Investigating Design Implications towards a Social Robot as a Memory Trainer

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ABSTRACT

Most currently existing tools for cognitive memory therapy require physical interaction or at least the presence of another person. The goal of this paper is to investigate whether a social robot might be an acceptable solution for a more inclusive therapy for people with memory disorder and severe physical limitations. Applying a user-centered design approach, we conducted semi-structured interviews with five healthcare professionals; four medical doctors and a psychologist, in three iterations followed by a focus group activity. An analysis of the collected data suggests several implications for design with an emphasis on embodiment, social skills, interaction, and memory training exercises.

Author Keywords

Social robot; memory training; immobility; personalized robots; user-centered design.

ACM Classification Keyword

H.5.2 User Interfaces: User-centered design.

INTRODUCTION

Interactive Social Agents have been deployed in recent years spanning several domains, including sport training and therapy [7, 10]. Their apparent positive impact has motivated many researchers to pursue further development to explore their use in new areas such as medical rehabilitation and training [14, 18]. In this paper, we investigate the design implications for a social robotic agent aimed at helping the elderly as a memory training tool.

Our motivation is derived from related research on cognitive disabilities and social robots where a positive effect was noted on participants' increasing abilities when interacting with robotic agents in comparison to non-robotic approaches [11, 16]. In addition, research shows that social interaction while learning can have a positive impact on memory capacities [9], as it is perceived as more challenging and emotionally involving. Therefore, a social robotic agent could help individuals with memory loss, and the realisation of what characteristics are needed in the design of such robots is a logical first step. The goal of this paper (and our contribution to the HAI research community) is to gather design requirements for the appearance, behavior and abilities of a social robotic agent as a memory trainer and, based on these requirements, to derive design implications

Our approach is based on semi-structured interviews with medical professionals in an iterative, user-centred design approach followed by a focus group. In the context of our research, our target population is people with memory disorders who additionally suffer from physical impairments of mobility but excluding head movements. The results of the study are presented in the design implications section while the background and methodology sections provide the basis for the user interviews and hence, the design implications.

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BACKGROUND

Memory problems can be symptoms of various diseases and illnesses, such as Alzheimer's, Parkinson's and other disorders [1, 4], and are therefore very common accessory symptoms. There is as yet no universal solution to dysfunctional memory; however, there are numerous alternatives for assistive trainings aimed at step by step memory improvement.

Many memory training activities include exercises; both computerized [5] and physical that require some level of dexterity [19]. Since we cannot assume that all people in need of cognitive memory training are sufficiently mobile, we propose to replace the necessary physical interaction by agency of the robot. Movements that are currently unavoidable should be shifted to a social robot. Necessary movements, in this case, are movements required to interact with the current memory training equipment, which often includes hand gestures (e.g. physical puzzle games). Limiting the need of physical interaction would possibly enable treatment of more patients in need of memory training. The motivation to introduce a social robot in this field is based on research conducted by Park [11] as well as by Tapus et al. [16] who analysed the effect of social robots in the learning process of cognitively disabled children as well as elderly people, and observed a favourable reception of interaction with social robots. In both research projects, interaction with social robots was tested on different age groups, including test subjects with differing mental and physical conditions. Both studies showcased results that argue for the use of a social robot.

Moreover, by showing the advantages of a social robot, we also point out aspects that should be avoided when designing as highlighted in the research by Rosenthal von der Pütten & Krämer [13], Walters et al. [18], Rızvanoğlu et al. [12] and Ferrari et al. [6]. All presented studies evaluating which aspects might be perceived as more intimidating, including their definitions of the uncanny valley. One of many important key takeaways from these was that androids were perceived as the least popular embodiment due to overt likeness to the human shape without the corresponding movement patterns [13]. Especially in regard to individuals with a fragile mental condition, this suggests caution about using android embodiment. However, participants in Walter et al. [18] also mentioned that a certain similarity in look and appearance in regard to non-verbal interaction between humans and a robot was very important, reasoning that a humanoid appearance simplified the interaction and gave participants a more comfortable feeling due to its familiarity. More specifically, in Rızvanoğlu et al. [12] participants of both genders preferred to interact with a female gendered robot in the healthcare sector. Finally, Pütten & Krämer [13] found that "human like appearance without a connected functionality was not appreciated". In summary, the surveyed research suggests that future design solutions for a memory coach should probably avoid complete android embodiment while still retaining some level of human likeness, foremost in regard to motions and facial expressions. This should be expressed in a simplistic way by avoiding any unutilized human shapes, and by giving it preferably a female gender, especially considering the current demographic of the target domain.

Overall, although most of these studies were performed with small samples, there is evidence to suggest that social robotic agents may have a positive impact in learning situations, especially in the context of physical or mental disabilities. However, very little research seems to have investigated the usage of social robots in memory training sessions. Our research addresses this gap and provides several design implications that can help direct designers and developers.

APPROACH

In order to gain a deeper understanding of how memory training sessions are currently conducted as well as to gather valid design implications, our method was based on an explorative approach including semi-structured interviews and a focus group. The semi-structured interviews were conducted with five professionals from the medical sector and the focus group was conducted with four professionals based in Sweden.

Participants

We decided to consult a group of professionals of the medical and health sectors, so that gathered information and requirements include valid, thorough considerations based on expert knowledge and experience. Furthermore, we wanted to ensure that our design implications were in the best interest of the patient, including his or her mental and physical well-being. Therefore, four general practitioners (3 male, 1 female) and one psychologist (female) participated in this study; in the following abbreviated as P1 - P5 (Participant 1 – Participant 5), of which one was located in Germany and others in Sweden. The mixed geographical background was due to the researchers' differing contact possibilities and influenced this study only to the extend that some statements were translated from German to English. Participants had anywhere from 5 to 30 years of practical experience in their area of expertise including practical experience working with people with memory disorder. Each was informed about the study approach and signed a consent form for both, the interviews and the focus group session.

Interviews

Each participant was interviewed three times; of which the first was conducted face-to-face, the second and third either by phone or face-to-face, depending on the participants' availability. Each session took about 15 minutes and included a short recapitulation of the former session in the 2nd and 3rd iteration; a discussion of the different features of a possible social robot in regard to user needs and a summary of the interview. This summary was noted by the observer during the session and approved by the participant. For the first iteration, an introduction about the background, the approach and the goal of the study was given. Participants were further introduced to a scenario of the current problem situation and the possibility of introducing a robot as a solution. The definition of a robot was not explained, so the participants would not feel bound by it when sharing their ideas.

Analysis of Interviews

After each iteration, an analysis was done in the form of discussing and evaluating the participants' statements and suggestions, followed by brainstorming to create relations between the different aspects and, hence, clear design implications or open discussion points for the next iteration. After the third iteration, the derived design implications served as the discussion basis for the focus group.

Focus Group

As a follow up, we conducted a focus group with the four interviewed professionals based in Sweden.

The group was presented with possible design proposals for the social robot based on the outcomes from the interviews. The different design proposals, including scenarios in which they were applied, stimulated the discussion of the group.

Analysis

During the focus group, moderators took notes about discussion points and participants' reactions towards the provided design proposals. The following analysis was based on comparing the observed and concluding statements to derive design implications as presented in the next section.

DISCUSSION AND DESIGN IMPLICATIONS

Overall, participants seemed excited and positive towards a social robot as memory trainer, especially considering the current lack of tools for patients with limited mobility. The most common solutions are currently face-to-face sessions with professionals or relatives assisting the patient with memory exercises. A big drawback in this practice is that relatives are not educated professionals, lacking the expertise to understand and evaluate the level of performance delivered by the patient. Also, relatives could be highly affected emotionally from possible provocative or incorrect (re-)actions by the patient. However, relatives provide a stronger emotional connection for the patient. A memory of a relative or a person that has a long-term relationship with the patient can be more easily recalled than a short-term memory of a flash card picture. Therefore, the longer and the more intense a relationship or an experience, the easier it is to remember it. Regarding medical professionals, there is a constraint in regards to availability as there is currently a greater demand than supply for these services.

The derived design implications are summarized in Table 1, and based on the participants' requirement that the end user should be enabled to interact autonomously with the social agent during the training sessions. The categories in Table 1 andour overall results are based on the themes that recurred throughout the interviews. Additionally, there are different levels of cognitive functions amongst individuals, so an agent shared between users should be designed to adjust to the user's individual cognitive (dis-)abilities, for example to be able to insert, update and read information about the user. Hence, participants asked us to consider different user groups as presented in Figure 1 and, accordingly, different purposes for interaction with the social robotic agent.

The user receiving the training session is here referred to as main user (MU). Other users include relatives and caretakers that update information and lastly medical supervisors and doctors who review performance data and decide on necessary adaptations. These groups were identified under the assumption that MUs had the training sessions in the private households where the patients are taking care of by relatives or caretakers.

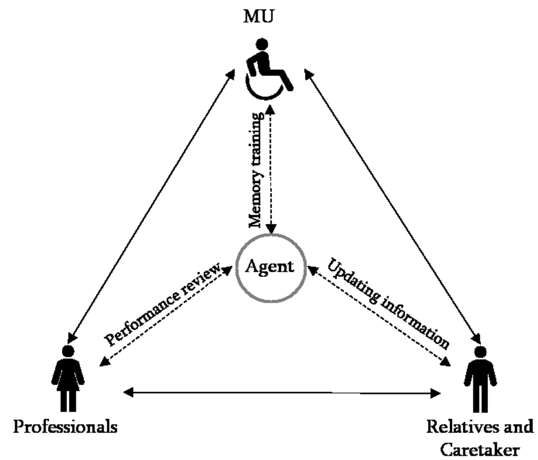

Figure 1: Relationships between user groups and agent.

The following sections represent the four categories identified as important considerations when designing a social robotic agent.

Exercises

Without going into detail about effective memory training exercises, a rough overview is needed to determine the levels of interaction, based on what input and output is required. For example, participants agreed that exercises should partly include aspects of personal memories, such as matching names of relatives with pictures. However, P3 stressed to include generic exercises as well, to train more abstract thinking and the short term memory in a way that emotional memories cannot. Other exercises require sorting numbers or repeating a list of previously mentioned objects.

Interaction

In regard to interaction, the interviewees expressed a strong need of not requiring relatives to conduct any technical or instructional administration of the robot. In most cases, they would feel neither technically, nor medically competent enough to maintain the robot in case of technical or performative issues. Here lies a potential problem, regarding what would happen when the robot is not functioning in a planned manner. Considering that the robot would provide visual information to the end user, professionals proposed that a screen should allow for easy adjusting in terms of distance to the user. Many interviewees also pointed out that patients often have hearing problems and, additionally, may not always be able to speak in an easy to interpret fashion. Thus, a robot should be equipped with a distinct voice as well as sensitive audio inputs. If MUs are immobile, their interaction with the robot should mainly be based on voice commands and head movements. P5 also mentioned that *"[...]air-breathing or eye-blinking are practiced communication ways"* for patients with even greater immobility.

Exercises	Interaction
• Train also with personal memories • Adapt to the user's level of difficulty • Exercises via e.g. adaptable screen • Comfortable and concentrated learning environment	• Main interaction: voice and head movements • Screen adjustment (angle, distance and luminosity) • Robot voice should be clear and distinct • Minimum level of administration of the robot • Ability to control and administer the robot remotely • In the long term, consider group training
Social skills	**Embodiment**
• Consider user's language, speech, level of disability and degree of cognitive disorder • Include extremer emotional user (re-)actions • Represent clearly the role of a coach	• Humanoid appearance to invoke feeling of trust • Ability to move around the house • Movements should appear human-like • Robot cartoon-like faces are easier to interpret

Table 1. Design implications overview.

A more concrete interaction example between a social robot and MUs could be facial recognition training. In this context, a professional prepares the robot in the user's home environment and inputs the required user data, while a relative connects to the robot (e.g. via bluetooth) and adds images and names of the user's family and relatives. When the user initiates the training (via voice), the robot can show pictures of the relatives and ask the user to name them. After the training, the robot sends the performance data to the professionals. For this study, the interaction is mainly discussed through a memory training perspective and does not include any other interaction scenarios.

In further iterations, participants discussed the possibility of group sessions or of sharing performance results between MUs including the agent as coach and medium to communicate. On the one hand, the effect of group dynamics allows to shift the attention away from the social robotic agent and to socialize with others with a similar problem. However, participants also expressed concern about the effectiveness of this as MUs might rather distract each other from performing and focusing on the exercises. Hence, an evaluation of group versus individual sessions conducted by a social robotic agent would be required to draw a conclusion.

Considering other user groups such as professionals, it was suggested to regularly send performance data to the professional, so that without physically being at the location, results could be supervised and adaptations triggered in an early state if needed. Professionals mentioned that a regular remote control would be very appreciated for time-saving purposes as well as an additional control of the sessions' performances. A visual representation of the relationship between user, robot, relative and professionals can be found in Figure 1. As depicted, the professional is mainly responsible for setting up of the robot as well as reviewing the performance, while the relative will provide the robot with data that can be used in the training sessions.

Social Skills

For a successful training session, the robot's social and teaching abilities should adapt to the user in regard to language, speech, level of education as well as degree of cognitive disability. P4 stressed that "*... it is very important to meet the patients on their own level, just as we have to do as professionals.*"

This includes creating a comfortable and concentrated learning atmosphere. By analysing the user's facial expressions, body language and voice intonation, the robot should understand the MU and show an empathic, but professional reaction. As memory dysfunction is very often an epiphenomenon, the concerned patients often unconsciously change their behavior which may make them react erratically. Referring to previous experiences, the participants observed partly very stubborn and aggressive behavior of patients when their judgement was questioned. Such a scenario often appears within families when members have a different memory about a discussed situation. Arguing for the social robotic agent in this case, design solutions should consider more extreme human behaviors and reactions as well as define how an agent should handle such situations. As P5 mentioned "*It's the right of the patient to deny a collaboration. Hence, an easy and well-functioning robot, especially in the first contact situations, makes the patient's interest grow and the self-confidence to deal with the machine*". Therefore, in discussion with participants, we suggest to include communication models such as the Parent-Adult-Child communication model by Berne [2] or the mirroring approach as observed by Lewis et al. [15] for implementation purposes. Concerns were mentioned in regard to childish or too emotional reactions which should be avoided by the agent. Instead, the role of the agent should be very clearly the one of a coach; showing empathy and character, but focusing on motivational, objective attitude of an adult, or as P5 stated, the robot should not show "*exhorting behaviour*".

In regard to language and speech abilities, there is also a risk of vocal communicative limitations. Participants suggested to use simple, short and concise sentences in the MU's language. However, we suggest additionally to meet the MU on her/his individual level of speech, making the conversation more personal and close. To measure the users level of speech, there is for example the LIX-formula which is widely recognized as a valid Readability Index which considers the complexity of a text [9]. Since the formulas measure the complexity from more than one sentence, this feature would be activated as soon as the user had talked more than a few times. After a short period of use, the system would be in full function since the score would be more accurate the longer the robot was used. Therefore, we can conclude that the robot has to talk on a very basic level to begin with, and over time adjust more and more to the user's individual level.

To the question of how much social talk besides the teaching material the agent is supposed to know, participants had different opinions. They agreed to keep its role clear and hence limit its abilities to communicate with general small talk and coaching vocabulary. However, as this is still unspecific, further research would be necessary on this point.

Embodiment

Lastly, the physical embodiment of the social robotic agent was discussed considering [8], in which a physical embodiment proved to be more beneficial for social interaction than the use of disembodied agents. Overall, an accurate and engaging facial expression as well as body language was stressed by participants to be highly important for determining a successful outcome. Considering current research [13, 18] and participants' opinions the agent should include a simplistic humanoid-like appearance to avoid an uncanny valley impression ("*it should be avoided to be too human like or even scary*"; P2). Instead, as Rızvanoğlu et al. [12] presented, facial expressions should be conveyed in cartoon-like faces as emotions are more easily read and understood due to the simple representation of familiar features and entities, or as stated by one of the participants; "*Facial expressions should definitely adapt, but not be too childish*"(P1). Furthermore, each included extremity should have a clear functionality. Otherwise users get confused and, in the worst case, become distrustful of the social robotic agent. Additionally, an indicated female gender seems to be preferred in appearance, voice tone and movement, especially in the context of healthcare due to higher numbers of women in this sector [12]. Movements and range of movements should also be human-like and allow the robot to change rooms including up- and downstairs, considering that the "*guarantee of mobility between the rooms is very important*" (P5).

Conclusion and Future work

Altogether, this paper shows that a social robot provides an acceptable solution as memory training tool for patients who also suffer from mobility limitations. Furthermore, we have identified several aspects that are important to consider when designing a solution. One aspect, which we can only suggest, is to include pedagogical, motivational characteristics for assuring a well-conducted training session. Lacking a participant with this professional background, we recommend this as a further research topic. In total, the findings serve as a starting position and discussion points for further research.

In the presented work, the number of interviewed expert participants (5 in total) can be considered as low. Also, this paper includes only one user group, the professionals. However, general practitioners often deal with longer-term supervision of people with memory disorders which allows for detailed insights from a rather objective point of view which includes their medical expertise. In future work, we aim at interviewing a larger number of expert participants, in addition to widening the user-group to include MUs, relatives and caretakers. We also aim to explore the design and use of a social robotic trainer in different user environments such as private households, hospitals and nursing homes.

Moreover, we aim at overcoming one of the study limitations in the future work by conducting structured face-to-face interviews, compared to the semi-structured approach followed here. Overall, considering the explorative approach and the initial state of the current research area, this paper serves as a good starting point towards a social robot as memory training coach and indicates several further research possibilities based on it.

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