Improving the Engagement of Participants by Interacting with Agents who Are Persuaded During Decision-Making

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Abstract: A collaborative task execution by leveraging the respective strengths of human and artificial agents can solve problems more effectively than if both entities work separately. The important point is that humans have the mental attitude to transform their own opinions through active interaction with the agent. However, people do not often interact actively with agents because they often consider them to be mere information providers. In this study, our idea was to increase participant engagement by having participants experience interactions in which the agent is persuaded by the participant in a decision-making task. We performed an experiment to analyze whether the interaction with an agent that implements a persuasion interaction model could enhance the user's sense of self-efficacy and engagement in the task. As a result, the participant's behavior and the questionnaire's findings revealed that persuading the interaction partner generally improves engagement in the interaction. On the other hand, it was suggested that the experience of persuading the interaction partner and the experience of the partner agreeing influenced the subsequent engagement and subjective evaluation of the interaction.

1 INTRODUCTION

We believe that the final form of the interface between humans and artifacts can be roughly classified into two types: "transparent," in which the interface (and its accompanying artifacts) can be employed without concern for its presence, and "projective," in which the presence of the interface plays a crucial role in addition to the functions it offers. The "transparent" interface is ultimately the one in which the absence of interaction (or the perception of interaction) works best. Numerous common user-friendly interfaces and human-supporting artifacts are oriented this way. However, they are often oriented toward a "projective" form in situations that require agents. For instance, it has been reported that in idea support situations, idea generation is facilitated by communication with others (Sannomiya, 2015; Chen et al., 2019). In decision-making situations, some studies have demonstrated that agents enhance users' impressions of the decision-making process and their positive attitude toward decision-making by adding the agents' subjective opinions to their proposals (Ohmoto et al., 2014).

Traditional interactive systems often exist as tools that passively help humans performing a specific task and discovering the decision-making factors in which users are interested (Raux et al., 2005; Misu et al., 2011). The user must recognize that agents are more than just information providers in human-agent interaction. For example, the agent's recommendation and/or opinion opposing the user's idea has diminished importance to the user when the agent is just an information presentation interface to the user. Qiu and Benbasat (Qiu and Benbasat, 2009) proposed employing the perspective of social relationships between humans and the design of interfaces for software-based product recommendation agents, providing value beyond the functionality design and practical aspects of decision support systems. The results of a laboratory experiment show that employing humanoid embodiment and human voice-based communication significantly affects users' perceptions of social presence, which in turn improves users' trusting beliefs, perceptions of enjoyment, and their intentions to employ the agent as a decision aid.

However, it is crucial to accomplish the task while dynamically changing the roles and initiatives of both parties for numerous entities to accomplish a task cooperatively by leveraging their respective strengths. Such interaction techniques include "Mixed-Initiative

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Interaction" (Allen et al., 1999). Gianni et al. (Gianni et al., 2011) noted that to achieve a mutually initiated interaction between humans and agents, there are still some challenges. Additionally, each participant in the interaction must continuously interact with a certain degree of spontaneity to achieve the mixed-initiative interaction. Such a state in which a participant's spontaneous approach is applied is considered a state in which engagement with the tasks and interactions is high.

A possible way to enhance user engagement is to increase self-efficacy (Bandura, 1977). Self-efficacy is the state of knowing that one can achieve a certain goal. The higher the self-efficacy, the more proactive one is said to be in achieving a goal. Some studies aim to enhance human work motivation for monotonous and boring tasks by increasing self-efficacy (Fujino et al., 2007). In these studies, humans were required to convince a character agent of the task's importance, and work motivation was demonstrated to improve for tasks after the agent was persuaded. This indicates that the awareness of trying to persuade the agent enhances human engagement and improves self-efficacy when the agent can be persuaded.

This study's final goal is to develop a human-agent interaction model, which can realize a mixed-initiative interaction. To accomplish this, it is crucial to induce and maintain the engagement of the participants in the interaction. In this study, our idea was to increase participant engagement by having participants experience interactions in which the agent is persuaded by the participant in a decision-making task. A persuasion interaction model was proposed, and we examined whether the interaction with an agent that implemented the model could enhance the user's sense of self-efficacy and engagement.

2 INTERACTION MODEL FOR PERSUADED AGENTS

Numerous studies have analyzed ways to enhance engagement (e.g., (Kotze, 2018)). In these studies, having a sense that a person's actions affect one's collaborative partners and the environment was considered to play a crucial role. When performing tasks that involve actual work, it is easier to feel that a person has made an impact on others and the environment due to the feedback provided by the findings of the work. However, in tasks that focus on discussion and decision-making, it is challenging to obtain explicit feedback and to feel that a person has made changes in others and the environment during the task. In this study, we hypothesized that users could experience interactions, which persuade the agent in a decision-making task; thus, making them feel that they have made a change in others in a relatively explicit way, which could enhance their engagement.

It is crucial for the persuader to actively interact with the persuaded to persuade others. By making users aware that they must persuade the agent, it is expected to initiate an engagement in being actively involved in tasks that require interaction with the agent. Additionally, since proactive decision-making can increase confidence in one's abilities (Siebert et al., 2020), we expect that interactions that persuade the agent will increase self-efficacy.

2.1 Persuasion Interaction with Agents

The agent to be persuaded initially expresses an opinion that differs from the opinion of the interacting user in situations where decision-making is needed during the task. Through the human-agent interaction, the agent is encouraged by the user to change its opinion and finally changes its opinion to another opinion that conforms to the user's intention. Here, this is called "persuasion." Our preliminary experiments using a fully controlled agent by the experimenter confirmed that the sequence of persuasion interaction between the user and the agent to be persuaded often follows the following;

1. **Introduction Phase.** The agent encourages the user to express his/her opinions and tries to clarify the user's intentions and thoughts in decision-making situations. The user may express an ambiguous opinion. However, the agent infers some important factors of the user's opinion as much as possible. After the user's utterances, the agent expresses an opinion that is opposite to or does not immediately agree with the user.
2. **Persuasion Phase.** The agent encourages the user to persuade the agent against the agent's opinion. First, the agent makes an utterance agreeing with part of the user's opinion or incorporating a bit of the user's argument. Then, depending on the content of the user's response, the agent expresses reasons why the agent's proposal is better. Based on the user's objections to the agent's opinion, the agent infers the user's important factors, and the agent suggests points where it can compromise.
3. **Agreement Phase.** As the interaction progresses, the agent shows the user with a gradual shift in the agent's opinion from disagreeing to agreeing with the user. At the end of the persuasion interaction, the agent plainly agrees with the user's opinion, indicating that the agent has changed its opinion in response to the user's persuasion.

2.2 Implemented Interaction Model

The agent must change its response according to how the user interacts and the progress of the conversation for the user to feel that the agent has been persuaded by the user. In this study, we categorized the attitudes and the responses of users and agents in their persuasion interactions. The corresponding agent responses were then determined according to the user's attitude and the progress of the conversation. Table 1 summarizes the agent's reaction corresponding to each user's attitude and stage of the conversation.

Argument. Utterances that reinforce one's opinion, such as expressing a position, showing an advantage, or expressing one's thoughts, are considered "arguments." This includes rebuttals but does not consider whether the content of the utterance is valid or not.

Pointed Out (User Only). A denial of an agent's position or arguments, pointing out a fault, or similar utterances are considered a "pointed out" by the user. A refutation of the agent's previous utterance is an "argument."

Question. Utterances that ask for opinions or confirmation from others are considered "questions." If the user asks a question that the agent can answer with a "yes/no," the agent will in any case respond appropriately according to the content of the question.

Neutral. Utterances that do not amount to a denial of the others, or utterances that seem thoughtful or monologue (e.g., "What should I do"?) are considered "neutral." When a user makes an utterance that shows agreement or understanding with the agent, it is also treated as a neutral utterance. In other words, the agent does not persuade the user.

Suggestion. Regardless of the position, utterances that are necessary for the benefit of the whole are considered "suggestions." For example, "We should decide about XX," etc. These are suggestions that require consideration regardless of the position of either the user or the agent.

Acceptance (Agent Only.) Positive utterances such as agreeing with the user's opinion or showing empathy are considered "acceptance." The agent always makes an utterance of acceptance at the end of a conversation. This encourages the user's willingness to be persuaded.

Figure 1 shows the architecture of an agent that implements the above user attitudes and the agent's responses to them as persuaded actions in a decision-making situation. The user information component retains the user's position and arguments from the user's utterances. The attitude classification component classifies the estimated user's attitude according to the user's utterances and the conversation scenario. The agent reaction component determines the agent's reaction according to the correspondence in Table 1. To determine the agent's behavior from a predefined database, the agent's response, the phases of the decision-making scene, and the content that has already appeared in the conversation are integrated.

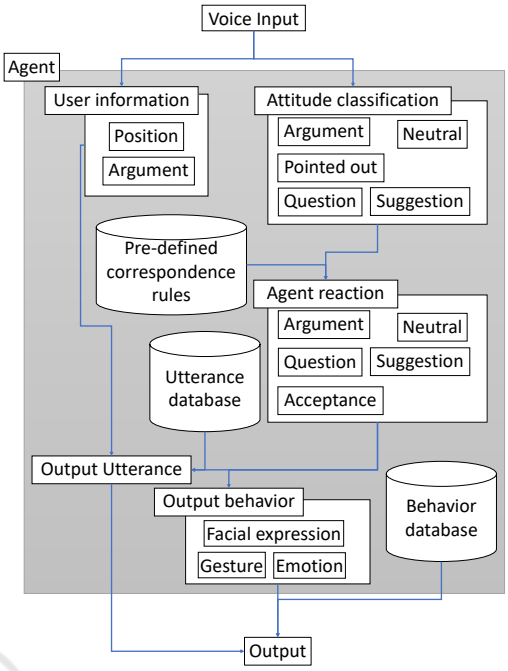

Figure 1: The architecture of an agent that implements the persuaded actions.

3 EXPERIMENT

An experiment was conducted employing an agent that implements the interaction model described above to test the hypothesis that the human persuasion of an agent increases self-efficacy and engagement in a task. In the experiment, participants conducted a decision-making task while conversing with an agent; one participant performed two different tasks and interacted with an agent with a different behavior model for each task. One behavioral model was the "persuaded agent," which naturally conducted conversations in which it was persuaded in decision-making situations, and the other behavioral model was the "agreeing agent," which agreed to human suggestions. Participants' conversational situations during the experiment were recorded by video and employed

Table 1: The agent's reaction corresponding to each user's attitude and phase of the conversation.

User's attitude	Agent responses		
	Persuasion phase (first half)	Persuasion phase (second phase)	Agreement phase
Argument	Argument, Suggestion	Question, Neutral	Neutral, Acceptance
Pointed out	Argument, Question	Question, Neutral	Neutral, Acceptance
Question	Argument, Suggestion	Argument, Acceptance	Suggestion, Acceptance
Neutral	Argument, Question	Suggestion, Neutral	Neutral, Acceptance
Suggestion	Argument, Question	Question, Neutral	Neutral, Acceptance

for evaluation. Participants completed a questionnaire in each session and a questionnaire directly comparing the two sessions at the end of the experiment.

3.1 Description of the Task

In the experiment, one participant performed both the "Persuaded condition" employing the persuaded agent and the "Agreeing condition" using the agreeing agent. Participants were taught to persuade the agents in a decision-making scene if necessary. The content of the decision-making situations in each session was different; however, the structure of the conversation was kept the same. In each session, there were two different decision-making scenes. Each session included two agents and a participant in the conversation; the two agents and the participant were taught that their positions were equal. The appearance of each agent in each session was different.

3.1.1 Common

In common with the two sessions, a scenario was set up in which the participant worked with two agents to write an introductory article on a given tourist destination as a school assignment. In the two conditions, the task commonly followed the following flow: 1. ice-breaker, 2. first decision-making scene, 3. chatting scene with scene changes, 4. second decision-making scene. In each decision-making scene, the participants were instructed to express their ideas about a course of action and to make a decision that had everyone, including the agent, take the same action. In the decision-making scene, they expressed their opinions twice, and in each case, they were also encouraged to state reasons why they were the way they were. A story connecting the preceding and following decision-making situations was facilitated through conversation in the chatting situation. The content of the conversation in the chatting scene was unrelated to the course of action in the decision-making scene.

Both the participants and agents were engaged in a voice conversation during the task. During the conversation, four options were displayed at the top of the screen to guide the participants' statements and

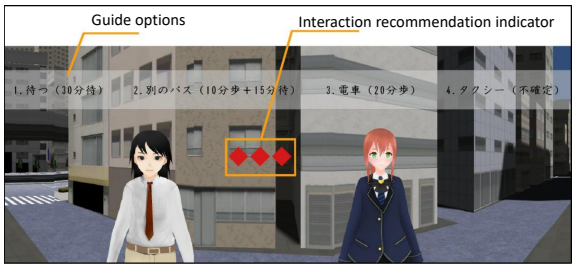

Figure 2: The screen shot of the experiment.

encourage them to keep their statements within a certain range. A similar system has been proposed by (Tominaga et al., 2021) and others. Since the turn of speech is often not obvious in interactions with artificial agents, a "◇◇◇" icon was shown on the screen as an "interaction recommendation indicator" at the point when the participant was encouraged to interact with the agents. Participants could interact with the agents even when the indicator was not displayed. If the participant's utterance agreed with an option, the option was indicated in red to show that the choice had been made. Figure 2 is an example of the displayed screen in the experiment.

Conversation scenarios were made in advance, and the timing of presenting the interaction recommendation indicator to the participant and options of speech guidelines presented to participants were determined according to the conversation scenarios. The timing of when the agents were persuaded was set as the point in time when seven conversation turns were performed with the agent, which was the same for all conditions.

Persuaded Condition. In the Persuaded condition, a scenario was set up in which the participants were to visit the museum, cover the event, and buy a souvenir to take home. The task was to decide which part of the museum to visit in the first decision-making scene. In the second decision-making scene, the task was to decide which souvenir to buy. In this condition, one agent took a neutral position while the other agent took a position that conflicted with the participant's opinion. The agent taking the neutral position was swapped in each decision-making scene.

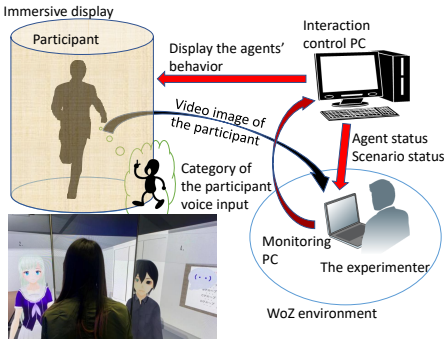

Figure 3: The experimental setting.

Agreeing Condition. In the Agreeing condition, a scenario was set up in which the participants would interview the garden park and leave from there. The task was to decide the division of the roles during the interview in the first decision-making scene. In the second decision-making scene, the task was to decide on public transportation to return home after the interview. In this condition, one agent took a neutral position while the other agent took a position agreeing with the participant's opinion. The agent taking the neutral position was swapped in each decision-making situation.

3.2 Experimental Setting

Figure 3 illustrates the experimental setting. We employed the Immersive Collaborative Interaction Environment (ICIE) (Nishida et al., 2014) and Unity (http://unity3d.com/) to construct the virtual environment and the two agents. The ICIE employs a 360-degree immersive display consisting of eight portrait orientation LCD monitors with a 65-inch octagonal screen. Participants in the experiment stood in the center of the displays and interacted with the two agents on the displays using their voice. The participants' utterance was transmitted to the operator using a microphone, and the operator controlled the agents according to the utterances based on the predefined rules (Wizard of Oz: WoZ). The participant's voice was recorded using microphones. The experimenter sat out of the participant's sight and observed the participant's behavior. The agents used audio to provide suggestions and presentations.

3.3 Procedure

First, the participants were instructed about the experiment and practiced interacting with the agents. A session on the decision-making task was started after it was determined that the participant was sufficiently proficient in how to interact with the agents. Two sessions were conducted for the entire experiment. After each session, the participant completed a questionnaire about their conversations during the task. Each session lasted around 30 minutes, and the entire experiment lasted about 1 hour.

The interaction during the experiment proceeded based on the participant's utterances. The experimenter classified the utterances according to predetermined rules (Wizard of Oz: WoZ). The agents' utterances were selected according to predetermined rules based on the category of the participant's utterances, which were entered by the WoZ operator. Based on input from the WoZ operator, the decision-making task proceeded automatically.

Twenty-eight undergraduate students participated in the experiment (22 were male and 6 were female). The participants ranged in age from 19 to 24 years, with an average age of 20.9 years (standard deviation: 2.78). Fourteen of the participants first interacted with the agents in the Persuaded condition (P-first group). The remaining fourteen participants first interacted with the agents in the Agreeing condition (A-first group).

3.4 Result

Speech latency was measured as an index to infer the participant's willingness to participate in the conversation in a decision-making task. Some researchers report that the speech reaction time is related to the divergent/convergent phases in discussion (Ichino, 2011) and in the human mental state in social interactions with agents (Bechade et al., 2015; Ono et al., 2016). Based on the speech recorded in the video, speech latency was defined as the period between the display of the interaction recommendation indicator and the participant's utterance. For utterances in situations in which the agent has not displayed the interaction recommendation indicator, the latency was defined as "0" if the agent was speaking, otherwise, the latency was defined as "the time since the previous agent's utterance."

The post-session questionnaire consisted of six questions regarding self-efficacy, engagement for the interaction, and satisfaction with the interactions during the sessions, each answered on a 7-point Likert scale. The questionnaires after all sessions consisted of three items that directly compared the sessions to each other regarding self-efficacy, engagement for the interaction, satisfaction with the interactions, and which of the two sessions was felt more strongly.

3.4.1 Speech Latency

Figure 4 shows the means and standard errors of speech latency. We performed a two-way analysis of variance (Group: P-first or A-first x Condition: Persuaded or Agreeing).

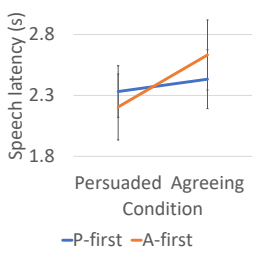

Figure 4: The speech latency between groups.

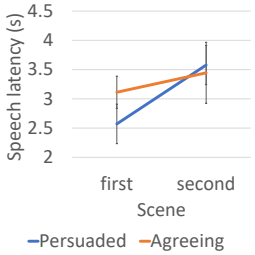

Figure 5: The speech latency between scenes.

The findings indicated a significant difference in condition ($F(1, 26) = 5.64$, $p = 0.025$; Persuaded $<$ Agreeing). The difference as a numerical value is insignificant. However, the fact that significant differences were found despite the explicit triggers for participants' utterances shows that they could grasp their partner's utterances well and could also quickly formulate their own opinions about their own opinions. Thus, the result demonstrates that participants' engagement with the interaction was increased in Persuaded condition.

We measured participants' speech latency in each of two decision-making scenes in one session to examine changes in participants' engagement over time. Figure 5 shows the mean and standard error of the speech latency. We performed the two-way analysis of variance (Scene: first or second x Condition: Persuaded or Agreeing) on these data.

The findings revealed that there was a marginally significant difference in Scene ($F(1, 27) = 4.13$, $p = 0.052$; first $<$ second). In other words, the results demonstrate that in both the Persuaded and Agreeing conditions, the speech latency tends to be longer in the second scene. This indicates that engagement may be decreasing as participants understand the prepared scenarios.

3.4.2 Questionnaires for Each Session

Questions were asked regarding self-efficacy, engagement in the interaction, and satisfaction with the interaction during each session. All participants answered the self-efficacy question; however, one participant in the P-first group did not answer the questions for engagement and satisfaction; so this participant was excluded from the analysis. Figure 6 shows the means and standard errors for each. We performed a two-way analysis of variance (Group: P-first or A-first x Condition: Persuaded or Agreeing) on these data.

Self-Efficiency.
The results demonstrated that the interaction was significant ($F(1,26) = 7.87$, $p = 0.0094$). A simple main effect test revealed that in the P-first group, scores were substantially lower in the Persuaded condition ($F(1, 26) = 8.32$, $p = 0.0078$). Another simple main effect test demonstrated that in the Persuaded condition, there was a marginally significant difference in the Group ($F(1, 52) = 3.78$, $p = 0.058$; P-first $<$ A-first). This indicates that participants who had not experienced being agreed with by their partner were less likely to feel a sense of self-efficacy when persuading, whereas participants who had experienced being agreed with by their partner did not experience a decrease in self-efficacy when persuading.

Engagement in the Interaction.
The result demonstrated a marginally significant difference in condition ($F(1,25) = 4.01$, $p = 0.056$; Persuaded $>$ Agreeing). However, a simple main effect was tested since the interaction was significant ($F(1,25) = 8.65$, $p = 0.0069$). The findings demonstrated that in the A-first group, the scores in the Agreeing condition were substantially lower than that in Persuaded condition ($F(1, 25) = 12.22$, $p = 0.0018$). This indicated that participants who had not experienced persuasion were less likely to enhance their engagement when the other party simply agreed without persuasion. The results also demonstrated that participants who had experienced persuasion did not experience a significant decrease in engagement when the other party agreed without persuasion.

Satisfaction with the Interactions.
The result demonstrated a marginally significant difference in condition ($F(1,25) = 3.41$, $p = 0.077$; Persuaded $>$ Agreeing). This shows that persuading or not may enhance interaction satisfaction, although the impact is not large.

3.4.3 Session-to-Session Comparison Questionnaire

To make direct comparisons between sessions, we analyzed the results of participants' answers to questionnaires regarding self-efficacy, engagement in the interaction, and satisfaction with the interactions. Each item was encoded with the middle as the reference (0), with the Persuaded condition in the positive direction and the Agreeing condition in the negative di-

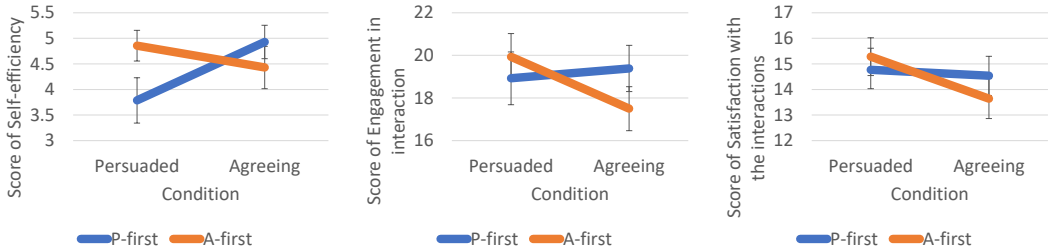

Figure 6: The results of questionnaires regarding self-efficacy, engagement, and satisfaction with the interaction.

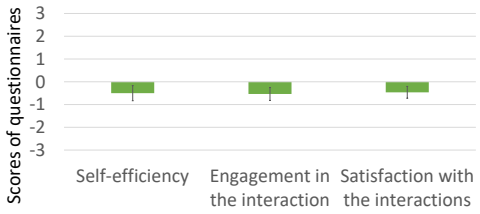

Figure 7: The results of questionnaires of direct comparisons between sessions.

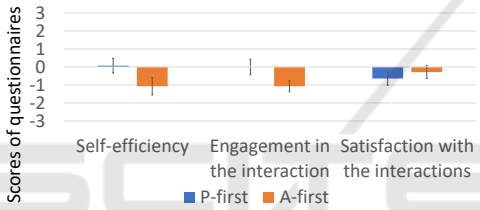

Figure 8: The results of questionnaires of direct comparisons between sessions in each group.

rection (+3 to -3). Figure 7 shows the results. A one-sample Wilcoxon Signed-Rank Test was conducted with the null hypothesis that the mean is 0 for each item. The findings showed marginally significant differences in engagement for the interaction (engagement, $p = 0.057$; Persuaded $>$ Agreeing).

Since Questionnaires for each session sometimes showed different trends by the group, they were tabulated separately for each group. Figure 8 shows the results. A one-sample Wilcoxon Signed-Rank Test was conducted in the same way for each group. The findings demonstrated that there were no significant differences in the P-first group, while there were marginal or significant differences in self-efficacy and engagement for the interaction in the A-first group (self-efficacy, $p = 0.070$; engagement for the interaction, $p = 0.011$; both, Persuaded ¿ Agreeing).

These results demonstrate that, when comparing the two interaction experiences overall, persuading produces positive, albeit not large, impressions in engagement and satisfaction. Additionally, the results show that participants' positive impressions of self-efficacy and engagement were stronger when participants were persuaded after they had experienced an interaction in which the others agreed with the participants. However, this may have been influenced by impressions from the second session conducted.

4 DISCUSSION

The participants' behavior and the results of the questionnaire demonstrated that, overall, persuading the interaction partner enhances engagement in the interaction. However, the experience of persuading the interaction partner and the experience of the partner agreeing influenced the subsequent engagement and subjective evaluation of the interaction. This indicates that participants made criteria for their interactions with others based on their prior experiences and assessed their own experiences based on these criteria. In other words, to enhance engagement in a particular situation, it is crucial to comprehensively design the series of interactions leading up to that situation.

The findings of the questionnaire after the two interaction sessions revealed that self-efficacy was lower when the agents were persuaded in the first session. However, engagement tended to score higher in the Persuaded condition. To analyze the relationship between these ratings, we computed the correlation coefficients among self-efficacy, engagement and satisfaction questionnaire findings in the Persuaded and Agreeing conditions, respectively, and discovered that although there was a strong correlation between engagement and satisfaction (Persuaded = 0.78, Agreeing = 0.73), there was no strong correlation between self-efficacy and engagement and between self-efficacy and satisfaction (between self-efficacy and engagement, Persuaded = 0.29, Agreeing = 0.17; between self-efficacy and satisfaction, Persuaded = 0.39, Agreeing = 0.33). This shows that self-efficacy has no direct effect on engagement in the current experimental task. Interaction factors, which can directly influence engagement must be considered.

In this experimental task, since the interactions proceeded according to a predetermined decision-

making scenario, participants might not have fully understood the need for persuasion in their interactions with the agent and in the task. It is also possible that although the participants were allowed to speak freely, they were guided in the direction of the interaction by displaying speech options, and thus did not have sufficient awareness that they were successfully persuaded by their own opinions. We would like to test this in a conversation with sufficient flexibility.

5 CONCLUSION

The aim of this study was to investigate whether the interaction with an agent that implemented the proposed persuasion model could enhance the user's sense of self-efficacy and engagement in the task. We conducted an experiment employing an agent that implements the interaction model described above to test the hypothesis that the human persuasion of an agent increases self-efficacy and engagement in a task. As a result, the participants' behavior and the results of the questionnaire demonstrated that, overall, persuading the interaction partner enhances engagement in the interaction. However, the experience of persuading the interaction partner and the experience of the partner agreeing influenced the subsequent engagement and subjective evaluation of the interaction. We believe that persuasion interaction plays an important role for intelligent agents to be recognized as independent entities with their own opinions, rather than just accepting human commands. In the future, we would like to examine whether persuasion interaction can contribute to improving the quality of collaborative decision making.

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