Social Presence in Long-Term Human-Computer Relationships

Iolanda Leite [1], Carlos Martinho[1], Ana Paiva[1] and André Pereira [1]

Abstract. Given the recent advances in robot and synthetic character technology, many researchers are now focused on ways of establishing social relations between these agents and humans over long periods of time. In this paper, we study the role of social presence in long-term human-computer interaction. We performed an experiment where children played one chess exercise against a social robot over five consecutive weeks. Social presence was evaluated through questionnaires and video evaluations. The results of the experiment suggest that, after the novelty effect of the first weeks, user's perceived social presence towards the robot starts decreasing.

1 INTRODUCTION

In the near future, we will live in a world populated with robots and artificial agents embedded in handhelds and other ubiquitous platforms whose purpose is assisting us in everyday tasks. Since these agents will interact with us on a regular basis, they should be able to create and maintain social relationships with us so they can be well accepted. Yet, most of the existing work on artificial agents (with virtual or robotic embodiments) has only considered short-term interactions. After the "novelty effect" people usually lose interest and change their attitudes towards the agents. Creating long-term relationships, or companionship between agents and users, requires research in several areas, such as social interaction, memory, cognition and learning, which is the aim of the LIREC Project [1].

Most human relationships begin with communication, the process that enables humans to share knowledge, attitudes and personal experiences. Communication can be split up in two different channels: verbal communication (i.e., speech) and nonverbal communication, which encompasses for example gestures, body posture and facial expression. In face-to-face interaction between two humans, communication is (under normal conditions) a natural process, which may not be the case in human-agent communication, especially if considering long-term interactions. In long-term interactions, the sense of social presence, awareness or intimacy may fade away, decreasing the user's willingness to establish a relationship with the agent.

The term Social Presence was initially proposed by Short, Williams and Christie [2] as the "degree of salience of the other person in the interaction and the consequent salience of the interpersonal relationships". This concept intends to measure the individual's perception of a particular media. Much of the studies regarding social presence are found in new forms of human-human communication such as computer conferencing [3].

In this paper, we intend to evaluate a long-term interaction between users and a social robot. Particularly, we assess if the user's perceived social presence towards the robot decreases over time and, if so, what are the critical factors for that. The document is organized as follows. The next session contains a brief literature review on long-term human-computer interaction studies. Then we present the scenario and the experiment that we conducted. After that, a discussion on the results is presented, followed by some conclusions and future work.

2 RELATED WORK

One of the first long-term experiments was performed by Kanda et al. [4]. They performed a field trial evaluation for two weeks with elementary school Japanese students and two English-speaking interactive humanoid robots behaving as peer English tutors for children. The study revealed that the robot failed to keep most of the children's interest after the first week, mostly because the robot's first impact created unreasonably high expectations in the children. A longer study was carried out at Carnegie Mellon's University using Valerie, a "roboceptionist" [5]. Students and university visitors interacted with the robot over nine months. The results indicated that many visitors continued to interact daily with the robot, but only few of them interacted for more than 30 seconds.

Some of the studies on long-term human-computer relationships are grounded on human social psychology theories, such as the work of Bickmore & Picard [6]. They developed a relational agent and evaluated it in a controlled experiment with approximately 100 users who were asked to interact daily with an exercise adoption system agent. After four weeks of interaction, the relational behaviours increased the participant's perceptions of the quality of the working alliance (on measures such as liking, trust and respect), when comparing the results with an agent without relational behaviours. Besides, participants interacting with the relational agent expressed significantly higher desire to continue interacting with the system.

The research on long-term interaction in artificial agents so far has been grounded on the analysis of the number of interactions, and how that number changes over time, given the assumption that people are free to interact (or not) with the agent. In this work we follow a different approach: by fixing the number of interactions (users interacted once a week during five consecutive weeks), we analyzed the differences on the user's mental model of the agent, particularly in terms of social presence.

[1] IST – Technical University of Lisbon and INESC-ID, Avenida Prof. Dr. Cavaco Silva, 2780-990 Porto Salto, Portugal. Email: {**iolanda.leite**, **carlos.martinho, andre.pereira}** **@tagus.ist.utl.pt, ana.paiva@inesc-id.pt.**

3 EXPERIMENT

We evaluated the effects of social presence in long-term human-robot interaction in a scenario where the Philips' iCat [7] is the opponent of a user in a chess game, and the robot's affective behaviour is influenced by the state of the game. By looking at iCat's facial expressions, users have a better perception of what happens in the game [8]. The agent architecture is divided in three main modules: game, emotion and animation. The game module contains the whole logic of the chess game, and the algorithms to perceive the user's moves and select the moves of the agent. The emotion module is influenced by the evaluation values computed in the game module. It is separated in two main components: emotions, which are immediate reactions to the user's move and are based on the *emotivector* anticipatory mechanism [9], and mood, a continuous background affective state. The animation module is responsible for conveying the two affective states of the emotion module in the iCat's embodiment.

The interaction starts with the iCat waking up. After that, it invites the user to play. After the user's move, the robot performs an affective reaction to that move (see Figure 1). Then, the iCat asks the user to play its move in chess coordinates. When the user makes that move, the iCat sends a confirmation signal to the user (a small utterance such as "ok, thank you" or a "nod" animation). The game continues until one of the opponents checkmates the other.

Figure 1. User Playing with the iCat

The experiment was performed over five consecutive weeks in a local chess club, where 7 participants played one chess problem every Saturday (although only 4 children played all the sessions). At the end of both the first and the last sessions children were asked to fill a social presence questionnaire. All the sessions were video recorded.

The social presence questionnaire was based on the Harms & Biocca [10] questionnaire, which conceptualizes social presence in six dimensions: "co-presence", "attentional allocation", "perceived message understanding", "perceived affective understanding", "perceived affective interdependence" and "perceived behavioural interdependence". We translated this questionnaire to Portuguese and selected two items for each dimension that would be adequate for children (see Table 1). Children were asked to express their agreement or disagreement regarding each item in a five-point Likert scale, where zero meant "totally disagree" and five stood for "totally agree".

Co-Presence		1st week	5th week
Q1	I noticed iCat.	4,00	3,75
Q2	iCat noticed me.	3,75	3,75
Attentional Allocation			
Q3	I remained focused on iCat.	3,50	2,75
Q4	iCat remained focused on me.	3,75	3,25
Perceived Message Understanding			
Q5	My thoughts were clear to iCat.	3,25	2,75
Q6	iCat's thoughts were clear to me.	3,00	3,25
Perceived Affective Understanding			
Q7	I could tell how iCat felt during the game.	3,00	3,00
Q8	iCat could tell how I felt during the game.	2,25	2,50
Perceived Emotional Interdependence			
Q9	I was sometimes influenced by iCat's moods.	3,75	3,00
Q10	iCat was sometimes influenced by my moods.	3,50	2,75
Perceived Behavioural interdependence			
Q11	My behaviour was closely tied to iCat's behaviour.	3,50	2,25
Q12	iCat's behaviour was closely tied to my behaviour.	3,50	2,00

Table 1. Social Presence Questionnaire Items and Means for the first and fifth week

The videos from both the first and last sessions of the four users who played the five exercises were analyzed using ANVIL, a free video annotation tool for adding structured human annotations to digital video material [11]. ANVIL allows coders to annotate regions in the video on multiple layers called tracks that are defined by the coder in an xml file. During the annotation process, the coder adds elements to a track. Each element can hold a number of attribute-value pairs. In this case, the defined tracks were "user looking at iCat", "user looking at sides", "user talk to iCat" and "facial expressions of the user". In order to have a more detailed analysis, the "looking at iCat" track holds the following three attributes: "after user's own move", "after playing iCat's move" and "during the game", which cover all the reasons why children are looking at the robot. For the same reason, the "talk to iCat" element also contains an attribute to annotate the utterances.

During the video annotations, some non-quantitative data was also retrieved, which proved to be of extreme relevance to understand the results of the social presence questionnaire.

3 RESULTS and DISCUSSION

The means for each questionnaire item for the first and fifth week are presented in Table 1. The sample of the data is too small to apply more sophisticated statistical tests. Yet, these results combined with the data collected through video observation already give us some clues on the most relevant social presence dimensions for long-term interaction.

In the "co-presence" dimension, considering the Q1 means, users seem to notice the iCat less on the last week. This could actually be asserted by video observation. The number of times that children look at the iCat on the last interactions is lower than in the first ones, as we will discuss later on in this section. This may happen due to the novelty effect, as none of the children had interacted with a social robot before. In spite of that, when asking if the iCat notice them (Q2), their opinion did not change significantly. The turn-taking nature of the chess game may be the main cause for this result. Since the iCat reacts to children's moves and after that asks them to play its move, children probably interpreted that as the robot noticing their presence. Both the items regarding "attentional allocation" (Q3 and Q4) decreased after five weeks. From our observations within the chess club, when kids are playing with each other, they refer to previous games they played together, explain to each other some theory behind a certain move and sometimes they even make fun of each other. Some of these behaviours could be implemented in the iCat to increase the user's attention to the robot, especially the ones related with memory. In the "perceived message understanding" category, it is interesting to see that although user's perception of how clear their thoughts were to the iCat (Q5) decreased, the opposite increased, i.e., after several weeks kids claimed to know better what iCat was thinking. This also happens for the "perceived affective understanding" dimension (Q7 and Q8). For instance, on the last weeks of interaction, when the iCat reacted sadly to a good move from the user, some of them talked to the robot: "I know you don't like that". The last two dimensions ("perceived emotional interdependence" and "perceived behavioural interdependence", from Q9 to Q12) were the ones whose means decreased the most after the long-term experiment. After a few weeks, iCat seems to be perceived much more as an automaton, behaving independently of how the users feel or act, only reacting to their moves.

The results of the questionnaire can be strengthened by the results of the video annotations. From the four tracks, "looking at iCat" was the one with the largest number of annotations and also the one with more different results between the two sessions for each user. The annotations on the remaining tracks were quite sporadic: we did not find very significant differences between the first and the last week of annotations.

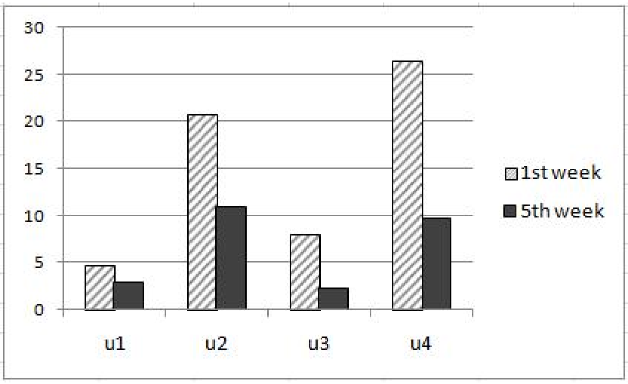

Figure 2. Total percentage of time that each user spent looking at the iCat in the first and fifth chess exercise they played.

ANVIL can export the data resulting from the annotations to text files containing tables with all the information of a certain track (one table for each exercise played by the user). In these tables, all track elements are listed in rows. Each row contains the element's start and the end time, its duration and the attributes values (if any). We combined all the entries of each table to come up with the total duration, in seconds, of a certain track. Since all the exercises had different durations (from 3 to 10 minutes), we computed the values as percentages of the total duration of the exercise, to be able to compare them between sessions. Figure 2 shows the percentages of the "look at iCat" track for each user in the first and last week of interaction. As one can see in the chart, the total time that children looked at the iCat on the last session is, on average, half of the time that they looked in the first one. These results are aligned with the ones obtained in the social presence questionnaire, especially for the "co-presence" and the "attentional allocation" dimensions. Another important issue is that the first user (u1) is fourteen years old, u2 is five, u3 is thirteen and u4 is nine. The ages of the users, when compared to the percentage of time they spend looking at the iCat, may suggest that young users (possibly below ten years old) feel much more engaged to this kind of robots. Yet, the decay of attention after five weeks was also verified in their case.

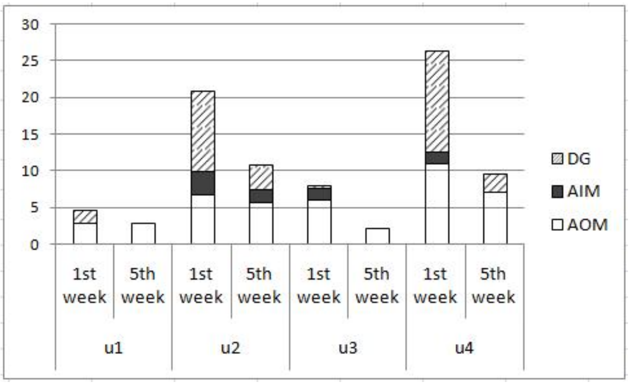

Figure 3. Percentages of the "looking at iCat" track for the first and fifth week of interaction at different stages of the game. DG stands for "During the Game", AIM for "After playing ICat's Move" and AOM for "After user's Own Move".

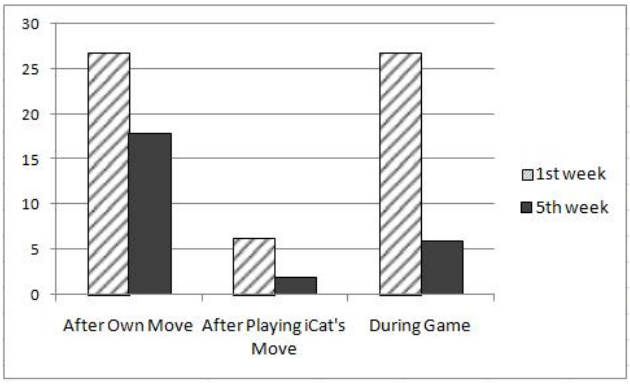

Figure 4. Total percentage of each attribute of the "looking at iCat" track for all the users.

A more detailed analysis of the "looking at iCat" attribute values is shown in Figure 3 and Figure 4. As mentioned earlier, we also annotated the stage of the game where the "looking at iCat" events happened. From the two charts above we can see that the attributes "during the game" (DG) and "after iCat's move" (AIM) were the ones that decreased the most between the two sessions. The sum for all the users of the DG in the first week is 26,9%, whereas in the last is 5,8%, and the sum of the

AIM is 6,4% in the first session and 1,9% in the last. The accentuated decrease in these two attributes may be explained by the novelty effect of the first sessions. The stage of the game with more similar results along the weeks was the "after own move" (AOM): in the first week is 26,8% and in the last week is 18%. These results were quite expected, as after the user's own move the iCat performs an affective reaction that can help the users in the game. Again, these results strengthen the ones obtained in the perceived message and affective understanding dimensions of the social presence questionnaire, which also remained similar over the weeks.

4 CONCLUSIONS and FUTURE WORK

In this paper we tackled the field of long-term human-robot interaction in terms of social presence. An experiment was performed, where users played a chess exercise against a social robot over a five week period. Social presence was evaluated using a questionnaire and through video observation.

The preliminary results of the evaluation suggest that the user's perception of social presence towards the iCat robot decreased after the five weeks of interaction. In the questionnaire, co-presence, attentional allocation, perceived emotional interdependence and perceived behavioural interdependence appear to be the dimensions of social presence that should be carefully considered when designing agents for long-term interaction. We are aware that those results were obtained in a very specific domain (a chess game), and as such more experiments should be performed to see if the results can be generalized to other domains and tasks. From the video observation, we noticed that the attention users dedicated to the robot decreased significantly over the weeks, which suggests that there must be developed new mechanisms and behaviours in the agent to maintain the engagement.

In the future we intend to evaluate also the videos of the in-between weeks (second, third and fourth), in the attempt to understand if the perceived social presence decreases gradually or if there is a big collapse between two weeks. Further, we want to implement new behaviours related with memory in the iCat and perform a new evaluation. Examples of new features that could maintain the perceived social presence over the weeks would be the iCat remembering the user's name and the results of the previous games they played together and refer to that during the game. Another example is the ability to conduct small talk, especially related to chess topics, which could increase the character's believability and credibility towards the user [12].

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