

Designing Tablet-Based Games for Seniors: the example of CogniPlay, a cognitive gaming platform

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ABSTRACT

This paper describes the analysis and design of a tablet-based gaming platform for seniors that promotes their quality-of-life and well-being by incorporating cognitive training mechanisms. A literature review of age-related changes and games for seniors indicated 'casual games' have the characteristics necessary to provide an enjoyable user experience for the senior audience. Having concluded that these games should target cognitive stimulation, the authors analysed mechanisms to achieve this purpose and compiled them into a matrix to be used as a starting point for the games design process. In parallel, the authors also gathered seniors' preferences and requirements regarding games, through observations and a *game book*. Low-, medium-, and high-fidelity prototypes for a gaming cognitive platform were developed, evaluated with end-users, and iteratively improved. Results showed that seniors easily interacted with the platform and were willing to use it in the future. Results and experience led to the identification of 10 rules of thumb that can be beneficial if applied to related projects. This paper concludes by identifying exciting areas for future research and development.

Author Keywords

Human-Computer Interaction; User Interface Design; Serious Games; Tablets; Seniors; Cognitive Stimulation; Elderly Entertainment.

ACM Classification Keywords

H.5.2. Information Interfaces and Presentation: User Interfaces

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General Terms

Design; Experimentation; Human Factors.

INTRODUCTION

Seniors (65+) are likely to encounter interactive devices in a number of settings. A common belief is that seniors are resistant to change and unwilling to interact with computer systems, however, the majority of studies that have examined seniors' attitudes towards technology indicate that seniors are receptive to using computers [9]. In reality, seniors may be reluctant to adopt technology because it has not been adapted to meet their needs. If adapted, technology has the potential to provide them with a wide range of benefits otherwise unavailable.

During the past decades, the 'games for adults' industry has had a tremendous growth as a consequence of the population ageing and its impact on the economy [24]. This demand on entertainment mechanisms for retirement-age adults has caught the attention of many researchers who have studied games' potential in providing not only enjoyment but also improvements related to wellbeing [37, 34, 35, 19, 18, 20, 31]. Their conclusions are optimistic and provide valuable information for future projects within the field.

The way in which users interact with technology has a huge impact on the way they feel about that experience [13]. When interacting with computers, users have to use 'indirect' input devices, such as the mouse and keyboard. Currently there is a new set of devices becoming more available and affordable. These alternative devices, such as the ones with touchscreens, are known as 'direct' input devices and allow for a more direct interaction with the system, opening up a new range of possibilities for designers to expand the way people interact with technology. In particular, those that incorporate touch and gesture-based interaction may afford an alternative and more natural interaction method [16], easing the adoption and use of technology by seniors.

With these premises in mind, the authors carried out a study focused on tablet games targeted at seniors. This study contributes to diminishing the current gap between seniors and technology, thus promoting its use and the wide range of benefits that it can provide.

The first section of this paper presents an overview of age-related changes. Next, some aspects of the technology used for this project are discussed. Then, an analysis of how seniors approach games is made, and the characteristics a game should have in order to enhance seniors' user experience are examined. Later, the overall aspects of conceptualizing cognitive games for seniors are detailed, as well as our findings on users' preferences regarding games. The following sections describe the platform's design as well as the high-fidelity prototype evaluation. Finally, the last section discusses our findings, details the platform's characteristics, and outlines opportunities for future research.

AGE-RELATED CHANGES

The ageing process is responsible for changes at both biological and psychosocial levels. These age-related changes may impact a number of different aspects of seniors' lives and limit the extent to which they are able to perform certain activities. These constraints can also be observed in their interaction with interactive technologies, which are yet to be fully prepared to accommodate seniors' capabilities and limitations [9]. In this section the authors document a number of age-related changes in motor, perceptual, cognitive and psychosocial skills that can impact users' interactions with tablet devices.

Perceptual and Motor Changes

Age-related changes affecting perceptual capabilities (such as vision or hearing) and motor skills are especially problematic for seniors when trying to interact with computer systems.

Seniors can experience challenges while reading at close distances as a result of a condition known as *presbyopia*, the inability to focus effectively on near objects [7]. Transitioning from light to dark environments or performing visual tasks under dim light can also be difficult [30]. Generally, seniors also experience a loss of static and dynamic visual acuity and yellowing of the lens, which decreases colour sensitiveness in the blue-to-green ranges [7].

Regarding hearing, many seniors, especially men, suffer from *presbycusis* - the reduced ability to hear high-frequency sounds which challenges the hearing of certain sounds such as the 's' sound, causing problems understanding speech [7] or listening to alert sounds such as 'beeps or pings' [10].

Age-related changes in motor skills include slower response times, declines in the ability to maintain continuous movements, disruptions in coordination, loss of flexibility and variability in movement [10]. The haptic processes can also suffer some changes, specifically the loss of sensitivity in the hands [23]. These motor skills can greatly influence users' interaction with a system, especially when devices require great precision.

Cognitive Changes

Many computer tasks are characterized by having high cognitive demands [10], so it is important to consider age-related changes on cognitive skills when designing for seniors.

Memory and attention are some of the most important cognitive abilities that may suffer decline with age. The capacity of short-term (or working) memory shows signs of decline with age and is known to affect many complex everyday tasks including decision-making, problem-solving, and planning goal-directed behaviours [15]. This is mainly due to the challenge seniors face when storing and managing large amounts of new information [7]. However, unlike working memory, long-term memory is mostly preserved in old age [15].

In general, attention is also affected by age. Seniors have shown to face challenges in tasks that require divided attention across multiple input channels and are also more prone to being distracted by irrelevant information [7].

Two other relevant skills are spatial cognition and language comprehension. The first is related to the ability to mentally manipulate images or patterns, whereas the latter is the ability to interpret verbal information [12]. Both these cognitive skills have shown to decline with age and can, along with memory and attention, affect the way seniors perceive and interpret information.

Psychosocial Changes

Although people are generally more aware of physical age-related changes due to their visibility, psychological and social changes are equally important. Being retired is many times associated with a loss of social importance and power due to the disengagement of an active social role [33]. This perceived lack of responsibilities to society may incite an identity crisis and consequently a loss of self-esteem [40]. Moreover, physical and cognitive changes that affect one's independence and autonomy can have psychologically distressing consequences, by posing a threat to one's ability to live safely and independently [3].

The above-mentioned problems are further aggravated by the reduction of the senior's social network. For seniors, social contact is one of the most important aspects of well-being. However, in old age there are various factors that hinder the maintenance of relationships, such as the death of friends and family, personal vulnerability, environmental and contextual obstacles, stress and psychological conflict [33].

Considering these changes while designing a system is of utmost importance, as a number of mechanisms can be introduced to specifically appeal to seniors. As an example, seniors that experience feelings of abandonment may favour a system that fosters social interaction.

THE POTENTIAL OF TABLETS AS PRIVILEGED DEVICES FOR SENIORS

Tablets have gained popularity recently and are becoming more accessible to the general audience. They can be defined as devices in the form of a notebook that use a touch screen as

the main input method. Their dimensions are usually larger than smartphones' and smaller than laptops', which allows for good levels of both mobility and visibility of contents. This is an especially interesting characteristic for users with physical impairments or who are bedridden, since mobility allows users to use the tablet in a comfortable place and position.

Due to the touch and gesture-based interaction method, tablets are considered direct input devices. Rogers et al. [28] compared direct and indirect devices and concluded that direct devices generally demand less training, thus being better suited for novice users or those that do not want to memorize commands. Conversely, indirect devices are more precise and are preferred by users with more experience and for longer periods of use. Direct devices are also considered to be easier to use because of their reduced coordination and cognitive demands, as their use requires little hand-eye coordination and minimal spatial demands [38]. Due to these characteristics, direct input mobile devices appear to be more suitable for seniors. Wood et al. [38] compared the performance of young adults and seniors using a mouse to interact with a computer and found that senior participants experienced difficulties when the task they were performing involved clicking or double clicking the mouse. Furthermore, studies show that seniors have problems when interacting with a computer using traditional 'indirect' devices, especially when they have some kind of disability, such as Arthritis [16].

THE IMPORTANCE OF GAMES TO PROMOTE THE WELL-BEING AND QUALITY-OF-LIFE OF SENIORS

A game, as defined by Juul [21], is: "a rule-based system with a variable and quantifiable outcome, where different outcomes are assigned different values, the player exerts effort in order to influence the outcome, the player feels emotionally attached to the outcome, and the consequences of the activity are negotiable". To design an appealing game for seniors it is necessary to analyze how this elements work.

After retirement, leisure activities usually occupy a large part of seniors' daily routine [26]. A wide range of motivations compel seniors to engage in these activities, like keeping themselves busy and mentally alert, being socially included or just having some fun [34]. Playing games is already part of many seniors' routines and although it is true that the majority of seniors solely play non-digital games, it is a misconception to think that the audience for games only consists of children and teenagers. In fact, in 2011, the average age of the American game player was 37 years old, and 29% of players were over 50 [1].

Games create fun and enjoyable experiences [22], and are also a means of communication that enables people to relate to each other, interact, and spend time together [29]. Their scope of benefits is broad, and their use as a tool to increase seniors' well-being is gaining significant importance.

Jung et al. [20] have studied the effects of Wii games on seniors' quality-of-life and their results showed that as seniors played, their overall well-being was significantly improved.

Games also contribute to seniors' well-being in the area of cognitive stimulation, and increasing attention is being placed on the cognitive effects of playing games on seniors [8, 11, 19, 35, 18]. Results show that seniors who play digital games are faster in their reaction time [8, 11], significantly improve their performance on visual fluency and visual perception ability tests [18], improve cognitive skills, and maintain their self-confidence and quality-of-life [35]. Moreover, a recent study reports that, in fact, these benefits remain for weeks and can be transferred to everyday tasks [2].

Improving User Experience in Games for Seniors

Due to either age-related changes or seniors' preferences, not all games are suitable for this audience. Therefore, at the beginning of the design process, the authors analysed the characteristics that a game should have in order to provide an enjoyable experience to the senior player.

Gámez et al.'s [6] theory of CEGE (Core Elements of the Gaming Experience) identifies five elements to have in mind throughout the game conceptual design process: i) environment, ii) game-play, iii) player's sense of control, iv) ownership and v) 'facilitators' (aesthetic value, time and previous experiences). The authors' literature research on games concluded that the 'casual games' category provides game elements that might be more suitable for the senior. Trefry [36] defines the characteristics of a 'casual game' in the following way: (1) Rules and goals must be clear; (2) Casual game play adapts to a player's life and schedule; (3) Players need to be able to quickly reach proficiency; and (4) Game concepts borrow familiar content and themes from life.

A player gains a sense of control in a game as soon as he learns how to manipulate it. Because seniors may find decision making more challenging due to cognitive impairments, game rules and goals must be clear enough for them to understand (as in Trefry definition 1). Moreover, the existence of goals in itself creates motivation and ultimately provides the feeling of accomplishment, which may also influence seniors' perception of the value of the game. In fact, it is this feeling that produces the sense of ownership, when players understand that their actions in the game have results and a positive (or negative) outcome. Logically, positive feedback will keep the player engaged, whereas constant negative feedback may lead to frustration. Although a game should be challenging, it is important to be aware of players' skill levels and adapt the level of difficulty. A user should be able to quickly reach proficiency (as in Trefry definition 3), reducing the risk of user dissatisfaction. This is especially important when designing for seniors, as they are less willing to learn via trial and error and can get frustrated more easily [34]. These two characteristics are also connected to the time factor because, contrary to what one may think, seniors do not have more free time after retirement. In fact, they tend to engage in specific routines and schedule all their activities in advance [27]. For this reason they do not want to spend time on unknown activities, thus requiring that games adapt to their lifestyle (as in Trefry definition 2) and are not time-consuming. Finally, since seniors of today have less extensive experience with some game genres than mainstream game users, they tend to misinterpret

	Working memory	Long-term memory	Attention	Spatial cognition	Language comprehension	Problem solving
Trivia		X			X	
Mimic	X	X	X		X	X
Patterns	X		X		X	X
Enigmas		X	X		X	
Find Differences	X		X	X		
Word Puzzles	X	X	X	X	X	
Sequences	X		X			X
Mazes			X	X		

Table 1. Game Elements and Stimulated Cognitive Constructs

some game concepts, such as the use of weapons, and favour games that portray real stories or realistic activities [31, 34, 35] (as in Trefry definition 4).

In essence, 'casual games' may provide a simple framework of game characteristics that should be considered when designing games for the senior audience.

COGNITIVE GAMES AND MECHANISMS FOR COGNITIVE TRAINING

As previously discussed, games are powerful tools for nurturing seniors' overall well-being. To understand the mechanisms that would best suit this purpose, the authors performed a literature review. Ijsselsteijn et al. [17] identified four areas of design opportunities for games for seniors: 1) relaxation and entertainment, 2) socialization, 3) cognitive stimulation and 4) motor skills training. These areas were addressed in the work described here.

A further analysis revealed that the tablet, due to its limited size and style of interaction, would not significantly improve motor skills, especially when compared to devices such as the Nintendo Wii and Microsoft Kinect, which are already being used by seniors with proven positive results (e.g. [20]).

A more interesting solution would be to use the tablet-based games as a cognitive stimulation tool while incorporating entertainment and socialization as motivational mechanisms. As mentioned above, cognitive impairments directly affect everyday tasks. Thus, by stimulating cognitive skills, several areas of seniors' life can be improved.

A cognitive game has the main purpose of stimulating cognitive abilities, while maintaining the typical elements of games (e.g. fun, challenge) in order to engage the senior in the gaming experience. After studying the cognitive changes that take place with age, the authors analysed cognitive stimulation exercises provided by literature on ageing [25, 40] and extracted patterns of gaming elements that should be capable of stimulating a given cognitive construct.

Table 1 shows the results of this analysis and summarizes the main elements to include in a game that aims to stimulate a specific cognitive construct.

Although all these categories apply to games, the authors performed a critical analysis of this matrix, along with a literature review, in order to settle on the most suitable categories for tablet-based games for seniors. The main purpose of trivia games is to stimulate long-term memory. This is not primarily affected by age; therefore this game category was excluded. Mimic games would not be suitable because the tablet would be a rather superfluous support for the game play, not providing more than a simple image viewer functionality. Patterns, enigmas, find differences, word puzzles, sequences, and mazes appear were determined to be the most appropriate game categories for this project.

GATHERING USERS PREFERENCES THROUGH OBSERVATION AND A GAME BOOK

Gathering requirements for games targeted at seniors is more demanding than the usual process for a general purpose device and audience. On the one hand, game requirements like "fun and absorbing are not well understood from the perspective of requirements engineering" [5]. On the other hand, "user requirements are usually elicited by a way of focus group, which is often difficult when working with older people" [39]. Thus, some reflection on the traditional methods was needed in order to overcome potential challenges in the requirements elicitation phase of this project.

To understand the context of game play by seniors, the authors resorted to natural observations and went to typical gathering places for seniors as well as an adult day care centre.

During observations at both sites it was clear that seniors favour games that promote social interaction. Moreover, competition seemed to have a significant role in the gaming experience since both game participants and observers continually commented on the game progress and strategies used by players during the games.

During informal conversations with caregivers working at the day care centre, authors were reminded of the need to provide seniors with a variety of games because, with the exception of some games that seniors play more regularly (e.g. cards, dominoes), they tend to easily tire of playing the same game for an extended period of time.

The aforementioned results informed the authors of seniors' preferences regarding games. However, to obtain more formal and accurate results and to better assess seniors' preferences and difficulties regarding cognitive games, the authors created a *game book* (Figure 1). The *game book* concept was developed based upon the idea of games as research proposed by Nathan Shedroff [32] and was distributed among seniors at a day care centre using a method similar to cultural probes [14]. It consisted of a paper book with 10 different games distributed across the following categories: 2 sequence games, 1 enigma game, 3 word puzzles, 2 labyrinths, and 2 find differences games. One may argue that using tablet games would provide more information regarding the technology; however, the authors opted for the *game book* in paper instead of other technology-based artefacts, for the sake of familiarity. Seniors are more comfortable with paper than with technology. The paper also offered the advantage of enabling them to solve the games at their own environment and pace. Furthermore, the tablet might act as a distraction or obstacle, and introducing it at such an early stage could compromise their acceptance of the project.



Figure 1. *Game Book*.

The *game book* was distributed to 13 individuals (10 female/3 male) with an average age of 80 (74-88); they were asked to solve the games and return the book within one week. When collecting it, and during an informal conversation, the authors performed a questionnaire to evaluate seniors' level of satisfaction, difficulties encountered, and reasons for not solving games.

Results showed that seniors felt most engaged in word puzzles and find differences games. This was mainly due to two factors: first, these games were more familiar to them, as they are commonly available in magazines and newspapers; and second, because they indicated these two categories of games were the easiest. This suggests a correlation between game preference and difficulty, as they tend to favour games that do not require a great effort to solve. Furthermore, the authors also found that despite being told that their results were not being evaluated, the participants requested our feedback on their performance and were fervent to compare scores with their counterparts. This indicates an acute sense of competi-

tion among them, verifying the preference for a social component in games witnessed in the previous observations.

DESIGN AND DEVELOPMENT OF COGNIPLAY, A COGNITIVE GAMING PLATFORM

After the literature review and user research, it became clear that an appropriate product for tablets targeted at seniors would benefit from incorporating: i) casual games that promote cognitive stimulation; ii) social interaction, namely competition; and iii) a variety of games. Having concluded this it was no longer valid to develop one single game for this project; the authors decided to develop a gaming platform instead. This platform would then need to include a multiplayer mode and score system in order to promote social interaction, and a diverse set of cognitive mini-games to satisfy seniors' need for variety. To address these requirements the system should:

1. Provide a set of 'casual games' incorporating cognitive stimulation mechanisms;
2. Organise the games by category in order to assist seniors' choice of game;
3. Include a user profile system, including photos and names, to enable the identification of players;
4. Supply users with a score system so they are able to keep track and compare their progress in relation to other players;
5. Offer accessibility options, such as Help and Text-to-Speech.

The development phase of the platform started with the design of low-fidelity prototypes, for both games and user interfaces, in order to test concepts and ideas. Those later evolved to medium and high-fidelity prototypes, which were then tested to validate previous choices and assess seniors' acceptance and interaction with the technology. The following sections further detail this process.

Iterative Prototyping

Figure 2 and 5 show examples of the low-fidelity prototypes of the system. These result from the combination and balance of the system requirements and the creativity of the design team. These prototypes were then systematically evaluated with seniors at a day care centre in order to assess the overall usability of the system. Usability testing assessed wording conventions, icon metaphors, layout, and navigation. A total of 10 evaluation sessions were performed, with an average of 8 users per test. The prototypes evaluated during these sessions were carefully chosen in order to abide by the following rationales:

1. Keep users interested in collaborating with us by providing them with fun activities that are relevant to them;
2. Increase task complexity and technology proximity as time progressed.

This means the authors began by evaluating games and then slowly progressed to more complex navigation tasks.

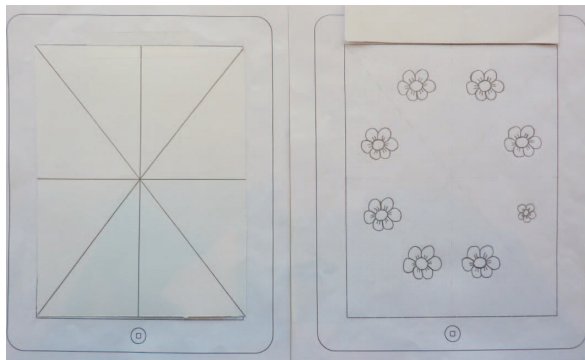


Figure 2. Find the Different Element Game Prototype.

Tests evaluated two different games, one specifically aiming to stimulate attention and another to stimulate working memory. Both draw their characteristics from the 'casual game' category. The first game (Figure 2) presents the senior with a set of similar images for a limited period of time during which he must identify the element that is different from the others (this element was, for this case, smaller than others, but the changes to this element may be different). Once the screen is cleared, the game asks the senior to identify the area in which the different element was located, as illustrated in Figure 2.



Figure 3. Matching Cards Game Prototype

The second game that was tested consisted of matching cards (Figure 3). The player had to turn over two cards at a time in order to find a matching pair. The uniqueness of this game was the use of pictures of people that seniors knew from their everyday life, namely the caregivers working at the day care centre they attend. At an earlier stage both unfamiliar and familiar faces were tested, and the results showed that seniors not only preferred pictures from their acquaintances, but 7 of 8 participants were also faster in finishing the game.

The next set of tests evaluated font sizes, naming conventions, and icons for several functionalities (Figure 4). The method used to test these aspects consisted of a very simple approach to card sorting, based on a one-to-one mapping scheme, where seniors were invited to connect functionalities to icons or names. This approach, which was similar to a game, was chosen to ease the interaction with seniors and their comprehension of the tasks.



Figure 4. Icons for the Score Functionality

In the last tests, the authors evaluated the platform's overall usability. Seniors were asked to perform a series of tasks, including: i) creating a player, ii) selecting a player or a group of players for the multiplayer mode, iii) removing players from groups, iv) choosing a game category and a game, v) checking scores, and vi) exiting the system. Figure 5 illustrates one of the tested layouts.

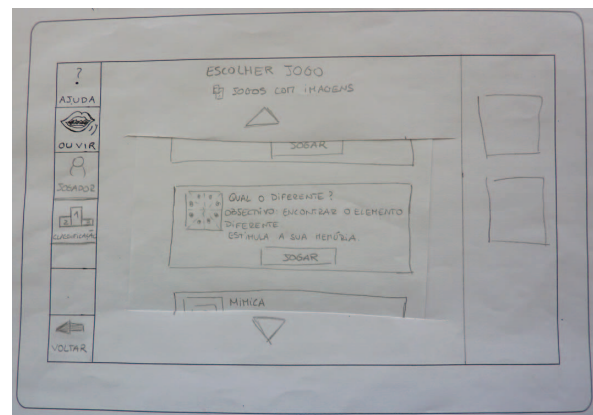


Figure 5. Choose Game Menu

Prototypes were iteratively improved after each test according to the obtained results, and as soon as an acceptable level of usability was met they evolved to medium- and a high-fidelity prototype. The general aspects of the evaluation with the last prototype are discussed in the next section.

PROTOTYPE EVALUATION

The evaluation of the high-fidelity prototype running on the tablet was conducted with eight users from a day care centre and aimed to test the platform and games' usability, as well as their acceptance by this audience. This evaluation followed a protocol that included a pre-description of the tasks to be carried out. Facilitators requested each participant to:

- Select the single player mode (Figure 6). From the main menu of the platform users had to choose "Play Alone" from three available options;
- Create a new player. This task required taking a picture with the front camera of the tablet, accepting it and entering their name through the on-screen keyboard;

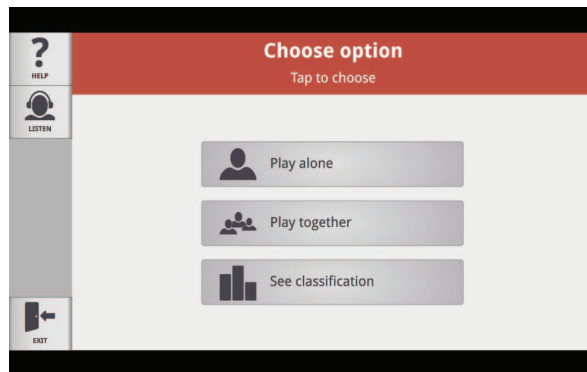


Figure 6. Main Menu

- Select a given player (Figure 7). There were two different ways the user could choose a player: i) touch the player's picture and confirm their selection, or ii) drag the player's picture and drop it in the selected player area. Participants were informed about the two ways and allowed to choose the one they preferred;

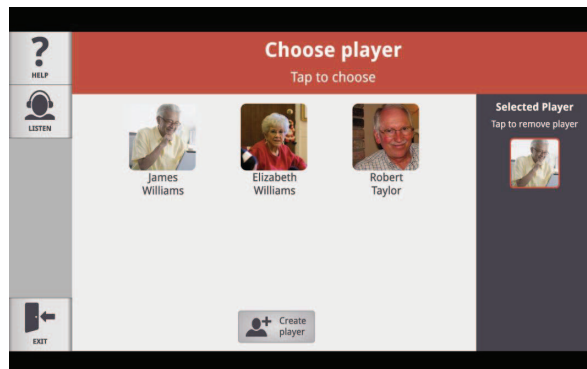


Figure 7. Choose Player Menu

- Choose a game category and game. Users had to choose a given category from four available and then choose a given game from the two available. All players were instructed to choose the same category and game;
- Play a game (Figure 8). Users played the matching cards game with pictures of caregivers at the dare care centre.

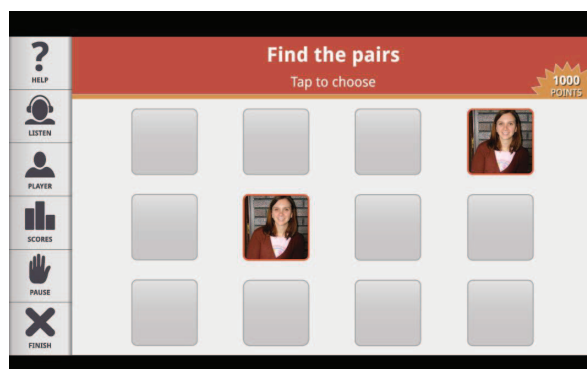


Figure 8. Matching Cards Game

The tasks were evaluated in terms of their effectiveness, provided by completion rates, and subjective satisfaction, assessed through a short questionnaire administrated after the test.

All tasks were successfully completed, however, all players faced challenges when inserting their names through the on-screen keyboard, resulting in errors. Errors occurred because seniors pressed keys for longer than is usually necessary, causing letters to automatically be switched to other symbols. As soon as the facilitators realised the difficulty was related to the keyboard features, this particular feature was turned off and the error no longer occurred.

To assess users' satisfaction, seniors answered the following questionnaire:

1. Did you enjoy this experience? (Yes/No)
2. Did you find any task too challenging? (No/1 or 2 tasks/3 or 4 tasks/All tasks)
3. If there was a tablet available here at the day care centre, how often would you use it? (Very often/Often/Seldom/Never)

All seniors indicated they found the experience enjoyable, and only one thought that 1 or 2 tasks were particularly challenging. Regarding how often they would use the tablet, the results were also positive, with 6 of 8 stating they would use it very often and 2 stating they would use it often.

DISCUSSION

This section presents the authors' reflection on the work that was carried out as well as the way it relates to the literature. Special emphasis is placed on the ten rules of thumb the experience with this project enabled us to identify.

- The use of pictures to identify each player seemed to motivate the participants and generated a conversation theme among seniors regarding their looks and memories of their younger years. The use of avatars to represent an individual in the game is already widely used and more recent systems also incorporate cameras that 'include' the person in the game. Arguably, the use of such mechanisms generated a feeling of familiarity and proximity between the user and the game, which is likely to compel its use.
- Seniors tend to favour games that portray themes from the real world [34, 35]. By customizing a game to one's real world it is possible to provide a better gaming experience, as our results have previously showed.
- The authors used low- and high-fidelity prototypes to support the development and evaluation of the gaming platform. The first consisted mainly of paper prototypes while the latter was closer to a functional prototype of the platform that was already running on a tablet device. The results of the evaluation showed that different problems with the designs can be identified by each of these means. For instance, while low-fidelity prototypes show how to improve the concept of a game, high-fidelity reveal potential problems regarding the interaction with the device itself.

- Although available research suggests that gestures may provide an easier way of interacting with touch-based systems, in the case of seniors this assumption requires careful attention. For example, during the task of selecting a given player, it was observed that dragging elements is hard for individuals who suffer from some form of fine motor skill decline. Therefore, it is necessary to carefully adapt the way gestures are used in a system for this audience in order to accommodate possible impairments.
- Engaging in the gaming experience is sometimes a challenge for seniors. While performing the *game book* activity, several participants indicated that they could not solve the games without help and that they often did not participate because they felt they did not have enough skill. For this reason, games should be easy enough to allow a wide range of users without being dull. As a result of taking this into consideration while designing the game used in the evaluation, participants had a more successful and enjoyable experience.
- Using the tablet with the default settings may not be appropriate for seniors. For instance, since these users tend to press button for longer than necessary, the input methods should be prepared to accommodate these differences.

Ten rules of thumb for a gaming platform targeted at seniors

Our primary goal was developing an artefact with the characteristics necessary to provide an enjoyable experience to the senior audience. The overall specification and design of the platform considered their characteristics and needs, but further analysis of the prototype revealed a number of features that are of paramount importance, which are the following:

1. **Usage of direct input devices.** As literature suggests, this kind of device has the potential to ease the interaction between seniors and technology [16]. Therefore, by using them it is possible to reduce seniors' anxiety towards technology.
2. **Mobility.** A tablet can be transported and played anywhere, allowing seniors with physical limitations to play more easily, in a comfortable position and environment.
3. **Senior adapted interface.** By implementing a design that accommodates the changes seniors experience as they age, the interaction with the system will be more rewarding. This can be accomplished by testing icons and naming conventions as well as including accessibility options.
4. **Expandability.** The platform allows for the development and inclusion of new games; these can accommodate new trends as well as demonstrated preferences and needs, responding to future demographic changes.
5. **Variety.** Providing more than one game allows seniors to choose to play their favourite ones, swapping among them, preventing them from growing tired of any single game. This concurs with the caregivers' advice for providing a variety of games in order to maintain seniors' interest in playing, as described above.
6. **Customization.** Games that can be adapted to a specific individual through the use of familiar pictures, videos or sounds are expected to enhance the user experience; this was observed when testing the matching cards game. Moreover, user interfaces that have customizable fonts or icons can adapt to a wider range of users.
7. **Instant Feedback.** When a system provides feedback, users are aware of the impact of their actions. In a game this enables them to know when they succeeded or failed and why [29]. By having this kind of instant information, players are able to improve their skills, while remaining motivated by their actions' outcome.
8. **Engaging goals.** To keep the user's focus on the objective of the game there should be clear goals. Goals also act as challenges that keep the user engaged in the game.
9. **Immediate rewards.** Since the benefits of cognitive games might only be noticed in the long term, users should be immediately rewarded by the system for their performance at all times. The rewards can also be used to show results to friends and track progress. Rewards can promote a healthy competition, which is greatly appreciated by senior players, as observed during the initial stages of the project.
10. **Social interaction promotion.** The lack of a social network in mature life greatly impacts seniors' psychological well-being [33]. Therefore, seniors prefer systems that promote social interaction. This platform promotes this by including the multiplayer mode and the rewards system. Both of these features can be a topic of conversation among seniors, while enabling friendly competition.

Validating these characteristics is beyond the scope of this paper; however, it would certainly be valuable to assess each of these rules of thumb in the gaming experience of seniors.

CONCLUSIONS AND FUTURE WORK

The results of the evaluations indicate that seniors can easily interact with the platform and do not find the required tasks excessively challenging.

Although results already indicate that the platform satisfies the various aspects of usability and has great positive acceptance by seniors, it still needs further formal validation, in particular through long term tests with a wider audience of users.

Regarding future work, and due to the expandability of the platform, more games and relevant levels of difficulty should be developed to adapt to a wider group of users. By having more variety and gaming mechanisms it will be possible to evaluate how the user experience can be affected when new elements like video, sound and better graphics are added to the game. Furthermore, the platform is capable of saving a series of parameters regarding user performance that may be used not only to track an individual's progress, but also as a monitoring tool for detecting cognitive problems at an early stage. This was already studied by Jimison and Pavel [19] and should be a future area of study for this project as well.

Another aspect that is yet to be fully explored is the cognitive improvements that games can have on seniors in the long run. Although games are proven to have that potential, "currently little is known regarding how the schedule of game practices affects transfer to other perceptual and cognitive abilities" [4]. However, despite the conclusions that future research may reach on this subject, a game should always be a fun and free activity, and imposing schedules could negatively influence the user experience. For this matter, a solution that motivates users, as opposed to one that obligates them to play a game, is needed. A mission/goals mechanism that would reward users that engage in a specific game playing routine could potentially be a solution for this issue.

Finally, studying an online player mode provides yet another way to promote social interaction, especially beneficial to seniors who are isolated for geographic or health reasons.

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