Biography-based Games for Cognitive Stimulation of Older Adults*

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***Abstract*— Currently, cognitive stimulation exercises conducted with Mild Cognitive Impairment (MCI)-affected older adults are typically administered by care professionals through exercises, which require a high degree of involvement by professional therapists, and are often perceived as tedious by the older adults. We aim to offer novel digital training through serious games designed using personally relevant material from the older adults' life. They will be based on memories associated with their biography, thus making interactions personalised, relevant, and more engaging. The serious games can be accessed through humanoid robots, which can make the training exercise more engaging because of their human-like behaviour. In this paper we discuss our approach to biography-based games for older adults**

I. INTRODUCTION

As the proportion of older adults increases in society, it is of increasing economic and social importance to understand how to maintain the health of the ageing mind. The number of Mild Cognitive Impaired (MCI) older adults (i.e. those assumed to be an intermediate stage between normal cognition and dementia) is also increasing; thus, it becomes more and more important to provide them with support. One way is to offer them opportunities to engage in mentally stimulating activities. To this end, interactive serious games can be useful, in that they are meant not only to entertain but also to provide training. They are a broad category of digital applications: they can be implemented on various types of devices, can offer different types of games and user interface designs, and can be played through different modalities. So far, most of them have been deployed through tablets, which represent a cost-effective solution but offer only limited possibilities for truly engaging such users in a multimodal manner. Furthermore, though researchers have found that digital games may provide benefits for some cognitive domains, the game industry seems to have ignored this important part of the population as a special category of users. Tahmassebi [1] found that older adults complain about the complexity of both hardware and software, which can be problematic due to their age-related cognitive and physical limitations. So far there have been mixed results related to game-based interventions [2]. Game and game system design that do not consider the preferences and abilities of older gamers may contribute to low digital game adoption rates, disinterest in gaming, and poor intervention adherence [3]. Unfortunately, despite the potential benefits to cognition described above, older adult populations are generally not targeted audiences when it comes to the design of digital games. However, we have found [4] that emerging humanoid robots may open up new possibilities in more effectively engaging MCI older adults during repetitive cognitive training. While the use of multiple modalities such as speech and visual interfaces has already been explored for older adults, social robots have recently shown to have the potential to support their care and independent living. Humanoid robots are now capable of exhibiting natural-appearing social characteristics. Thus, they can help formal and informal caregivers to monitor and support older adults, in particular those with MCI, while also providing a mixture of empathy, motivation, encouragement and companionship. In addition, they are becoming increasingly affordable and popular, since they can help users in a variety of real-world tasks. Indeed, while the use of robots is already fairly common in work settings and expected to grow in the future (by 2025, one in three jobs will be converted to software, robots or smart machines [5]), social robots are also being progressively introduced into many domains spanning entertainment, education, and even therapy/assistive scenarios.

Fasola and Matari [6] found that interacting with a robot able to perform human-like gestures and speech could increase the interest of users in executing their tasks. Feedback from persons who interacted with a more relational robot (i.e. praise, reassuring feedback after failure, continuity in speech) was more positive than the one gathered from those who interacted with a less communicative robot. The motivation of the former group was also higher due to the robot's social behaviour. Thus, a human-like robot able to talk and perform expressive body movements can significantly increase engagement, positive affect, and perceived social intelligence during the interaction.

Since several studies have shown that certain cognitive domains benefit less than others from training with serious games, this work will focus on those which have proven likely to show improvement. A recent meta-analysis [7] has provided a review of the commercially available cognitive games which are effective in improving cognitive function in older adults above 60 years old. Their analysis shows that not all cognitive functions evaluated showed improvement. The domains which did show improvement as a result of interventions with cognitive games were: processing speed, working memory, executive functions and verbal memory.

The goal of this paper is to discuss the design and development of a novel solution of serious games, based on users' memories and played through the social humanoid robot, that helps older adults to maintain their cognitive functional level, and prolong independent living. The serious games, installed on the humanoid robot will motivate older adults by engaging them in playful situations that draw on their personal memories, with which they can interact. Indeed, such serious games are designed in such a way to use personally relevant material from older adults' life. Specifically, the games are based on elements associated with the biography of the older adults, thus making interactions more relevant and more likely to keep them engaged while enhancing their well-being as well.

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The psychological well-being of older adults may be affected by some age-related conditions, such as approaching death, loss of family members, reduced autonomy. A meta-analysis [8] indicates that the practice of life review, even more than reminiscence, is a good instrument for improving the psychological well-being of the older adults: in fact, its effect sizes are comparable to those of cognitive-behavioural therapy. Serrano et al. [9] found that the practice of autobiographical memory improved the mood of the elderly by improving their life satisfaction. Furthermore, Damianakis et al. [10] report that interventions which contextualise history, personality and life experiences can contribute to improving both communication and social interactions between family members and between family members and formal caregivers. Biographical information can be exploited in games that support tasks related to Activities of Daily Living (ADL), which seem to have some potential in terms of both utility and cognitive stimulation according to a recent systematic review [11] that has analysed various game types employed in previous research.

II. THE SERENI PLATFORM

According to the requirements discussed in the previous section, we have designed the SERENI platform, to deliver serious games designed using personally relevant material from older adults' life through a humanoid robot. It aims to stimulate cognitive functions through play sessions, which should last 15-20 minutes. The exercises should be useful for making the participants think and reason to provide the correct answer. The platform can be a solution for day-care centres where older adults with mild cognitive impairments can go to perform relevant exercises.

The platform is based on various components. The first one is the Remind App, which is a responsive multimodal Web application to collect memories from the older adults and their relatives. The memories can be entered both through graphical and vocal interaction.

Six categories of memories have been identified:

- music-related, concerning songs or singers of their youth;
- game-related, game activities they liked;
- event-related, specific events that they still remember;
- locations, which are associated to particular memories;
- food-related, with the possibility to indicate the corresponding recipes by listing the steps that should be performed;
- hobbies, which they particularly liked.

The entered memories are stored in a database from which they can be retrieved to provide contents for the games to play with the humanoid robot.

We have used a Pepper robot for proposing the games. It is a 1,2 tall robot with the ability to use various interaction modalities (speech, touch, gestures, graphics through a screen on the chest).

An initial set of four types of games have been identified:

- Memory completion, where a memory is presented by the robot with a missing detail, which should be indicated by the user (for example: when you were 12 years old you use to spend your summer time in…grandfather house);
- Activities ordering, which can be applied to hobby or food recipes, in which sequence of tasks should be put in the right order by the user;
- Associate memories, where 3-4 memories are briefly described along with a set of details, and the user has to connect each memory with the corresponding detail (for example associate song titles to the corresponding singers);
- Memory-related question, where the user has to answer specific questions about an event drawn from the memories (for example: what happened in 1945? The end of the second world war).

The platform is also able to store some data regarding the user performance, such as:

- when and for how long the user played with a given game;
- the number of errors in a session,
- the type of games that have been played.

Such information can be delivered to older adults and their caregivers both through the robot and the Web app.

In order to gather further information useful to assess the user experience, we have started the integration of a E4 Empatica wristband in the platform. It is a device equipped with various sensors to measure Blood Volume Pulse (BVP), from which heart rate variability can be derived, and the constantly fluctuating changes in certain electrical properties of the skin, capture motion-based activity through a 3-axis accelerometer, read peripheral skin temperature, and tag events and link them to physiological signals. In this way, it can be possible to perform unobtrusive monitoring of anxiety and mood-related information of the older adults.

III. CONCLUSIONS AND FUTURE WORK

We have presented an approach for memory-based games delivered through a Pepper humanoid robot. We have identified a first set of memory and game types, which can be extended in the following. A first prototype of the platform for collecting the memories, and exploiting them in a set of games for cognitive stimulation has been delivered.

We plan to carry out a test with older adults with Mild Cognitive Impairments in the next months to assess their user experience with such games.

Future work will be dedicated to investigating the possibility to extend the sources of information content for the games through integration with wikidata information, and introduce additional tools for game personalization by caregivers.

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