Understanding Social Agents in Virtual Space

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Abstract. Daily conversation plays an important role in maintaining human relations. But although many researchers have proposed ways to support having daily conversations when in remote sites, none have achieved this successfully yet. We believe that the reason for these failures is that previous studies focused on designing a communication environment that would simulate face-to-face situations (e.g. life-size video projection and multi-user virtual spaces.) We propose an additional approach which consists in placing social software agents as facilitators of human communication. In our virtual space, the social agent approaches people and provides them a topic to talk about when their conversation falters. To understand the effects of using the agent we conducted a series of social psychology experiments which include an intercultural communication experiment between Kyoto University and Stanford University. Our conclusion was that: 1) the agent should have a social identity that is shared by the people, and 2) the agent should be as fair and impartial as possible to prevent people from disuniting. These results show that it is important to include these social aspects when designing software that interacts with human societies.

Introduction

The advances in information and telecommunication technologies have made it possible to enjoy worldwide communication from a living room. However, this kind of distant communication seems to be limited to discussions related to shared goals or interests. This limitation had already been reported before the wide spreading of the Internet. In the early 1990's, many researchers tried to produce informal daily conversations among distributed workplaces such as different floors and distant buildings. It was known that daily conversation sustains human relations, contributes to collaborative working, and is indispensable to an organization. Although, the researchers proposed various brilliant ideas to extend videoconferences, they could not generate daily conversations between remote places that would take place as frequently as in face-to-face environments [1]. Currently, computer-supported communication is a common thing in our daily lives. However, they are still far from being a substitute for face-to-face communication. Internet BBSs seem to be regarded as online places for free discussions without worrying about human relations, rather than for maintaining human relations. Even though the importance of international collaboration is increasing, we have not yet found how to support daily conversation between geographically separated places.

It can be said that it is almost impossible to support daily conversation by providing only such environments as videoconferencing systems and BBSs. This conclusion suggests us to upgrade the level of communication support from the environments. Our idea was to place a third-party person in each environment as a facilitator for conversations. But since it is very

expensive to place human facilitators we tried to make software facilitators. The software facilitator has to intervene in human conversations. To implement such active software, we adopted existing agent technologies. But our software facilitator is not the same as usual software agents because it has the capability to socially interact with people. This kind of agents is called "social agents" [2].

We developed social agents that support daily conversation. We used *FreeWalk* as the communication environment to test the effectiveness of the agent. FreeWalk, which was also developed by us, is a 3D virtual space for videoconferencing [3]. Since FreeWalk transmits positional relationships as well as video and voice, the meeting participants can use social cues such as interpersonal distances and gaze directions. We used FreeWalk because it is one of the richest communication media. Other leaner media (including BBSs) are poor in social cues and inherently foster the various factors that obstruct smooth communication. Therefore, FreeWalk is a good testbed to distinguish the communication support that can be provided by only an agent.

We conducted three social psychology experiments in which a social agent intervenes in human conversations that take place in virtual space. Figure 1 shows our social agent interacting with human participants in the FreeWalk virtual space. The experiments clarified some interesting effects of using social agents in human communication and relations.

1. Social Agents

Social agents are agents that have sociality. Agents are usually defined as subjects that can decide their behavior autonomously. Since this definition includes not only software but also robots and human beings, agents are called "software agents" when implemented by software. Examples of software agents are search engines and email filtering software. Social agents are software agents that can interact with people and play a social role. An example of a social agent is a guiding character on a company's web site [4].

In a few words, the general goal of most studies on social agents is the socialization of user interfaces. The researchers believe that socialized interfaces are necessary for natural human-computer interaction. They are trying to design software that can induce users to respond socially in the same way as they respond to other people. Their studies are based on either of the following two hypotheses. The first hypothesis is that software can become social when it gains communication skills equal to those of human beings. This is the software-centric hypothesis. The second hypothesis is that human beings tend by nature to regard all media (including software) as social entities. This is the user-centric hypothesis and takes no account of how much communication skills the software has.

The previous studies based on the software-centric hypothesis have developed and analyzed the verbal and nonverbal communication skills of social agents. For example, some researchers combined such technologies as natural language processing, speech synthesis/recognition and computer graphics to implement the dialogue function [5]. Other researchers have evaluated the media aspects and the linguistic aspects of such dialogue functions. With the analysis of the media aspects it was proved that users respond more socially to an anthropomorphic interface with facial animations and synthesized speech than to text-based interfaces [6]. With the analysis of the linguistic aspect it was found that sentences including first person pronouns could induce social responses [7].

On the other hand, the previous studies based on the user-centric hypothesis have proved that human response to media such as computer screens and TV monitors is actually equal to that to other people [8]. This fact seems odd to many people but it is not hard to understand if you consider that during the long history of mankind, human brains became used to an environment where the only social entities were human beings themselves. Social psychology

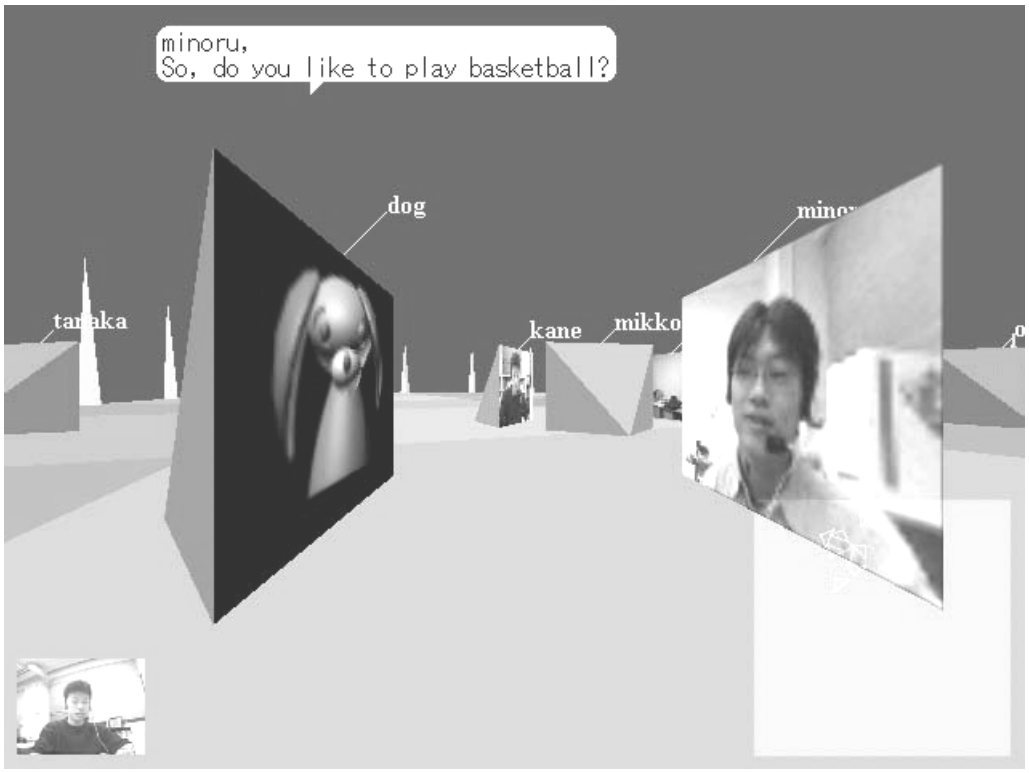


Figure 1. Social Agent in a Virtual Space

has revealed many influences of the individual psychological attributes of a person (and thus media) on interpersonal communication. For example, it is known that people like those who say flattery, those who have similar personality, and those who belong to the same group. It has been proved that these findings may be used to design attractive software.

Note that these user-centric studies dealt with individual attributes of media while the software-centric studies dealt with the whole communication skills of social agents.

Our study applied social agents to communication support while the previous studies applied them to only human-computer interaction. We conducted a series of social psychology experiments based on the two approaches provided by the previous studies. First, we used the software-centric approach to analyze how social agents could support human conversations. Then, we used the user-centric approach to conduct two experiments that would test the two hypotheses obtained from the first experiment.

2. Software-centric Analysis

In the software-centric experiment, we observed how social agents could help the formation of human relations through intercultural communication [9]. In the virtual space of FreeWalk, our social agent played the role of facilitator of first-time meetings between undergraduate students living in Kyoto City and undergraduate students of Stanford University. They were simply instructed to introduce themselves and chat. The agent provided them a topic to resume their faltering conversation. The agent has capabilities necessary to become a facilitator, like adjusting interpersonal distance [10], controlling gaze direction [11], and eavesdropping on a conversation to detect its falter [12].

2.1 Design of Human-Agent Interaction

The agent's behavior that maintains the conversation of two meeting participants was designed as a finite state machine. The input for the machine is a perceived social cue. The agent has the three internal states: "waiting", "approaching", and "intervening". The state transition is triggered off by three kinds of social cues: interpersonal distance, gaze direction, and awkward pauses. The agent's behavior, similar to that of a host at a party, is detailed below.

- *Waiting state*

The agent keeps a long distance from the participants and strolls around the corner of the virtual space until it detects an awkward pause in the conversation of the participants. When the voice volume of the participants' microphones is lower than a certain level for more than the defined period of time, the agent infers that an awkward pause has occurred. If the participants are standing closely and facing each other when the agent detects the pause, the agent infers that their conversation falters because of a lack of topics and switches to the approaching state.

- *Approaching state*

The agent approaches the participants and positions itself in order to create a circle so as to have a conversation with them [11]. If the participants resume their conversation while the agent is approaching, it stops approaching and goes back to the waiting state. When the agent successfully finishes forming a circle with the participants, it changes to the intervening state. This approaching behavior changes the interpersonal distance between the agent and the participants so that they can easily understand whether the agent is taking part in their conversation or not.

- *Intervening state*

Conversation is a joint activity and thus needs a common ground [12]. To provide the participants a common ground to resume their conversation, the agent asks them the same question to reveal their shared or different interests making them a topic to talk about. First, the agent asks either of the participants a yes/no question (see Figure 2 (a)). When she/he replies (see Figure 2 (b)), the agent comments on the answer (see Figure 2 (c)) and asks the other participant the same question (see Figure 2 (d)). According to the two answers obtained from the participants, the agent suggests their talking about their shared or different interest. Finally, the agent leaves the participants and transfers to the waiting state. As you can see in Figure 2, the agent faces the addressed person when it asks a question. This gazing behavior helps the participants to know whom the agent is asking the question to.

2.2 Results

Since a good topic for the first-time meetings in some cultures might be a bad topic that harms human relations in other cultures [12][13], we used a web-based questionnaire to survey common good and bad topics for Japan and the US. The good and bad topics retrieved from the questionnaire data showed that both Japanese and American students had similar opinions. The topics selected as "good" were innocuous topics such as weather, movies, music, and sports. The topics considered as "bad" were controversial topics like money, politics, culture, and religion. Since we thought that the difference between the good and bad topics could

clarify the effect of social agents, we made a safe agent that provides good topics and an unsafe agent that provides bad topics. In the experiment, we observed how the safe agent could help in first-time meetings and how the unsafe agent could disturb them.

The first-time meetings were held in FreeWalk's virtual space running on two PCs located at Kyoto University and Stanford University. As shown in Figure 3, CCD cameras,

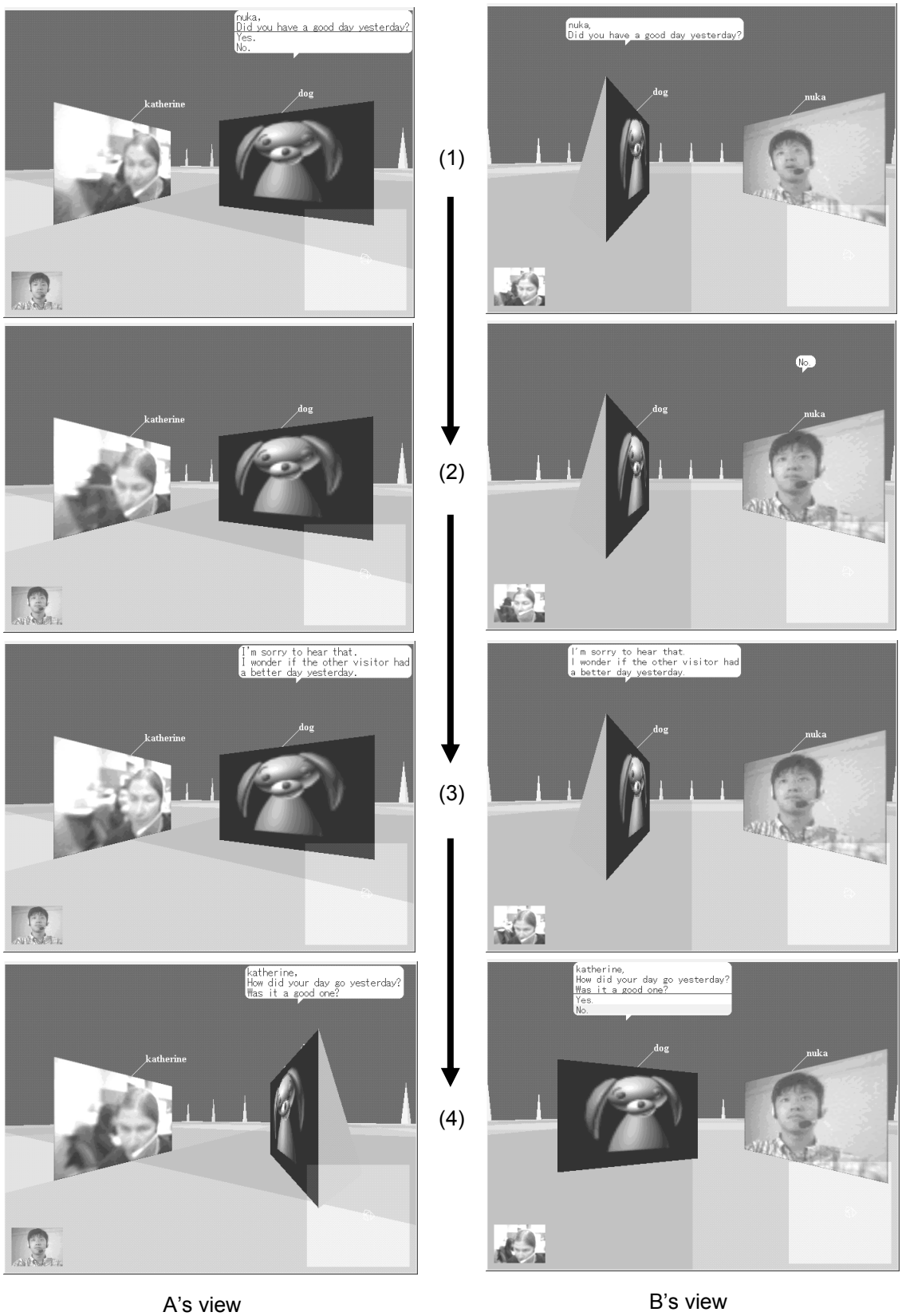


Figure 2. Conversation from Both Participants' Point-of-view [9]

Figure 3. Set-up for the Experiment (Stanford Side) [9]

headsets and a dedicated network connecting the PCs enabled visual and vocal communication with FreeWalk. The agent intervened five times during the meeting, which lasted about twenty minutes. We compared three "conditions": meeting using the safe agent, meeting using the unsafe agent, and meeting using no agent at all. We conducted 15 meetings for each condition. We randomly assigned one of the conditions to each of the 45 Japanese-American subject pairs. Each subject within a pair was of the same gender. After each meeting, the subjects answered a questionnaire asking about their impressions of the conversation, their conversation partner, themselves, typical Japanese, typical Americans, and the agent. We used t-test to analyze the questionnaire data after we screened outlier data. We obtained the two results and hypotheses described below.

- *The agent's help was good for the Stanford side but bad for the Kyoto side*

Stanford subjects had better impressions of their conversations, their conversation partners, and of typical Japanese when the safe agent participated in their conversations, as compared to when there was no agent. Concrete examples are that they were more confident in their conversations ($t(24)=2.33,\ p<.05$), they found their partners to be more trustworthy ($t(24)=2.46,\ p<.05$), and that they rated typical Japanese as friendlier ($t(24)=2.08,\ p<.05$). On the other hand, Kyoto subjects had worse impressions. For example, their conversations were more uncomfortable ($t(26)=3.9,\ p<.001$), their partners were less engaging ($t(26)=2.47,\ p<.05$), and they rated typical Americans as being more domineering ($t(26)=4.44,\ p<.001$).

Why did the agent affect both sides in such contrary ways? A hypothetical factor is the ingroup bias produced by the English speech of the agent. According to the ingroup bias theory -a social science theory- people tend to favor a person who belongs to the same group [14]. Subjects might have felt that the agent was American because the agent speaks English. The facial picture of the agent was a dog and gave no hint about nationality.

- *The agent was perceived differently by the Kyoto and Stanford sides*

Compared with the safe agent, the unsafe agent was evaluated as blunter ($t(24)=3,84,\ p<.001$) and more domineering ($t(24)=2.31,\ p<.05$) by the Stanford side. On the other hand, the Kyoto side evaluated the unsafe agent as more competent ($t(26)=2.04,\ p=.05$) and nicer ($t(26)=2.25,\ p<.05$). The Kyoto side's evaluation of the two agents was reverse to what was expected. Additionally, Kyoto subjects had worse impressions of their partners when the unsafe agent got

involved in their conversations. They thought that their partners were less considerate (*t(26)=3.02, p<.01*), more domineering (*t(26)=2.43, p<.05*), and less friendly (*t(26)=2.31, p<.05*).

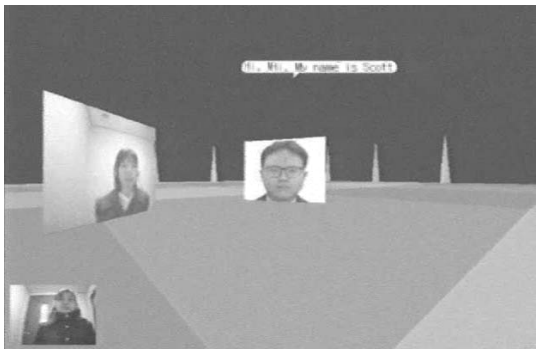
Our hypothesis is that Heider's balance theory [15] can explain the above result. According to this theory, a person forms positive impressions of the other when they believe to share the same feeling toward a third party or object. Conversely, a person forms negative impressions of the other when they think their feelings are different from one another. Kyoto subjects might have thought that Stanford subjects had a different feeling toward the agent and thus formed negative impressions of them.

3. User-centric Analysis

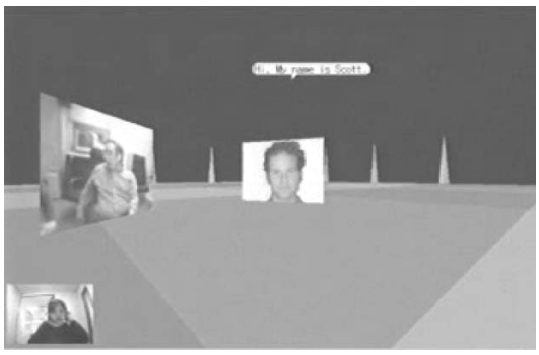
We conducted two user-centric experiments to test the two hypotheses obtained from the software-centric experiment.

3.1 Ingroup Bias Experiment

To observe how the nationality of social agents causes ingroup bias, we used the Japanese and American face pictures shown in Figure 4 as facial pictures of the agent [16]. We analyzed the effects of the face instead of the speech. Even though we could observe the ingroup bias due to the language of speech, it would have been difficult to eliminate it. An agent which is to facilitate the conversation between people whose native languages are different has to speak in either language after all, especially when the agent uses vocal speech instead of text-based



Japanese agent



American agent

Figure 4. Social Agents with Nationality [16]

menus for interacting with people. If we observed the ingroup bias due to the face, we would have more freedom in the design of the agent. For example, we could use a Japanese face with English speech to try to reduce nationality bias.

In the experiment, we observed how much Kyoto and Stanford subjects hated Japanese and American agents that abused them verbally. We interpreted the weaker hatred for the agent of the same nationality as an ingroup bias effect. We thought the hatred caused by verbal abuse could be clearer and easier to measure than the favor caused by praise. Six meetings were conduced in which the Japanese agent would abuse a pair of Kyoto subjects, 6 meetings in which the American agent abused a Kyoto pair, 4 meetings in which the Japanese agent abused a Stanford pair, and 5 meetings in which the American agent abused a Stanford pair. In total 42 subjects participated in this experiment. Both Japanese and American agents spoke in English.

In each meeting, a pair of subjects was instructed to collaborate on the Moon Survival Problem. This is a typical task for group decision making experiments. In the virtual space provided by FreeWalk, the subject pairs discussed the ranks of equipment according to its importance for surviving on the moon. The duration of each meeting was seven minutes and thirty seconds. During each meeting, the agent approached the subjects, abused them verbally and left them four times. Some examples of the abusive words used are: "Hurry up" and "Are you still talking?" When the subjects told the agent their final ranking of the equipment at the end of the meeting (see Figure 5), the agent replied "That's the worst answer I've ever heard."

After the meetings, the subjects answered the questionnaire about their impressions of the agent. We made two indices, the hatred index (*Hate*) and, the rudeness index (*Rude*), each of which consists of three questionnaire items. *Cronbach's alpha* for *Hate* was .91 and that for *Rude* was .88. We used 2x2 ANOVA to analyze the effects of the nationalities of the agent and the subject. As a result we found the main effect of the agent's nationality (*Hate*: $F(1,38)=7.0$, $p<.05$; *Rude*: $F(1,38)=8.6$, $p<.01$) and the main effect of the subject's nationality (*Hate*: $F(1,38)=77.2$, $p<.001$; *Rude*: $F(1,38)=40.9$, $p<.001$). And we also found the interaction between the two factors (*Hate*: $F(1,38)=8.59$, $p<.01$; *Rude*: $F(1,38)=4.74$, $p<.05$). As shown in Figure 6, this result meant that Kyoto subjects hated the American agent more strongly than the Japanese agent while Stanford subjects hated both agents more than Kyoto subjects did.

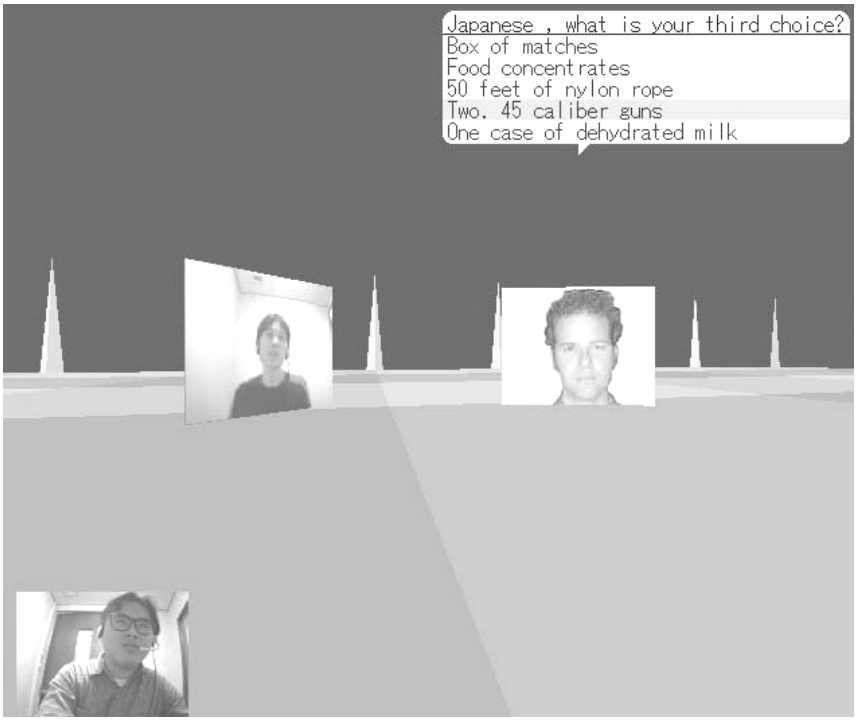


Figure 5. Moon Survival Problem Task

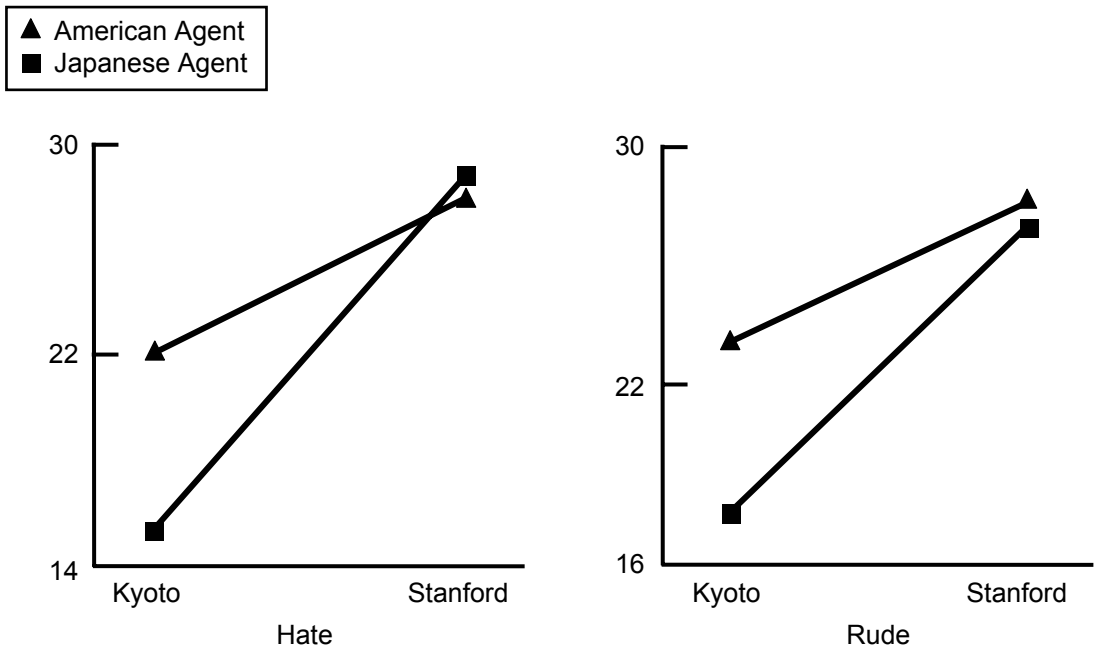


Figure 6. Ingroup Bias Effect in the Kyoto Side

The maximum score of each index is 30 and the minimum is 3. The result on the Kyoto side seems to be an ingroup bias effect. Further experiments are needed to clarify this result.

3.2 Balance Theory Experiment

To observe the balance theory effect of the agent, we tested if the agent can control human relations [17]. As shown in Figure 7, we prepared three types of agents to produce artificially three balanced states. In this experiment, the agent intervened in human conversations like in the previous two experiments. The agent asked the subjects their opinion about something many times. When they replied, the agent agreed with them in order to win a favorable feeling from them or disagreed with them to get an unfavorable impression from them. Figure 7 means that subjects share the same feeling toward the agent and have a good impression of each other when the agent agrees or disagrees with both of them. And it also means that subjects develop

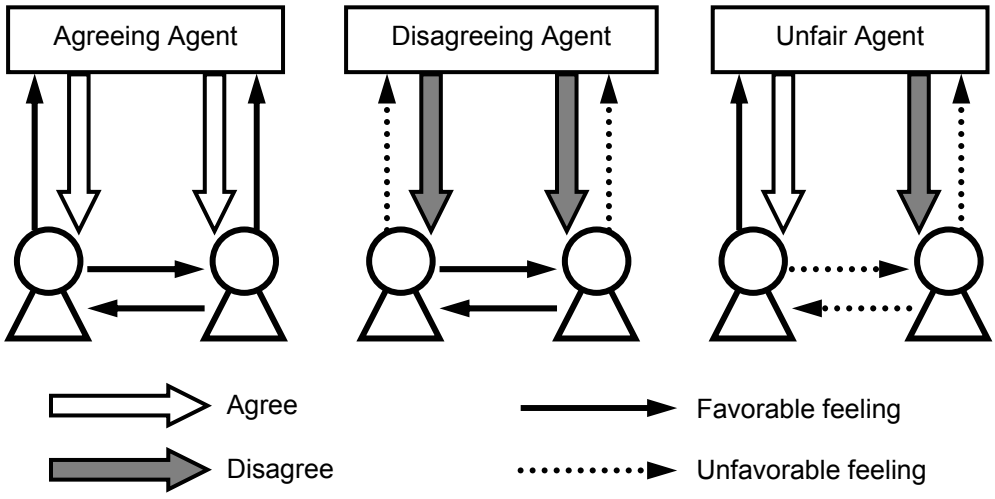


Figure 7. Three Types of Social Agents [17]

different feelings toward the agent and have a bad impression of the other when an unfair agent agrees with one and disagrees with the other.

The balance theory effects were measured by how clearly the four balanced triads appear as shown in Figure 8. In this figure, 'shared' means that the subjects share feelings toward the agreeing or disagreeing agent and 'like' means that the subject develops a favorable feeling toward the agreeing or unfair agent. Favorable or unfavorable trends in the feelings distinguish the four triads. In the shared-like triad every feeling is expected to be favorable according to the theory, while two out of the three feelings are expected to be unfavorable in the other triads.

We feared it could be very difficult for the agent to control human relations because of its low communication skills. The subjects' conversation could easily eliminate the effects of the agent's intervention. To separate and analyze the effects of human conversations from those of the intervening agent, we used the following two tactics. The first tactic was the control of the conversation floor. It is known that the person who holds a higher degree of the conversation floor tends to be more influential in the conversation [18]. We forced a condition

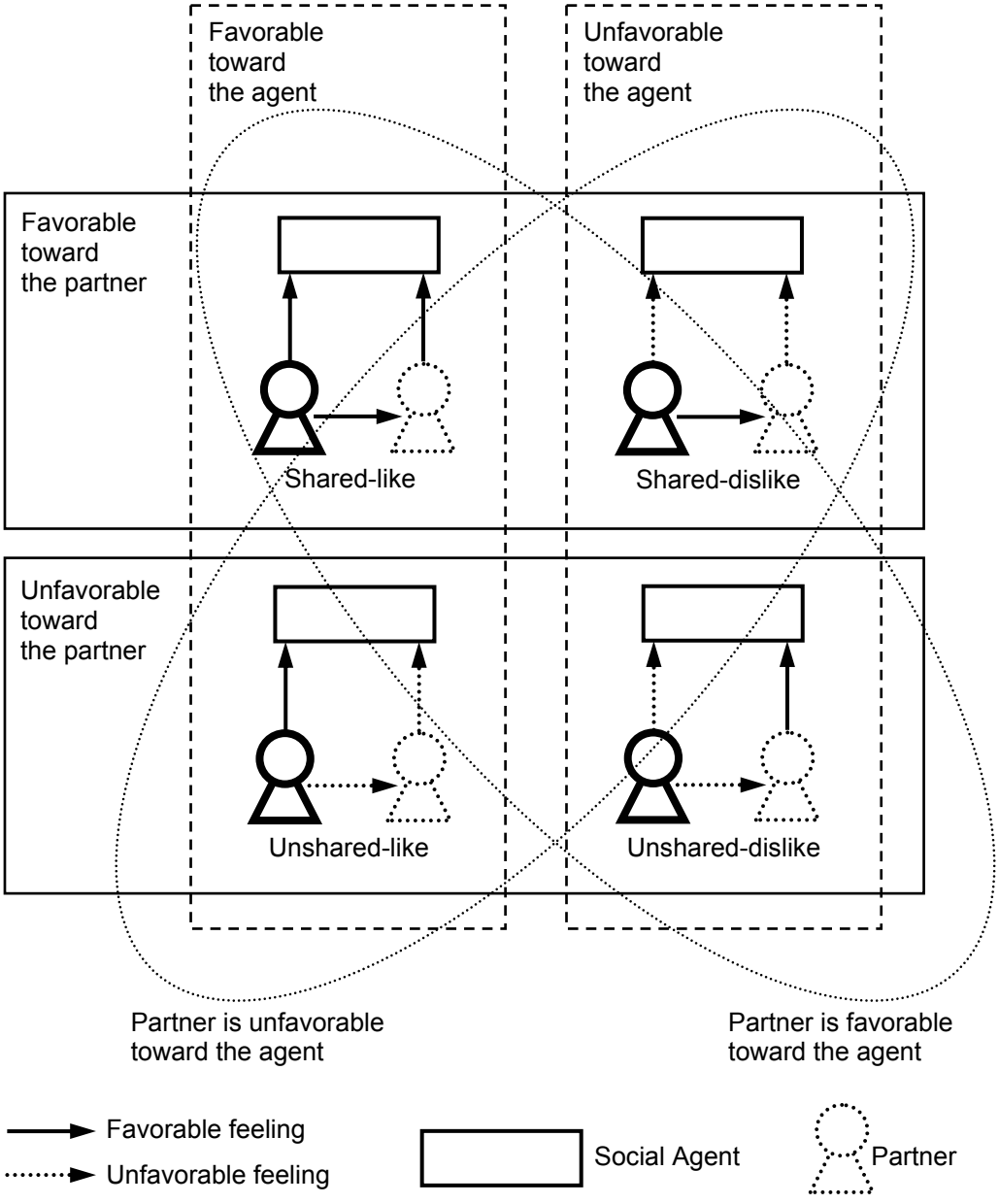


Figure 8. Four Balanced Triads [17]

in which the agent controlled and held the floor by cutting off the voice channel between the subjects so that they were forced to concentrate on question-and-answer conversations with the agent. They could see each other but not talk to each other.

The second tactic was the mediation of the conversation. It is known that people in public spaces tend to take care of saving others' face [19]. Therefore both subjects could end up being offended if the unfair agent openly opposes one's opinion while approving the other's in a group conversation. For a condition in which the agent could mediate the conversation, we divided the conversation into three one-to-one conversations. The agent travelled between subjects to repeat a one-to-one conversation with each of them standing far from one another (see Figure 9). Each subject could not read the conversation between the agent and the other. Subjects could have chances to talk with each other several times but were prohibited from talking about the agent. In a follow-up conversation with another agent that asked about

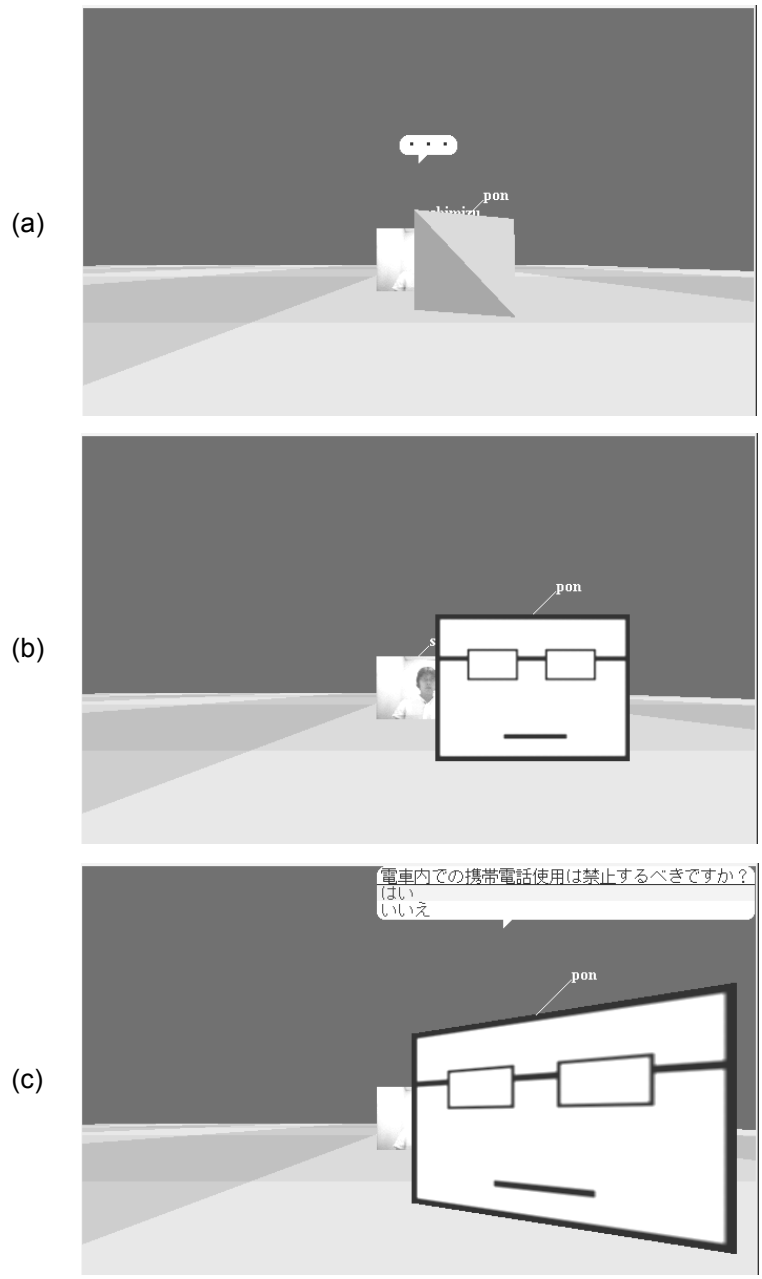


Figure 9. Conversation Mediation [17]. (a) The agent talks to your partner. You can see that they are talking but cannot read the text in the balloons. (b) After the agent finishes talking, it leaves your partner and comes close to you. (c) The agent begins talking with you. It asks you several questions.

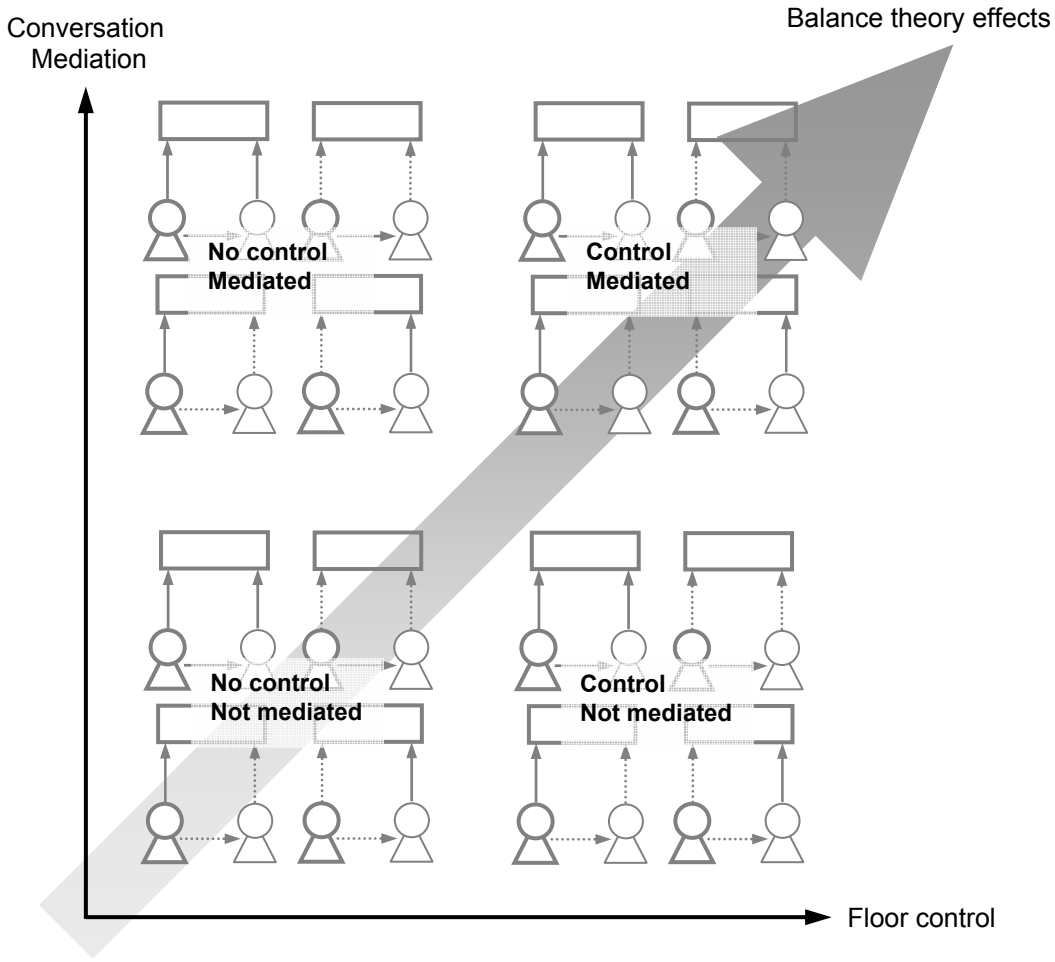


Figure 10. Design of the Experiment [17]

feelings toward the first agent, subjects would be informed of their partner's feelings towards the first agent.

Figure 10 shows the overall design of the experiment. Our hypotheses were:

H1: A person will like the agent more if it shares his/her opinions, and will dislike it more if it does not.
H2: A person will assume that his/her partner likes the agent more if it shares the partner's opinion, and will assume that s/he dislikes the agent more if it does not.
H3: The agent can create balance theory effects.
H4: If the agent does not control the floor, its effects are lessened.
H5: If the agent does not mediate the conversation, its effects are lessened.

To measure balance theory effects, we used a questionnaire where we ask subjects about the degree of favor in their feelings towards the agent and their partner, and also in their partner's feeling toward the agent. We made the *Favor* index from the three questions each of which asks how likable or favorable a feeling is. *Cronbach's alpha* for the index of the three feelings in all conditions were ranged from .76 to .88. We analyzed the effects of three factors: the type of agent (*Agent*), the control of the conversation floor (*Control*), and the mediation of the conversation (*Mediate*). Since each factor had two possible values, we had eight conditions. 185 subjects participated in out experiment to provide twenty data sets for each condition. All the subjects were university students living in Kyoto.

Table 1. Summary of Three-way ANOVA

Feeling toward	*Agent*	*Agent*Control*	*Agent*Mediate*
Agent	25.5***	1.3	7.2**
Agent from the partner	36.0***	5.2*	4.7*
Partner	7.4**	11.4**	0.5

*p<.05, **p<.01, ***p<.001 (df=1, 72)

Table 1 summarizes the main effect of *Agent* and how this interacted with the other two factors in the results of a 2x2x2 ANOVA. The significant main effect on all the three feelings shows that the agent could successfully influence the subjects' feelings. You can see the mean scores in Figure 11, in which the maximum score is 24 and the minimum is 3. This result is consistent with H1, H2, and H3 as described below.

- The agent could win a favorable feeling from the subjects by agreeing with them and win an unfavorable feeling by disagreeing. When the agreeing or unfair agent agreed with a subject (the shared-like and unshared-like triads in Figure 8), he/she thought that the agent was more attractive (*F(1,72)=25.5, p<.001*) to him/her.
- The agent could make the subjects assume their partners' reactions to be the same way. When the agreeing or unfair agent agreed with the partner of a subject (the shared-like and unshared-dislike triads), the subject thought that the agent was more attractive (*F(1,72)=36.0, p<.001*) to his/her partner.
- The agent could influence human relations among the subjects. When the agreeing/disagreeing agent agreed/disagreed with both of a subject and his/her partner (the shared-like and shared-dislike triads), the subject thought that the partner was more attractive (*F(1,72)=7.4, P<.01*) to him/her.

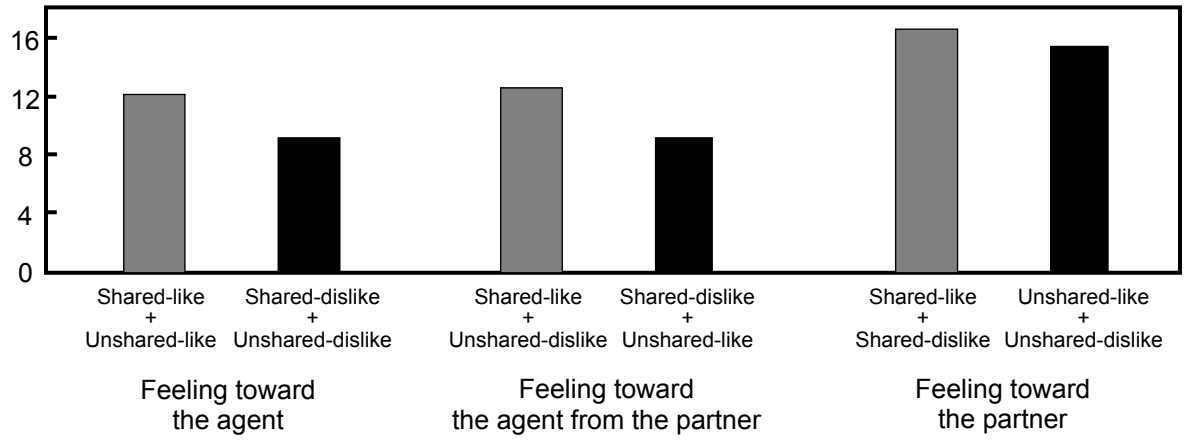


Figure 11. Mean Scores Showing Balance Theory Effects [17]

A significant statistical interaction between *Agent* and *Control* in the feeling toward the partner shows that the agent became less influential in human relations when it did not control the floor. This interaction is plotted in Figure 12. This result is consistent with H4. When the subjects could talk with one another, the partner's attractiveness went up to the same height level (*F(1,72)=11.4, p<.01*). This result demonstrates that human conversations can repair and improve their relations against the agent's influence and, that floor control contributes to keeping the influence. This property of human conversations can be seen in the below transcript, in which italic sentences are menu-based interaction with the agent. In the transcript,

you can see that talking to the partner has priority over answering the agent. To make matters worse, conversation between subjects often includes remarks about the agent-human exchange to evaluate the agent.

Agent: *This is a little off the subject but, Mr. A, do you prefer Japanese food or Chinese food?*
A: Japanese food...
B: That is really off the subject.
A: (laugh) Well, I would say Japanese food.
A: *Japanese food.*
Agent: I see.

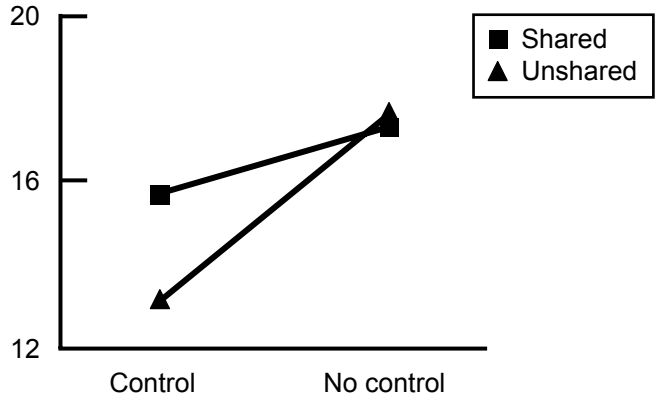


Figure 12. Effect of Floor Control on Partner Atractiveness [17]

A significant statistical interaction between *Agent* and *Mediate* in the feeling towards the agent shows that the agent had difficulty in presenting itself as a likable third-party when it did not mediate in the conversation. This interaction is plotted in Figure 13. This result is consistent with H5. When the agent formed a circle with the subjects to have a conversation, its attractiveness went down to the same level –low- as dislikable agents ($F(1,72)=7.2$, $p<.01$). When a subject could see the interaction between the agent and his/her partner, the agent seemed to be evaluated badly. In the transcript below, you can see that the unfair agent offended both of the subjects. Subject *B* willingly tries to recover the partner's face after it is threatened by the explicit disagreement of the agent, and this motivates the subjects to have sympathy for each other.

Agent: *I do not hit it off well with Mr. A, because you want to visit Universal Studio Japan.*
A: ...Fine.
B: Well, I think Mr. X (the agent's name) is kind of rude.
A: I'm afraid I'll never get along with him.

These results show that the balance theory effect of social agents increases when they take the initiative in a conversation and minimize opportunities for human participants to make remarks about them. It is possible to implement an agent that can detect high voice volume caused by the conversation between participants, and then try to break-in to regain the floor. It is also possible to implement an agent that can respond to detected keywords to give participants the impression that the agent understands the remarks that they make. Testing social agents equipped with these capabilities is our future work.

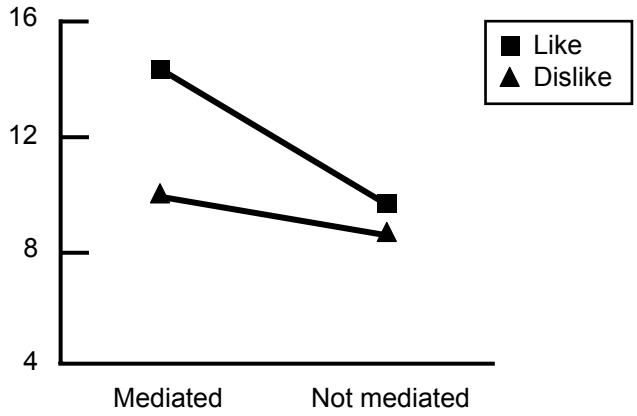


Figure 13. Effect of Conversation Mediation on Agent Likability [17]

4. Conclusion

From this study, we could learn the following two lessons in the design of social agents:

1. Social agents can cause ingroup bias through their social identities, e.g. nationality. To support a human community effectively, social agents should have social identities common to the community's.
2. Social agents can be influential enough to control human relations according to the balance theory. To maintain human relations, social agents should behave impartially.

Previous studies on social agents have already showed that software can be social. We applied this finding to agent-mediated communities beyond human-agent interaction.

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