

Young Users' Perception of a Social Robot Displaying Familiarity and Eliciting Disclosure

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Abstract. Establishing a positive relationship between a user and a system is considered important or even necessary in applications of social robots or other computational artifacts which require long-term engagement. We discuss several experiments investigating the effects of specific relational verbal behaviors within the broader context of developing a social robot for long-term support of self-management improvement in children with Type 1 diabetes. Our results show that displaying familiarity with a user as well as eliciting the user's self-disclosure in off-activity talk contribute to the user's perception of the social robot as a friend. We also observed increased commitment to interaction success related to familiarity display and increased interest in further interactions related to off-activity talk.

Keywords: child-robot interaction; human-robot interaction; long-term interaction; social robot; verbal behavior; personalization; continuity behaviors; familiarity display; self-disclosure; off-activity talk; perception of robot as friend

1 Introduction

It has become a commonplace vision that robots will partake in many areas of our lives. The role they are envisaged to fulfill has shifted from that of a mere tool to a teammate, peer, companion, friend. Thus, being conceived of as social actors, which will be explicitly and intentionally entering into relationships with humans. Social science research has identified a plethora of behaviors that are prevalent and influential in establishing and maintaining human-human relationships. Inspired by the seminal work on relational agents by Bickmore and colleagues [3] a growing body of research now studies what effects do such behaviors have in human-machine, and more specifically human-robot relationships, and how we can implement the corresponding functionality to enable machines/robots to perform these behaviors autonomously. Overviewing this body of literature, it is clear that the more we know, the more we know what we do not know. There remain many aspects to be studied.

The research presented here concerns relational verbal behaviors that contribute to the perception of an agent as a friend. It is set within the broader vision of developing a robotic companion to provide long-term support to children with Type 1 Diabetes Mellitus (T1DM) to help them learn and improve their ability to independently manage their condition. During the process of self-management development, children with T1DM need to acquire knowledge about diabetes and suitable healthy nutrition, develop various relevant skills and learn to adhere to the therapy requirements. Similarly to what was noted for health behavior change applications [3], establishing and maintaining a positive relationship is considered to be a necessary (though likely not sufficient) condition for addressing the further goal of influencing diabetes self-management. In this paper we focus on two aspects of relational verbal behavior which personalize an interaction by linking it to the experiences of a given user: signaling continuity over time by references to joint experiences of the user and the robot in interaction with one another (Familiarity Display – FD); and eliciting disclosure about separate experiences of the user (Off-Activity Talk - OAT). In a series of experiments with an implemented integrated system, comparing independently a condition with and without FD and with and without OAT, we found that these behaviors contribute to young users’ perception of the robot as a friend. We first review related work on such relational verbal behaviors in Sec. 2. In Sec. 3 we describe our system. In Sec. 4 and 5 we present the methodology and results of the experiments addressing FD and OAT, respectively. We discuss the observed effects and conclude in Sec. 6.

2 Background

Bickmore and colleagues developed the concept of relational agents, referring to computational artifacts designed to establish and maintain long-term social-emotional relationships with their users [3]. They discussed a myriad of strategic relational behaviors, instantiated them in systems and carried out numerous studies to evaluate the effects of various aspects of relational agent behavior on long-term engagement and behavior change, e.g., [4]. This inspired many other researchers to perform further studies and experiments in this area. What we call familiarity display has been called continuity behaviors in some previous literature. For example, the continuity behaviors implemented in the FitTrack system [3] and the person memory model of a virtual agent described in [13] include greetings and farewells referring to past/future encounters and reference to mutual knowledge, e.g., user’s biographical facts, preferences and interests mentioned in a previous session. The exercise advice system described in [8] also implements continuity behaviors as means of relationship maintenance, namely reference to previously given advice and gradually more personal greetings, including some small talk. Various other systems have included a user model or some form of long-term memory and used it to refer to content from previous interactions [1, 5, 16, 18].

Our concept of Off-Activity Talk corresponds to the reciprocal self-disclosure discussed as another relational behavior and found to increase trust, closeness and liking in work cited by [3]. While the OAT in our system allows reciprocity, we have fo-

cused on eliciting disclosure from the users so far. This resembles the gathering of personal information in [1, 5, 13, 18], but is more conversational.

A comparison of existing results concerning the effects of various relational behaviors is complicated by the fact that each study uses measures and methodologies adjusted to its purpose. For example, [3] evaluated the effects of all the relational behaviors combined. They found an effect on long-term relationship, but not on behavior change in a real usage longitudinal study. On the other hand, [8] evaluated the isolated impact of relationship maintenance on users' attitudes and found an effect on various metrics and [13] investigated the impact on social presence, likability and communication satisfaction of using personal information during the interaction sessions. These studies were done with adults, the systems of [3] and [8] were not robots, and the metrics did not include a classification of the user's perception of their relationship with the system. Some of the experiments did not involve usage in real life, but the participants used the system to play out hypothetical situations, e.g. [8].

3 System and Setup

Our experiments were carried out with the system developed gradually in the course of the Aliz-E project [7]. The robot we use is the small humanoid robot Nao from Aldebaran Robotics. The system integrates components for speech recognition and interpretation as well as natural language generation and synthesis, gesture capture and interpretation, nonverbal behavior production and motor control, activity-, interaction- and dialog management, and a user model to store key information about each child [9]. Several game-like activities were implemented in the system: Quiz, Imitation, Dance and Collaborative Sorting [9, 2, 15]. A range of relational social behaviors reported in the literature was implemented across the activities, including informal greetings, introductory small talk, the use of first names, empathy related to the performance in an activity, the robot's ability to make mistakes, nonverbal bodily cues, allowing children to touch the robot [14]. Although the robot was presented as autonomous to the participants, we relied on a partially Wizard-of-Oz setup, where a human Wizard simulated the speech and gesture input interpretation, could override the automatic dialog management decisions, if needed, and fully controlled off-activity talk.

4 Experimental Study 1: Familiarity Display

The first study was a longitudinal experiment investigating the use and effects of continuation behaviors. We investigated how the robot can acquire familiarity with a user and display it in interactions, and what effect this would have on children's perception of the robot.

4.1 Familiarity Display

When humans interact with each other over a series of encounters, they become familiar, i.e., they accumulate shared knowledge (shared history, personal common ground) [6]. The goal of this study was to endow the robot with the ability to acquire a persistent interaction history respective to each individual user and allow it to manifest its familiarity with the user both verbally and nonverbally later in the same interaction or in subsequent interactions. We selected several parameters that the robot would use to represent the interaction history: the user's name; whether it is the first or a subsequent encounter of the user with the robot; for each activity whether the user has already performed it or not and some details about it (e.g.: for each Quiz question, whether it has been asked before in a interaction with the user); the user's last performance on each activity. The values of these parameters for each user were stored in a persistent user model. We designed templates for verbal output generation which allowed to include content based on the user model. The robot would use these verbalizations to explicitly display its familiarity with the user. Such verbal moves would also be accompanied by nonverbal behaviors showing familiarity, e.g., nodding, higher excitement. We also designed alternative verbalizations which were neutral, i.e., they would not show whether the robot is or is not familiar with the user. Examples of verbalizations of both kinds are shown in **Table 1**.

Table 1. Examples of verbalizations that signal familiarity (used in the FD condition, see paragraph 4.2) or are neutral in this respect (used in the ND condition, see paragraph 4.2).

Familiarity display	Neutral display
<i>Use of user's name:</i> So, which answer do you choose, <i>Marco</i> ?	So, which answer do you choose?
<i>References to previous encounters and play experiences:</i> I am happy to see you <i>again</i> . It was nice playing with you <i>last time</i> .	I am happy to see you. -
<i>References to previous performance in an activity:</i> Are you ready to play <i>again</i> ? Today you were <i>again</i> very good at quiz. Well done, you've done <i>better than last time</i> .	Are you ready to play the quiz? Today you were really good at quiz. Well done.

4.2 Experiment Methodology

As described in detail in [10], 19 children participated in total (11 male, 8 female; age 5-12, all Italian), of which 13 participated in three sessions on different days as fore-seen in the protocol (9 male, 4 female; 6 with T1DM, 7 healthy).

We exerted a between-subjects design with two conditions: the Familiarity-Display (*FD* - 9 children) condition and the Neutral Display (*ND* - 10 children) condition. The robot used the verbal and nonverbal behaviors described in Sec. 4.1, respectively.

The experiment took place at a research lab at the San Raffaele hospital in Milan. The sessions were organized on several Saturdays over a period of two months and full participation involved three sessions on different dates per child, where s/he could

choose among one (or more, time permitting) of the available activities to be performed with the robot: Quiz, Imitation game and Dance. Each session of the experiment lasted maximally one hour, including the interaction session with the robot and filling in 3 post-interaction questionnaires. These latter were multiple choice questionnaires reporting the child's self-assessment of: (Q1) *the perceived bond with the robot*, to be categorized between different levels of confidence and familiarity: stranger, neighbor, classmate, teacher, friend, relative, sibling, parents; (Q2) *the perceived role during the activities*: child leading, robot leading or on a par; (Q3) *the perception of the robot*: through a multi-adjective choice among friend, toy, pet or game console. Children were also asked to briefly explain their choices. The questionnaires were administered to the participants at the end of each session, in order to see if there was any change over time.

4.3 Results

We analyzed the post-interaction questionnaires, linking to each multiple choice answer a numerical value. We calculated the means and standard deviations of the scores per child across the interaction sessions.

Questionnaires Q1 and Q2 did not reveal any statistical significance regarding the perception of either the bond with the robot or the level of the established relationship, neither between the two experimental conditions (*FD* and *ND*) or across the sessions (for those children who interacted three times). From the explanations that the participants gave to justify their answers, as a qualitative insight we saw that, independently from the two conditions, high rates of perception of the bond (from friend to parent) were related to the play dimensions (e.g.: "having fun" and "play together") and the friendly approach ("it's nice/cute/tender") that the robot showed to children. Lower values, linked to the perception of different levels of relationship (stranger, neighbor, teacher), were mainly related to a low satisfaction and engagement in the activity/ies performed (e.g. "too difficult questions/tasks", "questions like homework", etc.). In addition, there was an overall perception of the interactions with the robot as being "at the same level".

An interesting result was found in Q3: a comparison of the adjective choices revealed that all 9/9 children in the *FD* condition perceived the robot as friend after the first session as opposed to the only 4/10 *ND* children (Fisher's test: two-tailed $P=0.0108$). Among the 13 children who continued to have 3 interactions 5/6 *FD* children maintained the perception of the robot as friend, only one changed it to a toy. No trend was observed among the 7 *ND* children.

5 Experimental Study 2: Off-Activity Talk

The second study investigated the effects of Off-Activity Talk (OAT) in one-on-one interaction sessions held in the context of two different educational summer camps for children with T1DM, organized by the Italian patient's association SOSstegno70 (www.sostegno70.org) and the pediatric department of San Raffaele hospital

(Milan). We investigated how the robot can engage a child in OAT on topics related to diabetes and healthy lifestyle and how this would impact children's perception of their relationship to the robot; interest to undergo further interactions with it; willingness to talk about diabetes and self-disclosure; adherence to a therapy-related requirement to fill in a nutritional diary. The methodology and results of the 2013 experiment have been published in [11, 12]. We only repeat those points that are relevant for a comparison with the 2014 experiment.

5.1 Off-Activity Talk

OAT are sub-dialogs interspersed within the talk pertaining to a particular activity, without being directly part of it [11, 12]. The main OAT topics we defined were pertinent to: hobbies, diabetes, nutritional habits, relationships with friends and adults with respect to diabetes (for examples, see [11]). For each topic, several OAT-initiation system utterances were formulated and implemented as canned text in the system. The initiation of OAT was triggered by the Wizard at opportune moments during the interaction(s) within the course of an activity. For example, during the Collaborative Sorting game, OAT about nutritional habits was triggered while the child was playing a virtual game about the food and carbohydrates counting (see the example extracted from a longer interaction in the left column in **Table 2**).

Table 2. Examples of OAT subdialogs from the 2014 experiment (translated from Italian). *Left:* OAT on nutritional habits linked to the contents of the Sorting Game. *Right:* Child self-disclosure concerning diabetes.

<p>Nao: <i>what is your favourite food among these?</i> Child: <i>among the remaining ones - ice cream. I really like it. although I can't always eat it, it's not good for me.</i> Nao: <i>which flavour do you prefer?</i> Child: <i><EH> stracciatella.</i> Nao: <i>that's good.</i> Child: <i><laughter></i> Nao: <i>can you distinguish foods according to carbohydrates?</i> Child: <i>yes, I do count - as I do for the insulin at home. I count carbohydrates.</i></p>	<p>Nao: <i>do you measure glycaemia yourself at home?</i> Child: <i>yes, I do it myself, because now I'm quite big, so -</i> Nao: <i>you're so good.</i> Child: <i>thanks.</i> Nao: <i>I was told that it is difficult.</i> Child: <i><EH> a - well, it is a bit difficult at the beginning, because even - say - accept that you have diabetes is a bit difficult. but then you get used to it. [...]</i> Nao: <i>I'd like to ask you how do you do it.</i> Child: <i>how do I measure glycemia?</i> Nao: <i>yes.</i> Child: <i>so, basically <EH> I take my measuring set, I disinfect the finger I want to prick, I take the pen, prick and then put the blood in the strip, which automatically measures glycaemia, so that I see the value on the screen of the set.</i></p>
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5.2 Experiment Methodology and Results

Participants. The experiments for this study have been conducted in two different educational summer camps in 2013 and 2014. In the 2013 experiment, 20 children

(age 11–14, 10 females and 10 males) among the total of 59 attending the camp volunteered to participate in the individual sessions with the robot. In 2014 it was 28¹ (age 10–14, 10 females and 18 males) out of 41. The remaining children were in both cases included in the control group and experienced the robot in the camp only as a theater performance character during recreational evening activities.

Procedure. In both the 2013 and 2014 summer camps, children who volunteered for individual session(s) with the robot were given an appointment during their spare time at the camp. Before beginning the interaction, they were instructed about the available game activities with the system and the possibility to freely choose among them during their session. The session lasted a maximum of 30 minutes. The interactions were carried out using the system described in Sec. 3.

2013 Camp Experiment overview. The specific objectives of the 2013 camp were to investigate the feasibility and acceptance of OAT, its effects on children’s perception of the robot and on adherence to medical advice (i.e.: filling in a nutritional diary). The study was carried out in a between-subjects design with 3 conditions: (1) *OAT*: one-on-one interaction with the OAT feature turned on; (2) *non-OAT*: one-on-one interaction without OAT; (3) *CONTROL*: no one-on-one interaction.

The results related to this study are discussed in detail in [11, 12] but with respect to the present contribution, it is interesting to mention that qualitatively children’s acceptance of OAT was good: they engaged in it readily and elicited self-disclosure from the robot [12]. However, their responses to the robot’s OAT prompts were brief and concise, maybe due to their formulation as closed questions. Moreover, the presence of OAT turned out to have a positive effect on the children’s interest to interact with the robot again: although all subjects in the two intervention conditions expressed interest to play again with the robot, only 11 actually booked another slot: 9/10 in the *OAT* group and 2/10 in *non-OAT* (Fisher’s test, two-tailed $P=0.0055$).

2014 Camp Design. Based on the positive experience with OAT in the 2013 experiment, we decided to drop the non-OAT condition. The 2014 experiment thus had a between-subject design with the *OAT* and the *CONTROL* condition. We revised the OAT prompts, to include more open questions or clusters of closed interconnected questions, in order to elicit more complex OAT dialogs with more child talk. **Table 3** shows some examples of these variations; **Table 2** shows OAT interaction examples.

Table 3. Examples of the different verbalization of the OAT prompts used in the two Camps.

2013 OAT prompts formulation	2014 OAT prompts formulation
Can you draw?	Can you draw? What do you like to draw?
Do you realize when your glycaemia is low?	Do you realize when your glycaemia is low? What do you do in these cases?
What is the strangest food you've ever tried?	What is the strangest food you've ever tried? Where were you when you tried it? Abroad?

¹ The data of one subject was discarded as the child did not finish the interaction.

We also further elaborated the evaluation of children's perception of the robot. We designed a new questionnaire composed of two closed questions. The first one asked to describe the robot by choosing one out of the following set words: friend, toy, pet, adult, computer. The second one asked to choose one of 16 listed adjectives describing the robot. The adjectives belonged to three categories of perception: machine (e.g. fake, scientific, etc.), relational (e.g. interested in me, someone to trust, etc.), humanized (e.g. spontaneous, empathetic, etc.). This questionnaire was administered to all the participants of the camp at the end of their stay. Furthermore, to evaluate children's willingness and spontaneity to talk about diabetes, we performed an analysis of the interactions similar to the one described in [12]: 3 coders (native speakers) evaluated every OAT sub-dialog regarding diabetes on a 4 point scale (i.e.: 1= "not responding or not willing at all", 2= "forced or annoyed", 3="clear, simple and courteous", 4="very interested and active") as well as assigned an overall score per child to how the OAT diabetes sub-dialog were going.

2014 Camp Results. OAT had an effect on the children's perception of their relationship to the robot: 26/27 in the *OAT* group and only 4/13 in the *CONTROL* group selected the word "friend" among the 5 options offered in the questionnaire. The difference between the two proportions is strongly statistically significant ($\chi^2=20.09$ with probability 1%, two-tailed $p=0.0001$). Regarding the multiple adjective choice, even if not supported by statistical significance, we observe that children in the *OAT* condition chose no machine category adjectives, 30% of the chosen adjectives belonged to the humanized category and 70% to the relational one. Whereas in the *CONTROL* condition 20% of the adjectives chosen belonged to the machine category, 20% to the humanized one and 60% to the relational one. The children's willingness and spontaneity to engage in OAT and talk about diabetes was high. Moreover, the coders noticed qualitatively a common attitude of the children in sharing their practical notions about diabetes with the robot and their personal experiences on what it is like to deal with diabetes in their daily lives (see the excerpt in the right column of **Table 2**).

6 Discussion and Conclusion

We described a series of experiments with a robotic multi-activity system designed to provide long-term support to children with T1DM. We addressed the potentialities of specific relational verbal behaviors in contributing to the perception of a robotic character as a friend by the young participants: familiarity display and off-activity talk. Both these features were introduced in order to personalize the interactions in a way that resembles typical human interactions between friends: making reference to joint experiences and fostering self-disclosure about personal topics (in this case diabetes- and health related topics). We found that children interacting with the robot displaying familiarity, clearly perceived it as a friend after the first interaction as well as after three interactions in a longitudinal study. They also felt to have been at the same level of control with the robot during the interactions. This outcome was also confirmed by the investigations of the 2014 summer camp experiment, carried out

with a different set of children in a real world setting, even though the set of words available to define the role of the robot was slightly different on the two occasions. In the 2014 summer camp experiment the set of choices included also the word “adult” in order to allow for a difference in the level of the perceived relationship biased towards the robot (robot compared to a figure that usually leads situations), rather than towards the child (as in the case of a pet or a video game). Confirming the previous results, none of the children chose this description. As for Off-Activity Talk, children were at ease during the dialogs with the robot and seemed to appreciate the interest that it showed for their daily lives and experiences. The combination of these factors led to a natural adaptation of children’s behaviors to the specific single interaction dynamics and triggering, a spontaneous conversation regarding the delicate topic of diabetes. Moreover, the dialog structure enriched with the OAT prompts seemed to be a key factor in engaging children and making them interested to interact again with the system. This is a significant achievement in the long term perspective of our research, even though more longitudinal studies are needed to address this point. To conclude, the fact that the robot is perceived by children as a friend capable to establish and maintain a positive relationship is extremely impactful in a broader real life application perspective of a robotic companion. Children could be more inclined to feel at ease and open themselves with such a robot, thus offering the diabetology teams of caregivers a valuable instrument to support their work of education, addressing the goal to improve self-management of young patients.

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