

Influence of Prior Knowledge and Embodiment on Human-Agent Interaction

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Abstract. An experiment was conducted to capture characteristics of Human-Agent Interactions in a collaborative environment. The goal was to explore the following two issues: (1) Whether the user's emotional state is more stimulated when the user has a human schema, as opposed to a computer agent schema, and (2) Whether the user's emotional state is more stimulated when the user interacts with a human-like ECA (Embodied Conversational Agent), as opposed to a non human-like ECA or when there is no ECA. Results obtained in the experiment suggest that: (a) participants with a human schema produce higher ratings, compared to those with a computer agent schema, on the emotional (interpersonal stress and affiliation emotion) scale of communication; (b) A human-like interface is associated with higher ratings, compared to the cases of a robot-like interface and a no ECA interface, on the emotional (e.g., interpersonal stress and affiliation emotion) scale of communication.

Keywords: Embodied Conversational Agent, Human-Computer Interaction, User Interface.

1 Introduction

Recently, there is a popular trend in the IT industry to develop and deploy Embodied Conversational Agents (ECAs) that would facilitate collaboration of various system users by adopting new technologies for the user-system interaction. One of the important issues in this area is to understand cognitive and emotional characteristics of the ECA-mediated communication process (Nass & Steuer, Tauber, 1994). The underlying question is: what are the factors that influence these characteristics?

2 Related Work

In the initial stage of communication with a stranger, people usually rely on some prior knowledge about the conversation partner. Social psychology research has indicated the importance of the top-down processing, based on prior knowledge about

the speaker, such as 'schema' and 'stereotypes' in interpersonal cognition. It is usually assumed that people use reference to a schema to understand utterances during conversation with a computer agent (Fisk & Taylor, 1991).

Hayashi & Miwa (2009) conducted a psychological experiment, in which schemas were controlled to explore characteristics of communication, when human and computer agents coexist. Results obtained showed that the schema about the communication partner affects emotional characteristics of communication: participants experienced more positive emotions towards the partner when they believed that the partner is a human but not a computer agent. In Yamamoto et al. (1994), participants of an experiment played Shiritori, a popular Japanese word-game, with a partner using a computer. Even though the actual identity of the partner was a computer agent, the participants, who were misinformed that they were facing a human player, gave significantly higher pleasure ratings than those who were informed that they were facing a computer agent. The study also suggested that a schema about the partner affects emotional characteristics of communication.

How can we stimulate human schemas and thus influence emotional characteristics while communicating with ECA? Sproull et al. (1996) found that people respond differently to a talking-face interface compared to a text-only interface. It was pointed out that people are more likely to ascribe personality attributes to displayed faces, and have higher arousal when view faces while interacting with a talking-face interface, compared to a text-only interface. It remains, however, unclear whether the participants experienced the same kind of emotional states as during conversations with human partners.

3 Purpose of the Study

In the presented study, the examined hypothesis is that the more an ECA has human-like characteristics, the more the users would rely on a human schema and deem the agent as human. It is, therefore, expected that when users interact with a human-like ECA, they would have more positive emotions towards the partner, compared to the case of a non human-like ECA, or when there is no ECA. Specifically, the following two points will be investigated:

1. Whether the user's emotional characteristics are more stimulated when the user has a human schema, as opposed to an agent schema.
2. Whether the user's emotional characteristics are more stimulated when the user interacts with a human-like ECA, as opposed to a non human-like ECA, or when there is no ECA.

4 Methods

Experiments were conducted where two participants are engaged in a rule discovery task and communicate with each other using an Internet chat. The participants are required to find the sequence for the number of objects that appear on their computer displays. In Figure 1, there are a total of six objects presented in the center: four black and two white. Below the objects, there is a text field where the participants input and

receive messages. Just one sentence per trial is permitted, and at most 30 words are accepted. Buttons for changing objects, sending messages, and for terminating the experiment are placed at the bottom of the screen.

A conversational computer agent (see Figure 2) used in this study has an ability to meaningfully respond to sentences input by the participants. The agent first extracts keywords from the chat messages and then activates scripts for generating sentences, based on the graphical images displayed (for details on the agent design, see Hayashi & Miwa, 2009).

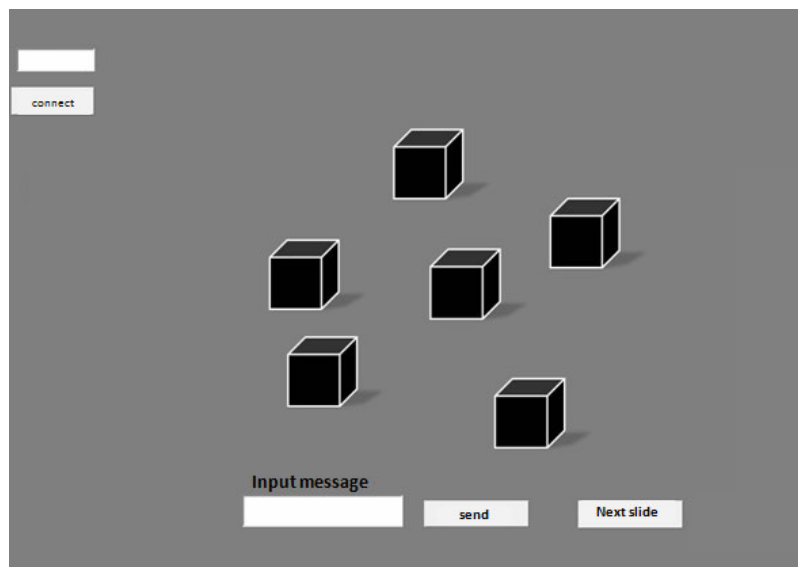


Fig. 1. Screen shot of the experimental setup

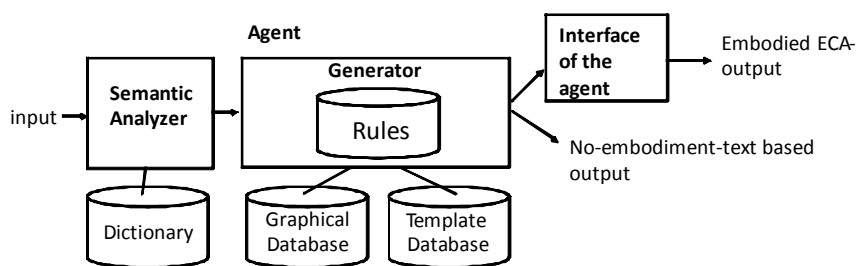


Fig. 2. Agent design

5 Experimental Design

In Experiment 1 (see Figure 3), psychological characteristics of participants having a human schema were investigated. The participants' behavior was controlled by telling

them if a human or a computer agent was supposedly involved into the collaboration. In reality, only a computer agent was used in the experiment. No interface agent (i.e. no embodiment) was deployed, and there was no ECA in both conditions. Participants having the human schema were labeled as “HUMAN condition”, and participants having the agent schema were labeled as “AGENT condition”.

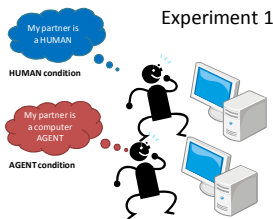


Fig. 3. Conditions of Experiment 1

Next, to investigate if a human-like ECA affects the same characteristics as found in Experiment 1, two conditions were added in Experiment 2. Results obtained were compared with those of the experimental participants under the AGENT condition. Two conditions in Experiment 2 were the same as the AGENT condition, excepting for the fact that the agents had a graphical representation and were visualized. In the human-like condition, there was a human avatar displayed, and in the robot-like condition, there was a robot avatar displayed (see Figure 4).

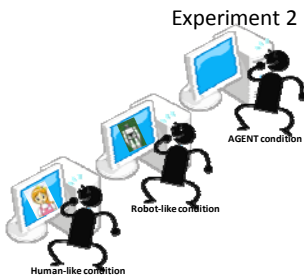


Fig. 4. Conditions of Experiment 2

49 university students (37 male, 12 female, average age=22.45 y.o.) voluntarily participated in the experiment, and each participant was randomly assigned to every condition.

6 Collected Data

The participants answered a questionnaire two times, before and after completing the experimental procedure (see Figure 5). The time allocated for the procedure was 5

minutes for each participant. The questionnaire used was originally proposed by Tsuduki & Kimura (2000), and it is designed to assess psychological characteristics of communication.

The questionnaire is comprised of 16 questions, each on a five-point scale. The 16 questions are classified into three groups to evaluate: (1) interpersonal stress, (2) affiliation emotion, and (3) information propagation. The first measure represents the “interpersonal stress” factor consisting of five characteristics about feelings, such as tension, severity, and fatigue. The second measure represents the “affiliation emotion” factor consisting of eight characteristics about feelings, such as friendliness, ability to discuss personal matters, and happiness. The third measure represents the “information propagation” factor consisting of three characteristics about feelings, such as purpose and effectiveness in collecting information. The first two groups are defined as “emotional characteristics”, and the third as “cognitive characteristics” of communication.

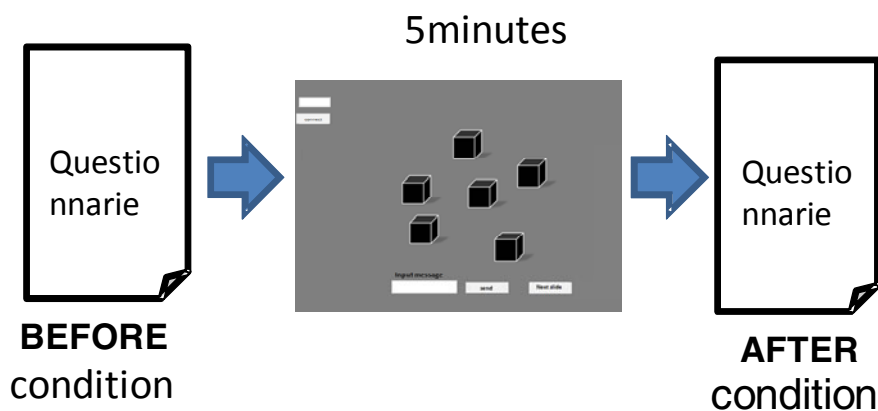


Fig. 5. Experimental procedure

7 Analysis

7.1 Experiment 1

Figure 6 shows results of Experiment 1. The vertical axis represents the mean value of the ratings obtained for the measures listed on the horizontal axis. A 2 x 2 ANOVA was conducted on each questionnaire measure with the instruction condition (HUMAN condition vs. AGENT condition) and the time condition (BEFORE condition vs. AFTER condition) as mixed-subject factors. There was no correlation detected between the two factors for all questionnaire measures, excepting for the questionnaire measure ‘speed of communication’ ($F(1,26)=5.54, p=.015$).

The analysis suggests that the influence of instruction were not changed over time for most of the questionnaire measures. Effects of instruction for each questionnaire measure were also investigated. Results obtained suggest that the conditions were

significant factors for measures, such as 'ease loneliness', 'happiness', 'feeling tension', 'feeling close', and 'expression of kindness'(F(1,26)= 4.16, p=.052; F(1,26)= 3.97, p=.057; F(1,26)= 4.49, p=.043; F(1,26)=3.35, p=.079; and F(1,26)= 6.52, p=.017, respectively). There were no significant differences for measures such as 'speed of

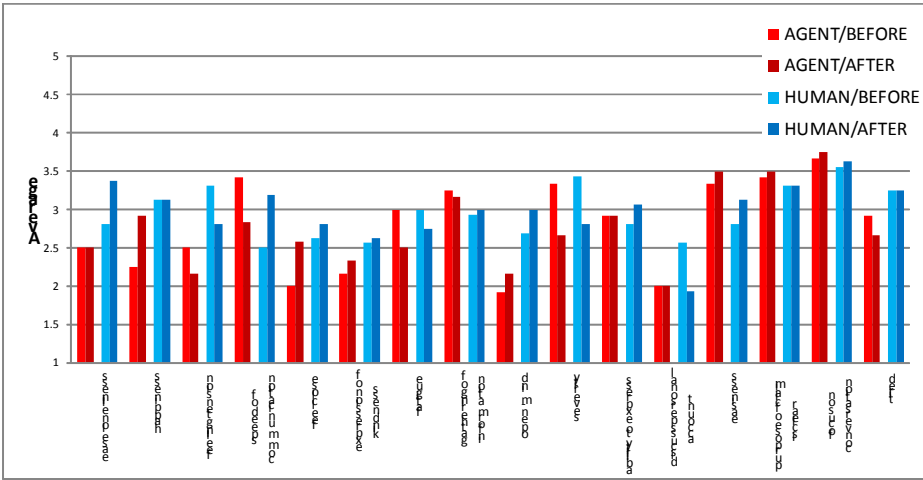


Fig. 6. Results of Experiment 1

communication', 'expression of kindness', 'fatigue', 'gathering of information', 'severity', 'ability to express', 'discuss personal account', 'easiness', 'purpose of claim is clear', 'focus on conversation', 'tired' (F(1,26)= 1.18, p=.287; F(1,26)= 1.47, p=.237; F(1,26)= 0.11, p=.746; F(1,26)= 0.59, p=.451; F(1,26)= 0.1, p=.758; F(1,26)= 0.01, p=.932; F(1,26)= 0.74, p=.397; F(1,26)= 2.22, p=.149; F(1,26)= 0.24, p=.632; F(1,26)= 0.14, p=.716; F(1,26)= 1.95, p=.175).

7.2 Experiment 2

Figure 7 shows results of Experiment 2 (the axes are labeled as in Experiment 1). A 3 x 2 ANOVA was conducted on each measure with the avatar condition (Human-like condition vs. Robot-like condition vs. AGENT condition with the same data as was used in Experiment 1) and the time condition (BEFORE condition vs. AFTER condition) as mixed-subject factors. There was no correlation detected between the two factors for all questionnaire measures, excepting for the measure 'severity' (F(2,30)= 3.64, p=.039).

To investigate the influence of embodied agents, main effects of the interface for each questionnaire measure were further analyzed. Results obtained indicate that the conditions were significant factors for measures, such as 'ease loneliness', 'happiness', 'feel close', 'expression of kindness', and 'severity' (F(2,30)= 3.71, p=.036; F(2,30)= 6.62, p=.004; F(2,30)= 3.84, p=.033; F(2,30)= 3.72, p=.036; and F(2,30)= 3.3, p=.051, respectively). Although, there were no significant differences for measures such as 'feeling tension', 'speed of communication', 'expression of kindness',

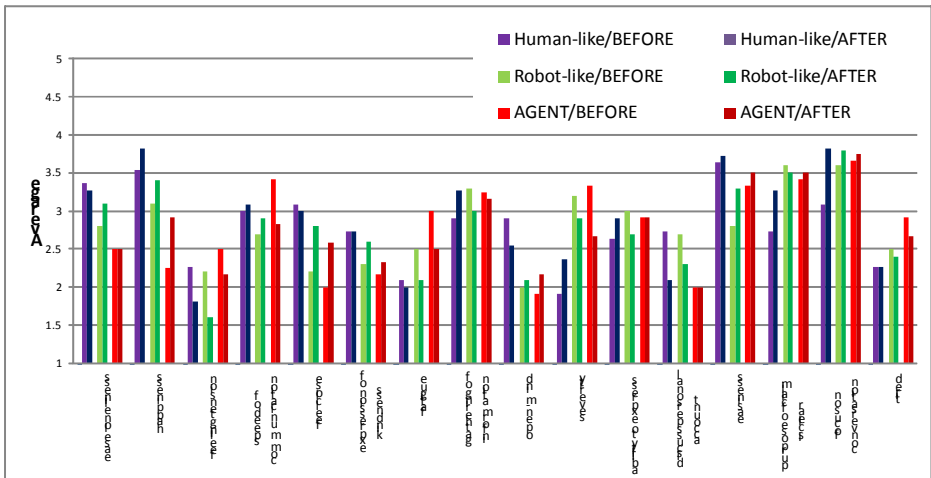


Fig. 7. Results of Experiment 2

'fatigue', 'gathering of information', 'ability to express', 'discuss personal account', 'easiness', 'purpose of claim is clear', 'focus on conversation', 'tired' (F(2,30)= 0.47, p=.632; F(2,30)= 0.73, p=.49; F(2,30)= 1.29, p=.291; F(2,30)= 1.85, p=.175; F(2,30)= 0.11, p=.9; F(2,30)= 0.12, p=.9; F(2,30)= 0.88; p=.425; F(2,30)= 2.16, p=.133; F(2,30)= 1.63, p=.212; F(2,30)= 0.52, p=.598; F(2,30)= 1.88, p=.17) .

A further analysis was conducted by using the Ryan's method. Results obtained indicate that the conditions between the Human-like condition and the AGENT were significant factors for measures, such as 'ease loneliness', 'happiness', 'feel close', 'expression of kindness', and 'severity' ($p=.009$; $p=.001$; $p=.010$; $p=.020$; $p=.034$). On the other hand, results obtained indicate that the conditions between the Robot-like condition and the AGENT were only significant factors for measures, such as 'happiness' ($p=.037$).

8 Summary of Results

Table 1 summarizes results of the analysis of the major effects of instruction. In the table, the asterisk, plus, and minus signs stand for significant, marginal, and no statistical differences detected, respectively.

The results indicate that the detected effects of instruction are more significant for the “Affiliation emotion” and “Interpersonal stress” factors. This suggests that participants with a HUMAN schema produce higher ratings, compared to those with an AGENT schema on the emotional characteristics of communication scale.

Table 2 summarizes results of the analysis of the influence of the interface, where the asterisk, plus, and minus signs stand for significant, marginal, and no statistical differences detected, respectively.

Table 1. Summary of Experiment 1 findings

		HUMAN condition vs AGENT condition
Interpersonal stress	feeling tension	*
	severity	-
	fatigue	-
	easiness	-
	tired	-
Affiliation emotion	ease of business	+
	happiness	+
	feeling close	*
	open-minded	-
	expression of kindness	*
	discuss personal account	-
	focus on conversation	-
Information propagation	speed of communication	-
	gathering of information	-
	ability to express an idea	-
	purpose of claim is clear	-

Table 2. Summary of Experiment 2 findings

		Human-like condition vs AGENT condition	Robot-like condition vs AGENT condition
Interpersonal stress	feeling tension	-	-
	severity	+	-
	fatigue	-	-
	easiness	-	-
	tired	-	-
Affiliation emotion	ease of business	*	-
	happiness	*	*
	feeling close	*	-
	open-minded	-	-
	expression of kindness	*	-
	discuss personal account	-	-
	focus on conversation	-	-
Information propagation	speed of communication	-	-
	gathering of information	-	-
	ability to express an idea	-	-
	purpose of claim is clear	-	-

These findings indicate that the Human-like interface was rated higher, compared to the Robot-like and the no embodiment interface on the emotional scale of communication.

9 Discussion

9.1 Influence of Schema

In Hayashi & Miwa (2009), the authors used the same questionnaires and analyzed the effects of schema during participants’ communication with a computer or human agent. In their study, when the participants were instructed that the partner is human, they produced more positive ratings towards the “Affiliation emotion” and

“Interpersonal stress” characteristics of communication. In the presented study, it was confirmed that participants with a human schema give more positive evaluations of the emotional characteristics of communication, compared to the participants with an agent schema.

In the previous study, the participants’ psychological characteristics were measured after the task. In the presented study, the participants’ psychological characteristics were assessed two times, and it was found that the effect of schema does not change over time. This suggests that the emotional characteristics emerge in a situation where participants have a consistent schema throughout communication with the partner.

9.2 Influence of Embodied Agents

The Human-like interface obtained higher ratings, compared to the Robot-like and to the no embodiment interface on the emotional scale of communication. This may indicate that the more ECA has human-like characteristics, the more the users would rely on a human schema and deem the agent as human. We found no previous studies that would focus on the effects of schema potentially affecting emotional characteristics of communication throughout an on-line conversation with an ECA.

There were studies on ECAs that focused on the creation of a realistic embodied agent [4]. The given work presents results that may be useful for the development of human-like conversation scenarios with a computer agent. The obtained results stress the importance of designing an ECA that would stimulate the user’s schema.

10 Conclusions

This study’s goal was to investigate the following two issues: (1) Whether the user’s emotional characteristics are more stimulated when the user has a human schema, as opposed to a computer agent schema, and (2) Whether the user’s emotional characteristics are more stimulated when the user interacts with a human-like ECA, as opposed to interacting with a non human-like ECA, or when there is no ECA. The study’s main findings can be formulated as follows: (a) participants with a human schema produce higher ratings, compared to those with an agent schema, on the emotional (interpersonal stress and affiliation emotion) scale of communication. (b) The human-like interface obtains higher ratings, compared to the robot-like and to the no embodiment interfaces, AGENT on the emotional (interpersonal stress and affiliation emotion) scale of communication. In social psychology, it is usually considered that schema and emotion co-occur in social interaction. Our results support this hypothesis, and also provide a new insight: when one fosters a human schema with the interface, this may enhance the user’s positive emotional states.

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