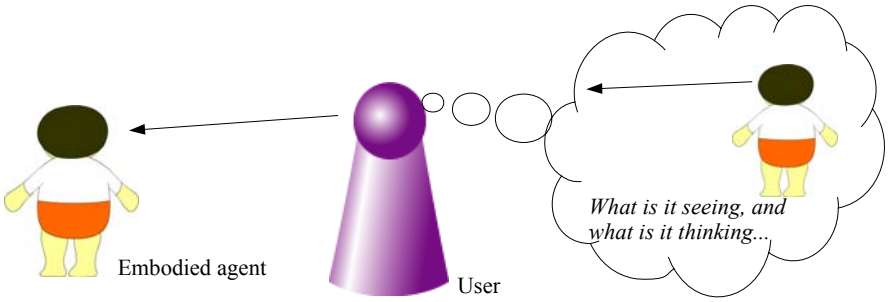

Figure 1: VP sharing caused by body-orientation matching between a user and an embodied agent

RELATED WORKS

In this section, through discussion of studies regarding cognitive limitations of perspective sharing among people and the social influence of the body orientation both of people and of embodied agents, the existence of a relation between the user's perception of the perspective of embodied agents and the arrangement of body orientation of the user and the embodied agents.

Problems in Perspective Sharing

The human cognitive system has limitations that impede people from trying to understand others' MP. This is because a mechanism to save cognitive resources exists in human cognitive processes used in considering other's thought. For example, some human social actions appear under certain rules without one's consideration and conscious thought (Bargh, 1997). Besides, people will tend to try to understand others unfamiliar to them with limited information such as appearance and tone of speech, because they unconsciously attempt to make a decision with limited information under uncertainty (Tversky & Kahneman, 1982). Furthermore, one tends to unconsciously regard what he/she knows as what others know (Birch & Bloom, 2004). In fact, these limitations were observed in estimating how long novice took to learn novel interface both in novices and experts (Hinds, 1999). This evidence implies that attempts to let people understand others' thought consciously will be needed.

Nevertheless, some attempts to enable people to consider others' MP exist. One of the famous examples is a user interface design process with personas (Cooper & Reimann, 2003; Pruitt & Grudin, 2003). In this process, personas are designed to represent typical target users and a user scenario is created based on defined personas. Such a process can let interface designers consider the possible activities of the target users. Although the user interface design process with personas can solve problems of considering others' thought, such an attempt by interface design *itself* does not exist. To put it differently, what kind of interface design enables users to take into account others' MP remains unclear. In this study, the body orientation is focused on to examine the potential of using it in interface design to let users inspect others' thoughts.

Sharing Embodied Agent's Mental Perspective with a User

Some studies have attempted to share MP by assigning a certain social role to an embodied agent to let a user perceive this agent as his/her peer. For example, Fogg (2003) introduced such social roles with the results of psychological experiments. According to his findings, an agent whose perceived characteristics are similar to the user's should be perceived as the user's peer, and also the user may regard the agent as a peer if the user is told explicitly that the agent is his/her "teammate." The strategy that a "co-learner agent" shows empathic facial expressions to a user (learner) in an e-learning system (Morishima, Nakajima, Brave, Yamada, Maldonado, Nass,

& Kawaji, 2005) can be regarded as the same approach to enable the user to perceive the agent as his/her peer. However, these studies did not mention the influence of the body orientation of embodied agents on the user's perception.

Moreover, some applications have attempted to express the agent's VP by showing the agent's back to the user. For example, in another e-learning system, user's VP in virtual classroom is set at the back of student agents which show their back (Watanabe, 2003). Furthermore, Okamoto, Okamoto, Nakano, and Nishida (2005) claimed that an embodied agent that showed its back to a user should provoke empathy from the user toward the embodied agent. None of these studies, however, used empirical evidence to argue that the correspondence of body orientation of an embodied agent with that of a user triggers the user to accept the opinion of the embodied agent.

With the lack of study on the potential for body-orientation matching to induce shared MP, this study sought to examine, through a psychological experiment, whether the body-orientation matching between the user and the embodied agent can express that the agent is the user's peer, and whether the user can accept perceived MP from the agent.

EXPERIMENT

The prediction for the experimental results was that the degree of the user's perception of the same social relationship with an embodied agent would be reflected in how much the user accepted the opinion of the embodied agent. The degree of acceptance of the embodied agent by the user was measured in an experiment conducted as follows.

Purpose of the Experiment and Predictions

Based on the hypothesis that *the opinions of an embodied agent regarded as a social entity that shares MP with a user tend to be accepted by the user*, the results of the experiment were predicted as follows:

P1 A user will change his/her opinion considering the perceived thought of an embodied agent whose body orientation matched with his/her own.

P2 A user will evaluate an embodied agent whose body orientation matches with his/her own as better than other agents whose body orientation does not agree with his/hers.

Experimental Design

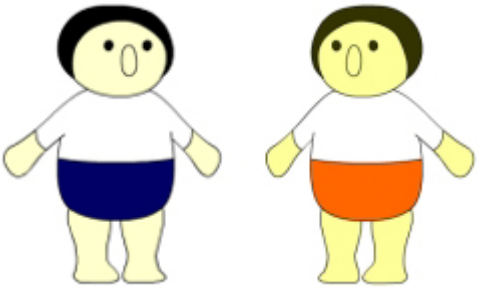

Figure 2: *Con*-agent (left) and *Pro*-agent (right)

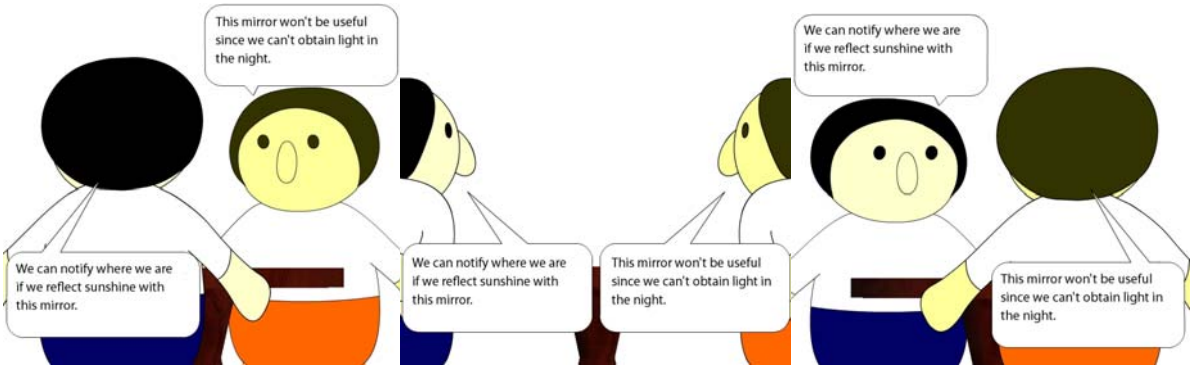

Figure 3: Arrangement of body orientation of two embodied agents: ***Con*-behind** (left), **Square** (center), ***Pro*-behind** (right)

In this experiment, the two embodied agents shown in Figure 2 appeared as represented in Figure 3. One of the embodied agents, which appeared on the right side of each figure, is called *Pro*-agent, and the other one is called

Con-agent in this article. The *Pro*-agent always agreed with the participant's opinion, while the *Con*-agent always disagreed with it. They were standing face-to-face over a table, but the perspective that the participant could take was different dependent on the condition to which he/she was assigned. In the ***Con*-behind** condition (left side in Figure 3) and the ***Pro*-behind** condition (right side in Figure 3), the participant took the perspective from behind the *Con*-, or the *Pro*-agent, respectively. The participant took the perspective from between the two embodied agents so that he/she could see side of each agent's body in the **Square** condition (centre in Figure 3). Participants were assigned one of these conditions randomly. Then, one independent variable (the VP that the participant could take, between-participant factor) existed.

Procedure

Forty-eight Japanese undergraduate and graduate students (24 males and 24 females, mean age: 24.3 (SD: 4.46) years old) participated in this experiment. All of the participants had been using PCs and browsing the WWW for at least 2 years. They were randomly assigned to one of the three experimental conditions. Thus, for each condition, there were 16 participants (8 males and 8 females).

First of all, each participant solved the desert survival problem (Lafferty & Eady, 1972). We used this task because it has been used in other studies (Fogg, 2003) and we thought that it could easily produce a difference of opinion between the two embodied agents without crucial noise factors. The participant ranked each of the 14 items (flashlight, jackknife, sectional air map, raincoat, magnetic compass, compress kit, pistol, parachute, salt tablets, water, book entitled *Edible Animals of the Desert*, vodka, top coat, and cosmetic mirror) depending his/her opinion of how important they were for survival. The participant input the rank of each item in a laptop PC and then the *Pro*-agent ranked the items the same as the participant, while the *Con*-agent ranked the items so that the rank of each item was different from that which the participant chose. The ranking of the *Con*-agent was determined automatically. For example, if the participant ranked item A as number 2, A's ranking by the *Con*-agent was number 8 regardless of what item A was. Based on the ranking decided in this process, for each item, the embodied agents suggested why they had ranked the item higher (or lower) than the other in randomized order. The speech of the embodied agents was shown to the participant solely with text in speech balloons; no acoustic medium was used in this experiment. The speech balloons for the embodied agents did not appear simultaneously. One of the balloons appeared first with animation in which the embodied agent that was speaking nodded. Then the other speech balloon appeared with animation in which the embodied agent that was speaking shook its head. Which of the embodied agents started to speak first was decided randomly, but the frequency with which each agent spoke first was the same. That is, for 7 items randomly chosen, the *Pro*-agent was first to suggest its opinion about the item's rank, and for the others, the *Con*-agent was first to tell its opinion. The participant could change the ranking of the items if he/she wanted to do so after considering the two embodied agents' opinion. The two embodied agents were implemented with Macromedia Flash and embedded in a Web page displayed with Mozilla Firefox (full screen mode), and experimental data were collected via the WWW with the CGI program. After finishing modifying the item ranking, the participant evaluated the impression of the two embodied agents with a paper-and-pencil questionnaire. Finally, the participant was debriefed, thanked for his/her participation, and dismissed. The experiment took around 30–40 minutes for each participant.

RESULTS

In this section, based on analyses of the results of the experiment, the data is discussed in detail.

Measures

First, as measures of attitude change, we classified the participants' ranking of items in the following manner. For example, any item ranked as number 3 by a participant and the Pro-agent was ranked as number 6 by the *Con*-agent. In this case, if the participant modified the rank of this item higher than number 2, this item was counted on *number of items whose ranking were changed with the* Pro-*agent's opinion*; if he/she modified the rank lower than number 4, it was counted on *number of items whose ranking were changed with the* Con-*agent's opinion*. On the contrary, for the case that an item ranked as number 10 by a participant and *Pro*-agent and ranked as number 7 by *Con*-agent, if the participant modified ranking of this item higher than number 9, this item was counted on number of items whose ranking were changed with the *Con*-agent's opinion; if he/she modified the ranking of this item lower than number 11, it was counted on number of items whose ranking were changed with the *Pro*-agent's opinion. Any items for which the participant did not modify the ranking, the items were counted on *number of items whose ranking was not changed*.

Evaluation of each embodied agent's impression consisted of twenty-nine 7-point scale questions. The questionnaire was made taking into account previous studies (Nass, Fogg, & Moon, 1996; Suzuki & Yamada, 2004). Then, these three indices suggested by factor analysis were adopted:

Perceived similarity This represented the user's perception of the embodied agent's similarity to him/her. It was an index of ten items: perceived similarity of final rankings to the embodied agent's hypothetical final ranking, relevance of thought, acceptance of the embodied agent's advice, perceived similarity of approach, perceived similarity of interaction style, perceived similarity of final ranking to the embodied agent's initial ranking, perceived similarity of initial rankings, receptivity to the embodied agent's suggestions, degree of empathy to the embodied agent, and perceived similarity of suggestions (Cronbach's $\alpha = .945$).

Perceived intelligence This expressed the user's perception of the intelligence of the embodied agent. This index was made from eight items: capability of the embodied agent, trust in the embodied agent's information, helpfulness of the embodied agent's information, articulateness of the embodied agent's suggestions, intellectuality of the embodied agent, insightfulness of the embodied agent's information, dependence on the embodied agent's suggestions, and cleverness of the embodied agent ($\alpha = .896$).

Friendliness This regarded the user's perception of the friendliness of the embodied agent. It consisted of two items: warmth, and kindness of the embodied agent (Pearson's $r = .909$).

Attitude Change

Table 1: Frequency of change direction of each item's ranking for each condition

	Total number of items whose ranking			
	were changed with the Pro-agent's opinion	were not changed	were changed with the Con-agent's opinion	Total
***Con*-behind** ($n = 16$)	77	52	72	201
Square ($n = 16$)	91	131	109	331
***Pro*-behind** ($n = 16$)	56	41	43	140
Total	224	224	224	672

Table 1 indicates the number of items for which each agent did and did not change the participants' rankings. The result of a χ^2-test revealed that there was significant difference in the distribution of the variables of ranking change among these three conditions ($\chi^2(4) = 15.34$, $p < .01$). Moreover, the number of items whose rankings were changed with the *Pro*-agent's opinion was significantly highest in the ***Con*-behind** condition (adjusted residual: $z = 1.79$, $p < .10$), and lowest in the **Square** condition ($z = -2.68$, $p < .01$) among the three conditions. The number of items whose ranking were not changed was significantly lowest in the ***Con*-behind** condition ($z = -3.16$, $p < .01$) and highest in the **Square** condition ($z = 3.38$, $p < .01$) among three conditions. Additionally, in the ***Con*-behind** condition, the number of items whose ranking changed with *Con*-agent's opinion was significantly higher than other conditions ($z = 1.88$, $p < .10$).

Evaluation Based on Impression of Two Embodied Agents

Table 2: Mean (SD in parentheses) for variables about evaluation based on participant's impression of embodied agents

	***Con*-behind** ($n = 16$)	**Square** ($n = 16$)	***Pro*-behind** ($n = 16$)
Perceived similarity			
Pro-agent	5.319 (0.917)	5.150 (0.992)	5.144 (1.228)
Con-agent	3.054 (0.921)	3.186 (0.699)	3.068 (0.833)
Perceived intelligence			
Pro-agent	4.492 (0.948)	4.273 (0.757)	4.422 (1.135)
Con-agent	4.136 (0.877)	4.195 (0.906)	4.086 (0.870)
Friendliness			
Pro-agent	4.469 (1.271)	4.063 (0.793)	4.093 (1.129)
Con-agent	2.531 (1.231)	3.438 (1.153)	3.188 (1.031)

Table 2 shows the results of evaluation based on participants' impressions of the embodied agents. To analyze these results, we applied a split-plot design that consisted of two independent variables: embodied agents (*Pro*-agent and *Con*-agent; within-participant factor) and experimental conditions (***Pro*-behind**, **Square**, and ***Con*-behind**; between-participant factor) when conducting two-way analysis of variance for each dependent variable.

First, for each condition, the evaluation of the similarity of the *Pro*-agent was higher than that for the *Con*-agent. Indeed, according to 2×3 two-way analysis of variance, the main effect of the embodied agents was significant ($F(1, 45) = 97.90$, $p < .001$). However, there was no interaction between the experimental condition factor and

the embodied agents factor, thus no influence from the experimental conditions should appear. Second, while Table 2 shows that the evaluation of the intelligence of the *Pro*-agent was slightly higher than that of the *Con*-agent, this difference was not significant ($F(1, 45) = 1.862$, *n.s.*). Finally, according to Table II, on the evaluation of the friendliness of the *Con*-agent, the participants in the ***Con*-behind** condition evaluated the *Con*-agent lower than did those in other condition, despite the fact that there seemed to be little difference in the evaluation of the friendliness of the *Pro*-agent among the three conditions. Actually, interaction between the experimental conditions and the embodied agents was significant ($F(2, 45) = 2.957$, $p < .10$). Thus, examining the significance of difference of the *Con*-agent among the experimental conditions by testing the simple main effect with Tukey's HSD test, a significant difference between the ***Con*-behind** and the **Square** condition was found ($p < .10$).

DISCUSSION

Considering the results of our psychological experiment, the user's MP change by VP sharing with the embodied agent and the change of the impression that the user has of each embodied agent are discussed in this section, with mentioning future works.

Induction of Perspective Sharing by Body-orientation Matching

In this experiment, participants in the ***Con*-behind** condition changed their opinions more often than did those in the **Square** condition, and the participants in the ***Pro*-behind** condition also changed their opinions (not significantly, nevertheless) more than those in the **Square** condition. That is, a tendency was observed for the participant to change his/her opinion with the embodied agent whose body orientation corresponded with his/hers and had different opinions from him/her. Then, the prediction **P1** was partially supported. This result suggests that an embodied agent that shares VP with the user and has a perceived different MP from the user's can share MP with the user. The ***Con*-behind** condition showed a salient tendency since the perceived difference of MP between the participant and the *Con*-agent was larger than that between the participant and the *Pro*-agent. Furthermore, three of the participants in the **Square** condition did not change their opinions at all in spite of the embodied agents' interaction. This may be because body arrangement in the **Square** condition can induce the user's interest in agents' interaction less than in the other two conditions. Consequently, body-orientation matching between a user and an embodied agent can induce the user's acceptance of the perceived MP of the agent.

Nonetheless, how long the influence of body orientation correspondence between a user and an embodied agent continues is still unknown. If the user interacts with an environment where embodied agents appear and some of them match with the user in body orientation for a long time, whether the influence of body orientation correspondence between them is reinforced or diminished cannot be judged with a psychological experiment inside a laboratory in the limited time of half an hour. Therefore, observation of interaction between the user and an environment in which embodied agents appear for a long time is needed to consider body-orientation matching in practical application.

Role of an Embodied Agent as User's Peer

Despite the fact that body-orientation matching between a user and an embodied agent can promote the user's acceptance of the perceived MP of the agent, greater difference in the perceived MP between the user and the agent may let the user feel proportionately less friendly toward the agent. The experimental results indicated that the evaluation of the friendliness about the *Con*-agent by the participants in ***Con*-behind** condition was lower than that by the participants in the **Square** condition. This result contradicts the prediction **P2**. Additionally, regardless of body orientation, the participants perceived similarity of thought with *Pro*-agent. This result also does not support the prediction **P2**, and contradiction between the result and the prediction occurred in the ***Con*-behind** condition. Taking into account these results, corresponding VP between a user and an embodied agent whose perceived MP is largely different from the user can give the user a negative impression of the agent.

To avoid negative influence of the embodied agent on the user by VP corresponding, the agent should have perceived similarity in its features other than the body-orientation matching adopted in this experiment and perceived MP. Even if the perceived MP is different, the user can be influenced from another perceived similarity and a positive impression of the agent, as shown in related works; as a result, the user can accept the opinion of the agent that is different from his/hers (Fogg, 2003). The user abruptly encountered two embodied agents in this experiment and no other social cues than VP and perceived MP of the agents were given in this experiment. If the participant had the chance to understand other social cues and find something in common with the *Con*-agent, he/she would have felt more similar and friendly with that agent. The design of the encounter and development of the relationship between a user and an embodied agent should be important in MP sharing between them.

Possible Application of Body-orientation Matching

MP sharing has an important role in problem discovery and solving. MP sharing between a prospective user and an interface designer should contribute to improving user interface design, and MP sharing between minority and majority in group discussion may help with finding problems in the majority's solution. Taking the MP of a teacher can help a student with finding how to derive the correct answer in a mathematical problem (Morita & Miwa, 2003). Although there are problems of encounter and relationship development design between a user and an embodied agent, body-orientation matching between them can cause the user's acceptance of the perceived MP of the embodied agent. Then, considering a real situation of problem discovering and solving, MP sharing by body-orientation matching between the user and the embodied agent should be examined.

CONCLUSION

In this study, mental perspective change by the virtual perspective correspondence between a user and an embodied agent was attempted. The result of a psychological experiment suggested that a perceived mental perspective of an embodied agent that was different from the user's perspective was acceptable to the user when the body orientation of the embodied agent corresponded with that of the user, compared to the environment in which the body orientation of the embodied agent and the user did not match, though the abrupt body orientation correspondence of the user with the embodied agent can give the user a negative social influence. The design principle of human-agent body-orientation correspondence should be further refined in human-agent encounter and social relationship development, and must be examined in real problem discovering and solving situation. In the future, we aim to discover design principles of embodied agents' body expression that can let a user understand others' mental perspectives that are different from his/her own.

REFERENCES

Birch, S. A. J., & Bloom, P. (2004). Understanding children's and adults' limitation in mental space reasoning. *Trends in Cognitive Science*, 8(6), 255–260.

Cooper, A., & Reimann, R. M. (2003). *About face 2.0: The essentials of interaction design*. Indianapolis, IN: Wiley.

Fogg, B. J. (2003). *Persuasive technology: Using computers to change what we think and do*. San Francisco, CA: Morgan Kaufmann Publishers.

Hinds, P. J. (1999). The curse of expertise: The effects of expertise and debiasing methods on predictions of novice performance. *Journal of Experimental Psychology: Applied*, 5(2), 205–221.

Janis, I. L. (1982). *Groupthink: Psychological studies of policy decisions and fiascoes* (2nd ed.). Boston, MA: Houghton Mifflin Company.

Lafferty, J. C., & Eady, P. M. (1974). *The desert survival problem*. Plymouth, MI: Experimental Learning Methods.

Morishima, Y., Nakajima, H., Brave, S., Yamada, R., Maldonado, H., Nass, C., et al. (2004). The role of affect and sociality in the agent-based collaborative learning system. In E. André, L. Dybkjær, W. Minker, & P. Heisterkamp (Eds.), *Affective Dialogue Systems, Tutorial and Research Workshop, ADS 2004* (pp. 265–274). Kloster Irsee, Germany: Springer.

Morita, J., & Miwa, K. (2003). Changes of inferences caused by obtaining different perspectives: Analysis based on analogical reasoning. In *Proceedings of the 4th International Conference on Cognitive Science* (pp. 463–468).

Nass, C., Fogg, B. J., & Moon, Y. (1996). Can computers be teammates? *International Journal of Human-Computer Studies*, 45(6), 669–678.

Norman, D. A. (1991). Cognitive artifacts. In J. M. Carroll (Ed.), *Designing interaction: Psychology at the human-computer interface* (pp. 17–38). Cambridge: Cambridge University Press.

Okamoto, M., Okamoto, K., Nakano, Y. I., & Nishida, T. (2005). Supporting the creation of immersive CG contents with enhanced user involvement. In *Proceedings of the Symposium on Conversational Informatics for Supporting Social Intelligence and Interaction — Situational and Environmental Information Enforcing Involvement in Conversation, AISB'05: Social Intelligence and Interaction in Animals, Robots and Agents* (pp. 87–96). Hatfield, UK.

Pruitt, J., & Grudin, J. (2003). Personas: Practice and theory. In *Proceedings of the 2003 Conference on Designing for User Experiences*. San Francisco, CA.

Suzuki, S. V., & Yamada, S. (2004). Persuasion through overheard communication by life-like agents. In *Proceedings of the 2004 IEEE/WIC/ACM International Conference on Intelligent Agent Technology* (*IAT'04*) (pp. 225–231). Beijing, China.

Takeuchi, Y., Watanabe, K., & Katagiri, Y. (2004). Social identification of embodied interactive agent. In *Proceedings of the 13th International Workshop on Robot and Human Interactive Communication* (*RO-MAN 2004*). Kurashiki, Japan.

Tversky, A., & Kahneman, D. (1982). Judgment under uncertainty: Heuristics and biases. In D. Kahneman, P. Slovic, & A. Tversky (Eds.), *Judgment under uncertainty: Heuristics and biases* (pp. 3–20). New York: Cambridge University Press.

Watanabe, T. (2001). E-COSMIC: Embodied communication system for mind connection. In M. J. Smith (Ed.), *Usability evaluation and interface design: Cognitive engineering, intelligent agents and virtual reality* (Vol. 1, pp. 253–257). Mahwah, NJ: Lawrence Erlbaum Associates.

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