Investigation of Users' Reactions toward Various Kinds of Artificial Agents: Comparison of an Robotic Agent with an On-screen Agent

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Abstract. We experimentally investigated users' reactions toward an on-screen agent appearing on three different types of media: a 42-inch television (120 cm away from participants), 17-inch display (80 cm), and 4.5-inch mobile PC (40 cm). Specifically, we observed whether the users accepted the agent's invitation to a Shiritori game while they were engaged in given tasks. The results showed that most participants who received the invitation from the on-screen agent appearing on a 4.5-inch mobile PC accepted the agent's invitation, while most participants did not accept the invitation from the agent appearing on the other two formats. We then investigated their reactions toward the agent the other situation; that is, appearing on 42-inch television (80 cm away), 17-inch display (40 cm) and 4.5-inch mobile PC (80 cm). The results showed that the participants still significantly accepted the invitation from the on-screen agent appearing on the 4.5-inch mobile PC from 40 cm away, and then clarified that both factors of the shorter distance from the agent and of the appropriate media type affected the participants behaviors whether they accepted or rejected the agents' invitations.

Keywords: On-screen agent, Media Terminals, Shiritori game.

1 Introduction

Various interactive agents such as robotic agents [1] or embedded conversational agents (ECAs) [2,3] have been developed to assist us with our daily tasks. Because of this situation, some researchers have started testing the effects of various agents appearing on different media on users' reactions and impressions. In particular, comparisons of on-screen agents appearing on computer displays with robotic agents have been conducted [4,5,6,7,8,9]. Most of these studies argued that robotic agents were much more comfortable and believable interactive partners than on-screen agents for users [5,6,7]. However, some studies have reported that people reacted toward

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on-screen agents as if they were reacting toward robotic ones [8,9]. Thus, these studies [8,9] showed that on-screen agents could also become comfortable and believable interaction partners for users.

Therefore, an on-screen agent could be utilized specifically in situations where a robotic agent cannot be used, e.g., in mobile situations, and these agents could appear on various media in home or office environments, such as big screen televisions, computer displays, mobile computers, or cell phones. However, the effects of different media on users' reactions during the users' interactions with on-screen agents have not been considered. Therefore, in this study, we focused on three different media terminals that could be generally utilized for the on-screen agents: e.g., a 42-inch big-screen television, a 17-inch LCD PC monitor, and a 4.5-inch mobile PC. We firstly conducted an experiment to investigate the effect of these three types of media placed on appropriate distances on participants' reactions during their interactions with on-screen agents.

2 Experiment 1

2.1 Overview

We utilized a "Shiritori game" environment as an experimental setting to observe the participants' reactions in their interactions with on-screen agents [7,8]. First, the participants were told that the purpose of this experiment was to investigate the computer mouse trajectory while they played a web-based puzzle video game "picross" by Nintendo Co., Ltd. Actually, this puzzle game was a dummy task for the participants. The experimenter then told them that an on-screen agent would conduct the experiment because the presence of a human experimenter would affect the results. One minute after the puzzle game started, an on-screen agent placed diagonally to the left and in front of the participants talked to them, and encouraged them to play a "Shiritori game" together. Shiritori is a Japanese word game where you have to use the last syllable of the word spoken by your opponent for the first syllable of the next word you use (the rule of this game shown in Fig. 1.). Most Japanese have a lot of experience playing this game, especially when they are children.

Japanese Last and First Game (*Shiritori)*

Rule:

- Two or more people take turns to play.
- Only nouns are permitted.
- A player who plays a word ending in the mora "*N*" loses the game, as no word begins with that character.
- Words may not be repeated.

Example:

Sakura (cherry blossom)-> *rajio* (radio)-> *onigiri* (rice ball)-> *risu* (squirrel) -> *sumou* (sumo wrestling) -> *udon* (Japanese noodle)

Note: The player who played the word *udon* lost this game.

Fig. 1. Rules of Shiritori from Wikipedia[1]

[1] http://en.wikipedia.org/wiki/Shiritori

The actual purpose of this experiment was to observe the participants' behavioral reaction when the agent talked to them: specifically, whether the participants accepted or rejected the invitation of the on-screen agents. The Shiritori game is a quite easy, so we assumed that the participants who accepted the invitation of the Shiritori game regarded the on-screen agent as a comfortable interactive partner.

2.2 Participants

30 Japanese university students participated (19–23 years old: 15 men and 15 women). These participants were randomly divided into the following three experimental groups (Fig. 2).

- Group 1 (10 participants): The on-screen agent appeared on a 42-inch LCD flat television (Sony Corporation: FWD-42PX2). The agent on the screen was about 38 cm tall, and the distance between the display and the participants was about 120 cm. The resolution of the on-screen agent on this television was 800 x 600 [pixels].
- Group 2 (10 participants): The on-screen agent appeared on a 17-inch flat display (Eizo Corporation: FlexScan S1701). The agent was about 14.5 cm tall, and the distance was about 80 cm. The resolution on this display was 800 x 600 [pixels].
- Group 3 (10 participants): The on-screen agent appeared on a 4.5-inch mobile PC's wide display (Sony Corporation: VAIO type U VGN-UX90S). The agent was about 4 cm tall, and the distance was about 40 cm. The resolution on this wide display was 1024 x 600 [pixels]

Fig. 2. Three dirrerent media terminals: 42-inch television (center), 4.5-inch mobile PC (left bottom) and 17-inch LCD display (right bottom)

We used NEC's CG robot software "RoboStudio," which is PaPeRo robot (by NEC) simulation software, for the on-screen agent. Before the experiment, we ensured that the participants did not know about RoboStudio or PaPeRo robot. Actually, the agent was placed in front of and to the left of the participants so that they could not look at the agent and the puzzle game simultaneously (Fig. 3 and 4). The distance between each type of media and the participants was decided based on the appropriate distance for each media. The sound pressure of the on-screen agent's voice at the participants' head level was set at about 50 dB (FAST, A). The agents behaviors (announcing the starting and ending signals and playing the Shiritori game) were remotely controlled by the experimenter in the next room using the wizard of oz (WOZ) method.

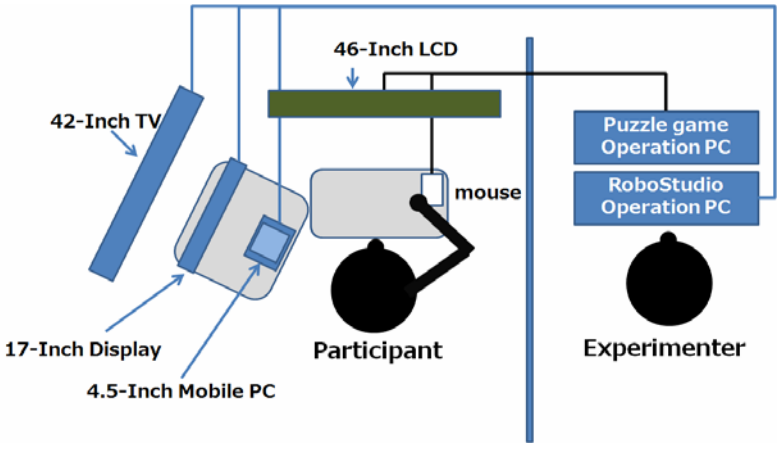

Fig. 3. Experimental Setting

Fig. 4. Actual Experimental Scene: Group 1 (left) and Group 3 (right)

2.3 Results

We investigated how many participants accepted the on-screen agent's invitation in each experimental group (Fig. 5). In Group 1 (42-inch TV), two out of 10 participants

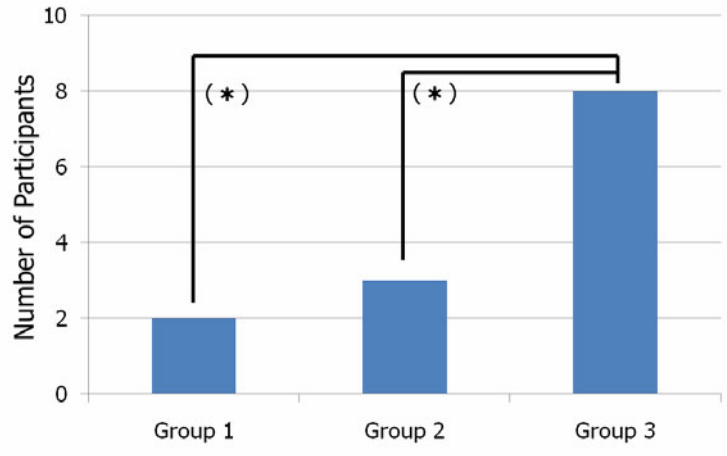

Fig. 5. Number of participants who accepted the agent's invitation in each experimental group

accepted the agent's invitation and actually played the Shiritori game. In Group 2 (17-inch Display), three out of 10 participants accepted the invitation, and in Group 3 (4.5-inch mobile PC), eight participants did so.

A Fisher's exact probability test was used to elucidate the effects of the different media by comparing all three groups. The results were that we found significant differences between Group 1 and 3 (one-sided testing: $p=0.012<0.05$ (*)), and between Group 2 and 3 ($p=0.035<0.05$ (*)). Therefore, the results of this experiment clarified that most participants in Group 3 (on-screen agent appearing on a 4.5-inch mobile PC) accepted the agent's invitation, while most participants in Group 1 (42-inch TV) and Group 2 (17-inch display) did not.

The results of the experiment suggest that a mobile PC is an appropriate media for an on-screen agent that is required for interaction with users. Interestingly, our finding seems to be completely opposite to the findings of Goldstein et al. [10]; that is, "people are NOT polite towards small computers." On the other hand, our finding seems to be in accord with the findings of Hall's proxemics [11]; that is, "the social distance between people is reliably correlated with physical distance." However, whether the media type itself (e.g., mobile PC or large display) or the distance between the agent and the participants affected the participants' reactions is still unclear from this results.

3 Experiment 2

We then conducted a follow-up study to investigate which factor (media type or distance) significantly affects the participants' reactions and to compare the acquired results with the findings of Goldstein [10] and Hall [11].

3.1 Participants

30 Japanese university students participated (19–22 years old: 15 men and 15 women). These participants were randomly divided into the following three experimental groups. In addition, they did not participate the Experiment 1.

- Group 4 (10 participants): The on-screen agent appeared on a 42-inch LCD flat television and the distance between the television and the participants was about 80 cm, which was 40 cm shorter than ones in Group 1. The resolution and the height of the on-screen agent on this television were the same with the ones in Group 1.
- Group 5 (10 participants): The on-screen agent appeared on a 17-inch flat display, and the distance was about 40 cm, which was 40 cm shorter than one in Group 2. The resolution and the height of the agent on this display were the same with the ones in Group 2.
- Group 6 (10 participants): The on-screen agent appeared on a 4.5-inch mobile PC's wide display and the distance was about 80 cm, which was 40 cm longer than . The resolution and the height of the agent were the same with the ones in Group 3.

The investigation of the participants' behaviors whether they accepted the agents' invitations or not in these additional three experimental conditions would clarify which factor (media type or distance) significantly affects the participants' reactions. Specifically, this investigation would clarify the one of the following two claims based on the acquired results.

- Case 1: the factor "distance" significantly affected the participants' reactions.
  1. The number of the participants who accepted the agents' invitations in Group 4 is larger than one in Group 1 (i.e., 80 cm in Group 4 vs. 120 cm in Group 1).
  2. The number of the participants who accepted the invitations in Group 5 is larger than one in Group 2 (i.e., 40 cm in Group 5 vs. 80 cm in Group 2).
  3. The number of the participants who accepted the invitations in Group 6 is smaller than one in Group 3 (i.e., 80 cm in Group 6 vs. 40 cm in Group 3).
- Case 2: the factor "media type" significantly affected the participants' reactions.
  1. The number of the participants who accepted the agents' invitations in Group 4 is the same with the one in Group 1 (i.e., the same media "42-inch TV" is utilized).
  2. The number of the participants who accepted the invitations in Group 5 is the same with the one in Group 2 (i.e., the same media "17-inch display" is utilized).
  3. The number of the participants who accepted the invitations in Group 6 is the same with the ones in Group 3 (i.e., the same media "4.5-inch mobile PC" is utilized).

Here, the procedure and setting of this experiment was the completely same with the ones in Experiment 1 except of the placed distance of each media from the participants.

3.2 Results

We investigated how many participants accepted the on-screen agent's invitation in each experimental group (Fig. 6). In Group 4 (42-inch TV with 40 cm shorter distance), three out of 10 participants accepted the agent's invitation and actually played the Shiritori game. In Group 5 (17-inch Display with 40 cm shorter distance), six out of 10 participants accepted the invitation, and in Group 6 (4.5-inch mobile PC with 40 cm longer distance), five participants did so.

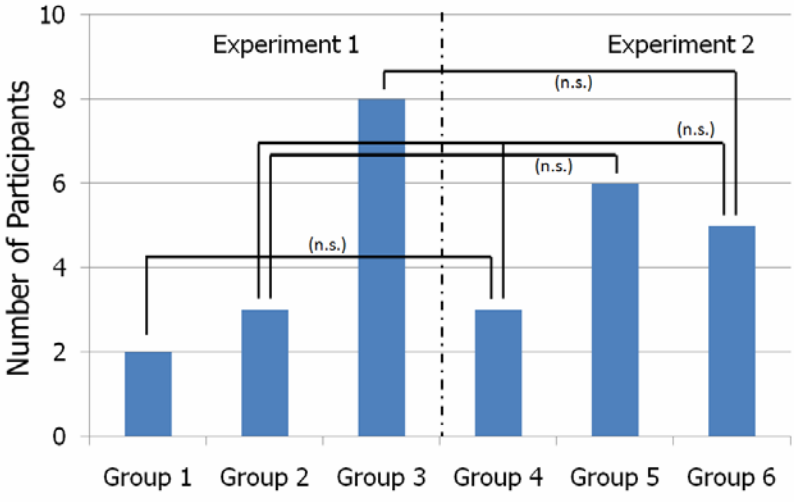

Fig. 6. Number of participants who accepted the agent's invitation in each experimental group

A Fisher's exact probability test was used to elucidate the effects of the different media and different distance by comparing the following four couples; that is, between Group 1 and 4, between Group 2 and 5, between Group 3 and 6, and between 2, 4 and 6. The results were that we found no significant differences in the all four couples (one-sided testing: p=0.50, n.s. (Group 1 and 4), p=0.1849, n.s. (Group 2 and 5), p=0.1749, n.s. (Group 3 and 6), p=0.350 (Group 2, 4 and 6). Therefore, it seemed that this result support the claim "Case 2" mentioned in the above, e.g., the factor "media type" significantly affected the participants' reactions. However, in between Group 3 and 6, the number of the participants who accepted the invitations was getting decreasing as its distance was getting longer (five participants with 80cm vs. eight with 40 cm). Moreover, in between Group 2 and 5, the number of the participants who accepted was getting increasing as its distance was getting shorter (three participants with 80 cm vs. six participants with 40 cm). Although there were no significant differences in these two couples, it would be hard to exclude the effects of the factor "distance" on the participants' reactions, and it would be simultaneously hard to say that the effects of the factor "media type" only affected the participants' reactions.

On the other hand, in between Group 1 and 4, the number of the participants did not change even though the 42-inch TV moved to the shorter distance to the participants (i.e., two participants with 120 cm in Group 1 vs. three participants with 80 cm in Group 4). This results might indicate that it would be uncomfortable for participants to react to the agent appearing on the media with large display regardless of the distance between them.

To sum up, we could confirm the following three phenomena based on the results of the Experiment 1 and 2:

- The number of the participants who accepted the invitations of the agent appearing on 4.5-inch mobile PC was decreasing as its distance between them was increasing.
- The number of the participants who accepted the invitations of the agent appearing on 17-inch display was increasing as its distance between them was decreasing.
- The participants did not react naturally to the agent appearing on 42-inch TV regardless of the distance between them.

Although these three phenomena could not clarify which factor ("media type" or "distance") significantly affects the participants' reactions or not, these would suggest the other interpretation, such as "each media terminal has an each appropriate distance to the users."

4 Conclusions

The purpose of this study was to clarify the effects of the different media terminals where the on-screen agent appears on the participants' behaviors or reactions. Specifically, we focused on the three different media terminals that could be generally utilized for the on-screen agents; that is, 42-inch big-screen TV with 120 cm away from the participants, 17-inch LCD PC monitor with 80 cm away, and 4.5-inch mobile PC with 40 cm away. We then investigated whether these participants accepted the agent's invitation to a Shiritori game while they were engaged in given task. The results showed that most participants who received the invitation from the agent appearing on a 4.5-inch mobile PC accepted the agent's invitation, while most participants did not accept the invitations from the agent appearing on the other two media terminals. However, whether the media type itself (e.g., mobile PC or large display) or the distance between the agent and the participants affected the participants' reactions was still unclear from this results.

We then conduct a follow-up experiment to investigate which factor (media type or distance) significantly affects the participants' reactions. Specifically, we prepared the three additional experimental conditions; that is, 42-inch TV with 40 cm shorter distance, 17-inch display with 40cm shorter distance, and 4.5-inch mobile PC with 40 cm longer distance. The results showed the following three phenomena; 1) The number of the participants who accepted the invitations of the agent appearing on 4.5-inch mobile PC was decreasing as its distance between them was increasing, 2) The number of the participants who accepted the invitations of the agent appearing on 17-inch display was increasing as its distance between them was decreasing, and 3) The participants did not react naturally to the agent appearing on 42-inch TV regardless of the distance between them. It seemed that this result suggest the other interpretation, such as "each media type has an each appropriate distance to the users. " Therefore, we could not clearly confirm which the claims of Goldstein or Hall was an appropriate for interacting between users and on-screen agents.

One of the interesting phenomena observed in the two experiment was that the participants did not look at the on-screen agent when they accepted the invitations to a Shiritori game or even during they were actually playing the game. This phenomenon would indicate that whether they accepted the agents' invitations or not would depend not on the visible existence based on the visual information but on the audible one based on the audio one. Therefore, there would be some possibilities that the

participants who listen the agents' invitation from the wearing headphone would accept the invitations and play the game regardless of the types of the media terminals and regardless of the distance between them.

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