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Designing an assistive robot for older adults: The ROBADOM project

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Abstract

Objective. – The ROBADOM project was devoted to the design of a "robot butler", capable of providing verbal and non-verbal interactions and feedbacks for assisting older adults at home. In this article we focused on the following issues: (1) study the social context for designing social robot; define the robot appearance and investigate the perceptions and attitudes of older adults towards an assistive robot; (2) examine the perception of the expressivity of the robot, the social signals showing the end-user engagement level and the role of agent embodiment during the interaction between older adults and a robot.
Method. – The design of the studies involved both qualitative and experimental methods.
Results & Discussion. – Small robots with some traits between human/animal and machine were appreciated by the participants. As regards services, cognitive stimulation, reminder and object localization were positively rated. Although the participants considered an assistive robot as useful, they were not yet ready to adopt it. The expressions of the robot were perceived differently in older and young adults. Thus, a robotic system dedicated to older adults should be tailored to the specific characteristics of this population. We also identified social signals as indicators of the user's engagement level during interaction. Finally, the issue of the added valued of a robotic system in comparison to a laptop was raised by our participants. Therefore, various issues (technological development, human-robot interaction, social context...) are to be explored before testing the impact of the robot at home.

1. Context and aims of the project

The world's population is growing older, thereby introducing a wide array of challenges. It is estimated that in 2040 there will be three times more people aged over 85 than they are today. Many are expected to need physical and cognitive assistance, due to physical and/or cognitive changes related to ageing. Cognitive impairment is one of the major health problems facing elderly people in the new millennium. This does not only refer to dementia, but also to lesser degrees of cognitive deficit that are associated with a decreased quality of life and, in many cases, progress to dementia. Growing ageing population has given rise to the development of device-based (helper-robots) home services. In the last years, this market has just started to become structured from emergency assistance to healthcare and now from assistance to dependant people. As a result, various definitions have been proposed for this new field of robotics namely service robotics, assistive robotics or social robotics. Assistive robots should operate semi- or fully-autonomously to perform services useful to the wellbeing of humans. Assistive robots are designed for reducing the disability of patients and include intelligent wheelchairs, manipulation aids, walkers... Most of the assistive robots are dealing with physical disabilities. The design of social robots is clearly focused on the improvement of communication skills for various applications including entertainment, education and healthcare. As regards healthcare, socially assistive robotics is defined as the intersection of assistive robotics and social robotics. The assistance is mainly provided by social interaction.

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The ROBADOM project is devoted to the design of a robot-based solution for assisting activities of daily living: management of shopping lists, meetings, medicines for older adults. The specificity of our project is to develop a specific robot for providing verbal and non-verbal helps, support and coaching during various tasks such as cognitive stimulation exercises. The robot is dedicated to mild cognitive impairment patients (MCI, i.e. the presence of cognitive impairment that is not severe enough to meet the criteria of dementia) according to criteria of Petersen et al. [1].

This research involved several steps including:

- identifying needs and general appearance of the robot with the users;
- setting functionalities and behavior of the robot for a better personalization interaction.

Thus we examined the perception of the expressivity of the robot, the social signals showing the engagement level of the participants and the role of embodiment during the interaction between older adults and robots. The last step of the ROBADOM project which encompassed the study of the acceptance and the impact of the robot in older adults is not addressed in the present article.

2. Participants

Participants were recruited from the Memory Clinic of the Broca hospital in Paris. They were community-dwelling older people, either healthy or diagnosed with MCI. Participants were explained the purpose of the research and given details about the ROBADOM project. Those who volunteered in the research were invited to participate in focus groups, interviews and/or experimentations depending on the studies and their preferences. All participants of the study signed informed consent. The project was approved by the Comité d'éthique local, the Comité consultatif sur le traitement de l'information en matière de recherche dans le domaine de la santé (CCTIRS) and the Commission nationale informatique et liberté (CNIL).

3. Needs of older adults and specifications of the robot

A major step in the design process of assistive technology is to gather the needs of potential users in the early stages of the project to ensure the adequacy of the system with the specified requirements.

The objectives of the first study were to explore the difficulties of older adults in daily life as well as their strategies to overcome them, their perceived needs in terms of assistance by a robot and their opinion regarding this device and its various features. A guide composed of questions was constructed and developed to provide a framework for interviews in 15 older adults with MCI. First we explored the problems and difficulties experienced in their daily life and the strategies used to compensate for them. Second, we presented a scenario where an assistive robot had the following functionalities: events and appointments reminder, object-finding, cognitive stimulation, video conferencing, remote surveillance and companionship. Attitudes and opinions towards these assistive functionalities were explored. Semi-structured interviews were audio taped and then transcribed, and the analyses of the transcripts and field notes were performed according to the inductive thematic analysis [2]. Findings revealed that participants reported difficulties in managing some daily activities including memory difficulties, somatic diseases and loneliness. However they did not mention any perceived needs to be assisted as they considered themselves able to cope with difficulties using self-elaborated strategies. They expressed that they did not need nor want a robot for the time being but considered this device potentially useful either for themselves in the future or for other older adults suffering from frailty, loneliness or disability. Although participants were not enthusiastic about the functionalities proposed by an assistive robot, they were interested in cognitive stimulation, medicine reminder and object-finding system services.

Three focus group sessions (encompassing eight healthy persons and seven older adults with MCI) were conducted in order to investigate how the elderly perceived a robot's appearance. Focus groups are used to discover more about topics that involve social norms and are useful in revealing the diversity and consensus of opinions regarding a given issue [3]. The sessions were facilitated by two members of the research team. The sessions were videotaped for further analysis. In the first step, participants were invited to talk about their representations and perceptions about robots. The second step consisted in a presentation of 26 different robot pictures followed by the display of video clips comprising robots in action (R2D2, robuLAB 10, Aibo, Amiet, Anybot Monty, Asimo, Nexi-MDS, Care-o-bot®3, Care-o-bot®II, Eve from WALL-E of Pixar, HRP4C, iRobiQ, Robot Housekeeper, Kobian, Mamoru, Mechadroid type c3, uBOT-5, Motoman SDA10, Nao, Paro, Pomi, My Spoon, Ri-Man, SmartPal, Toyota i-foot, Twendy-One). Again, the participants were invited to express their perceptions and opinions for each of the robots. The last step encompassed a card sorting exercise. Twenty-one pictures of robots were handed out to the group, and participants were invited to choose their three favorite ones. They were asked: "if you had an assistive robot at home, which appearance would you like it to have?" Our findings indicated that although participants were reluctant towards some humanoid robots, they did show very positive attitude towards some creative small robot with human traits [4]. As far as services were concerned, participants were mostly interested in cognitive stimulation.

4. Interaction with the robot

4.1. Perception of affects from non-facial expressions of the robot Nabaztag

Social robots are designed to be easy to use by communicating with people in humanlike ways, such as using language and affective expressions. Facial expression is often used as main method for expressing affect. Body movements, posture, orientation, color, and sound are used as either the primary method of expression or to provide affective expression redundancy

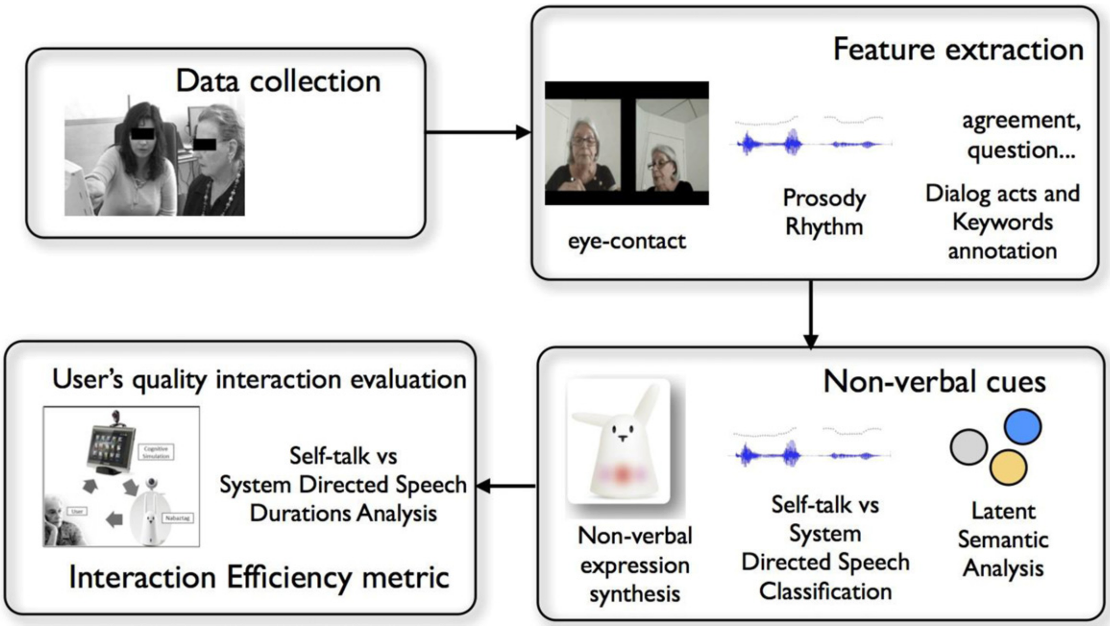

Fig. 1. Social activity characterization during cognitive stimulation experiments.

[5]. We investigated how the older adults and the young adults perceived affects from expressions of a rabbit robot Nabaztag, a non anthropomorphic robot capable of exhibiting only non-facial expressions. Twenty-seven expressions of Nabaztag were programmed, consisting in combinations of three colors: green, blue, and red, three ear positions: horizontal, vertical and asymmetric, three levels of speed of light blinking: rapid, slow and continuous. The participants (23 older adults and 20 young people) categorized each of the 27 expressions of Nabaztag into one of the eight affects in term of adjective (surprised, enthusiastic, joyful, calm, inactive, bored, sad and frustrated). These items were chosen based on the circumplex model of affects [6]. Results showed that the two groups of participants used different clues to interpret the expressions of the robot. For the younger adults, colors could be useful clues to help interpret affects. Blue (shorter-wavelength color) was most frequently related to "calmness" while red (longer-wavelength color) was most often associated to "frustration". The older adults used ear positions of Nabaztag as clues to interpret affects. Vertical ear position was mostly related to positive affects, such as joy and enthusiasm.

4.2. Social awareness mechanisms for interactive robots

We also studied patient-robot interaction schems during the completion of cognitive exercices. The key idea was to propose evaluation metrics for these interactions to further enhance the collaboration. Achieving efficient interaction requires several elements, and among them, engagement plays a fundamental role. Indeed, successful cooperation requires a dynamic commitment between partners as shown by Delaherche et al. [7] who presented an overview on interpersonal synchrony. Engagement is a complex phenomenon, and the literature has used numerous terms to describe it. Sidner et al. [8] consider engagement to be the process in which partners establish, maintain and end interactions. Poggi [9] defines engagement as the value that a participant in an interaction attributes to the goal of being together with the other participant(s) and continuing interaction.

We investigated engagement, social awareness and the quality of interaction in a triadic framework: user-computer (providing cognitive exercises) -robot (providing encouragements and backchannels) as shown on Fig. 1. We identified social signals, including system-directed speech and self-talk, as indicators of the user's engagement level during interaction.

We proposed an interaction efficiency (IE) metric exploiting multimodal information including verbal and non-verbal signals such as eye-contact, prosody and dialog acts [10]. The IE metric has been exploited in cognitive stimulation experiments performed at the Memory Clinic of the Broca hospital in Paris. The results have shown that, through this metric, older adults were able to characterize the interaction schemes.

4.3. Effect of agent embodiment on the elder user enjoyment of a game

Another area of interests in human-robot interaction studies is to investigate the effects of physical embodiment of social agents on their interaction with humans. A physically embodied robot, with both an actual physical shape and embedded sensors and motors and which is co-located with a human is considered to facilitate better social interaction by prompting human social expectations for proper social interaction than a disembodied or a virtual agent [11]. In order to understand how older adults perceive different kinds of agent embodiment and if there is any added value of the physical embodiment of a robot, we compared

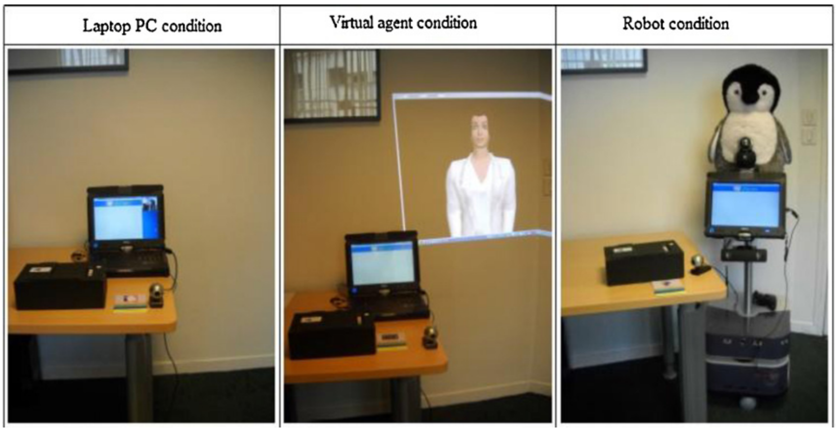

Fig. 2. Participants play a game of trivia in three conditions: laptop PC, robot and virtual agent.

older adult (three men and 16 women)'s enjoyment of a game of trivia in three conditions: participants playing the game with a laptop PC vs. a robot vs. a virtual agent (Figs. 2 and 3). The Arco architecture was used to manage the interaction between the 19 older adults and three companions (PC, robot and virtual agent) [12]. We designed a 5-point Likert questionnaire consisting in 13 items, measuring four dimensions (feedback, immersion, social interaction, concentration) of the GameFlow model [13] and two dimensions (intention to use, perceived enjoyment) of the united theory of acceptance and use of technology (UTAUT) [14]. We performed an intra-subject measure, the ANOVA measures, to examine user enjoyment under the three conditions. In addition, observation and note taking were carried out for qualitative analysis. Statistical analysis did not show any significant difference of the three devices on user enjoyment while qualitative analysis revealed a preference for the laptop PC condition, followed by the robot and the virtual agent. The older adults were more concentrated on the task performance than on the interaction with the systems. They preferred the laptop PC condition mainly because it provided less interfaces distracting them from performing the task proposed by the game than the two other conditions. Furthermore, the robot was preferred to a virtual agent because of its physical presence.

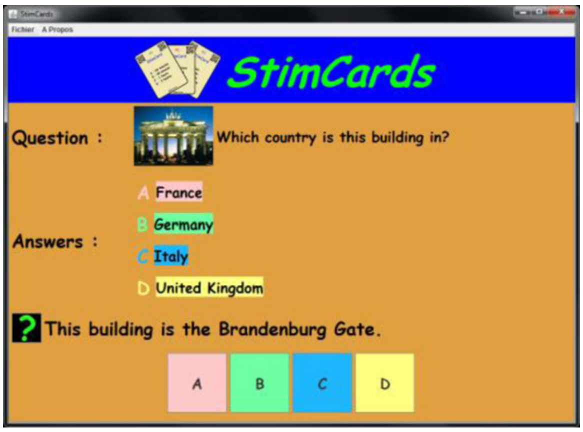

Fig. 3. A loaded card example in StimCards GUI.

5. Overall discussion

The results of the first two qualitative studies have helped us better understand the issue of the acceptability of an assistive or companion robot in older adults. Although participants considered this type of robot as useful, they did not seem ready to adopt it for the time being. We could identify several factors underlying this reluctance. First, the concept of assistive robotics was difficult to conceive for our participants. One still cannot find assistive robots on the market. Only can we see them in a few reports or exhibitions. As a result, it was very difficult for our participants to imagine how these highly innovative technologies could meet their needs related to cognitive difficulties or loneliness. In addition, for these older adults, the use of a robot was associated with a lack of humanity. They feared that the introduction of a robot in their home might induce a decrease of visits by their proxy and thus increased their social isolation. Finally, in line with the findings of Neven [15] our participants considered the use of an assistive robot as rather stigmatizing. For them, assistive robots symbolized old age, loneliness and disability from which they wanted to distance themselves. Thus, most participants expressed the following comments: "the robot is very useful for people with disabilities, older adults and lonely persons," "I do not need a robot at the moment but it could be useful later when I become disabled". However, we can assume that two conditions namely the large-scale commercialization of this product and the involvement of children when introducing the robot might reassure the older adults and reduce the barriers to their acceptance of robots.

The results of the experiments on human-robot interaction showed that perceptions of a robotic system in older adults were different from those of young people. It is therefore necessary to adapt the robotic system to the characteristics of older adults. We also identified social signals as indicators of the user's engagement level during interaction. In addition, a robotic system is better perceived than a virtual agent (or avatar) in a human-machine interaction. However, the question of the added value of a robot compared to a computer has been raised. Our participants preferred to be coached by a simple laptop rather than a robot during a trivia game.

6. Conclusion

This article summarizes five studies, carried out in the project "ROBADOM". We collected the needs and opinions of the older adults, determined their attitudes towards this type of robot and provided specifications for the implementation of an assistive robot in this population. During the development cycle of the system, studies on interactions "human-robot" were completed in order to better tailor the system to the older adults. Our ultimate goal is to have a robot robust enough to be tested by older adults and to assess the impact of such a system in their daily lives.

Acknowledgements

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