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Senior-Driven Design and Development of Tablet-Based Cognitive Games

João MARQUES[a], Ana VASCONCELOS[a,1] and Luís F. TEIXEIRA[b]
[a]*Fraunhofer Portugal – AICOS, Porto, Portugal*
[b]*Faculdade de Engenharia da Universidade do Porto, Porto, Portugal*

Abstract. This paper describes the design and development of a tablet-based gaming platform targeting the senior population, aiming at improving their overall wellbeing by stimulating their cognitive capabilities and promoting social interaction between players. To achieve these goals, we started by performing a study of the specific characteristics of the senior user as well as what makes a game appealing to the player. Furthermore we investigated why the tablet proves to be an advantageous device to our target audience. Based on the results of our research, we developed a solution that incorporates cognitive and social mechanisms into its games, while performing iterative evaluations together with the final user by adopting a user-centered design methodology. In each design phase, a pre-selected group of senior participants experimented with the game platform and provided feedback to improve its features and usability. Through a series of short-term and a long-term evaluation, the game platform proved to be appealing to its intended users, providing an enjoyable gaming experience.

Keywords. User interface design, serious games, tablets, seniors, cognitive stimulation, social interaction

Introduction

Population ageing is growing at exceptional rate. There are approximately 810 million persons aged 60 years or over in the world, and this number is projected to grow to more than 2 billion by 2050 [1]. As people age, their self-esteem tends to lower and their ability to independently perform regular daily tasks decreases as well [2], much due to the natural age-related changes that affect the human body and mind. Playing games can help to reduce the rate at which those age-related changes occur, as employing games to teach players new skills can be an effective approach [3].

One commonly held belief is that seniors are unwilling to engage in new technology. However, many studies that examined the attitude of seniors towards computers found that they are indeed receptive to their use [4]. One of the most noted reasons for lacking motivation of seniors to use computers is the lack of perceived benefit. Seniors tend to believe that they have no use for such device and there is no gain to them, either because the computer does not satisfy their needs or they do not understand the technology well enough to perceive their benefits [5].

[1] Corresponding Author: Ana Vasconcelos; Fraunhofer Portugal - AICOS, Rua Alfredo Allen, 455, 4200-135 Porto, Portugal; E-mail: ana.vasconcelos@fraunhofer.pt.

In recent years however, new devices revealed to possess the potential to change the way seniors perceive technology. Devices such as tablets and smartphones are incorporated with touch-screens that provide a more natural and intuitive method of interaction, which lowers the skill requirements that usually come attached with other type of peripherals such as keyboard and mouse [6].

1. Designing a Tablet-Based Cognitive Gaming Platform for Seniors

Designing a system to match the requirements of a specific audience such as the senior population provides significantly more challenges and constraints than one for an audience wider in age groups and technology knowledge. It is important first to understand that "design should begin by identifying a human or societal need, and then fulfill that need by tailoring the technology to the specific relevant human factors" [7]. For this reason, it was crucial to adopt a User-Centered Design methodology in order to understand all the limitations and specific needs that this target audience carried.

To better understand our user, we resorted to a literature review on which we identified the cognitive age-related changes that could constitute an obstacle to the design of the game platform. Following on our study, we analyzed the potential that the tablet device could bring to the development of a game platform, as well as successful methods and practices that other projects in the area have proven to be effective in stimulating the cognitive capabilities of the player while also promoting social interaction.

1.1. Methodology

A User-Centered Design methodology puts together a process in which the needs of the end user of a product are focused throughout all development stages, therefore promoting a better understanding of the users' needs and goals and leading to a more appropriate product [8]. The main difference from other product design philosophies is that user-centered design attempts to optimize the product around how users can, want or need to use the product, rather than forcing the users to change their behavior to accommodate it.

The methodology was applied in three phases: recruitment of senior participants in the usability tests, iterative and incremental prototyping of low- to high-fidelity models of the game platform, and evaluation of the same models by use of empirical studies [9] and Wizard-of-Oz techniques [10].

1.2. Research & Development Process

In the initial phases of designing the game platform, we conducted a recruitment process to interview potential seniors that could become participants in the usability tests. During this process, we engaged in a series of formal and informal conversations, with the help of a psychologist, in which we assessed the participants' knowledge and acceptance of modern technology, how affected they were by cognitive age-related changes and their willingness in helping us design a game platform. In the end, we composed a group of 10 senior participants – 7 women and 3 men, with ages ranging from 63 to 80 years old – who had achieved good scores in the cognitive assessment exercises. This was necessary so that we could correctly evaluate the efficiency of the

game platform and its games, as seniors who had serious struggles in mental ability due to illness or depression could bias the results.

We then began developing low-fidelity prototypes that allowed us to test the usability of the system as well as element positioning – text, buttons, icons, among others. By not developing a high-fidelity prototype on the application right from the start, many usability issues and problems with the interface could be solved and re-arranged at any moment, easing the process and allowing the exploration of new ideas and concepts without a great volume of work. Moreover, seniors find these paper prototypes less intimidating than handing to them a high-tech device in a first contact with the system. This is of utter importance as it enables them to understand its purpose and give favorable feedback for allowing a continuous improvement throughout all phases of design.

Using all the feedback we were able to retrieve from our usability tests performed with the initially pre-selected group of seniors, the prototypes then evolved into a fully functional application directly implemented on the tablet device. Using the application in its digital form enabled us to evaluate some aspects that could not be investigated when using paper prototypes, such as touch-based interaction. We were able to confirm that seniors easily adapt to the tablet device and that its natural and intuitive interaction paradigm is a better choice than more traditional ones.

Also, a mechanism allowing the extraction of players' game performance data was implemented in the game platform. For this effect, a long-term evaluation was conducted, where one tablet device was entrusted to the caregivers in one elderly center for a full month, so seniors could play every day for around 5 to 10 minutes at a time. Although more time is required to effectively analyze players' performance, this evaluation allowed for further improvements in the usability of the platform.

Having the opportunity to work directly with our target audience was essential to design and implement an appealing application for seniors, which they enjoyed and felt engaged with. It also allowed us to gather evidence on their ability to use new technologies and learn new concepts in an efficient way.

1.3. Platform and Game Design

Our main goal was to design and develop a game platform targeting the senior population that would provide cognitive training through the regular practice of a range of games, each focusing on some specific areas of the cognitive domain. Equally important was to provide mechanisms that would promote social interaction among seniors and help them realize the benefits of modern technology.

In the platform, we developed three playing modes: solo play, group play and online play. Since one of the games' main purposes was to cognitively stimulate the player, there was an implicit need to isolate him from other players. Otherwise, the player might receive help from others and not use his capabilities to its maximum potential, which is essential when trying to develop one's mind power. Therefore, the solo play allows a person to play alone, register the final score (and time) of a game session, and compete with other players. Due to these features, a register and login process was also included. In group play, several players can join a single game and collaborate to finish it. It features the same games and mechanisms as in solo play mode, however, it does not require a previous log on to the system, having been created simply for re-creative group play and social interaction promotion purposes. Reasonably, it does not record any of the game session's score or time. The third

playing mode, online play, was conceived so a senior with an Internet access would be able to play these games with friends from afar. At the present time and for evaluation purposes, this playing mode was designed as a simulated prototype, where an Internet connection was not required, and players would play against a basic computer artificial intelligence agent.

Two games were fully implemented in the platform with different cognitive stimulation goals (Figure 1). The first game implemented on the game platform was a card game with the main objective to pair cards with the same symbol. This is a well-known type of game, and it was chosen for its simple rules and the familiarity seniors in our test group had with it. The focus of this game was to train working memory, attention and spatial cognition. This is achieved by memorizing and recognizing cards contents and differences (memory and attention) and by creating mental representations that code the positions and relationships among cards (spatial cognition).

The second game developed was a word game with the main goal of creating as many valid words as possible, given 7 letters at random. The idea for this game came from the fact that long-term memory is usually not affected by ageing, therefore allowing seniors to more easily enjoy this kind of game. Also, due to the random assignment of letters, the game provides a greater amount of variety in each new attempt. This game focused on improving verbal-fluency, which describes the rate at which someone can produce words.

In order to maintain these games challenging, three difficulty modes were implemented to allow seniors to gradually improve their skills. Also, a leaderboard ranking system was incorporated to promote friendly competition among seniors and encourage them to perform better each time they played. All game features were iteratively evaluated with seniors providing useful feedback in improving usability and robustness.

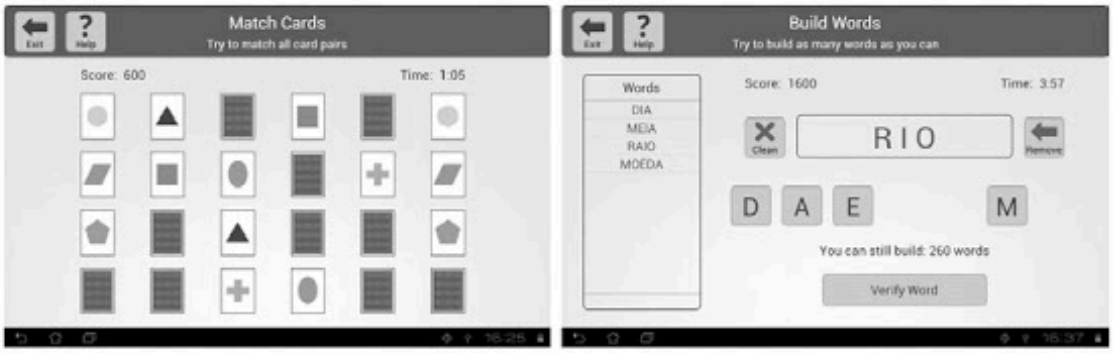

Figure 1. Cognitive Stimulation Games.

2. Results and Lessons Learned

During the month-long evaluation performed at the day-care center, we were already able to retrieve some data regarding seniors interaction with the platform. For each platform screen we logged the percentage of clicks as well as time spent on that screen and its percentage. Our results indicated that seniors spent 48% of the time playing on the Card Game Large Board and 15% of the time playing the Word Game. The time

effectively. For that reason, seniors often find it difficult to realize all the benefits that technology can bring to their lives.

Via an extended research of our target audience and the potential of digital games, we presented a solution which we believe has the potential of acting as a first step towards embracing new technology by means of the tablet device, while increasing its users' overall well-being through cognitive and social stimulation games. Furthermore, by using information retrieved from the game platform, a professional evaluator could determine if any formal cognitive evaluations would need to take place to verify initial suspicions from a first analysis of the data. Also, members from the senior's family could use this tool to be aware of any unexpected deviations in performance, and seek guidance from professionals.

For further improvements to the game platform, more games would prove to be very beneficial to the cognitive training of senior users. Games that target other areas of the cognitive domain, possibly incorporating other senses than touch and vision, such as games that use sound as their main mechanism of interaction. Also, extra difficulty levels could be created to leverage the learning curve and so produce a more effective cognitive training program. In addition we believe that reward mechanisms such as achievements and badges could prove to be efficient instruments in helping seniors engage in playing more often, regarded that such mechanisms are simple to understand and appealing to players.

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