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Analysis, design and evaluation of a tablet-based gaming platform for older adults

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Abstract

Technology has the potential to improve the quality of live and well-being of older adults. However, this audience still has to face several challenges in order to be included in a increasingly technological society. This fact puts older adults at a disadvantage and it requires researchers and practitioners to deliver products which are suitable for them, this way ensuring that they are not excluded from the benefits that technology can provide.

The stereotype that the older population is still unwilling to use computers is deprecated, and more and more, elders use technology in their daily life. In fact the main reason for a still lower acceptance rate of technology among older adults is the disregarding of their characteristics during the design process. Elders' characteristics and needs are very different from the mainstream audience and the number of systems that consider these differences is scarce to non-existent. This includes games, which up till some time ago, were still seen as an activity targeted at younger generations only. Nevertheless, games provide a wide range of mechanisms that can be used not only to appeal to the older audience but also to promote their active-ageing and well-being.

The main goal of this project is to analyse, design and evaluate a tablet-based gaming platform for older adults. To achieve this purpose we start by performing a study of users' characteristics as well as games' mechanisms and tablets' potential as privileged devices for older adults' use. Building upon the obtained results, we propose a solution that incorporates games with mechanisms for cognitive training and social stimulation in order to provide an enjoyable experience while promoting seniors' well-being and quality-of-life. The development phase of this solution was based on a user-centred methodology in which we iteratively redesigned and evaluated low-fidelity prototypes with older adults at a day care centre. At the end of this project, we were able to perform a trial with seniors, using a tablet device and a high-fidelity prototype of the proposed system. Results showed that the proposed solution satisfies the various aspects of usability as well as its great acceptance by the target audience.

Resumo

O uso da tecnologia tem o potencial de melhorar a qualidade de vida e o bem estar dos idosos. No entanto, este público ainda enfrenta diversos obstáculos quando pretende ser integrado numa sociedade cada vez mais tecnológica. Este facto deixa os idosos em desvantagem e é necessário que investigadores e profissionais desenvolvam produtos que são apropriados a uma população mais idosa, assegurando desta forma que estes não sejam excluídos dos benefícios que a tecnologia pode proporcionar.

O estereótipo de que a população idosa ainda não se encontra disposta a utilizar computadores é obsoleto, e cada vez mais, os idosos utilizam a tecnologia no seu dia-a-dia. De facto, a principal razão para a baixa taxa de aceitação da tecnologia entre os idosos é a falta de procupação em acomodar o desenho dos sistemas às suas características. Os idosos possuem características e necessidades bastante diferentes das do público geral e os sistemas que consideram estas diferenças são raros ou até mesmo inexistentes. Isto inclui os jogos, que até há algum tempo atrás, ainda eram vistos como uma actividade característica e exclusiva das gerações mais novas. No entanto, os jogos possuem uma série de mecanismos que poderão ser usados não só de forma a apelar a um público mais idoso como também para promover o seu envelhecimento activo e bem estar.

O principal objectivo deste projecto é analisar, desenhar e avaliar uma plataforma de jogos para *tablets* direccionada aos idosos. Para atingir este propósito, numa fase inicial, foi feito um estudo profundo das características dos utilizadores assim como dos mecanismos dos jogos e do potencial dos *tablets*. Com base nos resultados obtidos propomos uma solução que utiliza os jogos como ferramentas de treino cognitivo e estimulação social, de forma a proporcionar uma experiência agradável aos idosos, enquanto promove o sem bem estar e qualidade de vida. A fase de desenvolvimento desta solução foi baseada numa metodologia centrada no utilizador, na qual foram iterativamente redesenhados e avaliados protótipos de baixa-resolução com idosos de um centro de dia. Na fase final deste projecto foi efectuado um teste de um protótipo de alta-resolução com os idosos, no qual já se recorreu ao *tablet* como plataforma de jogo. Os nossos resultados revelam que a solução proposta satisfaz não só os diversos aspectos de usabilidade como tambám foi satisfatoriamente aceite pelos idosos.

Disclaimer

This dissertation is the result of my own work, under the supervision of Luís Filipe Teixeira and Paula Alexandra Silva and has not been submitted in support of an application for another degree at this or any other university. It is the result of my own work, research and judgment, and includes nothing which is the outcome of work done in collaboration, except where specifically indicated; therefore, I acknowledge full responsibility for the work presented. Excerpts of this thesis have been submitted to a conference as stated in Appendix 9.

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Abbreviations

HCI	Human-Computer Interaction
WHO	World Health Organization
PD	Participatory Design
UCD	User-Centred Design
USID	User Sensitive Inclusive Design

Chapter 1

Introduction

Older people are likely to encounter computers and other technological artefacts in a large number of settings. One commonly held belief is that this audience is resistant to change and unwilling to interact with computer systems, yet the majority of studies that examined the attitudes of seniors towards computers indicated that they "are receptive to using computers" [CL03]. Therefore, there is no valid reason for not considering seniors as a potential target audience for computer applications; on the contrary developing software with these users in mind is likely to provide them with a wide range of benefits that would otherwise be unreachable.

Despite the trend of an increased use of computers, this increase is lower among older adults when compared to younger ages [CL09]. The current situation in Portugal is that "most retired Portuguese seniors do not have access to the Internet or don't know how to use it (...) there are still a lot of people that are excluded from the use of technology" [Pú11].

Even though "technology holds great potential for improving the quality of life for older people" [CL09], studying the challenges that the elderly face while trying to use technology and how to overcome them are becoming a concern among researchers worldwide. One of the main reasons why some older adults still do not use computers is the lack of the perceived benefit of its use because "either the technology does not meet the needs of the user, or they do not understand the technology sufficiently to appreciate the benefits" [NWH10]. In effect, older adults "are increasingly feeling overwhelmed and frustrated" as technology evolves [Gre09] and some of the ones that already tried to use computers eventually gave up since "they did not find that the effort to learn and keep up (constant software upgrades) was worth it for them" [Han10].

The current situation brought us to an era of a "Digital Divide" between technology and the older population [MKCM10]. This situation can be modified by using a more creative approach [Opa01] and if developers become "more willing to draw from gerontologists and elders as they develop, test, refine, and market their products" [SF06]. In

doing so, the creation of systems and services that address a need or interest and that users perceive as worthwhile [Han10] could more easily appeal to the older audience, decreasing their qualms towards technology.

An interesting way to address the above-mentioned issues is to merge leisure activities with technology. Older adults that already engage in computer-mediated hobbies describe their experience as an enjoyable and pain reliever experience, which brings them new friendships and information while offering them the opportunity to be expressive, intellectually stimulated and to "pursue something intrinsically valuable to each individual" [Opa01]. During the past decades the industry of games for adults has suffered a tremendous growth as a consequence of the population ageing and its impact in the economy [MK01] and, in 2010, 26% of the American players were over the age of 50 [Ass10]. This increasing use of games by an older audience, along with a current demand on entertainment mechanisms for retirement-age adults has already caught the attention of many researchers. The acknowledgement that "games are too powerful to be regarded only as merely entertainment" and that they "have the potential to change society" [Wes03] has promoted studies that seek the comprehension of games potential in providing not only enjoyment but also well-being related improvements. Their conclusions are optimistic and provide a valuable theoretical background to support our research.

Currently a wide range of devices has reached a point where affordability, availability and consumer acceptance converge to make them reach a large number of users [Fol08]. Included in these novel devices is the tablet, which touch and gesture-based interaction "may afford an alternative and more natural interaction method" [Hol09], easing its use by older adults. Therefore it is fair to state that the necessary conditions to develop a product that will be indeed suitable for an older audience have now come together as never before. With this in mind the authors believe that, through the use of appropriate methodologies, it is possible to propose a solution based on the combination of games with touch-based devices that will have a higher acceptance rate among older adults than the currently available products. Ultimately, it is expected that the existing gap between this audience and technology can be diminished and its use promoted, along with the wide range of benefits it can provide.

1.1 Goals and Contribution

This thesis has a primary goal of analysing, designing and evaluating a tablet-based gaming platform for older adults.

To successfully accomplish this purpose a number of questions were addressed, namely:

Q1: What are the elderly main characteristics and how do these impact the design process?

Q2: What characteristics should a game hold in order to appeal to an older audience?

Q3: How can tablets enhance interaction between older adults and technology?

Q4: How can tablet games promote older adults' well-being?

Q5: Which are the appropriate methodologies to employ during each phase of the development process?

Therefore we performed an analysis of games' and tablets' characteristics in order to understand how can a combination of these elements result in a suitable artefact for such a specific audience. To inform the succeeding designs a series of techniques from literature review to observations and interviews were employed with the purpose of reaching a deep insight of seniors' capabilities and limitations. Afterwards, during an evaluation phase, the developed prototypes were tested to access their acceptance rate among the elderly. The overall process was based on a user-centred design philosophy. Since these methodologies promote an intensive communication with the target audience it is more likely that we will be able to achieve more informed results. Through the knowledge acquired during this process a set of general considerations regarding game design for older adults were derived as well as ideas on how to improve their interaction with touch-based devices. Given that there is still little research regarding the use of tablets as a gaming platform for older adults, the authors believe that this thesis' contribution will provide valuable information within the Human-Computer Interaction community, promoting better outcomes in future related projects.

1.2 Thesis Outline

This thesis is structured in six chapters:

This chapter (1) introduces the context of this research together with its goals and contribution and this thesis outline.

Chapter two (2) develops an understanding of the various areas this project involves: users, games and the tablet platform. It starts with a review on older adults' characteristics and age-related changes as well as the new trends that have recently emerged to support a pleasant ageing. Next, we discuss the potential of games as well-being enablers and the mechanisms they incorporate to achieve that goal as well as the tablets' advantages over other devices when considering an older audience. Finally, we discuss a possible solution that approaches tablet games as a cognitive stimulation tool for older adults.

The third chapter (3) discusses topics of Human-Computer Interaction as well as its methodologies and techniques. Building upon this discussion, chapter 3 then presents the methodology used for this project.

The solution proposal and its features are presented in chapter four (4). Chapter 4 also states the outcomes of the user research phase which are then contextualized in the description of the prototyping phase and corresponding evaluation.

Chapter five (5) discusses the overall research process and the challenges encountered when working with older adults. Furthermore, it presents ten characteristics for the proposed solution as well as some lessons learned throughout this thesis development.

Finally, chapter six (6) reflects on the conclusions of our work and its contribution, identifying a range of open-ended issues that can be object of future research.

Chapter 2

Understanding the use of games and tablets by seniors

The ageing process is responsible for changes at several levels, from biological to psychosocial. These age-related changes may impact on a number of different aspects of older adults lives and limit the extent to which they are able to perform certain activities. These constraints can also be observed in their ability to interact with computer systems, which are yet to be prepared to accommodate seniors' capabilities and limitations.

This chapter revises older adults' characteristics, in particular age-related changes, based on a literature review performed at the early stages of this project. Additionally, new trends that encourage a more pro-active and successful ageing were also approached in order to identify the different aspects in which this work can contribute to their promotion.

Later, and considering the fact that this project contemplates the use of tablet devices as gaming platforms, an analysis of their potential as enablers of well-being and facilitators of interaction between technology and older adults is also performed.

Finally, a solution that considers games as cognitive stimulation tools is discussed, along with the game elements that may impact elders' gaming experience.

2.1 The Problematic of ageing and its current trends

Understanding the user's characteristics is crucial to design a system that is adapted to their needs. Earlier on, little information was available about old age, which people generally perceived as a decline in one's capacities. But in the past 50 years, the science of gerontology, "which is the study of ageing from maturity through old age", [CBF06] has flourished and provided a deep insight on what ageing is and its implication on people's lives. Still, trying to define old age or elderly general characteristics can be challenging.

Firstly since “chronological age is not a precise marker for the changes that accompany ageing”[Org02] we cannot state the age at which a person can be considered old. Instead “an old person has several ages: the age of his body, of his genetic history, of his psychological component and of his connection with society” [Zim00]. This plurality of dimensions suggests that over time “individuals follow different developmental trajectories in the constancy, development, and deterioration of important attributes and behaviours” [Hoa09]. As a result, there are “dramatic variations in health status, participation and levels of independence among older people of the same age”[Org02]. Also, for the same person, his abilities may widely vary throughout time [REN04]. Moreover, cognitive and physical age-related changes occurrence is highly influenced by health behaviour habits and psychosocial factors [CMA06]. Therefore, classifying “older people” as a single separate group may imply homogeneity, and lead to a narrow stereotyping of the potential user [REN04], that would not accurately represent reality.

Thus, an understanding of the changes that take place with age is important but not sufficient to design a system suitable for the older audience. The crucial point is to acknowledge their individual differences and try to develop a design that has the ability to accommodate different stages and degrees of the below described impairments.

2.1.1 Perceptual and Motor Age-Related Changes

For the average person, vision is the primary source of information and their ability to visually perceive information affects the way computer systems are designed [ADA04]. For older adults, this information retrieval can embody some challenges as the prevalence of visual impairments increases with age. In fact, “if we live long enough, nearly all of us will have vision problems” [AFS09] and for this reason considering this limitation is essential while designing a system.

Visual acuity is one of the most used measures regarding vision. It refers to the “sharpness with which a person perceives a visual image” [PM10] and generally individuals begin to feel a loss of visual acuity around their forties. This loss can be corrected through the use of glasses but nevertheless their use may make certain tasks more demanding [AFS09]. In the particular case of computer systems, loss of visual acuity is known to increase visual search time, specially when icons or other images are particularly abstract or similar looking in shape, size or colouring [PM10]. Furthermore the color sensitiveness in the blue-to-green range diminishes due to the yellowing of the lens that elders may experience [CJ09].

Reading can also be affected in result of a condition known as presbyopia, “the inability to focus effectively on near objects” [CJ09], as well as the ability to adapt to light transitions or performing visual tasks under dim light as older adults tend to have reduced

contrast sensitivity [Sch06]. For these reasons, when designing for older adults, it is advisable to avoid the use of decorative and cursive fonts, smaller than 12-point x-height and contrast ratios below 50:1 [AFS09].

Hearing is usually under-estimated however, the auditory system can convey a lot of information [ADA04]. Many older adults, especially men, suffer from presbycusis – the reduced ability to hear high-frequency sounds – which difficult the hearing of certain sounds, such as the "s" sound, causing problems in correctly understanding speech [CJ09]. While using a computer system older users may find it challenging to perceive synthetic speech or hear alert sounds such as "beeps or pings" [CL09], which is why these mechanisms should be avoided, replaced by others when possible or should be provided in parallel with visual information.

Age-related changes in motor skills include slower response times, declines in ability to maintain continuous movements, disruptions in coordination, loss of flexibility and variability in movement [CL09] . The haptic processes, which involve the use of touch to obtain information about the features of an object, can also suffer some changes, specifically the loss of sensitivity in hands [MR10]. These motor skills can greatly influence the perception the user gets from interacting with a system, especially when manipulating devices that require great precision. To avoid unpleasant experiences, a system should allow sufficient time for inputs, help, guide or constrain movements and have an increased target size for objects in the screen [PM10] Moreover both interaction paradigm and device to be used should be carefully considered to ease the process from the users' point-of-view.

2.1.2 Cognitive Age-Related Changes

Many computer tasks are characterized by cognitive demands; data-entry and menu-based tasks rely on abilities such as psycho-motor speed and attention, and word-processing performance requires the use of memory [CL09].

Thus, such age-related changes, specially the ones related to memory and attention, can limit the extent to which older adults are able to use computers.

Memory can be divided into two major categories: working or short-term memory and long-term memory and they are affected by age to different extents. Working or short-term memory is the ability to maintain information over a short period of time [AFS09]. The capacity of short-term memory shows signs of decline with age and is known to affect many complex everyday tasks such as decision-making, problem-solving and the planning of goal-directed behaviours [Gli07], mainly due to the difficulty of older adults in store and manage large amounts of new information [CJ09]. Unlike working memory, in general long-term memory is largely preserved in old age [Gli07]. Often older adults show a knowledge advantage - termed "crystallized intelligence" - over younger adults as they are more likely to be able to answer questions dealing with definitions of words

or knowledge of facts [CJ09]. However, some declines can be noticeable in episodic or prospective memory, two of the long-term memory components, [MR10], which can result in a reattainment of general core information but a lack of details, context or source of information [Gli07].

In general, attention is also affected by age. Older adults have shown to have more difficulty in tasks that require divided attention across multiple input channels and are also more prone to being distracted by irrelevant information [CJ09].

The two above-mentioned cognitive constructs – memory and attention – should always be considered when presenting information to older adults as they may find it challenging to absorb and process large quantities of new information. Examples of guidelines that should be followed in a design that suits elderly with cognitive impairments are: i) provide only task-relevant information, clearly indicating the user where the information is provided; ii) alleviate working memory burden, through the use of common interface metaphors and iii) allow multiple ways of accessing informations [PM10]. Two other relevant skills that suffer modifications are spatial cognition and language comprehension. The first is related to the ability of mentally manipulating images or patterns whereas the latter is the ability to interpret verbal information [AFS09]. Both these cognitive skills have shown to decline with age and they can affect the way elders perceive and interpret information, thus it is advised the usage of language and icons that are familiar and easily recognizable by older adults.

2.1.3 Psychosocial Age-Related Changes

Even though people are in general more aware of the physical age-related changes due to their external visibility, psychological and social changes that occur in elders' lives are equally important.

One of the main triggers of social or psychological changes is retirement. Being retired is many times associated to a loss of social importance and power due to the disengagement of an active social role, and presents itself as an open door to old age [LSC04]. This perceived lack of responsibilities towards society may incite an identity crisis and consequently a loss of self-esteem [Zim00]. At the same time, physical and cognitive changes begin to be more noticeable, affecting one's independence and autonomy, hence constricting the performance of daily life activities. This can also be psychologically distressing by posing a threat to one's ability to live safely and independently [BS10].

The above-mentioned problems are aggravated by the reduction of elders social network. For the older individual, the social component is one of the most important means towards well-being, however in old age there is a series of barriers that difficult the maintenance of relationships such as the death of friends and family, personal vulnerability, environmental and contextual obstacles, stress and conflict [LSC04].

Coping with all these losses can be extremely difficult and may trigger some problematic reactions, particularly to individuals predisposed to mental disorders [Ass03]. For this reason, it is not uncommon to see seniors struggling with depression, hypochondria, paranoia or suicidal thoughts [Zim00]. However, it is also important to remark that "what is gained in late life, as a counterbalance to losses, may be wisdom" [CMA06]. All this process of loss and gain has an impact in a person's self-concept as they have to re-think their beliefs about themselves, such as their "likes, dislikes, values, appearance and competencies" [CH06]. As a consequence, elders tend to focus more on personal growth [Bru06] and to change the nature of their social relationships, valuing meaningful interactions with emotionally rewarding partners [Roo07].

While these changes may not seem important for a computer system design at first sight, they are indeed worthy of reflection if the goal is to design an artefact that appeals to this audience. As an example, older adults that experience feelings of abandonment may recognize the importance of a system that fosters social interaction which can consequently increase its acceptance rate.

2.1.4 New Trends

As the world's population ages an increasing attention is being placed on the way individuals age. The fact is that the stereotyped old person – the forgetful, debilitated, weak old man – is no longer the portrait of reality and because of the negative connotation that being old implies, many people that could be considered old according to their physical age, rarely perceive themselves this way [SELS08]. This concern on trying not to be or feel old has created a new way of facing life among elderly arising a need to create new spaces, products and services and to reformulate concepts and postures [Zim00].

The current major concern of society towards the elderly is to promote their overall well-being. Well-being can be defined as an overall state of each individual, a summation or outcome of a person's varied life experiences, including his position in the context of his society, his objectives, expectations, patterns and concerns [KJ02][dMPP06]. It is often referred to as "happiness" or "life satisfaction" and much literature tend to face well-being only by its mental or psychological perspective [All08a]. However, well-being is a subjective and multidimensional concept that includes both positive and negative aspects [dMPP06] and that is strictly connected to the concept of health. In 1948, health was defined by the the World Health Organization (WHO) as "a state of complete physical, mental and social well-being" thus specifying three dimensions of well-being that must be approached when the aiming is the overall well-being promotion.

More recently the WHO has introduced the concept of active ageing as "the process of optimizing opportunities for health, participation and security in order to enhance quality

of life as people age" [Org02]. This new trend addresses the need for well-being promotion by providing a framework containing the essential elements to accomplish an overall physical and psychological healthy ageing; these are showed in Figure 2.1.

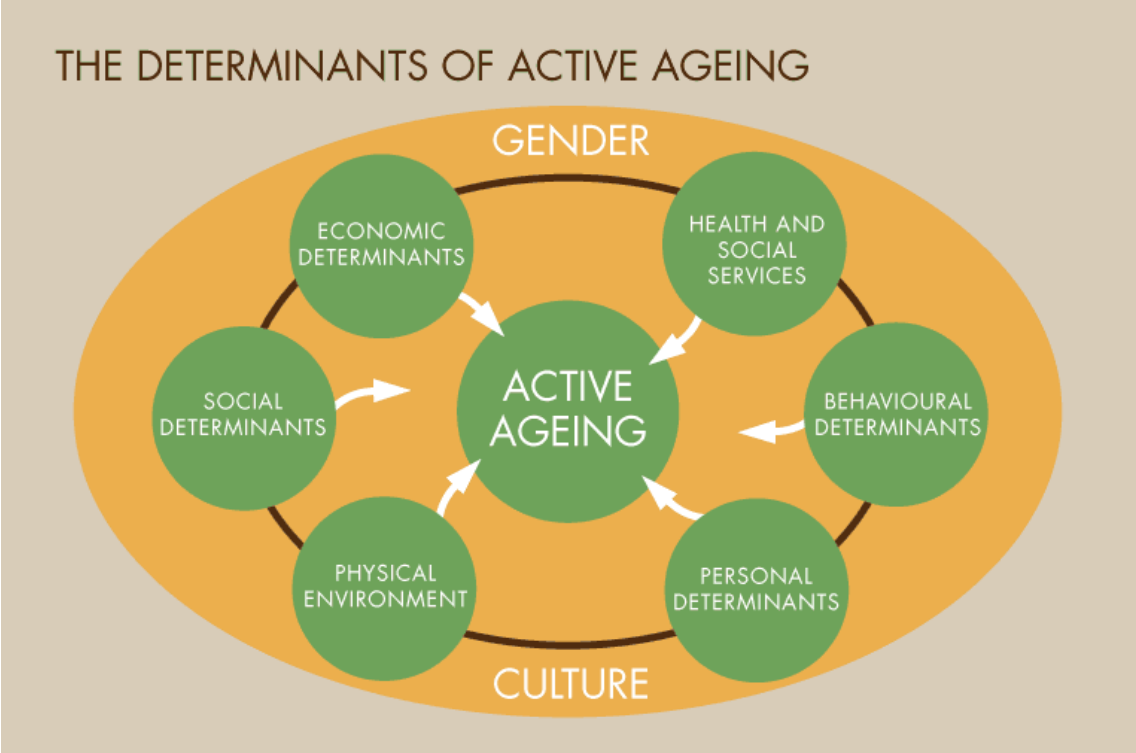

Figure 2.1: The Determinants of Active Ageing [Yea]

According to "Active Ageing: a policy framework" [Org02], WHO defines in more detail the focus of each one of these determinants and how can they be accomplished. In essence each determinant unfolds in numerous aspects. From them policies to be implemented by governments and institutions have emerged. More individualized projects can also rely on these determinants however, these are yet scarce [sRP11]. For this reason it is also this project's intention to focus on the promotion of an active ageing through the use of technology. Technology can play an important role in providing health-related information to seniors, its use as persuasive tools can influence users' adoption of healthier habits and the social aspect of games can also improve elders' "connectedness". In this context, this thesis focuses on the mechanisms that can be implemented in games to promote well-being and consequently an active ageing.

2.2 The role of games as well-being enablers

After retirement, leisure activities represent a big part of elderly daily life [SPBF09]. Playing games is already part of many older adults' routine and they can be understood as an

activity of leisure and entertainment, energy release, social interaction and to accomplish physical, psychomotor and intellectual objectives [Gei03].

Games are known to provide fun and enjoyable experiences, through a wide range of different mechanisms that usually appeal to the emotional connection that players feel towards games [Laz08]. The available research suggests a wide array of positive outcomes for elders who take part in the gaming experience. These benefits include social interaction stimulation and enhancement of perceptual motor skills [Whi90] as well as improvements of cognitive capacity [Tor08]. Their scope of benefits is actually broad and their use as a tool to increase seniors' well-being is starting to gain a significant importance.

2.2.1 Mechanisms for social interaction stimulation

In the case of older adults the most important factors underlying their mental health and well-being are social and community participation [All08a]. Fostering social interaction in older age is therefore determinant and games are "important direct means towards connectedness" [SA10]. When referring to social interaction in games we often think about collocated multi-player where more than one player play the game at the same time in the same space. This may hold true to traditional board or card games, however, social interaction can be achieved in various different ways. In fact, collocated multi-player is rare due to lack of interest from family and friends or to different skill sets, but social interaction can be achieved via online play, vicarious play or when help is requested from family members and friends to overcome any possible difficulty encountered while playing [SA10]. The concept of vicarious play is worth mentioning, as it is an unconventional way of social interaction that is not always recognized in games. It can be defined as "a form of collocated play in which one player is playing a game, while the other is participating mentally without actively using game controls" [SA10] having the possibility of engaging in conversation about the game play with the active player, even if they have different gaming knowledge and skills. As detailed in section 4.1 this is a kind of circumstance we observed in older adults at the day care centre.

Social interaction derived from games can also be experience outside the context of play. "A whole range of involvement extends beyond the game, including (...) players interacting socially, discussing details of games" [DeM07]. Playing can provide a conversation theme among older adults enabling the exchange of ideas and the sense of community thus promoting social interaction.

In essence, games have a strong social component that can be implemented using a wide range of different mechanisms. As concluded by Schutter and Abeele [SA10] games that are perceived to "1) foster connectedness, 2) cultivate oneself and others, and

3) contribute to society" can provide meaningful experiences to older adults thus being more easily accepted, while contributing to their well-being.

2.2.2 Mechanisms for motor skills enhancement

A recent trend that addresses the use of games to promote health and physical well-being among older adults are the exertion games. These games "demand intense physical effort from the players" and are believed to contribute to physical health by "encouraging players to exercise longer and more often" while providing a social experience more likely to attract wider user participation [FMV10]. When it was first launched, the Wii console platform was immediately recognized by introducing the physical component on games, and the "immense popularity [of Wii] among elderly debunks the notion that video games are only for young children and teenagers" [YJL09]. Its increasing popularity along with the potential for improving older adults' lives lead to a research carried out by Jung et al. [YJL09] whose aim was to study the effects of playing Wii games on physical and mental well-being of elders. Their results showed that the overall well-being of Wii players was significantly improved, demonstrating the "potential of Wii to impact diverse aspects of elders' lives, from psychological to physical well-being" [YJL09]. Recently, more gaming console systems started to implement mechanisms that also appeal to a more physical use of games, in particular Microsoft with Xbox 360's Kinect and Sony with PlayStation Move, showing that the market is growing as well as the public's adherence to these games.

2.2.3 Mechanisms for cognitive training

Increasing attention is being placed in the cognitive effects of games on older people [JECR87], [RDD92], [JP06], [Tor08], [HJP10]. Even tough there are some exceptions [JP06] and [HJP10], most research was based in games that were not specifically developed to meet older adults' needs. However, even with regular games, results show that seniors who played games were faster in their reaction time performance [HJP10], [RDD92], significantly improved their performance on tests of visual fluency and visual perception ability [HJP10], improved overall cognitive skills and maintained the self-concept and the quality of life [Tor08]. Moreover, a recent study reported that, in fact, these benefits remain for weeks and can be transferred to everyday tasks [All08b].

The use of cognitive training mechanisms in games has already been explored and a successful example is the Dr. Kawashima Brain Training Series for the Nintendo DS platform. These games were developed by Dr. Kawashima, a professor at the Tohoku University (Japan) trained in neuropsychology, and are based on the premise that "cognitive exercises can improve blood flow to the brain" [Nin06]. To assess the reliability of this argument they conducted memory tests on a wide range of people and even patients

with cognitive impairments that solved some of their exercises two to five times per week "were able to prevent the worsening of their condition and improve the functioning of their prefrontal cortices more than those who had not done such exercises" [Nin06]. This series of games has already appealed to an older audience that has recognized their importance for maintaining a good mental health. Moreover, the Nintendo DS was designed to appeal to older consumers because it has "no complicated set of controls – just a pen and touch pad – and players can turn the console sideways to make it feel more familiar, like a book" [Tok06]. It is important to acknowledge that is the junction of these two elements – cognitive training and a user-friendly platform – that resulted in a system that is perceived as useful and meets older adults' needs thus being well accepted by them.

2.2.4 Games as strategic tools

Games also have the potential to act as strategic tools in diverse domains and for different purposes. One of these domains could be the use of technology as persuasive tools. At the Conference on Human Factors in Computing Systems of 1997 (CHI 97), Fogg first introduced *captology* as the study of computers as persuasive technologies [Fog98]. Captology is therefore "focused on the design, research, and analysis of interactive computing products created for the purpose of changing people's attitudes or behaviours" [Fog03]. This concept is based on a human-computer interaction approach where "the computing product is a participant in the interaction and can be a source of persuasion", encouraging, providing incentive or even negotiating with the human [Fog03]. Games can also be persuasive as they are "rich in microsuasion elements" [Fog03].

One example is described by Oliveira et al. [RdOO10] who developed a mobile phone game called MoviPill with the objective of persuading "patients to be more adherent to their medication prescription by means of social competition". They hypothesized that facing medication not as an obligation but rather as an entertaining and engaging experience could potentially increase their compliance in taking the medications. The developed game was based on a point system that rewarded patients who took their medication "the right number of times per day (prescription adherence) and as close as possible to the time prescribed by their doctor (regimen adherence)". Eighteen participants completed all required steps during a 6-week study and, at the end, the authors gathered data that supported the hypothesis, concluding that, in fact, a mobile persuasive game could help elders adhere to both medication prescription and regimen. They concluded that "user's intake behaviour can be improved by means of a social game, even for an activity that is not biologically regulated by the human body" providing useful information for future work in the area.

Another example of the usage of games as strategic tools is the study presented by Jimison and Pavel [JP06] in which they presented "a novel methodology for incorporating

dynamic cognitive assessment algorithms within computer games designed to enhance cognitive performance". In this case, games are not only used as cognitive enhancement tools but also as detection tools for cognitive declines. The authors developed a series of games to measure and train various cognitive aspects such as: verbal fluency, short-term and working memory, planning ability and attention. After conducting a study with 30 elderly computer users in their homes over a period of one year, Jimison et al. [HJP10] showed their results and concluded that study participants "demonstrated significantly improved performance on tests of visual fluency (...) and visual perception ability". Their research provides a framework for managing cognitive health interventions in the home, that relies in frequent measures that "allow us to measure within subject trends and performance variability, enabling earlier detection of problems and more timely health management".

Another use for games that is worth mentioning is reported on the British Medical Journal that describes the use of games in health care as a tool for pain management. Even though this usage was only studied on children its potential has been proved and study the effect on older people could provide valuable information. Based in several case studies it was concluded that "the degree of attention needed to play such a game can distract the player from the sensation of pain" [Gri05].

2.3 Tablets as a privileged device for older adults

A successful human-computer interaction depends on the humans ability to communicate with the computer [WARP05]. Up until some time ago, this communication was predominantly mediated through indirect devices, which include peripherals like the keyboard or the mouse. These devices are mainly associated with the WIMP - Windows, Icons, Menus and Pointers - interaction paradigm and are still widely used in desktop and laptop computers.

However, "human communication is nuanced and complex (...) with a touch, a glance, or a motion, we can convey a host of information" [Fol08]. Such subtleties have been absent from our interaction with computers but a major concern in capturing and using them has arose. Currently there is a wide range of direct devices that were introduced for their potentially more intuitive and natural input methods that enable a more Direct Manipulation interaction paradigm. This paradigm is characterized by providing visibility of objects of interest, rapid feedback, reversibility and syntactic correctness of all actions and replacement of complex command languages with actions to manipulate directly the visible options [ADA04]. Although Direct Manipulation has already been implemented in WIMP-based system, "touch screens and gestural interfaces take direct manipulation to another level" [Fol08]. Users can simply touch the item they want to manipulate on

the screen itself and manipulate it very similarly as the way they would do it in the real world.

Touch-based devices are an example of this type of direct devices. Even though they are not recent, they are now being used in a very wide range of systems, becoming more available and affordable to the average user. To understand their advantages Table 2.1 shows a comparison between direct devices – which include touch screens – and indirect devices – like keyboards and mouse.

Table 2.1: Comparison between direct and indirect input devices [WARP05]

Devices	Advantages	Disadvantages
Direct Devices	Direct hand-eye coordination	Arm Fatigue
Examples: touch screen,	No need to memorize commands	Limited Resolution
light pen,	Minimal training	Difficulty with precision
voice recognition	High user acceptance	Slow entry
	Requires less space	Finger or arm may obscure screen
	Long, ballistic movements	Inadvertent activation
	accomplished quickly	
	Better for pointing tasks	No inherent feedback
Indirect Devices	Can adjust control-display ratio	Requires translation between
Examples: rotary		rotary and linear movement
encoder, mouse,	More precise	Requires translation between
joystick, trackball		hand and screen
	Gives tactile feedback	Requires learning time
	Experienced users prefer it	Movement time between
	for a long periods of use	controls is lengthy

When analysing this comparison there are some advantages of the direct devices that can indicate us that they are more suitable for a more inexperienced audience, such as older adults. These devices do not require the memorizing of commands and need minimal training, having a higher user acceptance whereas indirect devices require more learning time and are preferred for experienced users that use them for long periods of time. The disadvantages of indirect devices can also be specially challenging for older people since "with indirect positioning devices, people must learn to map control in one plane with movement in a different plane, and older adults in particular have difficulty with this mapping." [CJ09]. To support these assumptions Hollinworth [Hol09] developed some research to investigate "whether gestural commands on a multi-touch device can make interfaces easier to use, learn and remember for older adults". He presented several studies that investigate gestural input for computer interaction using touch pads and touch screens and concluded that the use of gestures "may afford an alternative and more natural interaction method, since users can apply existing motor skills and interact directly with virtual objects, rather than having to develop the necessary skills to manipulate a pointing device". With respect to multi-touch technology the author also argues that "the ability

to use both hands offers potential for a more efficient interaction method" with possibly easier to learn and remember commands if "they are designed to reflect the manipulations of real world physical objects" encouraging users to "play and explore an interface".

Nowadays there are a number of different devices that incorporate touch screens: mobile/smart phones, laptops, tablets and table tops. The purpose of this project was to study the use of tablets as a gaming platform for older adults.

A tablet PC is a type of notebook or slate-shaped mobile computer that is available as a touch screen, allowing the user to operate the computer with a fingertip[HHR09]. Besides being an ascending technology (it is predicted that 2011 will be the year of the tablet [Mor11]), they also present some advantages over devices that incorporate similar characteristics. Their average screen size is bigger than the one of smart phones allowing, the development of more complex games and the display of more information without losing its readability, comprehension or ease of use. Furthermore they offer more portability than laptops or table tops which enables their usage in different places, avoiding dislocations of the user or possibly uncomfortable positions.

In a related project Dewsbury et al. [GDO06] performed an analysis of several existing technologies from which they concluded that "Desktop PC's are importable and take up too much space, Laptops can be awkward to use, and some older people might find them too heavy to move around comfortably" and that "Palm sized devices can be too small for older people to read easily". Similarly they argue that tablets are a more viable option when working with older adults with potential to provide a successful human-computer interaction.

2.4 The potential of tablet-based cognitive games for older adults

As discussed before in this thesis (see section 2.2), games have the potential to positively impact the lives of older adults through a wide range of different mechanisms. However, the use of tablets as the supporting platform for this project limits the extent to which these mechanisms can be implemented in a game for older adults. Due to their size, collocated social interaction can be challenging, as they are more suitable for a single player use. On the other hand stimulating physical well-being is also limited to fine motor skills.

Therefore, studying a solution that uses games as a cognitive stimulation tool for older adults seems to be a more suitable option. 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 older adult into the gaming experience.

The first step to develop the best possible solution was studying the relevant cognitive changes that take place with age and that were already described in section 2.1. Subsequently, it was crucial to understand how to stimulate the affected cognitive constructs. As to do so, we analysed cognitive stimulation exercises provided by literature on ageing

[sRP11][Zim00] from which we were able to extract patterns of gaming elements, and to relate them with the cognitive construct they intend to train. Table 2.2 shows the matrix with the result of this analysis, which acted as a guide for the possible elements to include in a game that aims at the stimulation of a specific cognitive construct.

Table 2.2: Cognitive Exercises and Stimulated Cognitive constructs

	Cognitive Constructs					
	Working memory	Semantic 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		

Even though all these categories could be applied to games, we further performed a critical analysis of this matrix, along with a review of the literature, to settle on the most suitable ones for our platform and for older adults. We concluded that trivia and mimic games should not be considered in a first stage, since trivia games have the main purpose of stimulating semantic memory, which is not primarily affected by age. 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.

After considering the game elements that can provide cognitive stimulation, games' characteristics and components also needed to be reviewed in order to achieve a good balance between training cognitive constructs and providing a fun experience. A game, as defined by Juul [Juu05], is:

"a rule-based system (J1)
with a variable and quantifiable outcome, (J2)
where different outcomes are assigned different values, (J3)
the player exerts effort in order to influence the outcome, (J4)
the player feels emotionally attached to the outcome, (J5)
and the consequences of the activity are negotiable" (J6).

From this definition there are six elements that can be identified as the main features of the game: rules (J1), feedback (J2), reward (J3), challenge (J4), immersion (J5) and consequences (J6). This latter component is related to the consequences a game can have in one's real-life as "the same game can be played with or without real-life consequences" [Juu05]. This aspect has already been considered with the decision of incorporating cognitive training elements into the games which can impact elders well-being. However, it is

the combination of the remaining game features and their traits that build the gaming experience. It is true that games are about providing fun and enjoyable experiences [Bat04] but it is also important to acknowledge that "a game can be fun, but only if the player enjoys playing the game" [MC06]. The several ways in which game features can be approached to provide different experiences, have ultimately resulted in the wide variety of game genres currently available.

From the literature research, we learnt that the casual games category endues some of the game elements that we believe are more suitable for the older user. Trefry [Tre10] defines the characteristics of a casual game as:

"Rules and goals must be clear (T1);

Casual game play adapts to a player's life and schedule (T2);

Players need to be able to quickly reach proficiency (T3); and

Game concepts borrow familiar content and themes from life (T4)".

Gámez et al.[EHCGC10] have studied the gaming experience and proposed CEGE (Core Elements of the Gaming Experience) as the necessary, however not sufficient, elements that should exist in a game in order to provide a good user experience. Based on this, we mapped Gámez et al. theory with Trefry's definition of casual games to confirm that they indeed have the potential to be the most appropriate to an older audience. Moreover, we also indicate the game features identified by Juul, to ensure that all of them are understood and later incorporated into the game.

According to Gámez et al. "a positive experience (enjoyment) while playing games is achieved by the player's perception of the game and the interaction with it". Furthermore, they specify that the game perception is given by the environment and the game-play, whereas the interaction depends on the player's sense of control, ownership and through the facilitators: aesthetic value, time and previous experiences.

The sense of control in a game is given to a player as soon as he learns how to manipulate it. For this reason, and because older adults may find decision making more challenging due to their cognitive impairments, game rules (J1) and goals must be clear enough for them to understand (T1). Moreover, the existence of goals by itself creates motivation and ultimately provides the feeling of accomplishment, which may also influence the value of the game, as perceived by the older adults. In fact, this rewarding (J3) sense that they may experience is what produces ownership, when players understand that their actions in the game have results and a positive (or negative) outcome. Logically a positive outcome will keep the player engaged whereas a negative feedback (J2) can lead to frustration. Although a game should be challenging (J4) it is important to clearly understand what the player's skills level is, in order to adapt the game level of difficulty to it. If that balance is achieved a user should be able to quickly reach proficiency (T3) which will reduce the risk of user dissatisfaction. This is especially important when designing for older adults, as they are more unwilling to learn via trial and error and get frustrated more

easily [LDTF04]. These two characteristics are also connected to the time factor because, contrarily to what one may think, after retirement seniors do not have more free time. In fact they tend to engage in specific routines and have all their activities scheduled in advance [Pik76]. For this reason they are not willing to spend their time in an activity that is unknown to them, thus requiring that the game adapts to their lifestyle (T2) and not being time-consuming. Finally, as elders of today do not have previous experiences with computer games, they tend to misinterpret some game concepts – such as the use of weapons – and favour games that portrait real stories or realistic activities [LDTF04][Tor08] (T4) (J5).

In essence, it is fair to consider that casual games provide an adequate framework of game characteristics that can provide an enjoyable gaming experience to an older audience which, combined with the described cognitive training elements, have the potential to provide an overall positive experience.

Chapter 3

Methodology

Around 1980, the emergence of personal computing "made everyone in the developed world a potential user" [Car10] and since then, technology has been playing an increasingly important role in our daily lives. Its use has spread to several areas such as work, education, communication, entertainment or health and "in order to function independently and successfully interact with the environment, people of all ages need to interact with some form of technology" [CL09]. However, as technology is being created to better fit our knowledge of the physical world thus becoming more reliable, it is also growing in complexity resulting in artefacts which are "unusable by most human beings" [Vic04]. Contributing to this is also the fact that designing computer systems focusing on users other than ourselves is just not so natural as being more self-centred [PA06] and even user experience experts may have the tendency of assuming that they know how interfaces should be designed, resulting in designs that would work perfectly for them but that are unlikely to work for other users [Ore07].

To address these issues, it is important to understand that "design should begin by identifying a human or societal need – a problem worth solving – and then fulfil that need by tailoring the technology to the specific, relevant human factors" [Vic04]. Developing software and other technologies needs a more user-centred approach; it is not enough that it has more and more functionality or that users want to use it. It is also fundamental that users "will be able to effectively use them" [RH03], specially when developing software to such a specific audience like older adults. As stated before, this audience is not unwilling to use technology, it is rather the technology that is still yet to accommodate to their characteristics. Human Computer Interaction (HCI) is the "discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them" [HV96]. Building upon the knowledge, methods, techniques and principles of this research area we aim at developing

a product that is in fact "for human use" and that considers elders' characteristics in order to provide them the full benefits that technology can bring to their lives.

In this chapter we discuss the different methodologies and techniques that could be used within the scope of this project and, after performing a critical analysis, we described and justify the decisions made in regards of the implemented strategies to achieve our goals.

3.1 HCI Methodologies

Among the several HCI methodologies, Participatory Design (PD) and User-Centred Design (UCD) stand up for a user-centred philosophy that places the user at the centre of the design process throughout the whole development process. This is decisive to ensure that developers "gain a better understanding of [users] their needs and their goals, leading to a more appropriate, more usable product" [HSP07]. In this thesis, due to the specific nature of the target audience, understanding the users is of sheer importance and for this reason these are considered to be appropriate methodologies. An analysis of their features was conducted to assess which could be more suitable for the scope of this project.

3.1.1 User-Centred Design Methodologies

When PD emerged in the late 60's early 70's, users were merely considered throughout the process of design and development of a computer system. Workers of Scandinavian companies were dissatisfied with the way computers were introduced in their work as they reduced both their job content and efficiency leading to multiple problems of motivation [Kyn91]. In fact, the problem was that designers had little to no information about their needs or tasks which resulted in poor product designs that did not meet the workers or employers requirements. The need of a better communication between designers and users led to the development of a "cooperative design to emphasize the importance of bringing together the competence of designers and users", creating a process of "mutual learning" which "implies that designers learn about the application area and users learn about new technical possibilities" [Kyn91]. This is the real concept behind PD – involving users in the process of development - "they become an equal partner in the design team, and they design the product in cooperation with the designers" [HSP07].

Although this methodology has been applied to research in game design for older adults [AR06], it is important to acknowledge that this form of collaborative work may be challenging to perform. Teaming persons with different backgrounds can create difficulties with the specification process of a system as their cultural differences can become especially acute [HSP07]. In the case of older people these differences are aggravated, as Eisma et al. [RET03] have experienced. Moreover, elders could feel beleaguered by

the amount of new technical information that would surround them during the process, which could eventually lead to reluctance in participating and potentially compromising the development.

The main difference between the UCD methodology and the above-mentioned PD methodology is the degree to which the user is involved in the process. In UCD, the product is developed considering the user, however they are not a constituent part of the design team. This methodology was first introduced by Draper and Norman [ND86] in the book *User Centered System Design: New Perspectives on Human-Computer Interaction* where they present a new point-of-view over the design of computers: the user's point-of-view. They proposed that the system design should begin with the users, asking them what their goals, needs and tasks are. User-centred design is therefore "a philosophy based on the needs and interest of the user, with an emphasis on making products usable and understandable" [Nor98]. It implies the understanding of users since the very beginning of the development process and they become the main focus for the designers. Their characteristics, needs, tasks and context are deeply studied in order to deliver a solution that successfully meets their requirements. In essence, user-centred design is based on three basic principles: "1) analyse users and tasks; 2) design and implement the system iteratively through prototypes of increasing complexity; 3) evaluate design choices and prototypes with users" [Cos00].

Although we consider UCD to be the most appropriate methodology within the scope of this project, research indicates that some changes could be made to this approach while working with specific user groups like people with disabilities or older people [NG00]. The main concern about the UCD methodology is that it tends to rely upon homogeneous groups of users and, in the case of older people, there is a dynamic diversity that needs to be recognized and that makes UCD a less appropriate methodology [Zaj06]. Gregor and Newell [NG00], [NG01], [GN01], [PGZ02] have proposed a new design paradigm, Design for Dynamic Diversity and a new methodology to support it, User Sensitive Inclusive Design (USID). This approach has derived from the initiatives launched more recently that consider the integration of people with disabilities within the user group in product development teams. Basically, these initiatives have the main purpose of emphasizing the need of a "Universal Design" or "Design for All". However "except for a very limited range of products, "design for all" is a very difficult, if not often impossible task" [NG00]. The mentioned and proposed changes of Gregor and Newell [GN01] would appropriate the UCD techniques to specific groups such as older adults, addressing the issues of coping with:

- Much greater variety of user characteristics and functionality
- Finding and recruiting "representative users"
- Conflicts of interest between user groups

- The need to specify exactly the characteristics and functionality of the user group
- Tailored, personalisable and adaptive interfaces
- Provision for accessibility using additional components (hardware and software)

Nevertheless, despite providing useful knowledge and suggestions, this methodology is not yet consolidated and fully implemented within the best practices of the HCI discipline.

For all the reasons mentioned in this section, the methodology used to the development of this project will be based on a UCD approach. In the next sections are described the techniques adopted to support it.

3.2 HCI Phases and Techniques

The standard ISO 9241-210(2010) 3.1 provides guidance on human-centred design activities throughout the development life cycle of interactive computer-based systems. According to it, the activities are carried out in an iterative way, with the cycle being repeated until the design solutions meet the defined requirements.

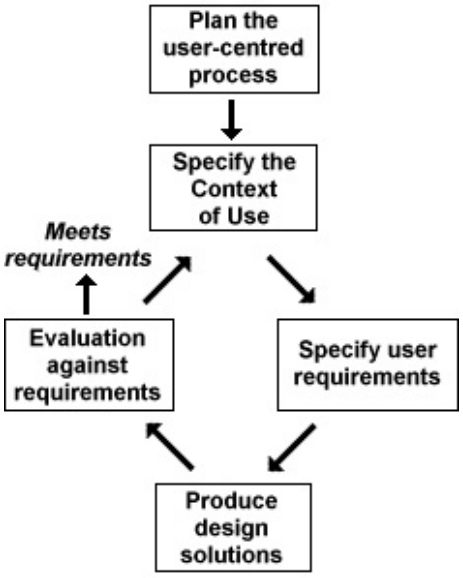

Figure 3.1: The ISO standard 9241-210(2010) Human-centred design process for iterative systems[Par]

For each stage of the process there are several techniques that can be used to achieve the proposed goals. An analysis of their advantages and disadvantages was performed in order to inform the decisions that needed to be made; these are presented in the next sections.

3.2.1 Observations and Interviews

Having a deep understanding of the users' context, terminology and processes is a key element that leads to innovation and aids the development of "intuitive" interfaces [Wil07]. Thus, after defining the approach, the next stage is getting involved with the users, attempting to collect data about their social and environmental context, preferred leisure activities and in particular about games. This project identified natural observation and interviews as the preferred techniques, since they were considered efficient in terms of time consumption and information gathering. Natural observation involves spending time with the target audience of the system while they perform their usual routines in their natural setting [HSP07]. A similar but more extensive technique is ethnography, which is used to study how people interact with each other [Boe10]. It also relies on the involvement of the researchers in the user's environment for an extended period of time, where he acts as an observer, trying to assimilate whatever relevant data may appear. However, and even though there are different ethnographic methods [JLH09], a complete study would have to be performed for a long period of time and the collected information would be overwhelmingly extensive to be processed on schedule. Even though acknowledging the benefits of this method and due to the limited time for the development of this research work, this method was not a possible option.

Interviews were also performed to complement the natural observations. This technique can provide the interviewers with a collection of detailed information that explores a wide range of concerns about a problem and, with the correct questions, reflection and consideration can be encouraged, generating ideas and giving insights that could have been lost with the use of other techniques [JLH09]. The goal was to conduct open-ended and exploratory interviews addressing the results of the performed observations and providing a deeper insight about them.

Therefore, to accomplish the goal of understanding the games' context of use by older adults we resorted to sites were elders usually gather to play card games – in specific city parks – and to a day care centre. The main objectives behind these observations was acknowledging the games that are already part of the older audiences routine and detect patterns of gaming behaviour. The interviews were conducted with older adults as well as with their caregivers. The interviews with caregivers proved to be a valuable source of information not only due to their experience with older adults but also because they are very much aware of the importance of games in elders' routine.

3.2.2 Game Book and Questionnaires

Gathering requirements for games designed for older adults may be more challenging than the usual process for a more conventional software artefact. On the one hand, game

"requirements like fun and absorbing are not well understood from the perspective of requirements engineering" [DCS05] and, on the other hand, "user requirements are usually elicited by a way of focus group, which is often difficult when working with older people" [Zaj06]. Thus, some reflection on the traditional techniques, as they are conventionally defined, was needed in order to overcome possible difficulties in the requirements elicitation phase of this project. The choice was to create and distribute a game book and to perform a questionnaire.

The game book was developed to better assess seniors' preferences and difficulties regarding games, in particular games that were designed with the purpose of stimulating cognitive skills. This game book concept was developed considering the idea of games as research proposed by Nathan Shedroff [She03] and was distributed among the elderly using the same method as the one of cultural probes [BGP99].

The game book consisted of 10 different games distributed over the following categories 7:

- 2 sequence games;
- 1 enigma game;
- 3 word puzzles;
- 2 labyrinths;
- 2 find differences games.

The games were chosen considering the matrix already presented 2.2 and were thought to appeal to the older adults. All games contained clear instructions in how to solve them and, at the beginning of the book, we included an introductory explanation to clarify that the intention was not to evaluate their results but instead their experience while solving the games.

The game book was then distributed to a group of 13 older adults (10 female/3 male) with an average age of 80 (74-88) who were asked to solve the games and return the book to us within a week.

At the time the elders returned the game book, a questionnaire was administrated with the main purpose of assessing their experience while collecting formal data. These series of questions evaluated their level of satisfaction, challenges encountered or reasons for not solving a game, and were based on likert scales. This questionnaire was performed in an informal conversation, in an attempt to collect general opinions about elders' overall experience.

3.2.3 Iterative and Incremental Prototyping

"Because human situations are complex and designers are not infallible it is likely that our first design will not be perfect" [ADA04] and for this reason the process of interaction design should be based on an iterative approach. This iterative nature implies a need for evaluation of each one of the iterations to improve the developed solutions thus requiring some sort of artefacts to be presented, generally prototypes. Prototypes are important not only for the development team but also for the client, as they are a way of communicating ideas and overcome potential misunderstandings while giving a better impression of the user experience than simple descriptions could ever do [HSP07]. There are different types of prototypes but they usually fall in one of two categories: low-fidelity or high-fidelity prototypes.

Low-fidelity prototyping – also known as paper prototyping – is a technique that started becoming a common practice within the software industry since the mid-1990's. Currently this technique is widely used at many companies, even if sometimes faced with scepticism [Sny03]. Low-fidelity prototypes do not look like the final product since they use very different material such as paper and cardboard. However it is important to understand that their purpose is not to look like the final product since they are used for exploration only [HSP07]. This technique is fast, brings results early in the development (when it is still relatively cheap to make changes), and allows a team to try far more ideas than they could with high-fidelity prototypes [Ret94]. Besides providing several benefits to the development team, from a user's point-of-view it also has some advantages. They are less intimidating than a computer, especially for novice users, and they encourage a more creative response from reviewers because of their "unfinished look" while discourage nitpick feedback as they focus on the concepts and functionality instead of the visual design [Sny03]. While working with older adults this can prove especially useful, since they may provide the possibility of gathering better feedback while allowing a bigger exploration of ideas for the development of games.

Included on the low-fidelity prototyping techniques is also storyboarding, "a series of sketches showing how a user might progress through a task using the device being developed" [HSP07]. The storyboarding technique was the starting point for this project's prototyping stage. A screen storyboard for all system functionalities was developed with the main goal of providing an overview of the platform (Figure 3.2). After having this, we were able to establish a priority for the low-fidelity prototypes to later develop and test with users. When converting the screens on the storyboard into higher fidelity prototypes we informed our choices with the existing guidelines for designing systems for older adults [AFS09] [PM10] as well as general design principles [ADA04]. These resulting prototypes were then iteratively evaluated with the older adults, using the techniques described in the next section (3.2.4).

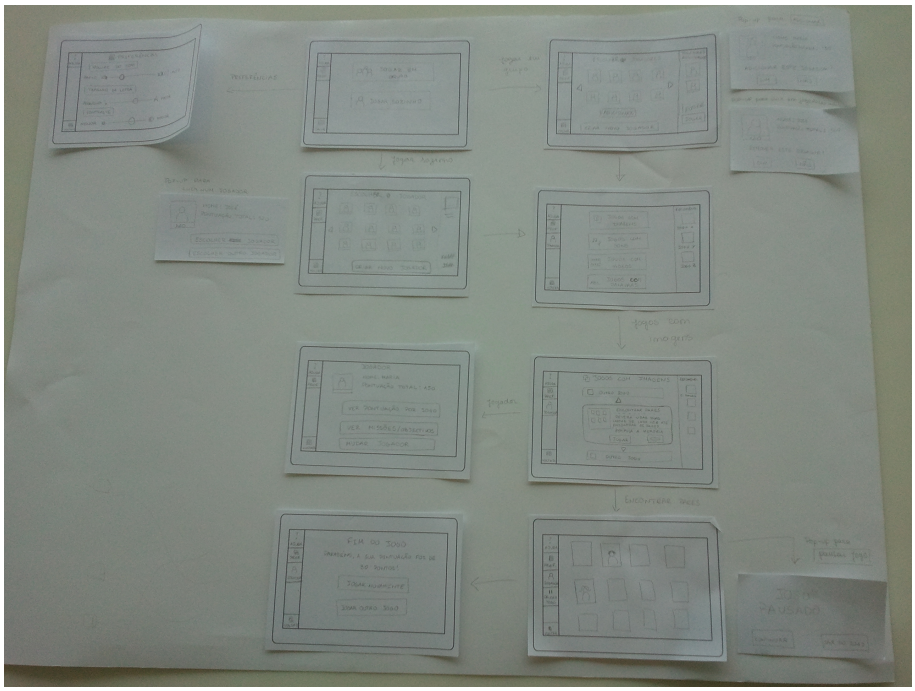

Figure 3.2: Part of the Developed Screen Storyboard

At the final stage of the prototyping phase, a high-fidelity prototype running on the tablet platform was developed and a trial with the elders conducted to assess its acceptance. Similarly to a high-fidelity prototype this one was already functional, fully interactive and had the look and feel of the final product [HSP07]. This kind of prototypes usually has the disadvantage of taking too long to build and consequently the developers are more unwilling to change something. Furthermore, they are more risky to test as a simple bug can bring a test to a halt [Ret94]. For these reasons the decision of testing a high-fidelity prototype was taken only later in the process, when the feedback from the tests with low-fidelity prototypes was already integrated in the final prototype.

3.2.4 Evaluation

After each iteration there is a need to evaluate the designed solution, in this case, the prototypes. There are two main forms of evaluation: formative and summative evaluation. Formative evaluation is "intended to improve designs" [ADA04] and is used as a "natural selection for ideas" [Ret94], whereas summative evaluation is a test of the final product, used as a last confirmation of the correctness of the produced artefacts [Cos00]. They are performed at different stages of the development and resort to different techniques. While formative evaluation is performed during the design stage of the prototypes and relies mainly on discount usability techniques, summative evaluation is performed at the final stage of their development where tests are made with the end users of the product. Before

the use of iterative development, (as discussed in the previous section) summative evaluation could only be performed at the very final stage of a project, when the final product was already developed; this could lead to a late discovering of possible issues when substantial changes had become hard to perform [Ret94]. However, one of the advantages of using iterative development processes and prototypes is that both formative and summative evaluation can be performed at earlier stages of development thus achieving better results on the final products.

While designing the prototypes for this project, and despite the concern in following existing guidelines (as mentioned in the previous section), formative evaluation was performed in an informal and non-systematically way, through brain-storming sessions with two experts. However, our main evaluation efforts were placed on usability tests performed with elders at a day care centre. These tests were described in evaluation protocols that detailed the objectives of the test, the tasks to be performed and the aspects that were being observed.

There were a number of techniques used to perform the prototypes' evaluation, which were customized according to our particular goals, namely: empirical studies, wizard-of-oz and card sorting. Additionally some of the tests incorporated questionnaires made to the elders before or after them to assess their experience, whether in the overall or regarding details of the prototype.

An empirical study aims at the gathering of information through observation and experimentation with users. In this approach "the evaluator chooses a hypothesis to test, which can be determined by measuring some attributes of participant behaviour" [ADA04]. However based in this technique, our approach was much more simplistic and informal than the one that an empirical study requires, mainly due to the environmental conditions of the performed tests, at the day care centre. In our tests we created a series of tasks to be performed which were described in a testing protocol followed during the user tests. The hypotheses were also previously defined and were mainly based on the ability of the user to complete a task or the time taken to perform a task, when using different interaction methods or layouts. In addition, the evaluator took notes to complement the gathered data and by these means draw more solid conclusions while assessing user satisfaction, i.e. "what the user says or thinks about his interaction with the product" [TA08].

The wizard-of-oz methodology was first used by Kelley [Kel84] to test a natural language application. He performed an experimental simulation where users were given the impression of interacting with a program that understood English as well as a human, when in fact the experimenter was intercepting the communications between the users and the program, supplying the answers himself. This technique has evolved and is currently widely used in testing and iterative design. Usually, this approach assumes that a software-based prototype has been developed [HSP07], however, for our work, this tech-

nique was used when testing paper prototypes. The evaluator simulated the system by switching prototypes or adding pieces of information to the screen.

Card sorting is a "process that involves sorting a series of cards, each labelled with a piece of content or functionality, into groups that make sense to users or participants" [SW04]. This technique was used in a very simplistic manner with a one-to-one mapping scheme. This means that instead of using it to group content into different categories, it was used to establish users' preferences on icons and naming conventions. They were provided with a series of cards with different options and were asked which one they felt was the most appropriate, considering the system functionality that it would define.

Chapter 4

Designing a Tablet-based Gaming Platform for Older Adults

After the literature review and the definition of the methodology to use, the following phase concerns the specification of users' requirements and design of solutions. This chapter discusses the outcomes of the performed user research and describes in detail the proposed solution. Subsequently, we present the results of the analysis, design and evaluation of games and user interfaces for the gaming platform as well as the results of a final evaluation performed with the users, using a high-fidelity prototype.

4.1 The users and their context

During the first stage of this project, and once the literature review phase ceased, the next step was to perform observations and interviews with the elderly to achieve a more complete and accurate definition of games' context of use. One of the main concerns when performing observations is to choose the more appropriate data-gathering technique to convey only the necessary amount of information. Regarding interviews, these can be structured, semi-structured or open, depending on the degree at which the interviewer sticks to a prepared set of questions [HSP07]. For the scope of this project, it was decided that field notes and open interviews would allow a better understanding of the users, without providing a large amount of information that would later be hard to analyse. With the collected information we built a board with the relevant conclusions that we should consider in the design phase of the process.

Both observations and interviews were performed at two places: at a public garden where older adults usually meet to play card games and at a day care centre. The observations performed at both sites had a target audience of older adults with different

motivations. On the one hand, the ones that play card games at the public garden engage in this activity voluntarily and go to this place with this specific drive. On the other hand, elders that attend to the day care centre are there for an assortment of reasons and their primary purpose may not be the playing activity.

At the public garden we observed that, despite the wide variety of existing card games, they preferred one in particular and that it was the only one being played. This particular game is played by four persons at a time, who are organized in two teams of two individuals each. Above all this is a game that requires a good individual strategy planning and concentration, especially because elements of the same team are not allowed to discuss the game or plan moves ahead.

However, regardless of the game rules, it was observed that players interacted very often not only among themselves but also with the assisting audience, particularly to express their emotions towards the game results and discuss past or current game moves. Their comments regarding the game development were also demonstrative of a high degree of concentration as they knew the game's result even before it was over. They were constantly aware of the approximate number of points their team had achieved so far and also of the cards that were already played. This also had an impact on their pairing as they tended to partner with players with similar skill levels which was not always possible, resulting in slight arguments and disputes.

During the interviews performed at the public garden we were told that although they usually played only one particular game, they were open to try out other games, if suggested. Even though most of them frequented this place with the main purpose of playing the card games, when questioned about their motivations, they indicated "spending time with friends" and "spend time outside the house" as their main incentives. This may indicate that the social aspect of the gaming experience surpasses the game itself. Some of the interviewed seniors also indicated that they played games at home, in particular computer card games, as they had no one else to play with them. Another important aspect that was observed was the importance given to the naming conventions used in the games. When the interviewer said that a team "won a point" one elder emphasized that the correct way to say it was "they won a game".

The environment observed at the day care centre was completely different of the one at the public garden. It was clear from the first contact that the majority of seniors that attended the centre had their physical and psychological capacities more limited than the ones we found at the public garden and was not so willing to engage in certain activities, including games. Nevertheless, every time we went there, several games were being played, including dominoes, card games and board games. Upon interviewing the caregiver about elders' preferences regarding the games we were told that dominoes was their favourite. Most of the other games were played because caregivers suggested and convinced seniors to play. Moreover, they emphasized the importance of providing them

with a wide variety of games in order to appeal to more elders and stimulate them with new challenges. The number of elders that had the initiative of playing a game was low; nonetheless some of them enjoyed solving cross word puzzles by themselves. The care-givers also informed us that they usually played along with the elders mainly because they would frequently need help. In addition to that, due to their acute sense of competition there were several arguments during the time they engaged in the playing activity.

To better understand their lack of motivation to play games, we asked several non-player older adults what were the main reasons for not playing. Their most common answers were: "there are other activities that I enjoy more"; "I never played and I do not feel the need to do it" and the most common was "I do not feel like I have the capacities to play". In order to motivate these older adults into the gaming experience, we decided to play a trivia game designed for this specific audience involving all the elders that attended the lounge room at the day care centre (approximately 30 persons). These games, as seen before (section 2.4), appeal to their semantic memory which is not primarily affected by age. Therefore this game was not expected to be a very challenging task. In the end, this activity was a success, since almost all older adults participated and tried to answer our questions. Furthermore, our main goal with this activity was not only to evaluate users' participation but also motivate them to the next phase of our project, which was the tests with low-fidelity game prototypes and the game book activity, described in section 3.2.2.

The audience's adherence to the game book upon its distribution was very high and we were able to give all the 24 prepared packages. All along we were aware that not all the game books would be returned to us since many older adults would probably forget about them due to their memory age-related losses. After a week, when we collected the game books, we were able to analyse the data of 13 participants, which was still a significant number. We analysed the games according to their success concluding that word and find differences games were the ones in which the participants had the best scores. To assess their preferences, difficulties and reasons for not solving a game we conducted a questionnaire. Upon receiving the game books, results showed that word and find differences games were the preferred ones while enigma and sequence were the least favourite. In terms of challenges encountered the sequences and mazes games were the most problematic whereas word and find differences games where the easiest ones to solve, according to the participants. These last results are in total agreement with the success rate analysis and also suggest that participants preferred the games that did not required a big effort to solve. Since the questionnaires were performed during an informal conversation with the older adults we were also able to collect some information regarding their experience and the context in which they solved the game book. Some examples are the following:

- "My daughter helped me overcome my challenges. I enjoyed the games and would play more" (M. F., 85, female)
- "I like to play both alone and with other people" (D., 77, female)
- "I solved it while I was making company to my husband who is sick and in bed. It was quite good because he saw I was busy and tried not to bother me so often, only when it was really necessary" (M. A., 79, female)
- "I like to play with my friends because we help each other" (M. A., 78, female)
- "I do not play that often, but when I do I usually need help" (A., 77, female)
- "I always need help to solve this kind of games. I become very tired and I lose my patience" (A., 77, male)
- "I solved the book while I was with my grandchildren. They were doing their school homework and when I needed help I asked them to help me." (L., 74, female)
- "I play to entertain myself and I usually play when I wake up in the middle of the night and I cannot go back to sleep. I also prefer to play alone so I can concentrate better" (F., 82, female)

From these testimonies we can also draw some valuable conclusions that should be used to inform our design. Several seniors emphasized the social component of games, not only the traditional collocated multi-player but especially vicarious play (see subsection 2.2.1) and the cooperation among them. Contrarily, others underlined that they also like to play the games alone. Additionally, some also talked about the challenges they face when trying to solve games and the need for help that we believe can also be provided by the use of the tablet as the gaming platform.

4.2 Solution Proposal - a cognitive games' platform

As stated before (in section 2.4) our solution is based on the use of games as cognitive training tools for older adults. The main goal was to design a game for older adults, however, due to the results obtained throughout the user research process it was concluded that a gaming platform would have several advantages over a single game.

Therefore, our solution is a gaming platform that will incorporate a series of cognitive games, designed to accommodate elders' capabilities and limitations, while acting as well-being promoters.

The platform was designed to an Android tablet with a 10.1-inch display and consists of two different modules targeted at two different audiences: the seniors and their caregivers. Although tablets are an ascending technology, currently they are still expensive

for the average older user. Therefore this solution was designed considering the use of a tablet device at a day care centre or a similar environment in which a number of users could share it.

4.2.0.1 Seniors' Functionalities - Games Platform Module

The actual game platform can, of course, be accessed by both elders and caregivers; however our main audience was the older adults. For this reason, games incorporate casual games' characteristics and elements for cognitive training, as already described in section 2.4.

There are two playing modes: single player and collocated multi-player. Since the games are expected to be played during a short period of time it was decided that the multi-player mode should act as a tool to manage player's turns, instead of allowing two or more players to use the tablet simultaneously. Furthermore, when considering that cognitive games can enhance seniors' abilities it is important to note that such effects only take place if a game is played by a single individual. Nevertheless, elders can still collaborate while solving a game, if they wish to do so.

As the application is launched the player can choose one of the playing modes or to see player's scores. When one of the gaming modes is selected, the user is asked to choose the player(s) that will play. For the case of first time players, whose profile has not yet been created, the user can choose to create a new profile. Through this option the user is asked to take a picture of himself using the tablet's front camera (if available) and to insert his name (optionally). Choosing a picture to identify the player is expected to promote a sense of proximity between the user and the system. Moreover, for users who cannot read, it should be easier to identify themselves in the players list (or their counterparts when starting a multi-player game).

After choosing the player(s), the Play button is displayed to the user and, when selected, a list of game categories becomes available. Additionally, it is also planned the existence of a game suggestions feature, based on player's previous choices.

Once the user chooses a game category, a series of games are displayed so that the player can choose the one of his preference. Finally, after choosing and starting the game, the user has the options to pause or exiting the game before finishing it.

Throughout all this process there will be a side bar with other functions to aid the user navigating through the platform. These functions include a Help button, a Text-to-speech functionality and the Back option. Furthermore there will be options that allow a user to see which player(s) is (are) currently selected and the scores.

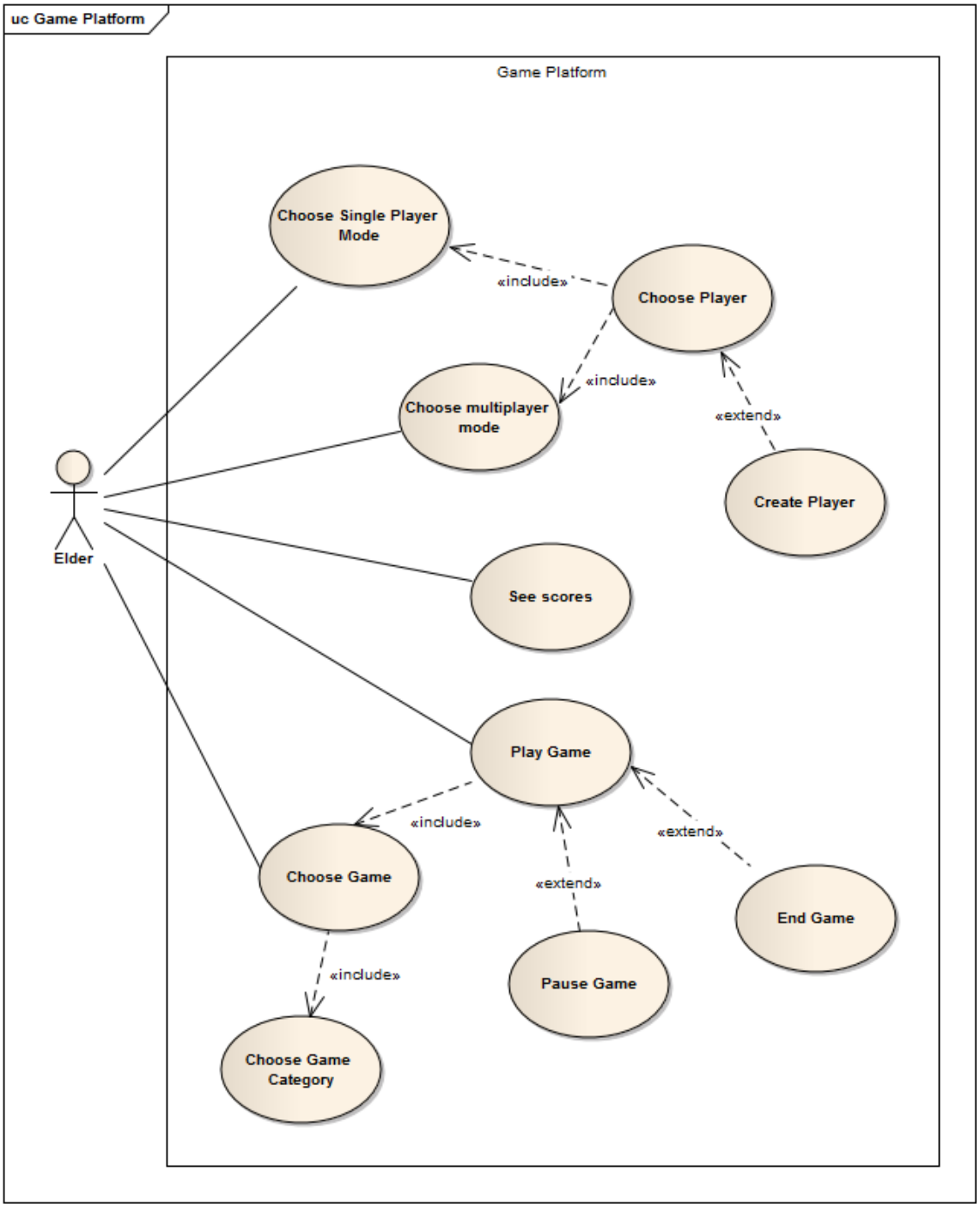

Figure 4.1: Seniors' Functionalities - Game Platform Module

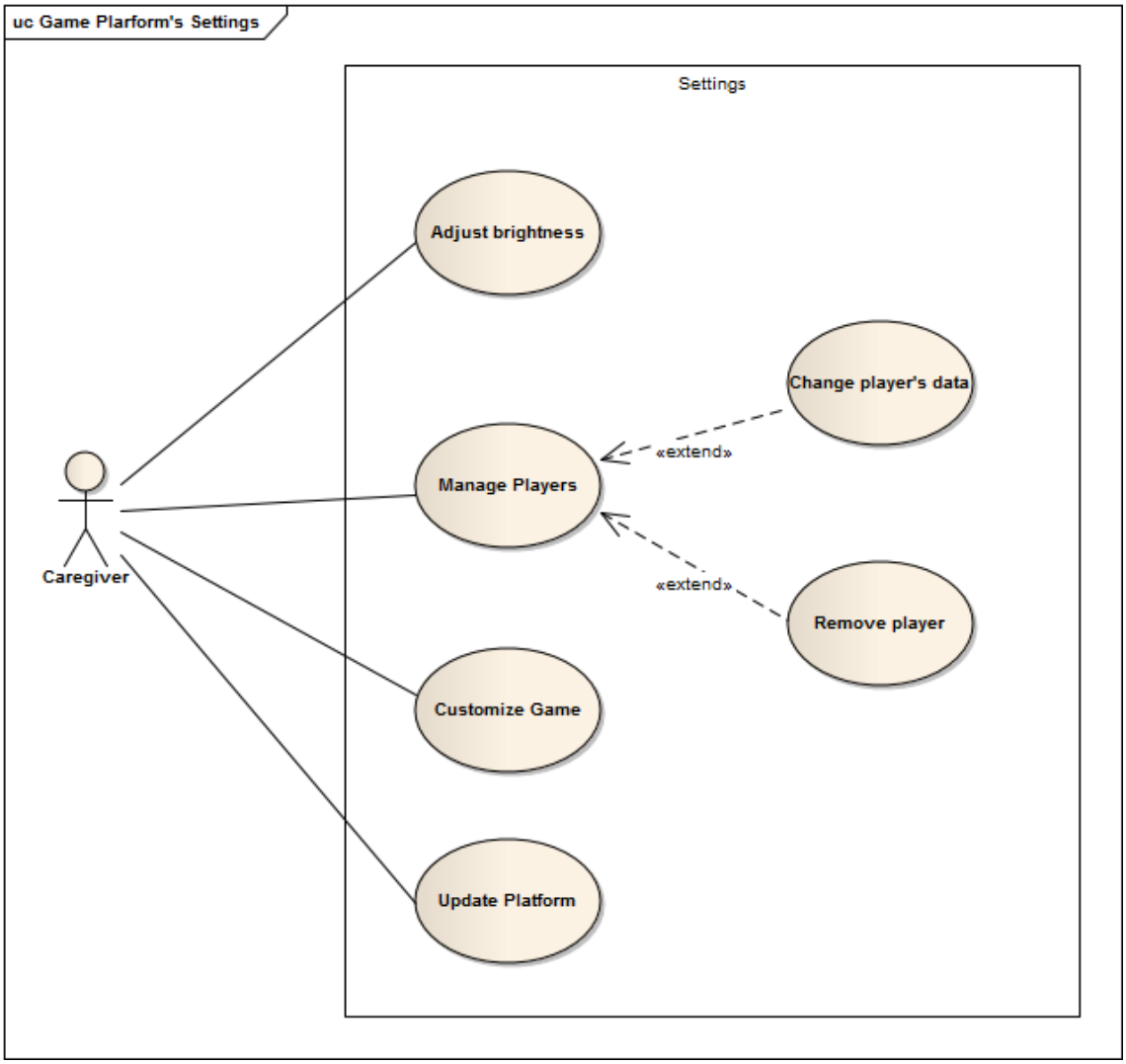

Figure 4.2: Caregivers' Functionalities - Settings Module

4.2.0.2 Caregivers' Functionalities - Settings Module

The need for a settings module arose when we considered incorporating a user profile system (which implies a user management feature), the customization of games and the possibility of updating the platform. Since these options may be too advanced for the elder user it was decided to incorporate them in the Android action bar. This way only more advanced users (which may also include older adults) that acknowledge the existence of this menu and functionality will access it. Furthermore, we wanted to avoid errors due to incomprehension of concepts such as screen brightness or unpleasant situation like having an elder deleting a deceased friend from the system.

The settings main menu contains four possible actions: Adjust brightness, Manage Players, Customize Games and Update Platform.

The adjust brightness option, as the name indicates, allows the user to adjust screen brightness, within a range that is suitable for older adults. The manage players menu allows access to the players of the platform and, upon selection, the user can choose to change a player's data – picture and name – or delete it. Finally, the games customization menu will show a list of games that can be customized (like is the case of the pairing game described in section 4.3.1) whereas the update platform option will redirect the user to the Android market, where he can choose to install new available updates.

Although these features play an important role in the system, they were not prototyped or evaluated. Since the target audience of this module was out of the scope of our research, it was decided that this functionalities should only be approached at a later stage of the system's development.

4.3 (Re)Design and Evaluation

The design and evaluation phase of this project was developed iteratively, according to the used UCD methodology. In each iteration the design was based on low-fidelity prototypes and the evaluation was based on user tests, resorting to the techniques described in section 3.2.4. The developed prototypes can be divided in two categories: user interfaces for games and user interface of the platform.

4.3.1 User Interfaces - Games

Although games are the most important component of the platform, it was our primary goal to prepare a platform to accommodate a wide range of games, providing a structure to a more extensive future work. Moreover, the designed games needed to be thoroughly planned in order to accomplish their ultimate goal: cognitive training. Therefore we only prototyped two games, both based on find differences elements, aiming at the training of working memory, attention and spatial cognition.

The rules for the first prototyped game were as following:

- A screen containing eight images is showed to the player;
- The player must observe the screen for a limited amount of time and find the elements that are different from the others;
- The screen is cleared and the player must touch the place where the different elements were located.

The images were distributed in the screen as showed in Fugures 4.3 and 4.4. In the first developed prototype, from the eight images shown to the elder, two were different from the others - one was bigger and the other one was facing another direction – and there was a space missing an image 4.3.

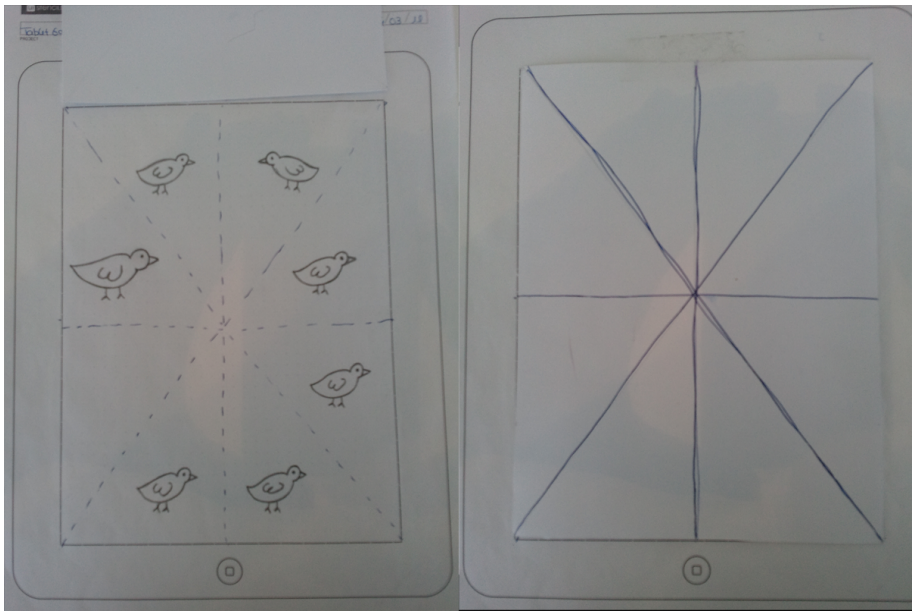

Figure 4.3: Memory Game

With this prototype our goal was to understand if elders were able to recognize the differences and memorize their positions. At this first stage we did not to limit the amount of time available for the initial screen observation. Still, many older adults were not able to identify all the differences, specially the image facing other direction and the empty space. Regarding the memorization of their positions all seniors that identified one difference were able to indicate its position whereas the ones that identified more than one did not performed so well in that task (see test in appendix 8.1). This indicated that we should focus one incorporating only one difference at a time.

Subsequently it was important to evaluate the time needed to identify differences and memorize their positions. Furthermore, in the initial prototype we also incorporated on-screen guidelines to aid the localization of images. These guidelines' importance also needed to be assessed.

Therefore we performed a second iteration for this game prototype (Figure 4.4) in which we tested if the elders could memorize the position of an element when observing the screen for 5 and 2 seconds and a third prototype with no guidelines. In the latter we did not constraint the time available for the initial screen observation.

From the performed test, it was concluded that 7 out of 10 participants were able to memorize the position after watching the screen for both 5 and 2 seconds (test in appendix 8.2). This indicated that the time difference was not significant. Likewise, the absence of on-screen guidelines did not revealed to be crucial since 9 out of the 10 participants were able to answer correctly. From this results we can also conclude that the time factor is more important when considering adding levels of difficulty to the game.

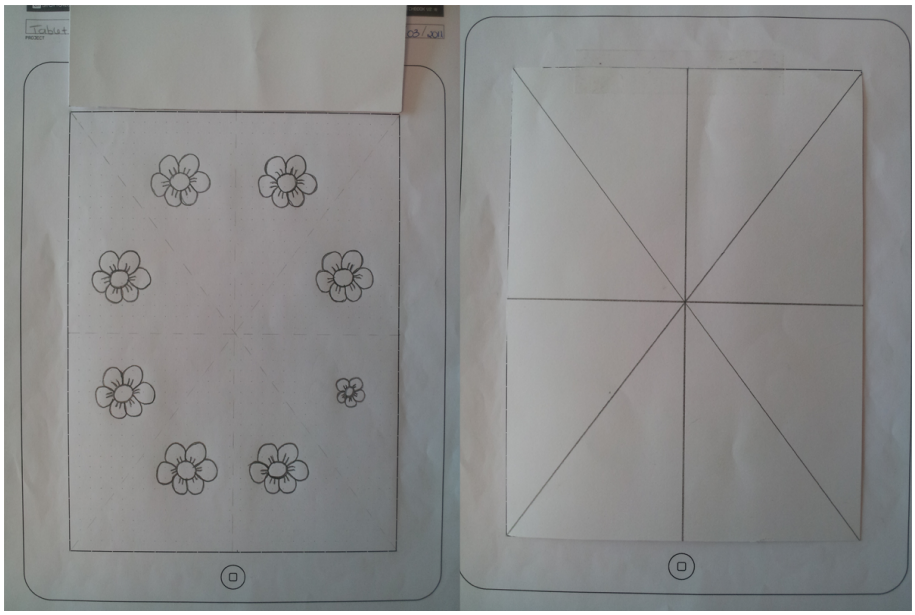

Figure 4.4: Memory Game - Second Iteration

The second game that we tested was based on a pairing cards game which was already known to them. Game rules are:

- In the screen are displayed a number of cards facing down;
- The player must touch two cards to turn them;
- If the cards have the same image they will remain up, otherwise they will turn and be facing down again;
- The game ends when the player uncovers all pairs.

With this prototype one of our main purposes was to test the importance of game customization. For that, we performed a test (in appendix 8.6) with two prototypes: in the first one they had to match pairs of cards with pictures from people unknown to them (Figure 4.5) and in the second one the pictures were from people they knew from their daily lives, in particular the caregivers at the day care centre (Figure 4.6).

During the test with the known pictures we observed that the majority of the participants did not recognize the persons immediately. This was mainly due to the images' size and complex backgrounds. However, once they did recognize the pictures, it was clearly easier for them to memorize their position. This fact was later proved by our results since they showed that participants took less time to complete the game using the pictures of known people.

Figure 4.5: Matching Pairs Game - Unknown Pictures

Figure 4.6: Matching Pairs Game - Known Pictures

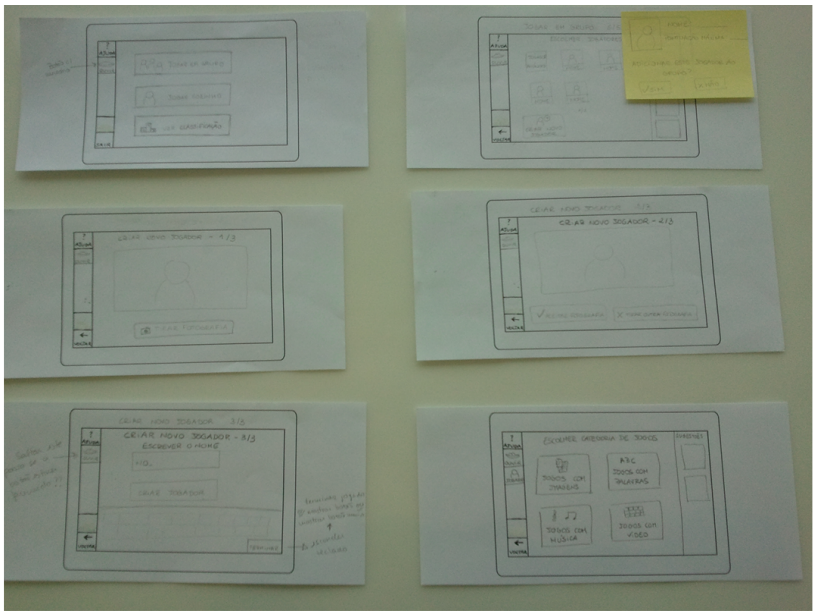

Figure 4.7: Part of the Screen Storyboard

After the test, we administered a brief questionnaire where we asked the participants if they would prefer a game with known pictures (friends or family) over a game with unknown pictures. All participants that answered the questionnaire replied affirmatively.

A second iteration of this game could have been done, in order to evaluate a more proper size and complexity of the images. However, we were aware that the ability to correctly view the images and recognize them would also depended on the tablet's screen. For this reason, it was decided that a test to a second version of this game should be performed at a later stage of the process, with a high-fidelity prototype already using the tablet device.

4.3.2 User Interfaces - Platform

The user interface prototyping phase started with a thorough mapping of all platform functionalities and, to ease this process, we resorted to the screen storyboarding technique. All user interfaces were prototyped at 50% of their real size to enable a faster and more agile process (Figure 4.7).

Having an overview of the user interfaces proved to be very useful in prioritizing the system functionalities and, as a result, the subsequent low-fidelity prototypes. Furthermore, the storyboard was also developed using an iterative approach. However, the redesign of the storyboard was not made based on user tests but in an overall analysis of the system through brainstorm sessions with experts and a review of literature guidelines compliance.

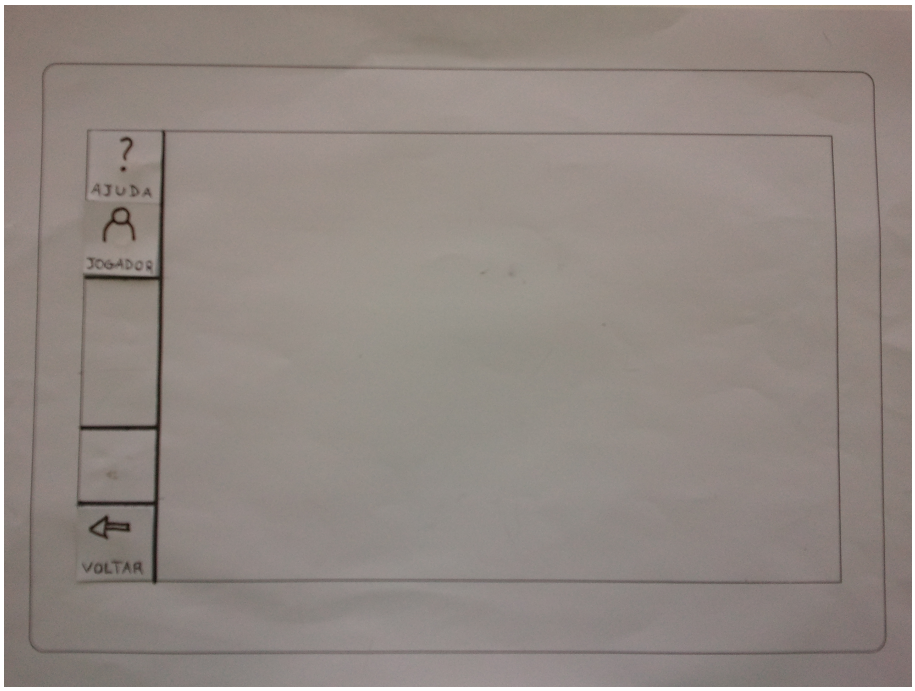

Figure 4.8: Screen Organization Prototype

At this early stage, we were also concerned with the way information would be organized on the screen. Due to age-related changes in working memory, older adults may find it challenging to interpret a large amount of information at a time. Therefore, it was decided that the screen should be divided into two main sections: a side bar placed at the left and the remaining part of the screen where the actions would take place (Figure 4.8).

The side bar's intention is to provide the user with secondary available options, including accessibility options. Placing it at the left side of the screen was agreed upon after considering that these options should be easily visible and accessible, but at the same time should not interfere with the gaming experience. Moreover, since most players are right-handed, placing the bar at the right side or at the bottom of the screen could be more error-prone since the players could unintentionally touch one of the options with their hand or wrist.

In this side bar we incorporated the Help and Text-to-Speech functionalities, the current player(s) information, the scores and the Back/Exit button. Additionally, while playing the game the user will have the option to Pause it.

The icons and lables of the buttons placed at the side bar were tested with older adults, with exception to the Player, Back and Help icons. However, both Player and Back icons were used during the tests and participants were able to correctly identify the functionality they referred to. Moreover, the Help icon was also not tested by the authors of this work but it was tested by co-workers at Fraunhofer AICOS [Fer11] who shared their results

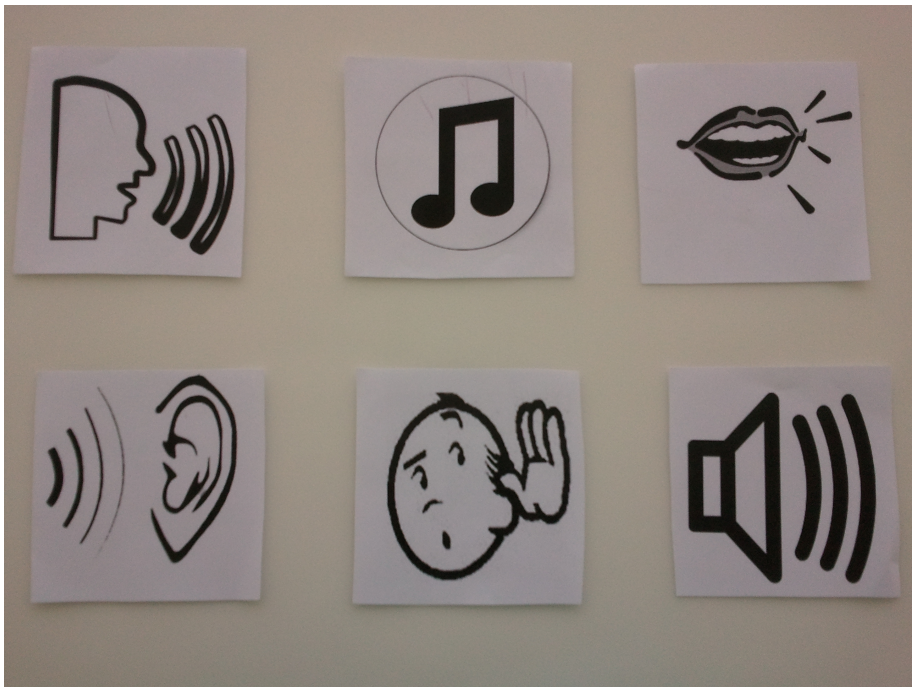

Figure 4.9: Text-to-speech Icons: Profile, Music, Mouth, Ear, Hand and Volume

with us.

The Text-to-Speech icon was tested more exhaustively since it was important to ease the interaction between illiterate older adults and the system thus promoting their independence and autonomy. The icon was iteratively redesigned and tested three times with the elders (see tests in appendix 8.3, 8.4 and 8.5). During the tests we specifically tried to include illiterate participants, even if they were only a minority of the sample. Additionally, we also asked the literate participants to read a set of sentences with different sizes. It was not our goal to assess the specific letter size to use in the project but instead have an overall idea of elders' vision-related impairements.

In the first test (8.3), we asked the participants to read a set of sentences with sizes varying from 20pt to 12pt. After, we used a role-playing approach [SN10] and asked them to pretend they did not know how to read (for those who knew) and gave them a set of six cards with different icons. The participants were requested to choose the one that illustrated the "I want to hear these sentences" action. In the case of participants that did not know how to read we simply performed the last part of the test.

From the icons that were given as options to the participants (Figure 4.9) the Mouth and Hand icons were the most frequently chosen ones. Therefore, in the two following evaluations we used redesigned and enhanced versions of these icons.

The following tests were performed in a similar way; however, we incorporated the icons in buttons at the bottom of a screen with several sentences and, instead of the card

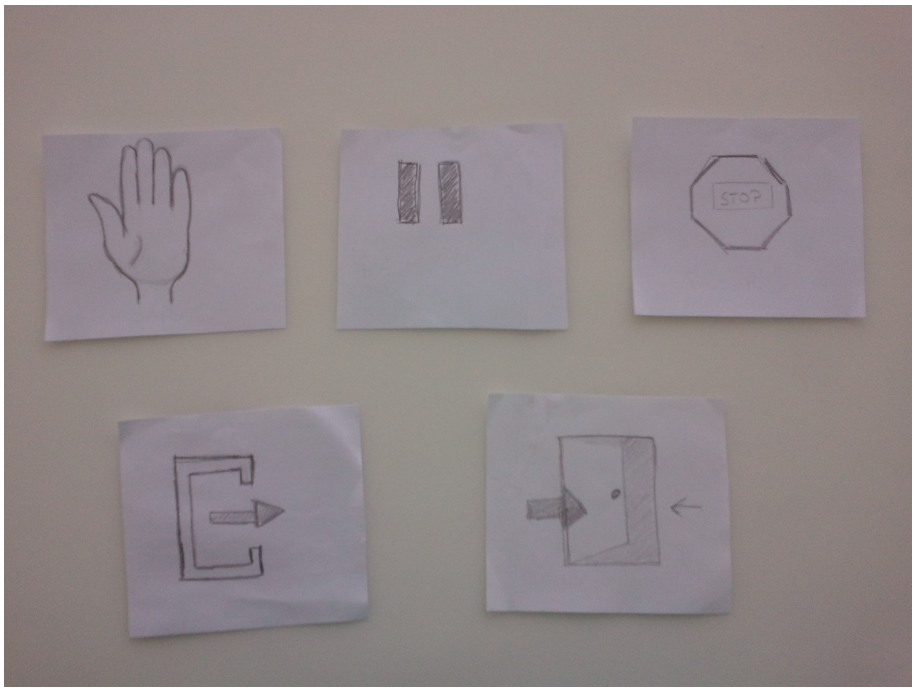

Figure 4.10: Pause and Exit Icons: Hand, Pause, Stop Sign, Arrow and Door

sorting technique, we asked the participants to simply touch one of the buttons. Final results indicated that the Mouth button was the most suitable one, not only because it was the one that most elders chose, but also because from the four illiterate users that participated in our tests, three indicated it as the most appropriate. In addicion to that, when performing the tests, it was clear that some participants misinterpreted the Hand symbol and chose it because it was more visually appealing.

The Exit and Pause icons were tested with the elders using the same adapted card sorting technique. Only one evaluation was performed (see appendix 8.3) and results showed that the chosen Exit icon was the Door and the Pause icon was the Hand, as illustrated in Figure 4.10.

Due to previous misinterpretation of the scores functionality, has observed in test 8.8, both icon and label for this functionality were tested. Again, the applied technique was the sorting card and the results showed that the podium icon (Figure 4.11) and the label "Classificação" (Classification) (Figure 4.12) were the most suitable ones.

The information on the right side of the screen was organized as demonstrated in Figure 4.13. The action that the users are expected to perform is emphasized at the top of the screen, in order to avoid the feeling of being "lost" in the system. The options to be made, in particular the choice of players, game categories and games, are displayed on the center whereas chosen players or game suggestions will be placed on the right side of the screen.

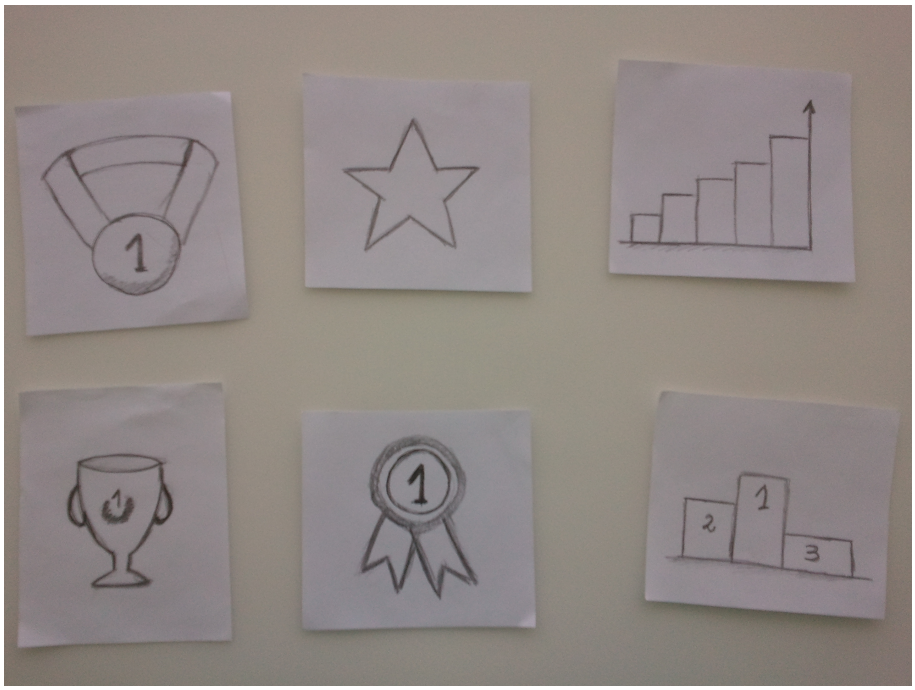

Figure 4.11: Score System Icons: Medal(neck), Star, Graphic, Trophy, Medal and Podium

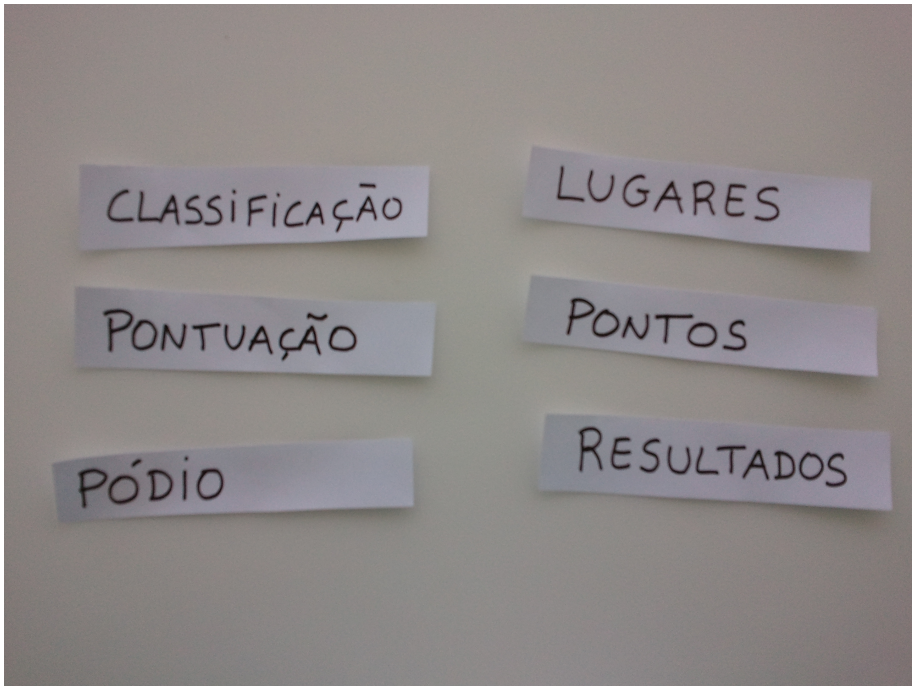

Figure 4.12: Score System Labels

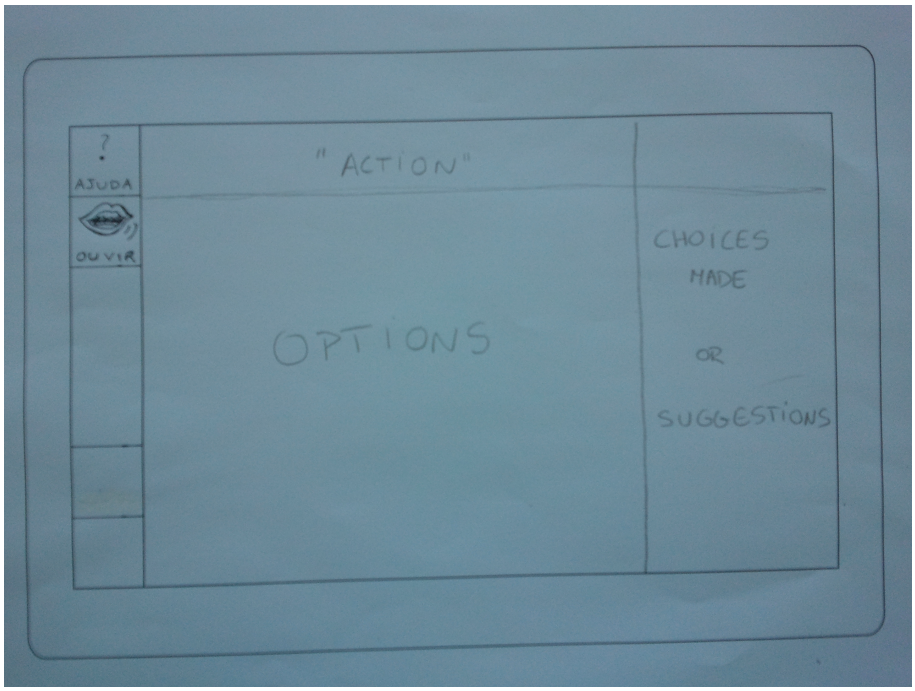

Figure 4.13: Information Organization

On the platforms' main menu (Figure 4.14) there are three available options: "Play alone", "Play in Group" and "See scores". On the first developed prototype of this menu the "Play Group" functionality was placed on top, followed by "Play alone". However, since the first option could possibly influence the users' choice, we did not want to promote the multi-player mode. This may seem inconsistent with the fact that it is our intention to support social interaction; however, cognitive games are likely to produce better results when a player exerts effort to play alone [sRP11]. Additionally, it is sometimes hard for an older adult to find a suitable partner, which could diminish his will to play. To counterbalance this decision, we incorporated the "See Scores" in the main menu to allow social interaction promotion through the comparison of scores, as already mentioned in section 2.2.1.

After selecting a playing mode, the user is asked to choose the player or a group of players. In the case of first time players whose profile is not yet created, the user should select the "Create New Player" option. This action consists of three steps, namely: taking a picture, accepting it and introducing player's name. When testing this functionality (see test 8.7) special attention was paid when the user introduced the player's name, using the on-screen keyboard. The paper prototype was a real-sized print of a tablet keyboard and we wanted to assess if both the QWERTY layout and the buttons' size was appropriate to the audience. It was observed that all participants easily introduced the name "Tiago" in a not excessive amount of time, even though the name purposely used letters placed in

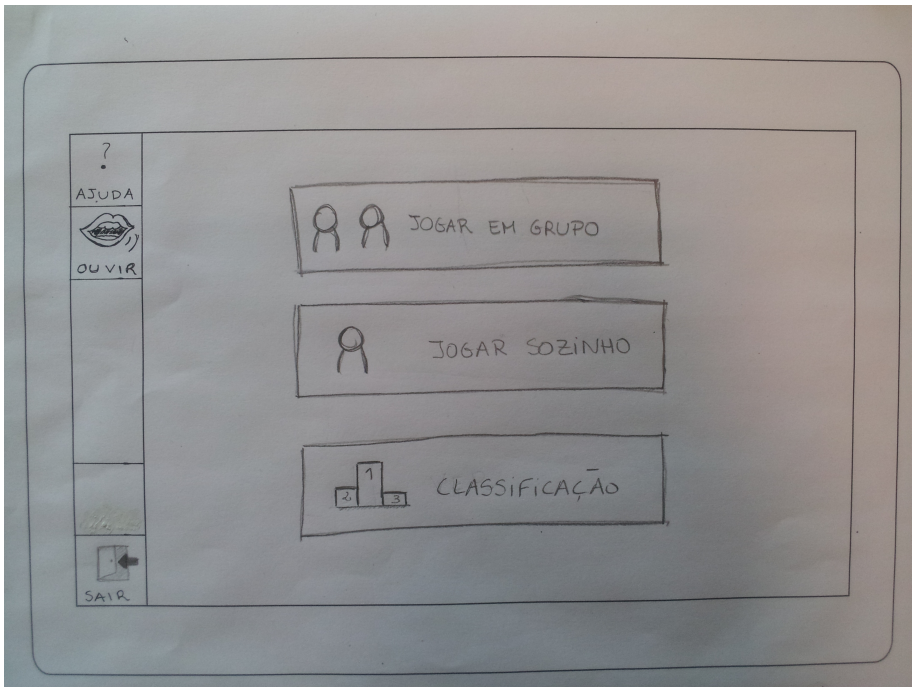

Figure 4.14: Main Menu Prototype

different regions of the keyboard.

At the choose player screen, the players' pictures and names are displayed in a 3x2 grid, constricting the amount of information showed to the users to six elements at a given time. According to the "7 +/- 2" guideline [ADA04] people can only hold 9 to 5 items of information in short-term memory. Considering older adults' characteristics the choice of displaying six elements seems to be appropriate. In case there are more than six players in the system, the interaction between screens is made through the use of arrows. Additionally, at the bottom of the grid, the current page and the total amount of pages are showed to the player (Figure 4.18).

Three different approaches to the process of selecting a user were evaluated. In the first prototype, the user selected the player by touching its picture and then choosing the option "Add Player" - a button located at the bottom of the screen. At this point a dialog box was displayed, asking for the user's confirmation on the selected player. The second prototype was a simplified version of the first one in which the dialog box was triggered as soon as the user touched the player's picture. Finally, the third prototype incorporated the drag and drop interaction method where the user simply had to drag a player's picture to the selected player area.

To test the efficacy of each scenario we measured the time that participants needed to select a user (see tests 8.7 and 8.8). Our results showed that the selection process based on the drag and drop interaction method was performed in less time than the others,

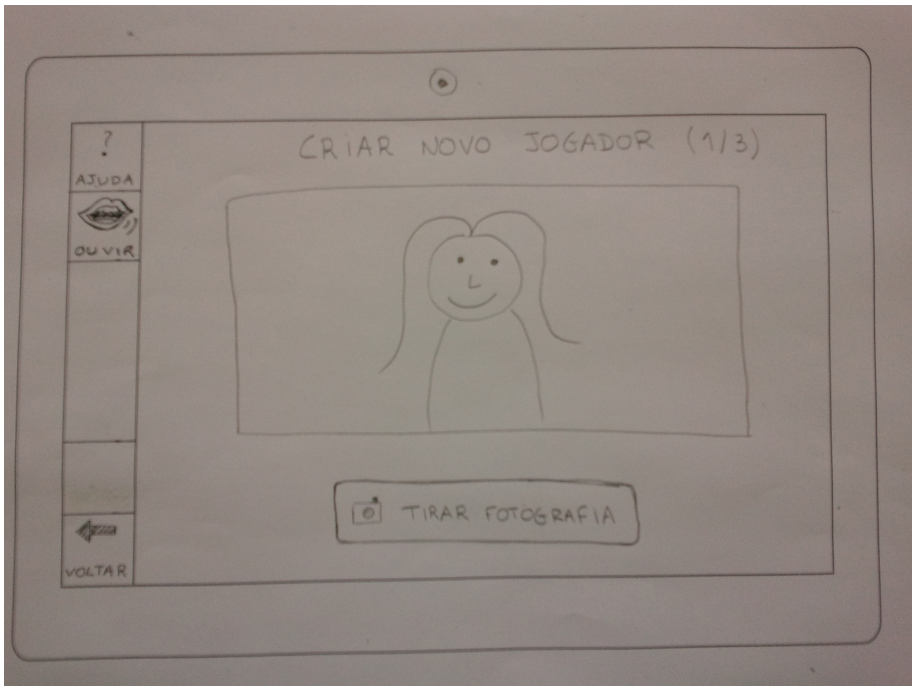

Figure 4.15: Create Player Prototype - Step 1 of 3

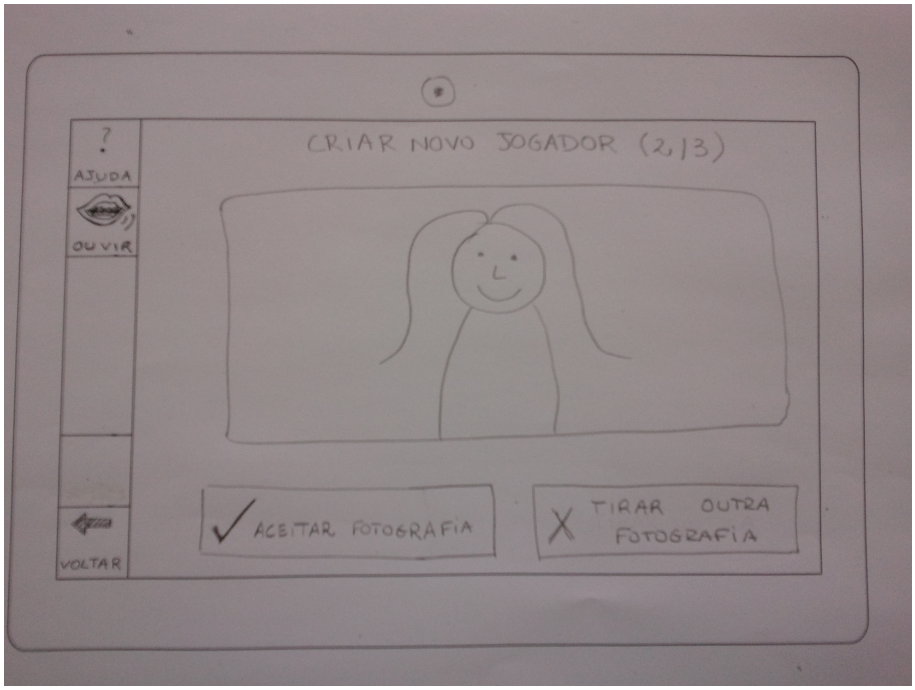

Figure 4.16: Create Player Prototype - Step 2 of 3

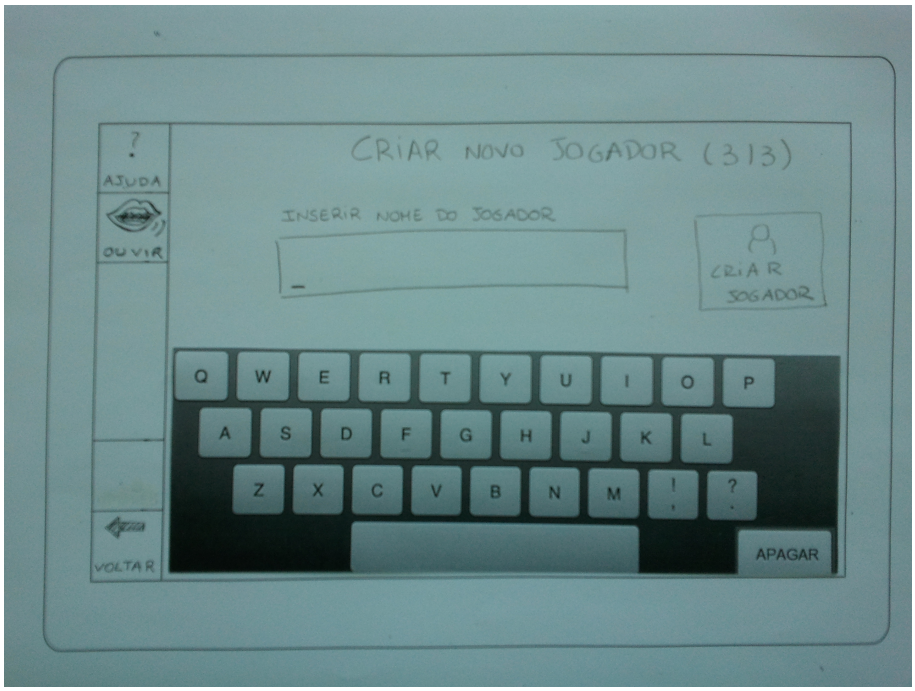

Figure 4.17: Create Player Prototype - Step 3 of 3

indicating it as the most appropriate option.

Considering the possibility that the user could choose the wrong player, in test 8.8 we asked the participants to remove a player from a group. In this test we only assessed if the elders were able to recognize how to perform this task, immediately after adding the player to a group. To maintain consistency of the system, the process of removing a player was similar to the one of adding it to the group. However, instead of selecting the player from the player's grid the participants had to choose it from the selected players area. The results showed that all participants were able to identify how to remove a player and we can conclude that, when the method for adding and removing is similar, older adults will be able to successfully perform both tasks.

Due to the possible expandability of the system regarding games, it was decided that grouping them into different categories would ease player's use of the platform. When analysing the possible categories, two option were identified. There was the possibility of grouping the games according to the cognitive constructs they train or into categories that considered elders preferences regarding games, as assessed through the game book 4.1. We performed an analysis of both advantages and disadvantages and concluded that the second option would be the most suitable choice. It is truth that grouping the games through the cognitive constructs they train could enhance elders perception of their possible impact in their well-being. However, it would also be more challenging for the player to memorize the category of a specific game. Moreover, many games have the potential to

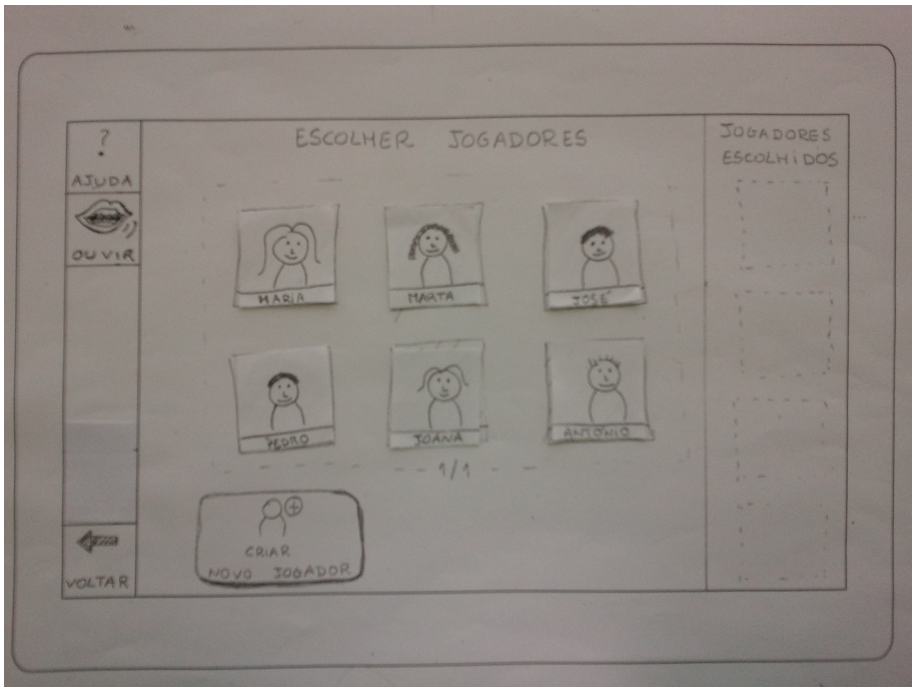

Figure 4.18: Choose Player Menu Prototype

train several cognitive skills, and choosing the category they belonged to could be difficult or trigger redundancies.

Therefore, four different categories were defined: image games, word games, music games and movie games. The first two options are related to the demonstrated preferences of users regarding games, namely find differences games and word games. Since games that incorporate find differences elements are limited, we extended the scope of the category to games that incorporate images. The word games were used as a category by itself mainly because it identifies a category that will not be suitable for all older adults. Since some of them do not know how to read they will be able to ignore this category, avoiding the frustration of engaging in a game that is beyond their capacities. The last two categories however, are related to the potential of tablets in providing novel experiences to the users. The possibility of incorporating music and movies in the games is something that only computer systems offer. Since the majority of older adults still don't use this kind of technology as much as they could, providing them with familiar entertainment mechanisms, may increase their interest in using the platform.

Two different layout options for this menu were tested (test 8.9) with the participants, as showed in Figures 4.19 and 4.20. Although we asked users which one they preferred, their opinions were not conclusive. Hence, data regarding the time the participants took to choose the several categories using both layouts was collected. The results showed that with the second layout (Figure 4.20) participants were clearly faster, which lead us to the

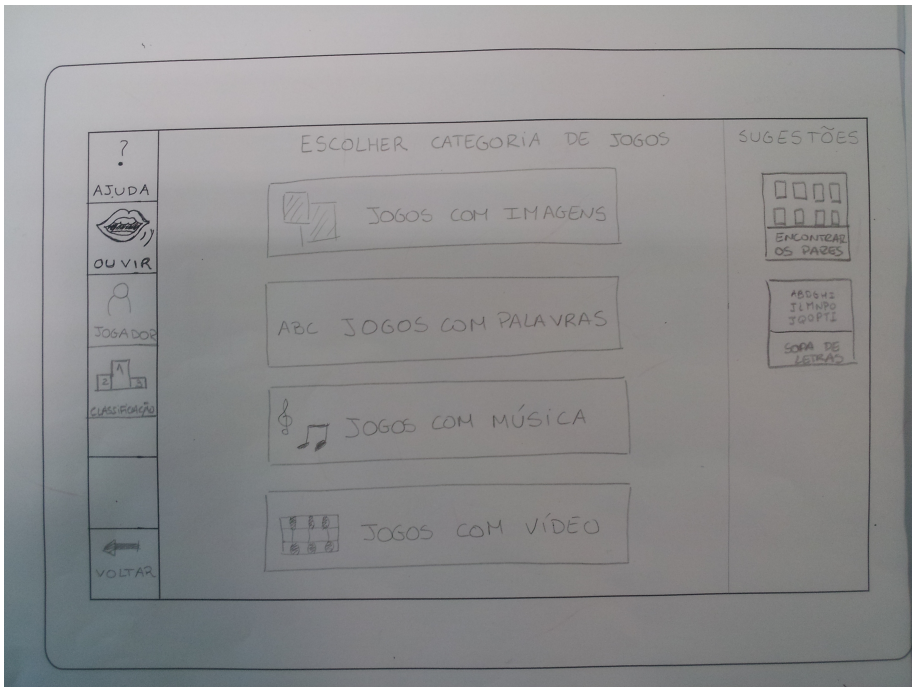

Figure 4.19: Choose Game Category Menu Prototype - Layout 1

conclusion that this was the best choice.

In the choose game menu it was decided that several methods of interaction should be tested, in order to assess touch-based interaction potential. Three different prototypes were developed, using three different types of selection.

The first prototype (Figure 4.21) was based on the before described select player menu. The player touches the game picture and a dialog box showing game instructions asks him to confirm his selection. Similarly to the select player menu, game's pictures are displayed in a 3x2 grid and the player navigates between screens using arrows. Information regarding the current screen and the total number of screens is also shown below the games' grid.

The second prototype used a list-based interaction where the players were shown a vertical list of games (Figure 4.22). To see the different available options the player could use both arrows or gesture to navigate the list. Since only one game is displayed at a time, to inform the player that there are more available options the previous and next items on the list are partially visible. To start playing a game the option "Play" was included after the game description.

The third prototype, to which we called the "balloon" method (Figure 4.23), was based on a horizontal list. Navigation was also based on arrows and gestures, like the previous prototype. The list showed three game pictures at a time and a partial view of previous or subsequent items. Upon clicking on a game a "balloon" would appear at the bottom of

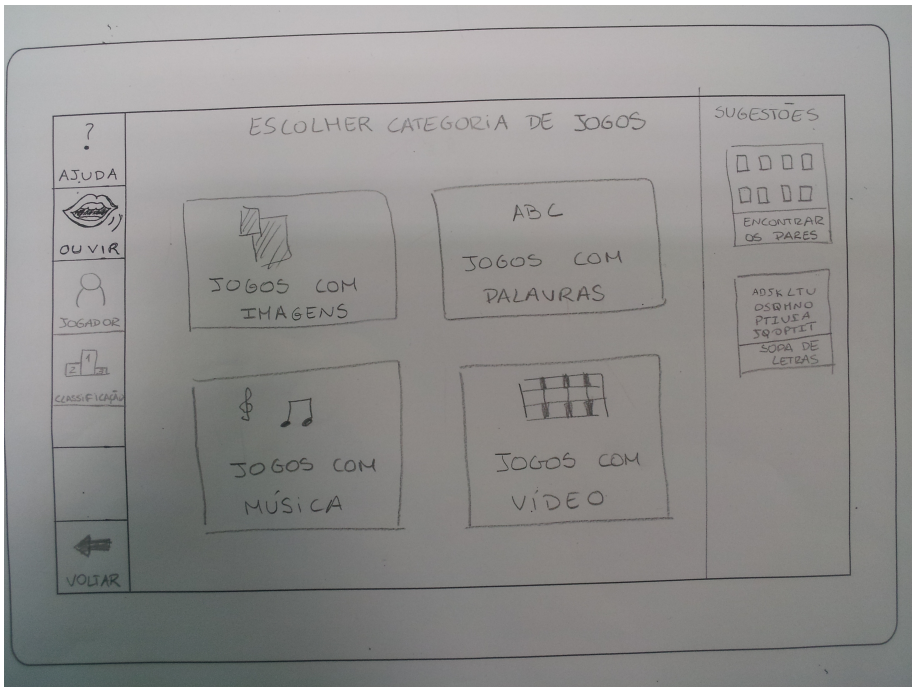

Figure 4.20: Choose Game Category Menu Prototype - Layout 2

the screen with both game instructions and the "Play" option.

Choosing the most appropriate method for this menu required a test with the elders (in appendix 8.9) from which we collected data regarding the time that participants needed to choose a specific game. Test results indicated that the best method was the first one. Moreover, it was also observed that all participants that took less time using this method had already tested the choose player menu using it. This may also indicate that there was a learning process and that using the same method for both menus can ease users' interaction with the system.

Finally, after performing the described user tests with the low-fidelity prototypes, we developed medium-fidelity prototypes that illustrated the user interfaces' final look and feel. These were later incorporated in a high-fidelity prototype used in the trial described in section 4.4.

4.3.3 Evaluation

As already mentioned in section 3.2.4 all performed tests were based on a previously defined protocol that described in detail the objectives and the tasks to be carried out. Questionnaires and a list of the variables to be measured were also included. The results and their analysis were later included in these protocols as well as the conclusions that were drawn after the test. Moreover, some field notes were taken during the user tests;

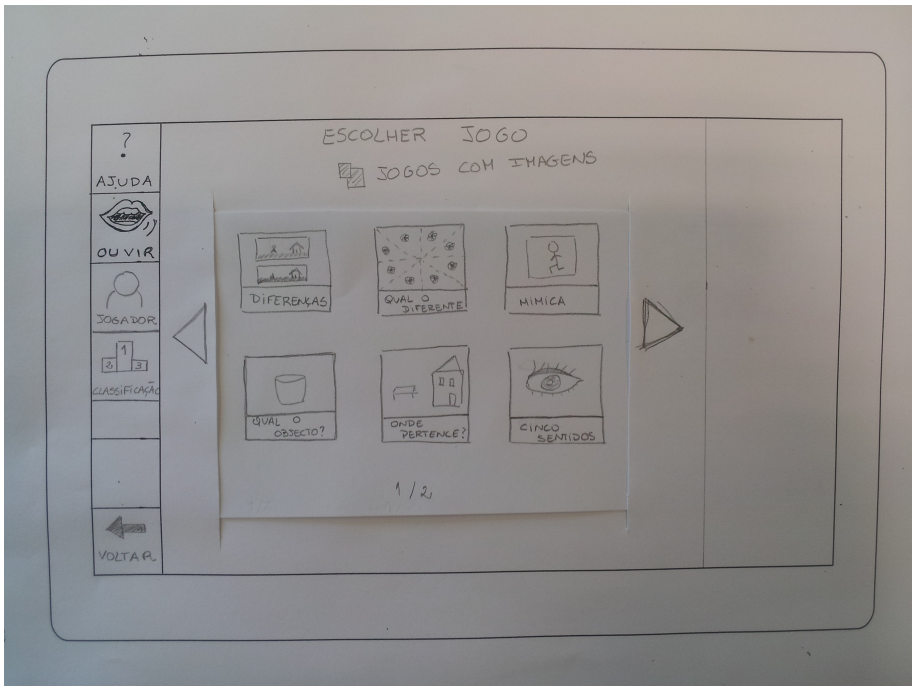

Figure 4.21: Choose Game Menu Prototype - Layout 1

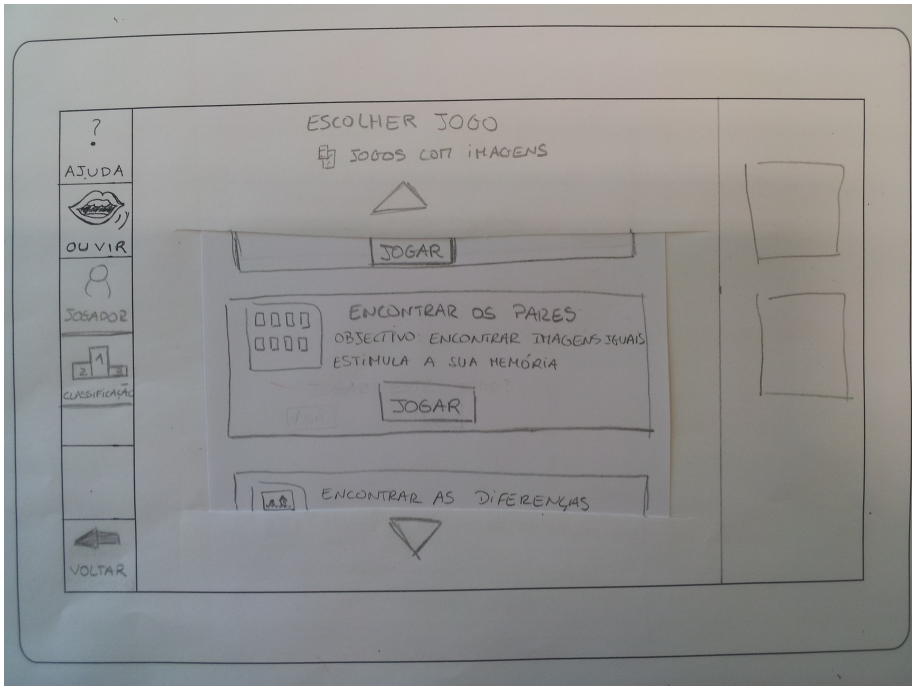

Figure 4.22: Choose Game Menu Prototype - Layout 2

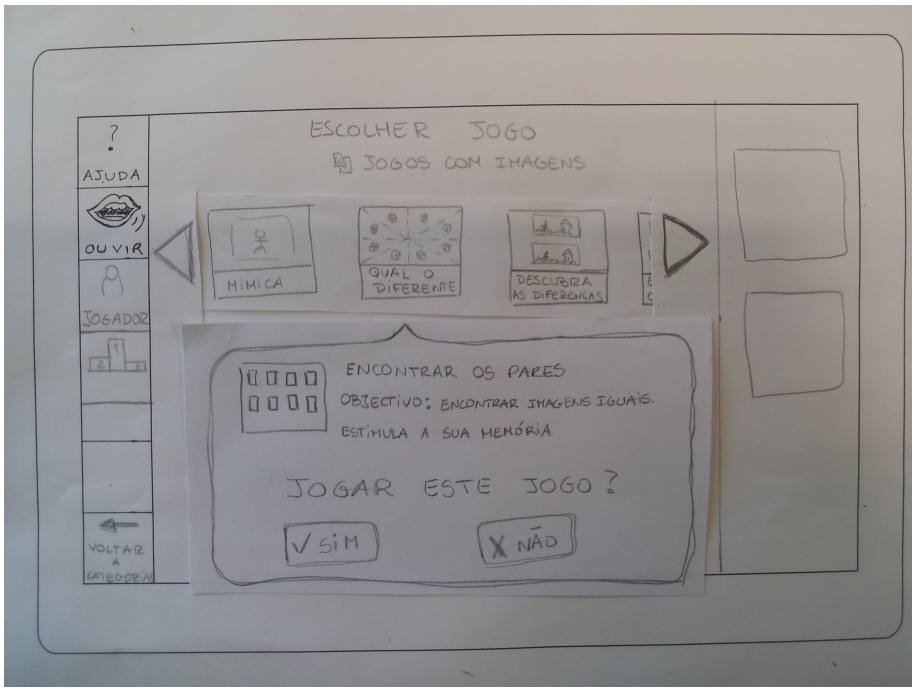

Figure 4.23: Choose Game Menu Prototype - Layout 3

however these were not included in the protocols due to their informal nature, and were only considered to redefine minor details.

In total 10 tests were performed at a day care centre in a two times per week basis. More considerations on the challenges faced during these tests are later discussed in section 5.2.

4.4 Final Evaluation

The last stage of the project included a trial of the gaming platform with the elders, using the tablet device. This high-fidelity prototype was developed by a co-worker at Fraunhofer AICOS [Cas11] and was based on the results of the previously tested low-fidelity prototypes. For this reason, our main goal was not only assessing system's usability and features but also understand if, in fact, older adults were able to interact with a touch-based system.

Like the above described user tests, the trial was performed following a pre-established protocol (see appendix 8.11) in which the tasks to be carried out were described in detail. Although the prototype was fully functional, the available options were limited and only a limited amount of scenarios was tested.

The trial was conducted with six users from the day care centre and, in the following sections, we will describe our results.

Table 4.1: Usability Tests in Appendix B

Test Number	Tested Elements
1	Memory Game
2	Memory Game
3	Text-to-speech icon Font Size
4	Text-to-speech icon Font Size
5	Text-to-speech icon
6	Matching pairs game
7	User Interface: Main Menu Create Player Select Player
8	User Interface: Select Group of Players Remove Player from Group Player Button Scores system
9	User Interface: Choose Game Category Exit Icon Pause Icon Scores Icon Scores Label
10	User Interface: Choose Game

4.4.1 Select Single Player Mode

The first task that we asked the participants to do was to look at the main menu of the platform (Figure 4.24) and select the "Play alone" option.

All participants were able to quickly perform this task; however, since it was the first time that all of them interacted with a touch-based system, some of them asked us how they should select the option. When elders touched the screen it was observed that they tended to use more strength than necessary.

4.4.2 Create New Player

After selecting the single player mode we asked the participants to choose the "Create new player" option.

Even though all participants were able to identify this option on the screen, upon noticing that there were already some created players, they took some time to look at the pictures and easily recognized the other players. This suggests that the option of using

Figure 4.24: Main Menu

pictures to identify the players was successful and provided enjoyment to the participants as they commented on the others players' appearance and demonstrated enthusiasm in taking their own picture. After selecting the "Create Player" option, the participants had to take their pictures, confirm the selected picture and introduce their name as illustrated in Figures 4.25, 4.26 and 4.26.

The participants demonstrated a special interest when taking their pictures and more than one asked to change it as they did not liked the first final result. Regarding the introduction of their name, the choice of using the default Android keyboard proved to be a bad one since many errors were introduced, as it can be observed in Figures 4.28 and 4.29. Although the keyboard had already been tested and participants were able to quickly select their name letters, the used keyboard incorporated the feature of selecting a different character when a key was pressed for a long period of time. As stated before, elders tended to use more strength than needed to touch the buttons and also took more time than necessary. Therefore, the keyboard automatically switched the letters to other symbols introducing errors in the participants' names. These results indicate that there is a need to evaluate the keyboard design and features in order to accommodate users' way of interacting with the system.

4.4.3 Select Player

Although at first this task may seem simple, some older adults struggled to perform it. From our tests regarding the user selection it was concluded that a drag and drop system would be easier for older adults to use (test 8.8). However, when considering older adults with fine motor skills impairments this method could be more challenging. To

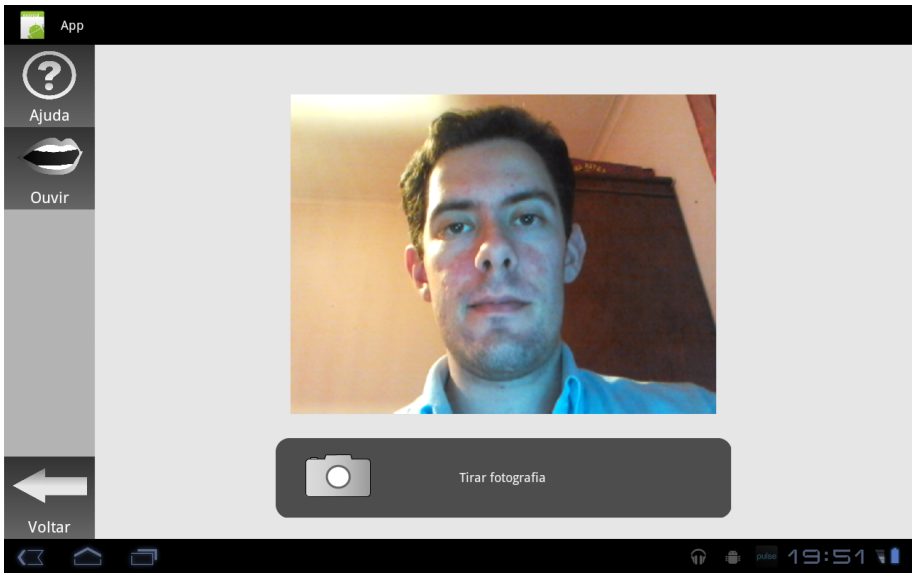

Figure 4.25: Create Player - Step 1/3

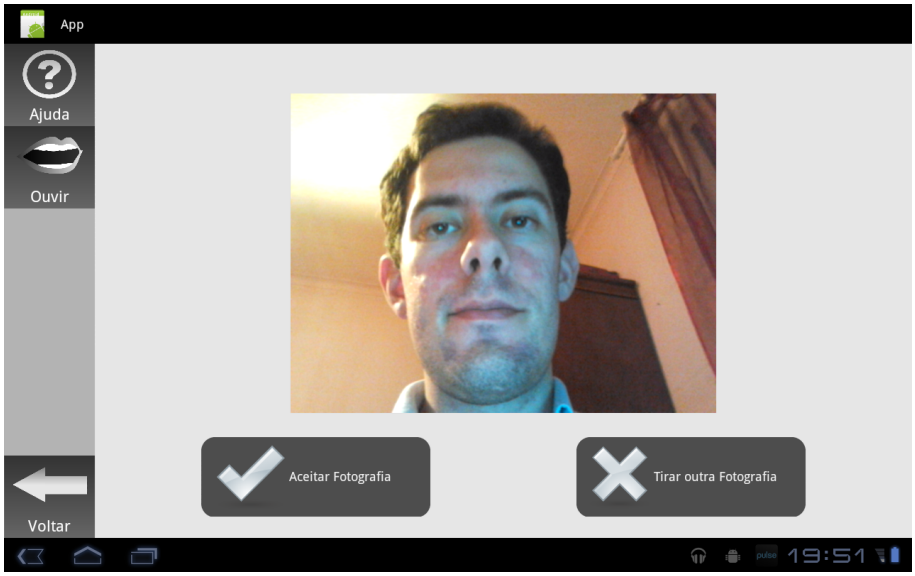

Figure 4.26: Create Player - Step 2/3

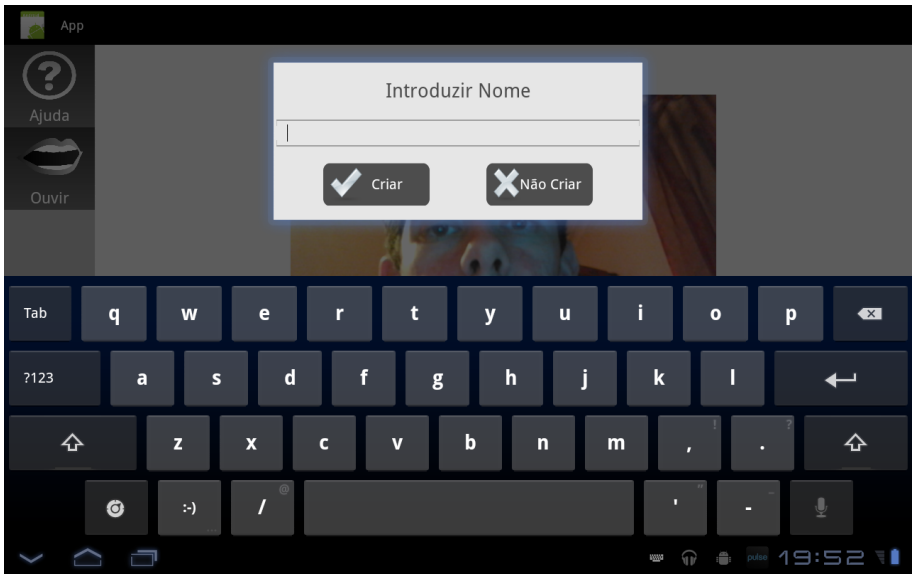

Figure 4.27: Create Player - Step 2/3

accommodate these users it was decided that both methods should be implemented enabling the player to choose the one he felt more comfortable with. Therefore, if an older user touched the player briefly a dialog box would be displayed; with a longer touch the player's picture would move, in order to be dragged to the selected player area. At the beginning of the trial the users were informed that they could use both methods, however as previously mentioned, the participants touched the players picture for more time than needed activating the drag and drop method of selection. They would then be confused about what to do next, which resulted in some challenges while choosing the players. Hence, it was concluded that only one method should be implemented, and that the drag and drop method would not be the most suitable one.

4.4.4 Choose Game Category and Game

After correctly selecting their player profile the participants were asked to choose the images' games category from the game category menu. In this screen, (Figure 4.30) the participants were able to accomplish the task very easily. However, choosing the game revealed to be more challenging, mainly due to the aesthetics of the games' buttons. The game was illustrated with an image of the game play, along with a label with its name. We believe that this could be the best option, since it appeals to recognition instead of memory, once a player already played that game. However, the button did not have a gray background like the previous ones and, for that reason, elders were not expecting it to be a button (Figure 4.31). Although this error in the interface design is easily solved, it showed us the importance of having a consistent interface design. After a brief explanation on how to select the game, the participants easily started playing it.

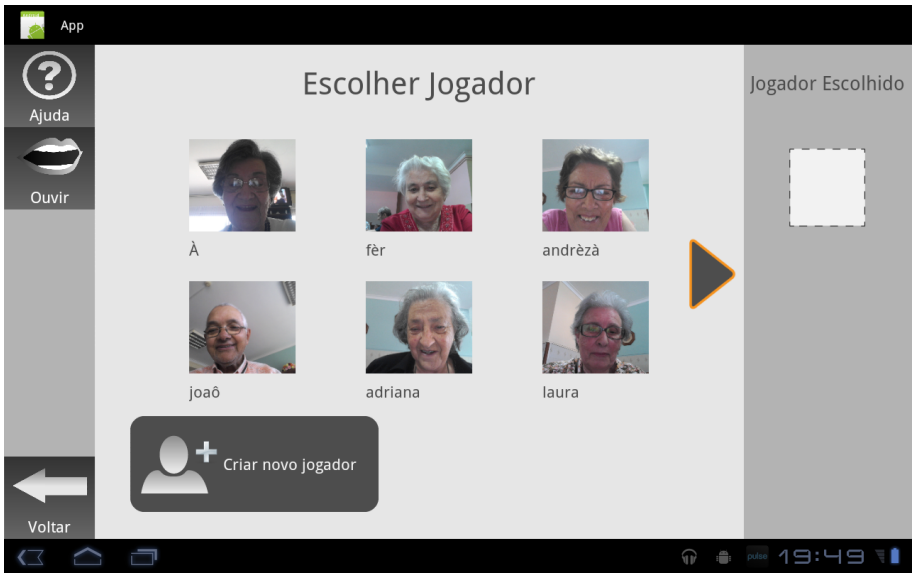

Figure 4.28: Select Player Menu

Figure 4.29: Select Player Menu with selected player

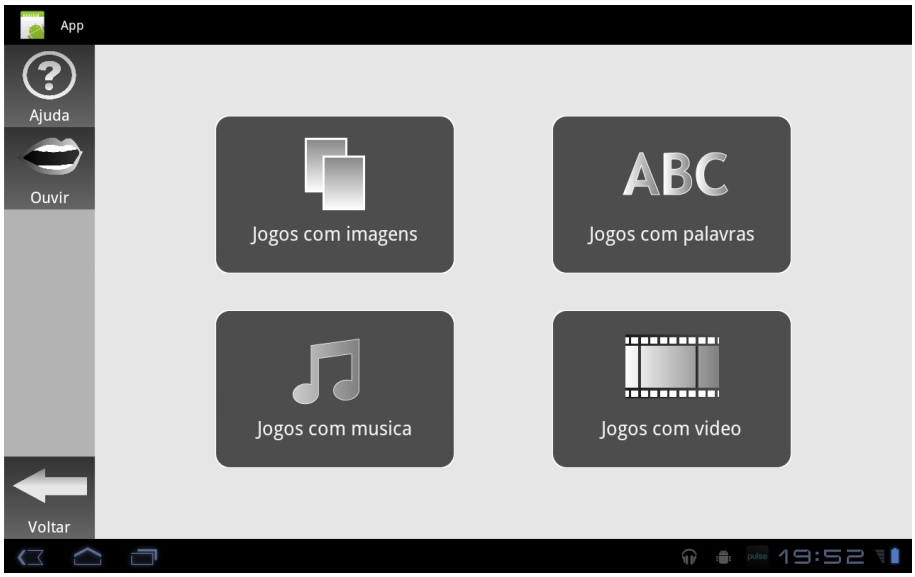

Figure 4.30: Select Game Category Menu

Figure 4.31: Select Game Menu

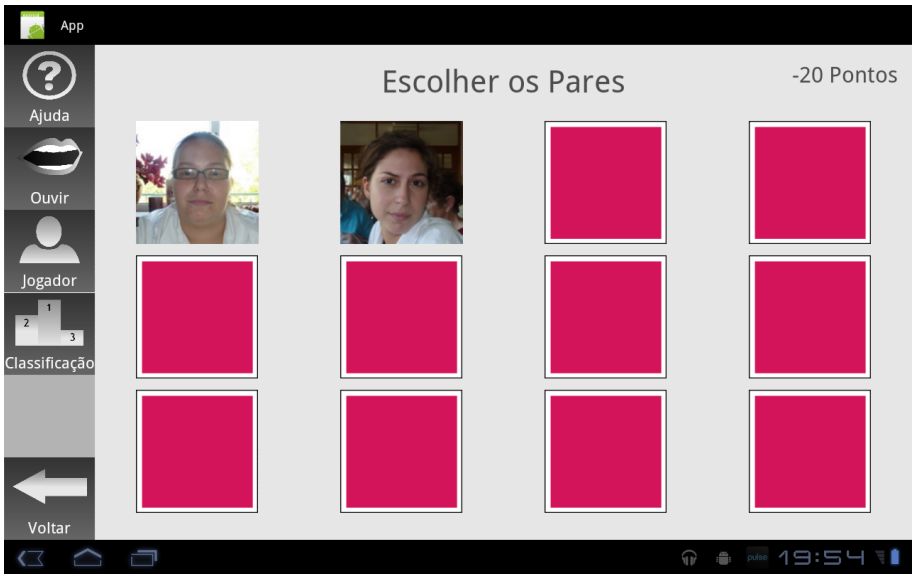

Figure 4.32: Matching Pairs Game

4.4.5 Play the Game

The matching pairs game was already familiar to some of the participants since they had previously tested its low-fidelity prototype version. Since this final prototype did not had an explanation of game instructions, we provided it to the participants ourselves. With this, all participants were able to play and complete the game successfully. Moreover, they were also able to quickly identify the pictures of their caregivers which, as mentioned before in section 4.3.1, did not happen with the low-fidelity prototype.

4.4.6 Questionnaire and Final Considerations

At the end of the trial we administered a questionnaire to the participants to access their level of satisfaction with the experience. When asked if they had enjoyed the experience all participants answered positively. Regarding the challenges encountered, only one participant found that 1 or 2 tasks were more difficult to perform. As to the frequency at which the participants would use the tablet if there was one available at the day care centre, the majority of the participants answered that they would play it often or very often with only one participant saying that would only seldom play on it.

The overall experience had a positive outcome and the acceptance rate of the product among this group of participants was optimal. The participants showed enthusiasm towards the use of the gaming platform and one senior went as far as asking us how much it would cost her to have a similar device. They also revealed a lot of interest in understanding the tablet's potential to be used in different domains other than playing games.

However, it was also evident that the platform is still a work in progress and that further tests are needed to reach a final product.

Chapter 5

Discussion

5.1 The Research Process

Designing a system to a specific audience like older adults is significantly more challenging than applying the same process for a mainstream audience. For this reason the use of a UCD methodology was crucial in order to keep the users' characteristics and limitations in mind throughout all the development process. To achieve this knowledge we resorted to a literature review on ageing from which we were able to identify a wide range of age-related changes that could impose boundaries to our design, as described in chapter 2. Nevertheless the next phase of the project allowed the establishment of a more accurate definition of the audience's characteristics and context through observations and interviews performed at older adults' get together sites and a day care centre.

At the same time an analysis of the use of games as well-being and quality-of-life promoters was performed in order to recognize their potential and the existing mechanisms that could be introduced in our games to achieve said purpose. From these studies, resulted the game book activity which was, in our opinion, a valuable asset to this project since it gave us a deep insight of elder preferences and difficulties regarding a specific type of games (cognitive enhancement games). Furthermore, it motivated seniors at the day care centre to be more participative towards our initiatives, easing the following approaches when the time to perform user tests came.

Based on the knowledge acquired from these techniques we started by developing a low-fidelity prototype of a game and tested it with the older adults' at the day care centre. The choice of starting with a game was deliberate, as we felt it was a way of keeping the users engaged in our activities, by providing them with easy and fun tasks to perform.

As the game platform idea was maturing and becoming clearer to us, we started developing a screen storyboard of the system in order to generate an overview of the system's

functionalities, which eased the prioritization for the later developed low-fidelity prototypes. At the same time, and since the available time to spend with the older adults was limited due to the day care centre impositions, we performed tests regarding font sizes and icon sizes as well as icon images to be used in accessibility options that, from the beginning of the project, we knew must exist in the system.

The next step was developing a series of low-fidelity prototypes to test the usability of the system as well as functionalities, naming conventions, icons, element positions and interaction methods. Having the possibility to test prototypes with the users was a valuable experience since their feedback allowed us an informed decision-making regarding the redesign and the achievement of results that indeed consider users' characteristics and preferences. The use of low-fidelity prototypes proved to be a good option since it allowed a bigger exploration of ideas and encouraged users' feedback regarding important aspects and not only the aesthetics of the prototypes. Despite having the possibility to perform several tests, it is also true that due to time constraints much more were needed in order to test all system functionalities.

However, after testing some of the most important aspects of both platform and games, we were able to produce a high-fidelity prototype of the gaming platform and conduct a trial using the tablet. Although theory already suggested that touch-based interaction was in fact easier to older adults, the performed trial aimed at addressing the extent of such findings and to test the actual interaction between older adults and the tablet. The results showed us that older adults easily adapted to this interaction method and did not find the tasks performed during the test particularly challenging. Having the possibility of performing this trial was of utter importance since it provided evidence that this platform really has the potential to be well accepted by older adults, suggesting that the assumptions on which this project was build upon were in fact valid.

5.2 The Problematic of Evaluating with Older Adults

Performing evaluation with older adults is particularly challenging. First of all, having access to this audience is not easy. However, we were able to work in partnership with a day care centre that allowed us a direct contact with our audience. Still there were some constraints regarding the time we spent with the elders due to their routines, and, for that reason, we were only allowed to perform two tests per week, with a total duration of two hours each.

At the time we had the first contact with the elders at the day care centre we became aware that many of them were not willing to participate in our activities and that many others were not able to do so due to their physical or psychological conditions. With the help of the caregivers we were able to identify a group of older adults that could participate, which comparing to our initial balance revealed to be a lot less than expected.

One of the main concerns when performing usability testing is assessing the number of users that is required to obtain the needed results. This issue is still widely discussed among the HCI community and a consensus has yet to be fully met [JLH09] however, in our particular case it was not such a matter of "how many users we must have" but yet "how many users we can get". In the end we were able to perform the tests with an average of 8 users (between 3 and 19) which, considering the scale of our project, should be enough to provide us the necessary feedback [Nie00][Dix11].

Managing the time available for testing was somehow complex due to several reasons. Older adults' daily disposition varies significantly and for that reason we always asked them at the beginning of every test if they were in the mood to help us that day. Many times the answer was negative, which limited the amount of tests that we were able to perform in a day. During the tests it was also our concern not to fatigue the elder, therefore they were informed that they were able to interrupt us at any time and stop the activity, which luckily only happened once. Furthermore, older adults were always eager to share their life stories or daily event which increased the time needed to perform the tests.

Finally, sometimes, due to normal age-related changes in speech, language, swallowing and hearing the ability to communicate effectively with older adults can be affected [Bus99]. For this reason, when people of younger ages interact with older ones, they tend to adapt their speech to a style termed patronizing speech or *elderspeak*, which has numerous potentially negative social implications [MLHW92]. Hence, the authors paid special attentions to literature that provides guidelines on how to communicate with older adults [Sch91] [KWH04] as well as more general guidelines for usability testing with this audience [SN10].

5.3 Ten Platform Characteristics

It was our main concern to develop an artefact that holds the needed characteristics for providing an enjoyable experience to our audience. The overall specification and design of the platform, as described in the previous chapter, considered their characteristics and needs. But there are a number of features we considered of paramount importance that summarize the several aspects in which the developed platform is suitable for older adults, which are as following:

1. **Usage of direct input devices**, to make the interaction as easy as possible and reduce the anxiety of elders towards technology;

2. **Mobile platform**, so it can be transported and played anywhere;

3. **Unique interface**, with a design that accommodates the changes elders experience as they age;

4. **Expandability**, so that new games can be created, made available and downloaded and play by elders;
5. **Variety**, by providing more than one game in each category enabling elders to choose their favourites;
6. **Customization**, since the games can be adapted to a specific individual through the use of pictures, videos or sounds that are familiar to him;
7. **Feedback**, for the user to know about his actions in the game, so that he knows where he was correct, where he failed and how;
8. **Goals**, to keep the users' focus on the objective of the game and that can act as challenges to keep the user engaged;
9. **Rewards**, to immediately award the user for his performance since the benefits of cognitive games might only be noticeable in the long run; the rewards can also be used to show to friends and keep track of the users' progress;
10. **Social interaction**, promoted by the multi-player mode and through the reward system as it provides a conversation theme among elders while enabling a friendly competition.

Not all these characteristics were validated, but it would certainly be interesting to assess their impact in the overall gaming experience of the older adults.

5.4 Lessons Learned

There are a number of interesting findings we can derive from the work carried out within the scope of this thesis. However needing further investigation, it is our conviction that some of our conclusions can inform other related projects, namely:

- The **use of pictures** to identify each player seemed to amuse the trial participants and generated a conversation theme among the older adults regarding their appearance 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. Through the use of such mechanisms a feeling of familiarity and proximity between the user and the game may be created, compelling its use.
- As stated before older adults favour games that portrait themes from the real world. By **customizing** a game to one's real-world it is possible to provide a better gaming experience, as our results have showed.

- Although available research suggests that **gestures** may be an easier way of interacting with touch-based systems, in the case of older adults this may not always be true. During the performed trial it was observed that dragging elements is hard for individuals who suffered from some form of fine motor skills decline, as a consequence of age-related changes. Therefore it necessary to carefully adapt the way gestures are incorporated in a system for this audience if we wish to accommodate possible impairments.

- Engaging in the gaming experience is sometimes a challenge for the older adults. At the time we performed the game book activity several participants indicated that they could not solve the games without help and that often they did not participated in some activities for feeling that they did not possess the needed skills. For this reason developed **games should be as easy as possible** to adapt to a wider range of users, without being dull.

Chapter 6

Conclusions and Future Work

As the population ages it is becoming increasingly important to provide older people with a set of conditions that promote a successful ageing. It is also undeniable that the use of technology affords an opportunity to enhance elders' quality-of-life through the use of a variety of mechanisms. Whether for information search, health control or just for providing enjoyable experiences, computer systems should be faced by elders as a tool to increase their overall well-being, instead of a world that is completely out of their reach. Therefore designing systems that meet older adults' needs and that consider both their capabilities and limitations, likes and dislikes, have the potential to create artefacts of sheer importance in the contemporary society.

This thesis had the main goal of analysing, designing and evaluating a tablet-based gaming platform for older adults. Through a deep understanding of the target audience as well as a profound study in games potential we were able to propose a solution that the authors believe holds the necessary characteristics for providing a pleasurable and easy experience to the elderly population, while increasing their overall well-being through cognitive and social stimulation. The use of an ascending device like the tablet and the non-existence of similar products are also likely to contribute to the successfulness of this solution.

Therefore the authors consider that the outcome of their work is a valuable contribution and a foundation for future research and work within the HCI field. The questions raised in the early stage of this project were successfully answered as following:

Q1: Through literature review we acknowledged the existence of a series of age-related changes and their impact on system design, as discussed in 2.1. Moreover, through observations, interviews, the game book and questionnaires we were able to identify older adults preferences and challenges faced on a daily basis. The results of this process are detailed in section 4.1.

Q2: Not all games are suitable for the elderly and the current game industry provides a wide range of options that aim different target audiences. From our research we were able to identify a series of game characteristics that are appropriate for this specific user group as argued in 2.4.

Q3: Research on the use of touch-based devices suggested that devices incorporating this interaction method could ease the use of technology by older adults (section 2.3). During our trial, described in section 4.4, we observed that in fact seniors were able to easily interact with the system, which corroborated the mentioned studies. However it was also concluded that gesture-based interaction should be carefully considered, as discussed in section 5.4.

Q4: The potential of games to positively impact older adults' lives and the different mechanisms to support it were described in section 2.2. However, the use of these mechanisms is constrained to the tablet characteristics. The conclusions of our work claim that cognitive training tools along with social interaction promotion were the most suitable options for the tablet device, as stated in section 2.4.

Q5: When developing a project like the one presented in this thesis, there is a wide range of methodologies and techniques that can be employed to achieve the proposed goals. The advantages of a user-centred design methodology are discussed in section 3.1.1 and we can conclude that the use of this methodology has in fact proved to be of utter importance when working with older users. However, it is also important to acknowledge that collaborating with this specific audience can be challenging (see section 5.2). Nevertheless, these issues can be overcame by accommodating the used techniques to the audience or creating novel experiences, as explained in section 3.2.

Building upon this research, a foundation for future research and work arises. At a first stage, it is important to study the incorporating of sound feedback and the use of colors in the user interfaces. Due to its expandability, this platform can also be complemented in the future with more games and relevant levels of difficulty, so it adapts to a wider group of users. Furthermore, we prepared it to save a series of parameters regarding user performance that may be used not only to track an individual's progress but also as monitoring tools, similarly to the ones studied by Jimison and Pavel [JP06]. Another aspect that is yet to be fully explored is the cognitive improvements that games can in fact have on older adults. Although games have proven to have that potential, "currently little is known regarding how the schedule of video game practices affects transfer to other perceptual and cognitive abilities" [WRBG08]. However, despite the conclusions that future research may reach on the subject, a game should always be a voluntary and free activity [Hui03] [CP90], and imposing schedules could possibly negatively influence the user experience. For this matter a solution that motivates users, opposing to obligate them to play a game is needed. We are currently studying a mission/goals mechanism that would reward users that engage in a specific game playing routine, which could potentially

be a solution for this issue. In addition, studying the implementation of an online playing system can also be approached.

Finally, however preliminary results have already indicated that the platform satisfies the various aspects of usability as well as its great acceptance by older adults, further formal validation is recommended. An interesting outcome of this validation would be a set of guidelines for designing games for older adults, providing a useful source of information for future project in the field.

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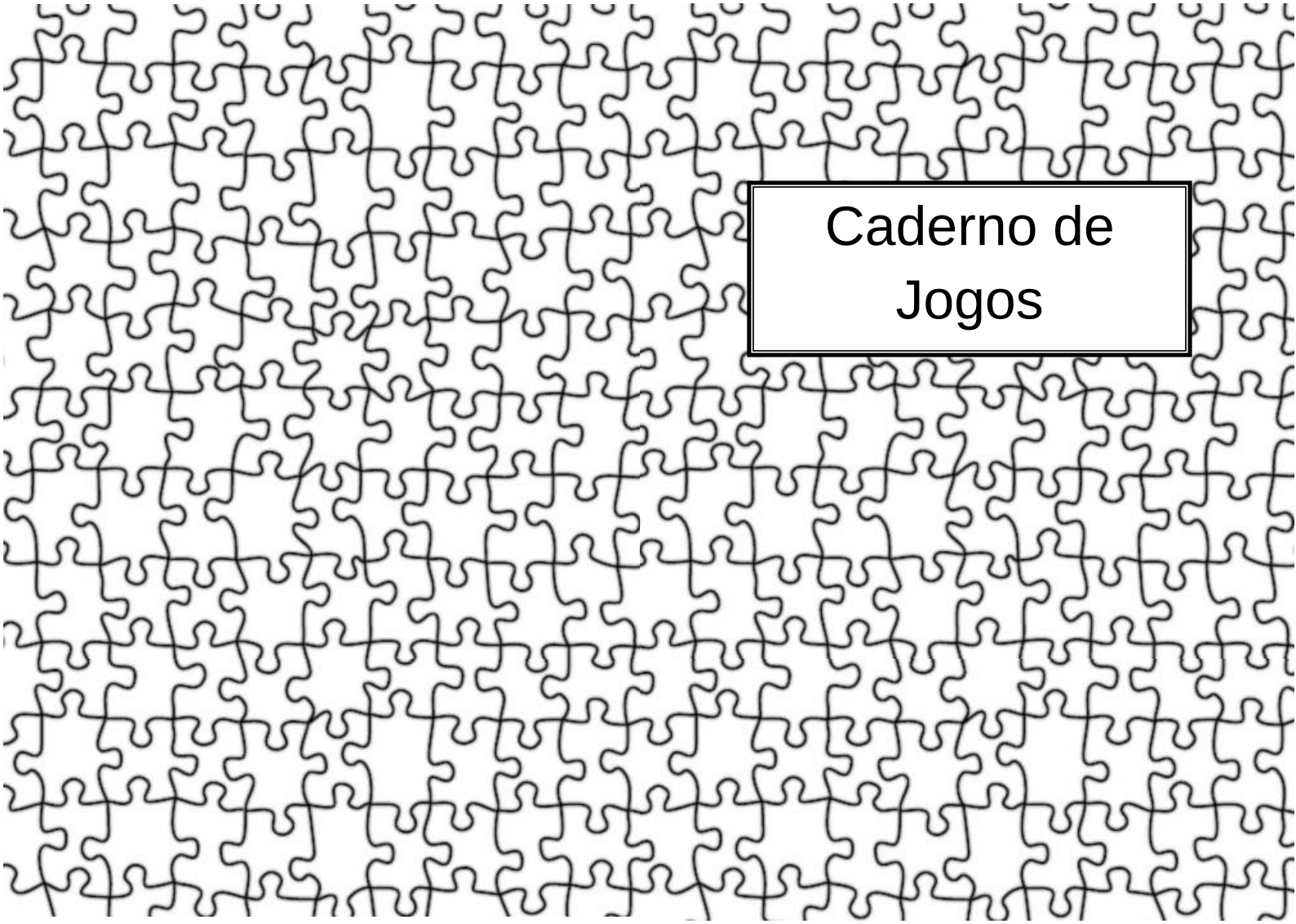
Chapter 7

Appendix A

In this appendix is an example of the game book used to elicit older adults' preferences and difficulties regarding games as well as its results.

7.1 Game Book Games


Caderno de
Jogos

Este Caderno de Jogos foi feito para que possam resolver os jogos aqui presentes sempre que vos apetecer e se vos apetecer.

Não queremos avaliar a vossa capacidade de os resolver mas sim saber se gostam destes exercícios e de que maneira os podemos melhorar.

A vossa ajuda é indispensável para que possamos desenvolver jogos que sejam divertidos e que vos ajudem a passar o tempo da melhor maneira possível.

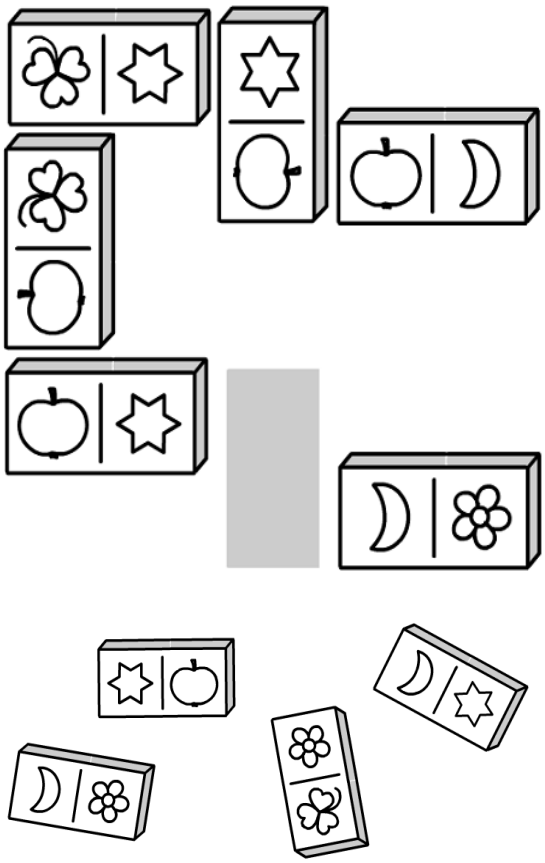
Muito obrigado pela vossa colaboração!

Nome: _____

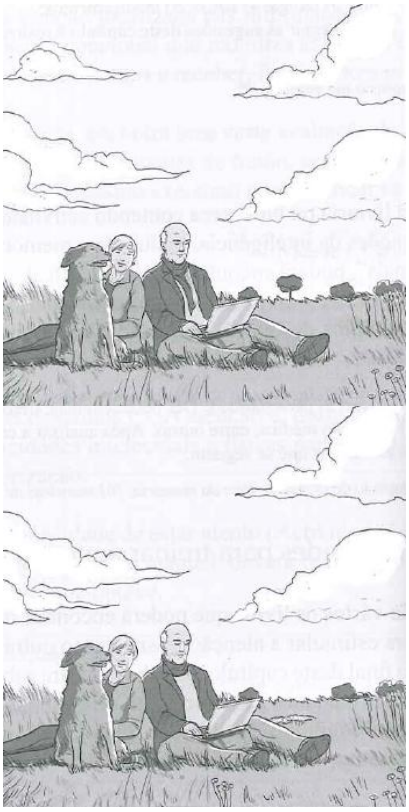
Idade: _____

Qual a peça que encaixa no jogo?

Faça um círculo na peça correcta.

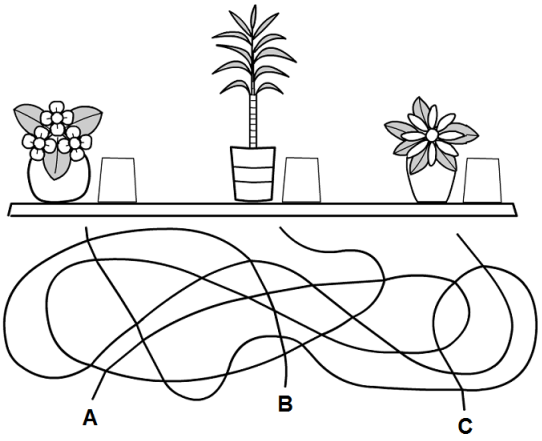


Encontre as 9 diferenças entre os desenhos.



Qual a letra que corresponde a cada vaso?

Escreva a letra correcta junto a cada vaso.



Ordene as sílabas para formar palavras.

LO GA ES LA CO VA LO CA SA ME

_____ _____ _____ _____

BRA SOM GAI PA PA O NE CA TA GO FI

_____ _____ _____ _____

Preencha a tabela com o nome de 10 objectos que pode encontrar na casa de banho, recorrendo à sua memória.

12 Objectos da casa de banho	

Resolva os enigmas!

Existe alguma lei que proíba o casamento de um homem com a irmã da sua viúva?

_____

O pai da Maria tem 5 filhas: Lálá, Lélé, Lili, Lóló e…..?

_____

Alguns meses têm 31 dias, outros têm 30 dias. Quantos têm 28 dias?

_____

Existe o 25 de Abril na Inglaterra?

_____

Numa prova de atletismo, o Pedro ultrapassou o colega que estava em 2º lugar. Em que lugar ficou o Pedro?

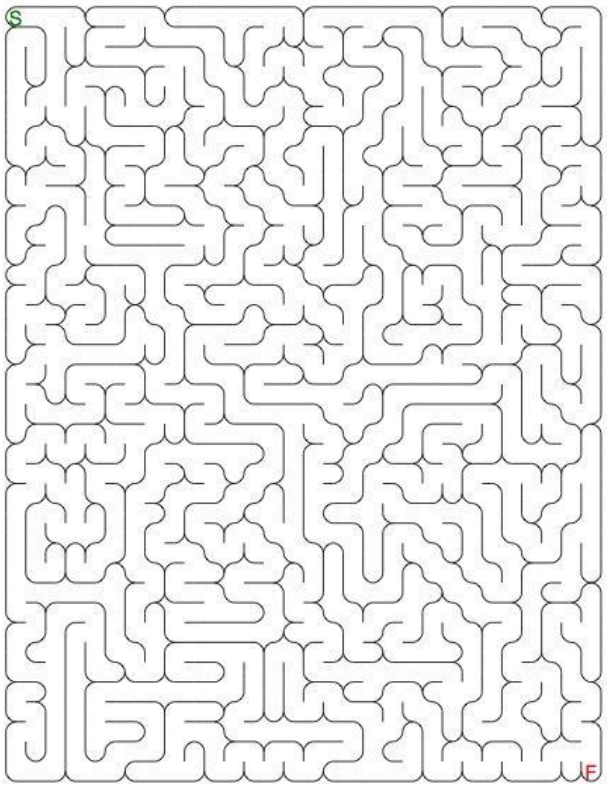
_____

Encontre as palavras na sopa de letras.

O T C B A T D A A O O K C K P
T O Z E B R A S M S U U A I N
A S C T A R T A R U G A N I T
G F Y A L A T U Z E L G G L I
L I O E C Ó V L K I U M U A G
T P Ã R P A F A R I G D R V R
O O U O M G M O M E E J U A E
C T P L C I G A B M W I T J C
I I A F G M G B G G B G C A O
H Y Z P R A U A S G E O T A R

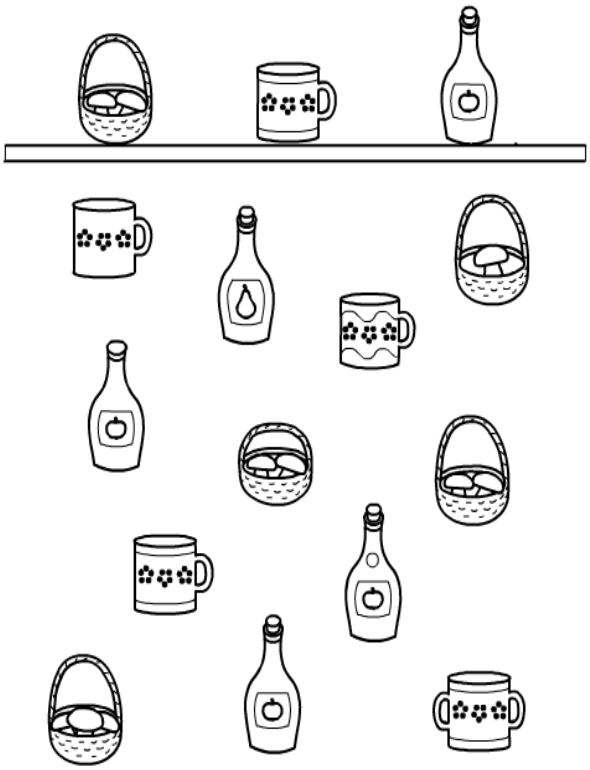
CANGURU
GIRAFA
JAVALI
PATO
RATO
URSO
FORMIGA
GORILA
LEÃO
PINGUIM
TARTARUGA
ZEBRA
GATO
HIPOPÓTAMO
MACACO
PULGA
TIGRE

Encontre o caminho correcto entre o S e o F.

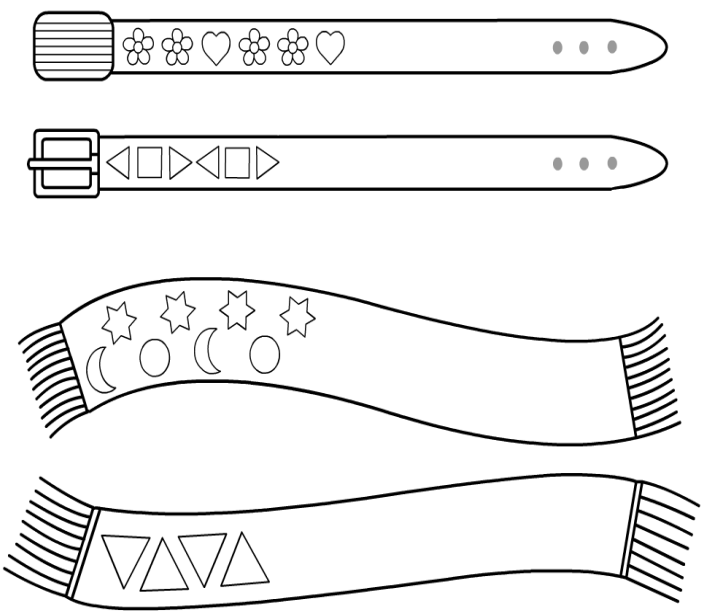


Existem três objectos exactamente iguais aos que estão na prateleira.

Encontre-os e faça um círculo à volta deles.



Complete as imagens de acordo com as sequências apresentadas.



7.2 Game Book Results

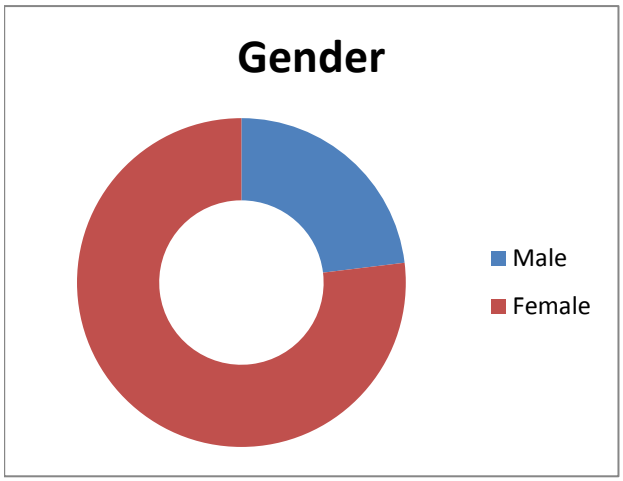
Game Book

Objectives:

- Assess the importance given to games by older adults.
- Understand the context in which older adults play.
- Observe possible social interactions that may occur while playing games that were developed to play alone.
- Evaluate the games individually to assess the satisfaction of players or difficulties encountered.
- Understand users' preferences.

Demographic Data:

- 13 participants (10 female/3 male)



- Average age: 80 (74 – 88)

Protocol:

- We delivered the book and explained its purpose and content to each participant independently.
- We asked them to solve the games whenever they wanted and only the ones they wanted to solve. We emphasized that they would not be evaluated for their solutions, instead we wanted an evaluation of the proposed games.
- We then asked them to return the book in a week from the delivery date, or when they completed it.
- When they returned the book we did a questionnaire regarding their satisfaction, perceived difficulty of the games and reasons for unsolved games.
- We also had an informal conversation regarding the solving of the book, if they needed help, their overall satisfaction, when and where they solved the games.
- In the end we explained that their feedback was very important to us and for our work, and that we hoped that they enjoyed the experience and that the outcome would be able to provide them better experiences in the future.

Questionnaire:

Satisfaction (choose one option):

1. I liked the game and would play it often.
2. I liked the game but would only play it sometimes.
3. I did not like the game that much, but would play it again.
4. I did not like the game at all and would not play it again.

Difficulty (choose one option):

1. I thought the game was easy and I solved its challenges without difficulties.
2. Although I thought the game was easy I encountered some difficulties while solving it.
3. I thought the game was difficult but after some tries I managed to solve it
4. I thought the game was too difficult, I tried to solve it but I gave up

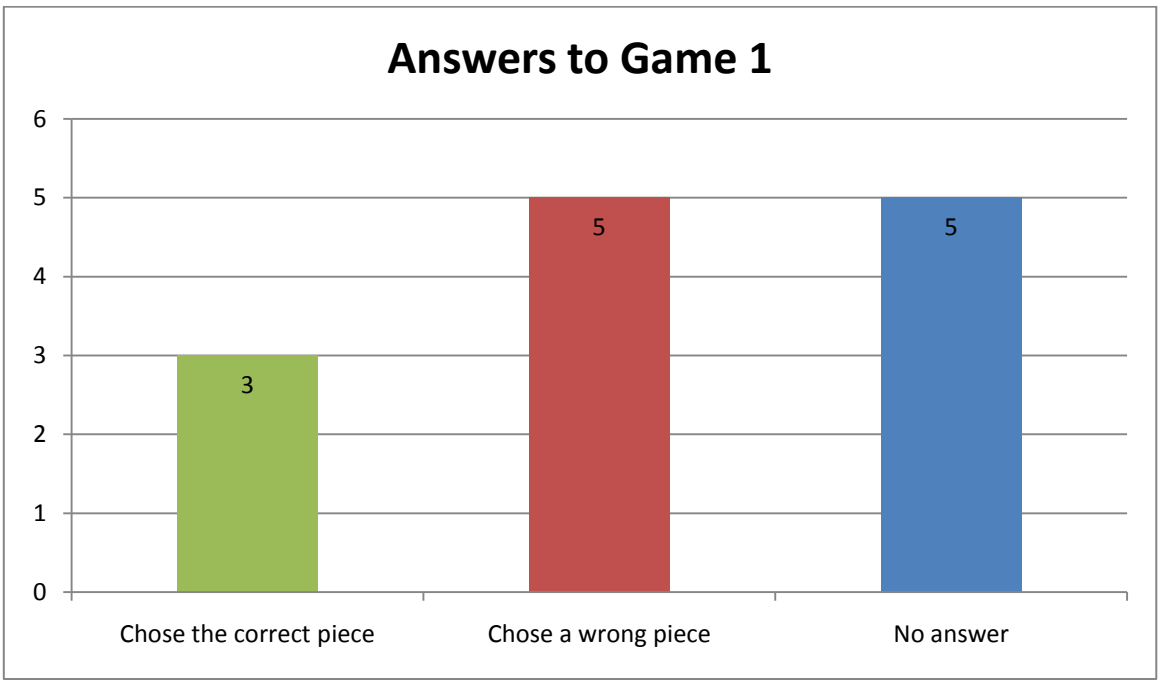
Unsolved Game (choose one option):

I didn't try to solve this game because:

1. I did not have the time.
2. It looked too difficult.
3. Because I did not like it.
4. Because I could not understand game instructions.

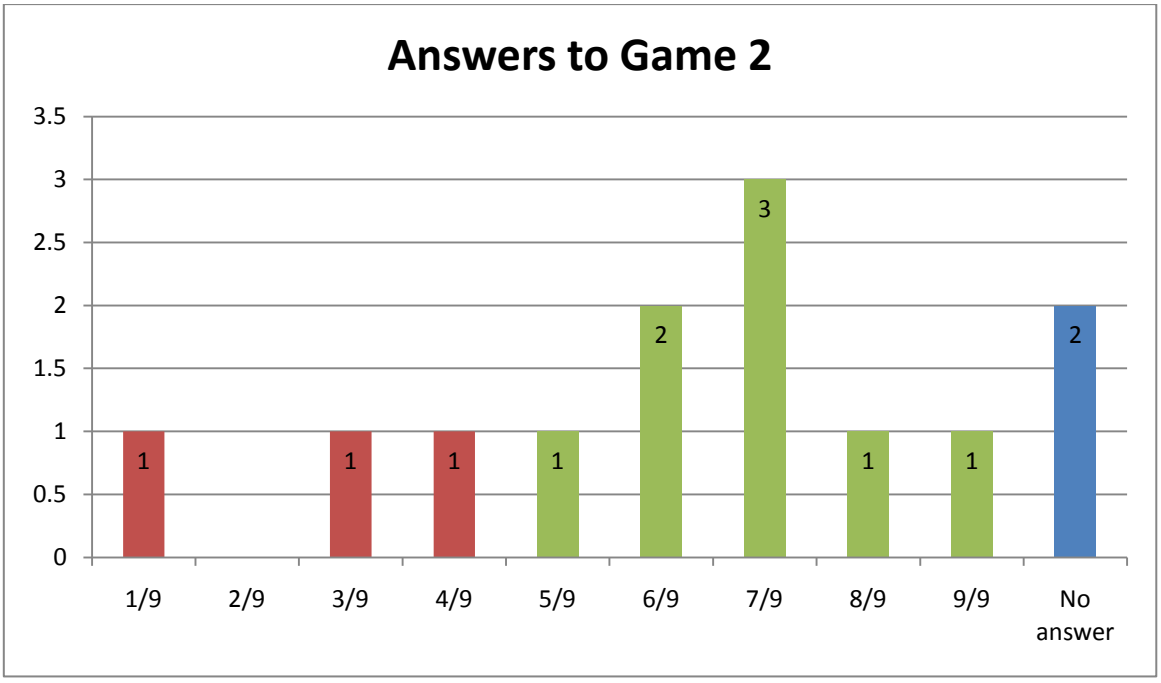
Results:

Game 1- Choose the correct piece to complete the sequence (Sequence Game)



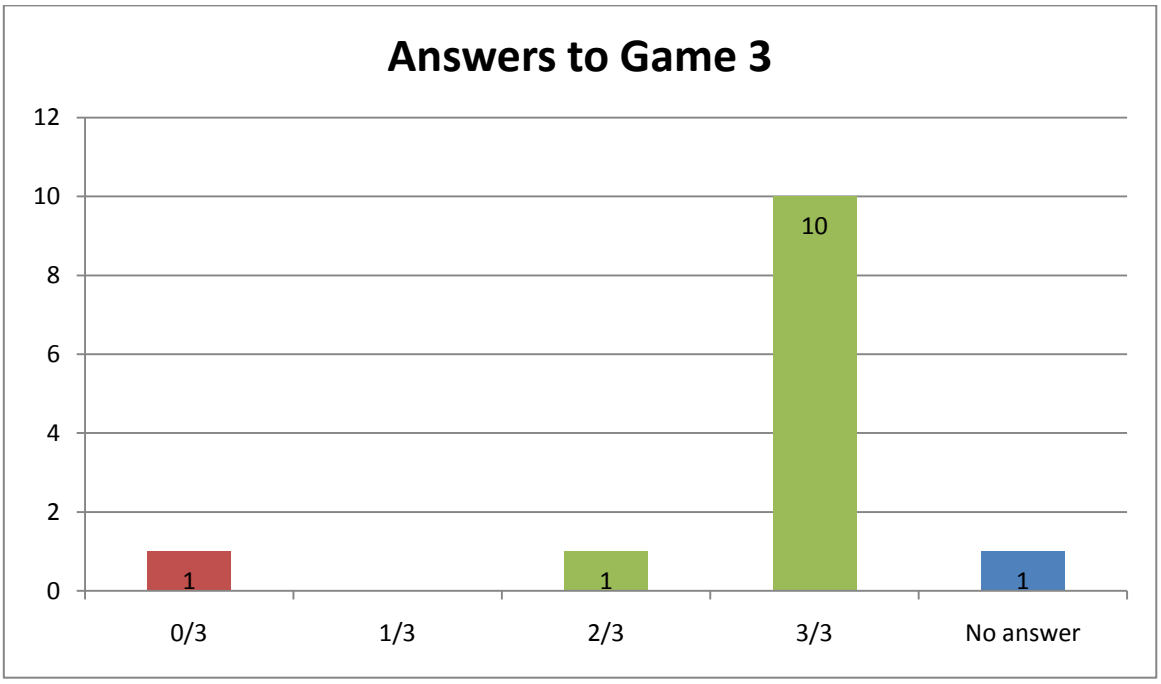
Success Rate – percentage of participants who chose the correct piece: 23%

- **Game 2 – Find 9 differences between two similar images (Find Differences Game)**



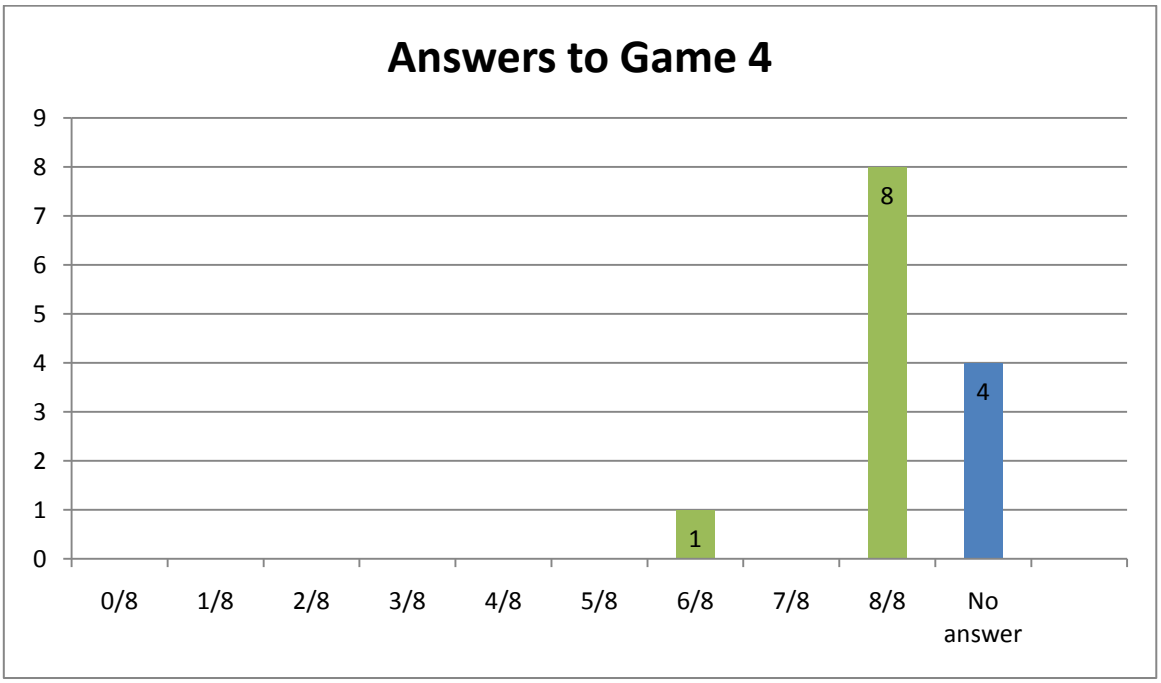
Success Rate – percentage of participants who found 5 differences or more: 62%

- **Game 3 – Match 3 letters to a picture, following a maze (Maze Game)**



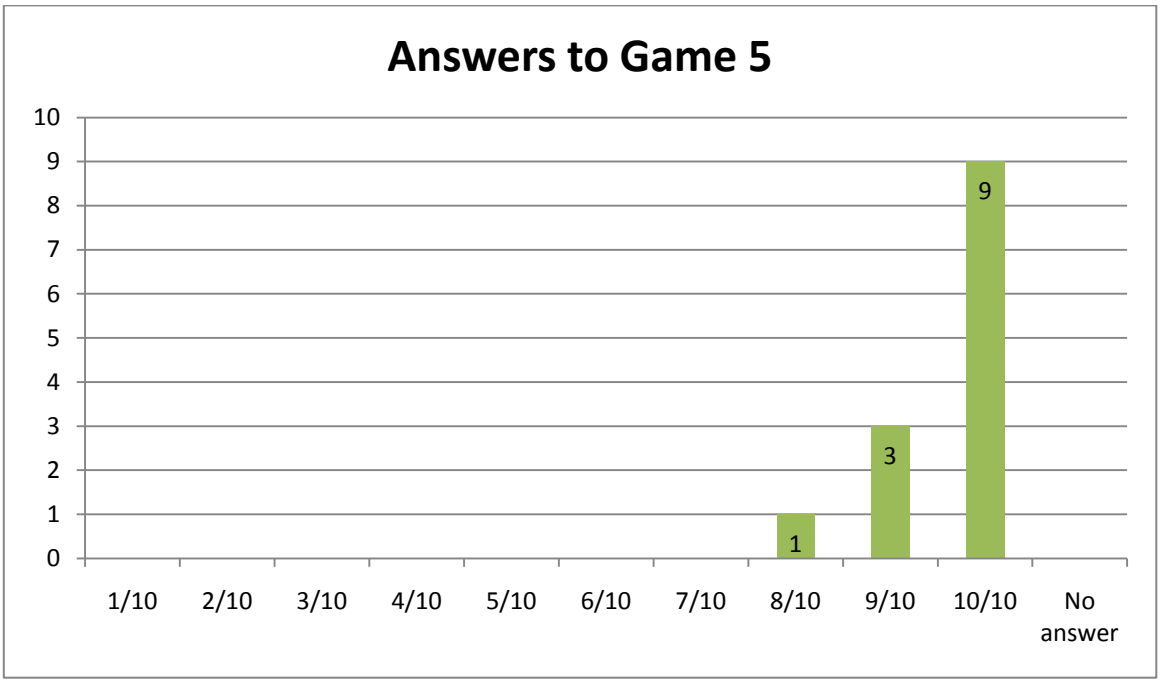
Success rate – percentage of participants that got 2 or more correct answers: 85%

- **Game 4 – Order syllables to form 8 words (Word Game)**



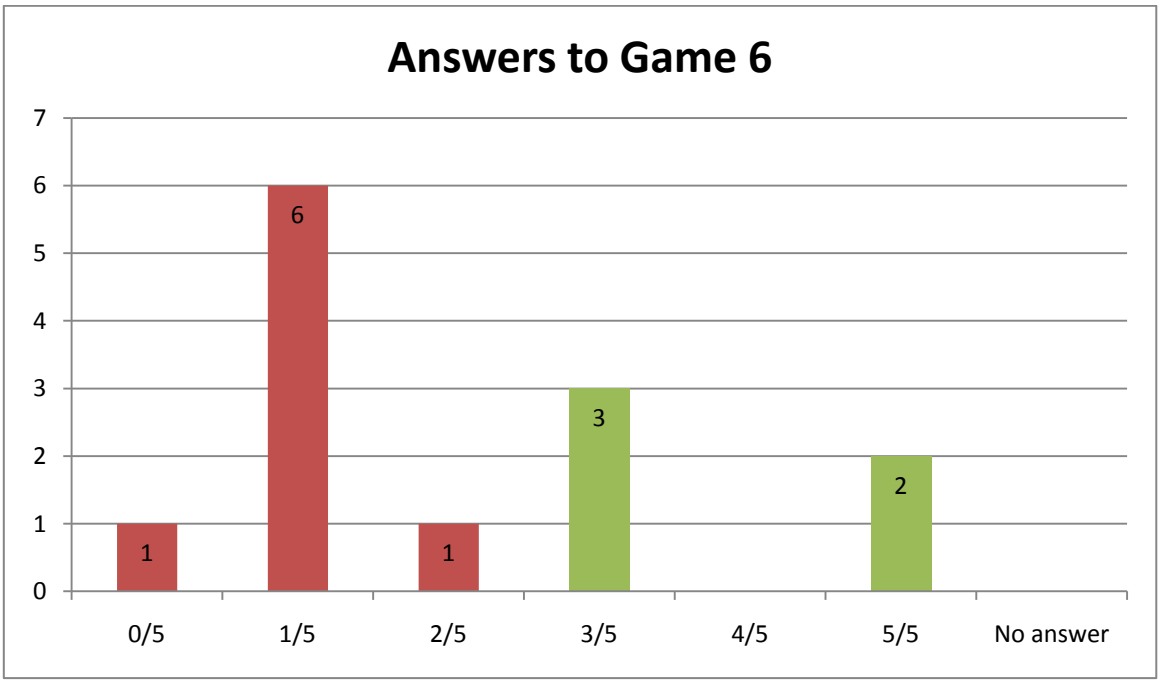
Success rate – percentage of participants that got 4 or more correct answers: 69%

- **Game 5 – Write, by memory, 10 bathroom objects (Word Game)**



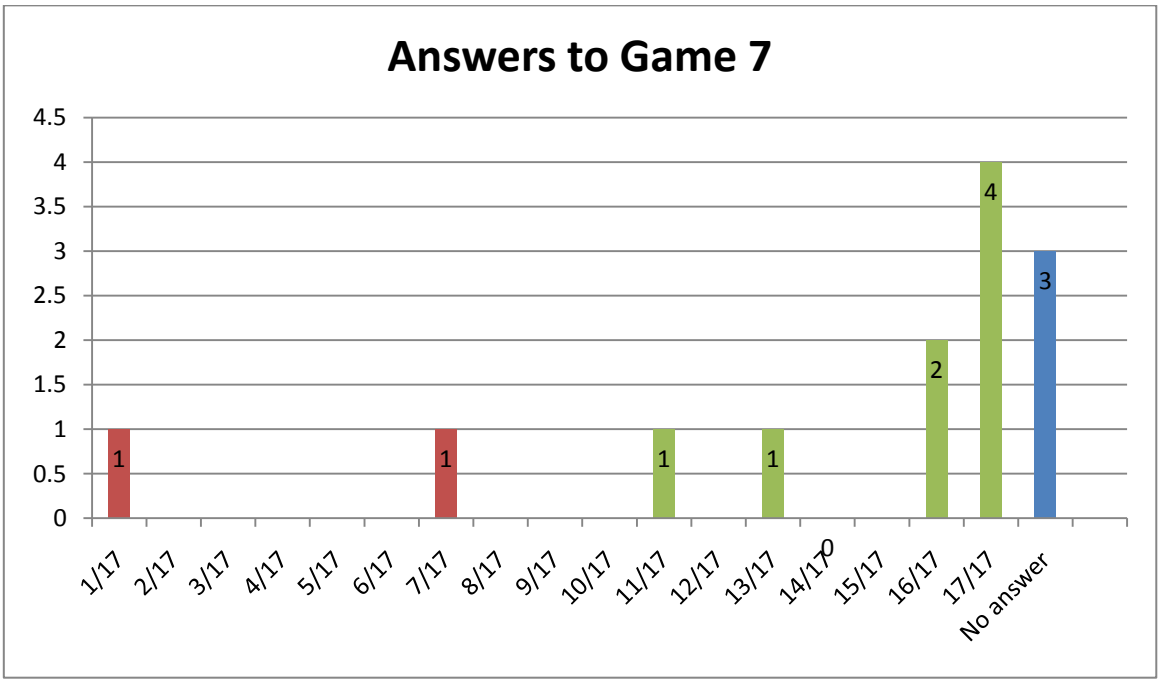
Success Rate – percentage of participants that answered 5 or more words : 100%

- **Game 6 – Answer 5 enigma questions (Enigma Game)**



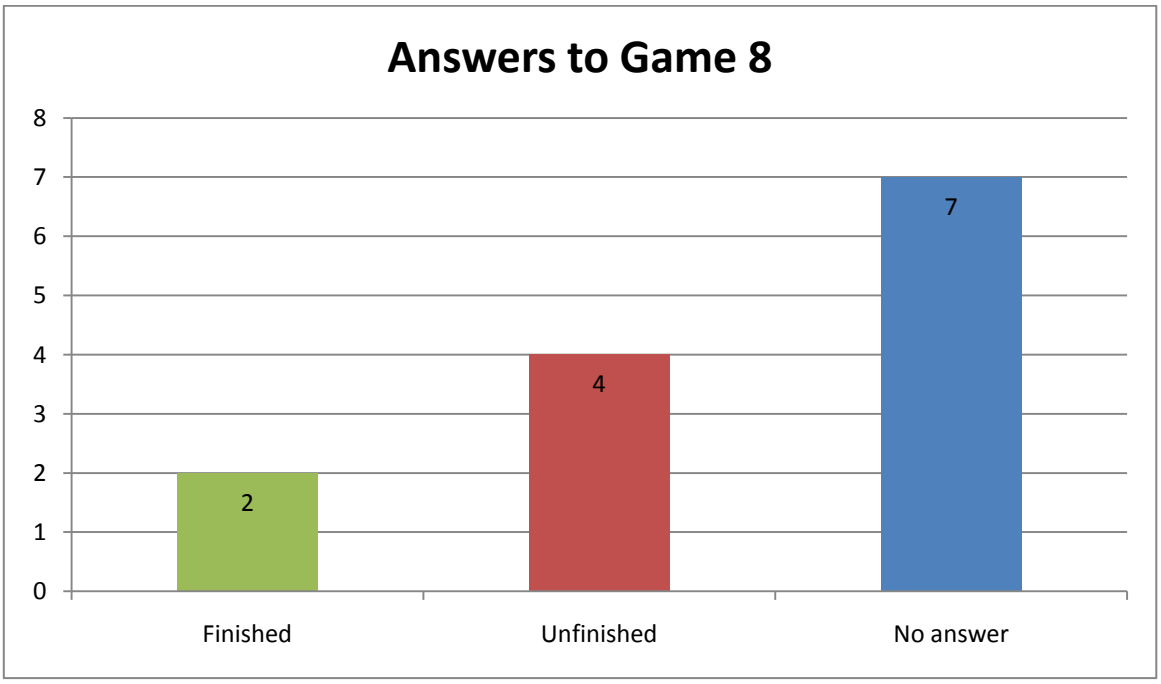
Success Rate – percentage of participants that answered correctly to 3 or more questions: 38%

- **Game 7- Find 17 words hidden in a letter s grid (Word Game)**



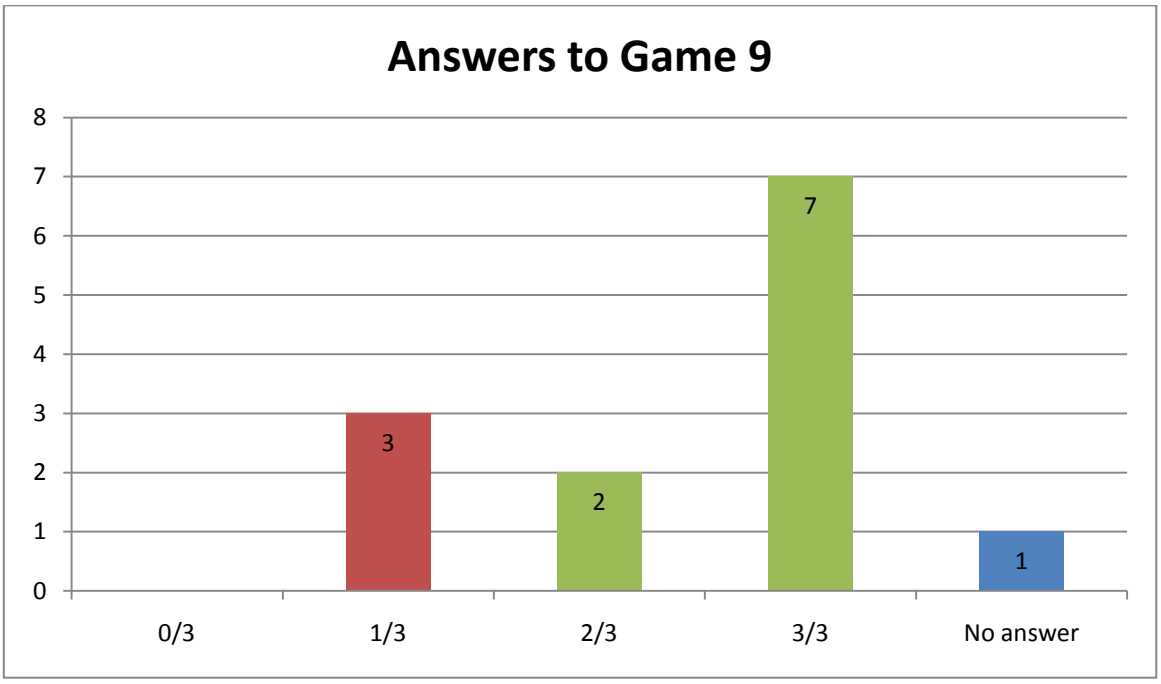
Success Rate – percentage of participants that found 9 words or more: 62%

- **Game 8 – Find the path between two points, through a maze (Maze Game)**



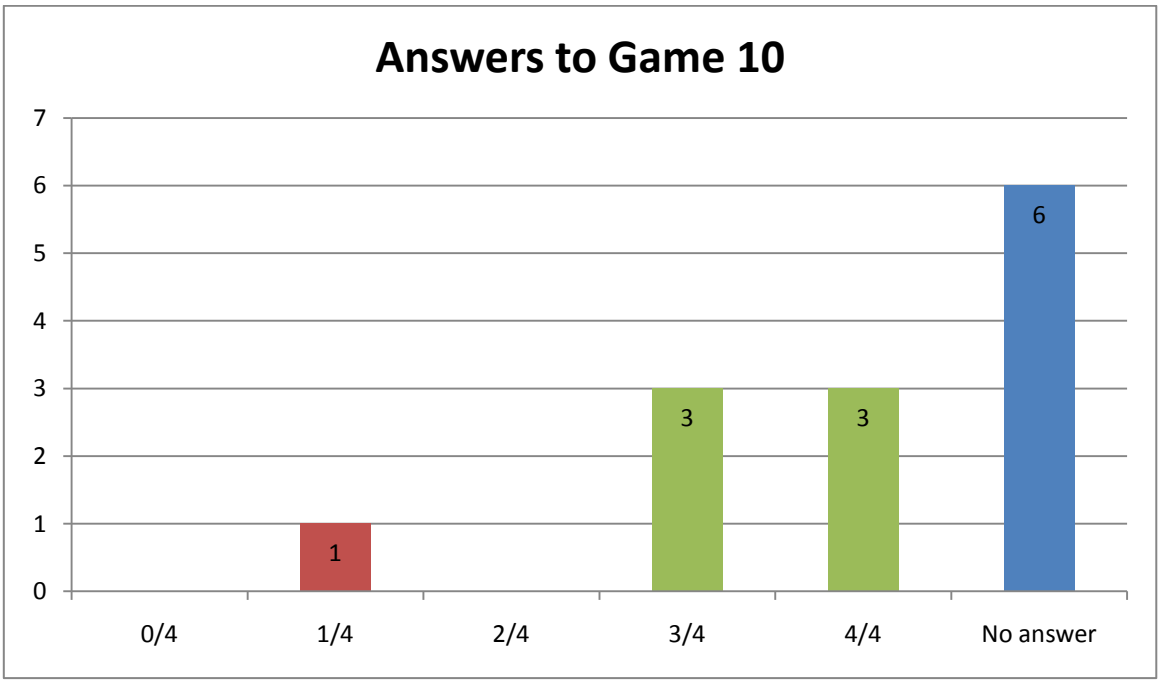
Success Rate – percentage of participants that completed the maze: 15%

- **Game 9 – Find 3 similar objects (Find Differences Game)**



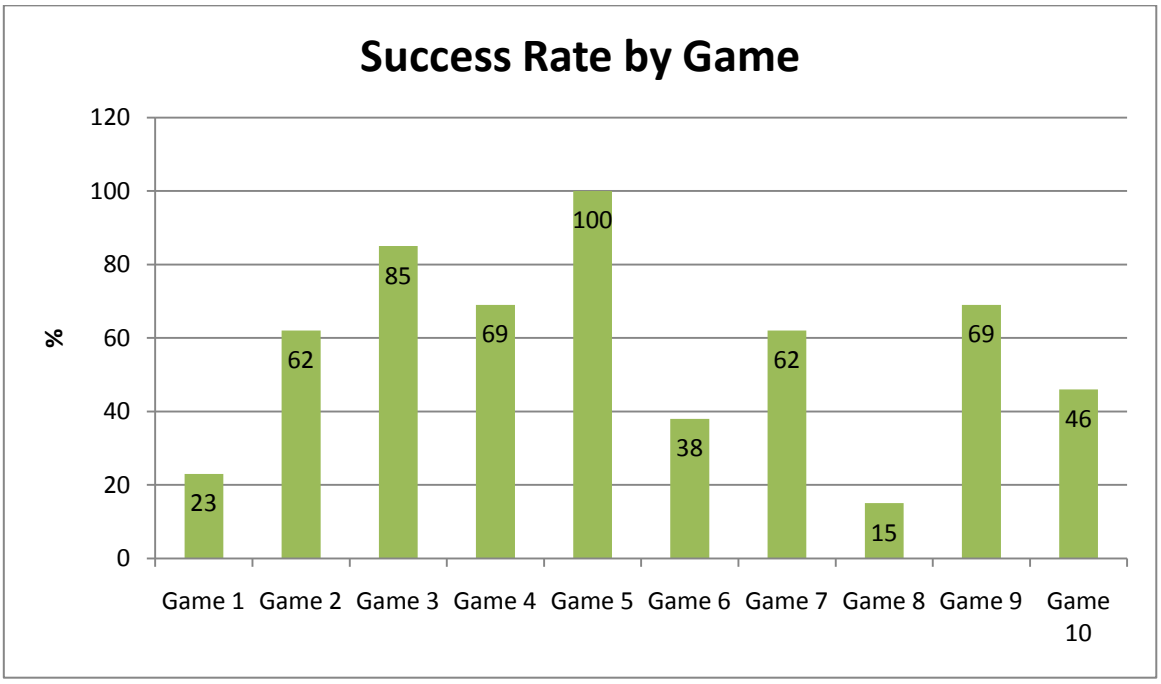
Success rate – percentage of participants that found 2 or more similar objects: 69%

- **Game 10 – Complete 4 sequences of symbols (Sequence Game)**

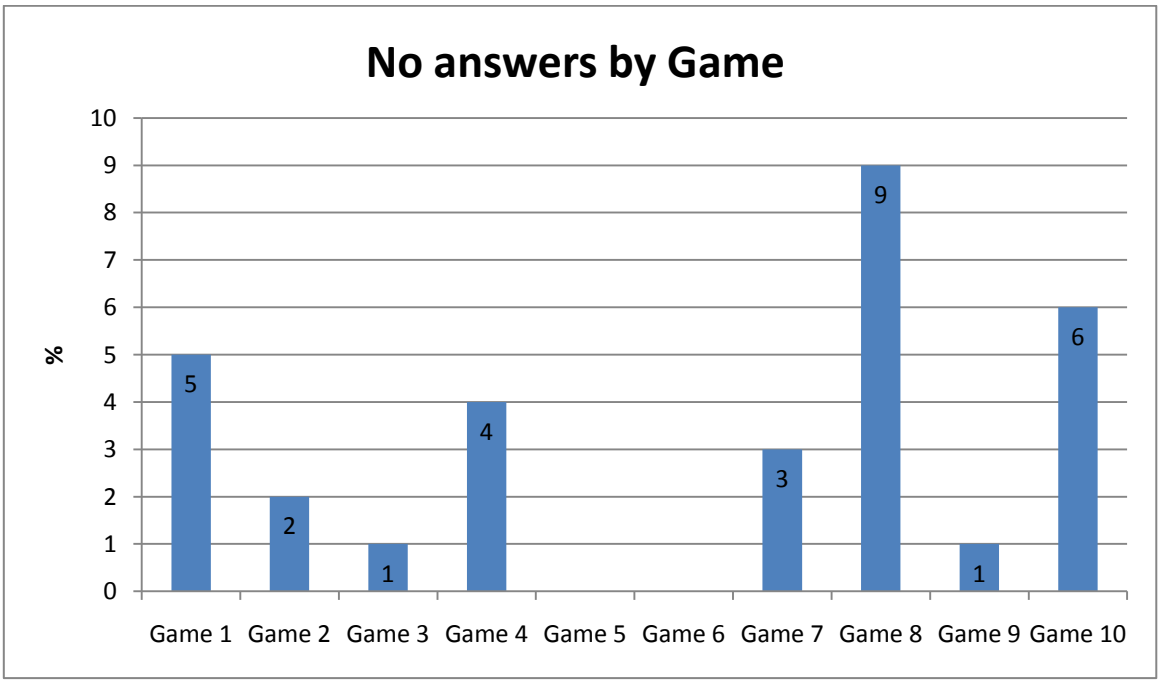


Success rate – participants that got 3 or more right sequences: 46%

- **Success Rate by game**

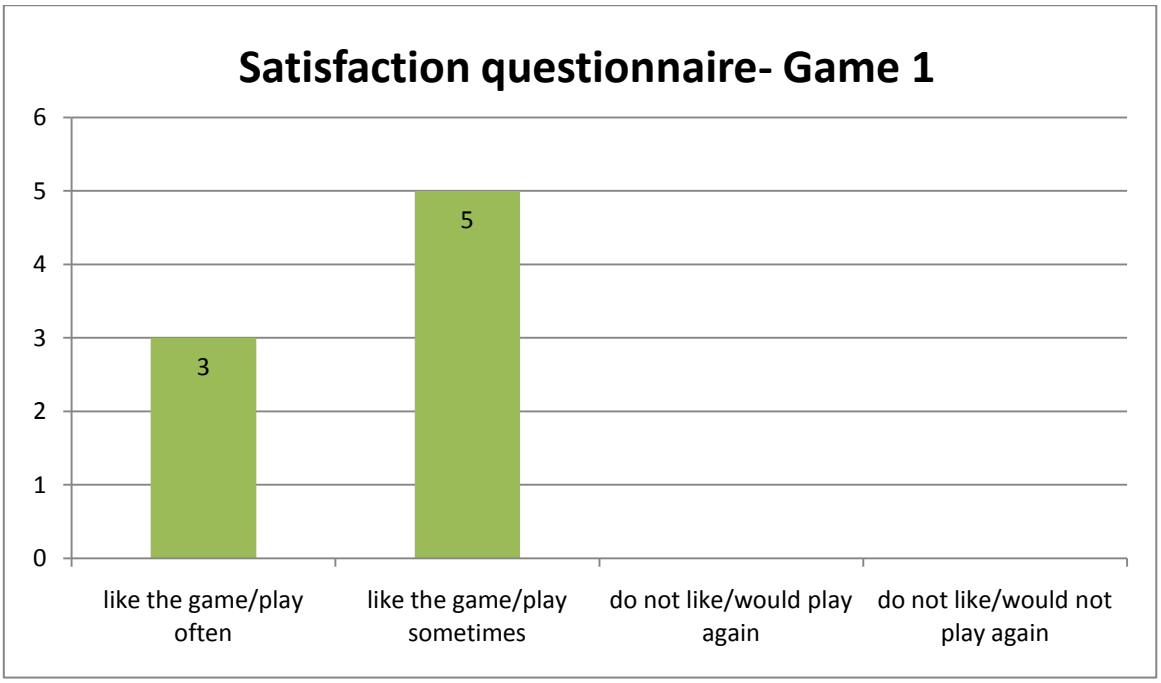


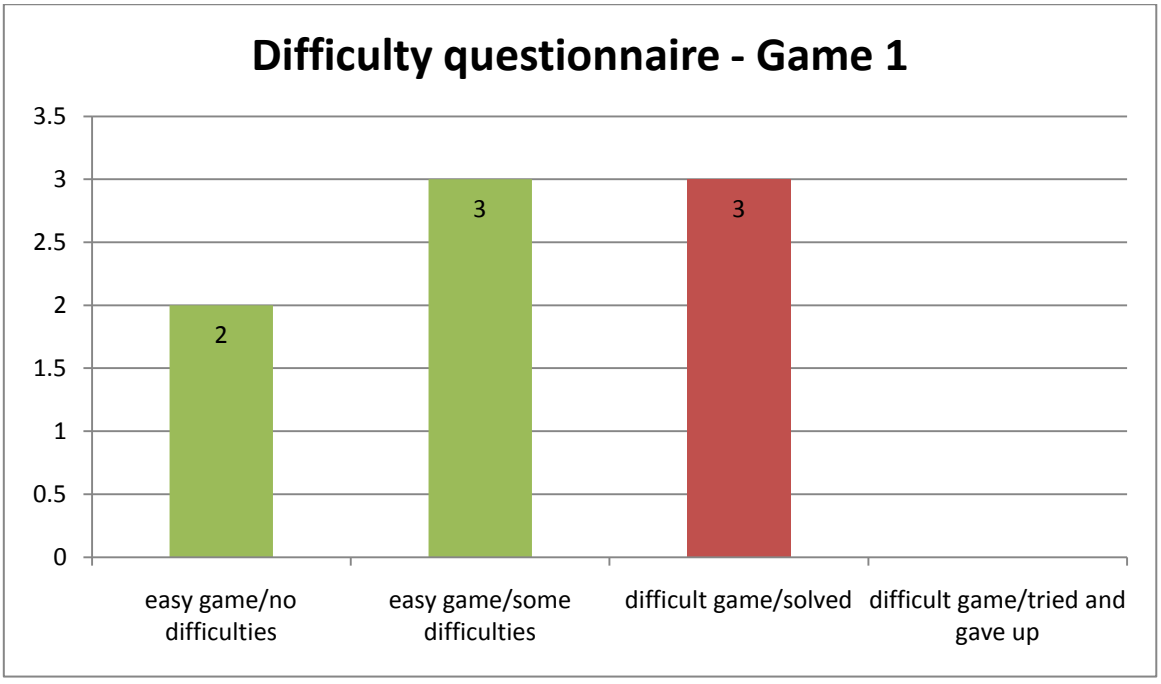
- **Percentage of players who did not answer a game**



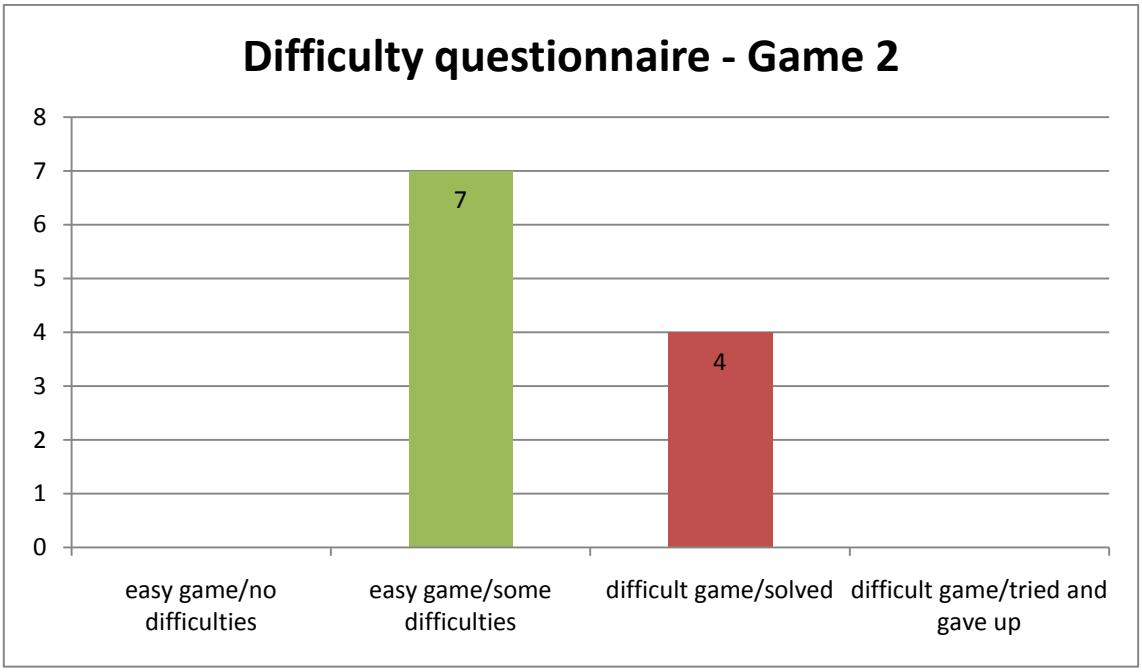
Answers to the questionnaires

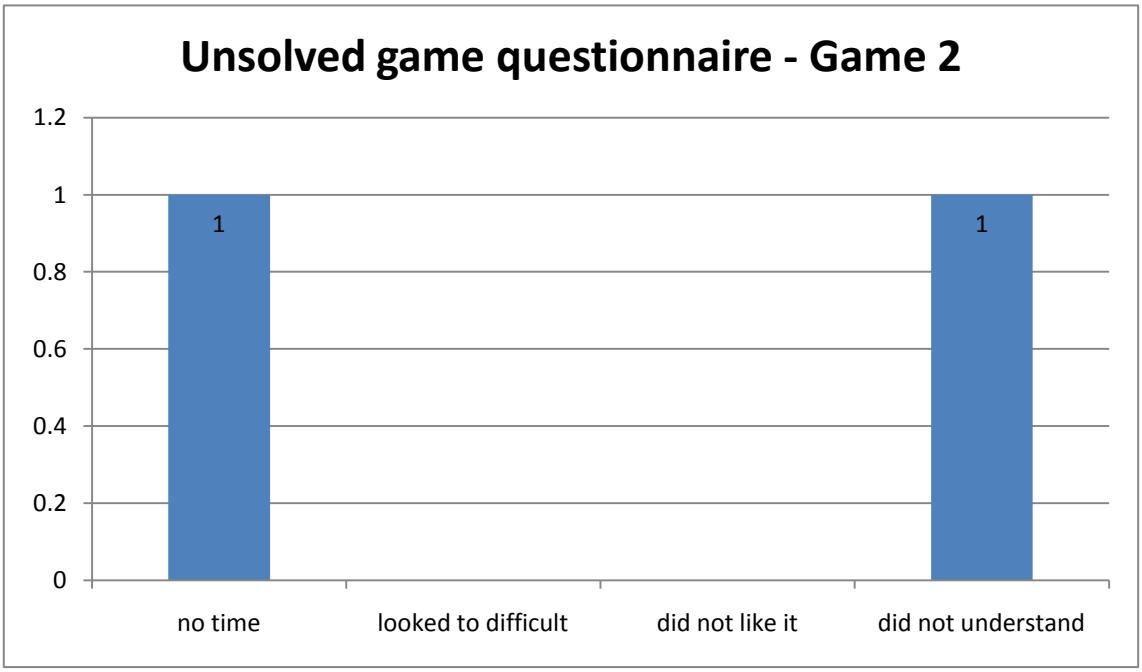
- **Game 1- Choose the correct piece to complete the sequence (Sequence Game)**



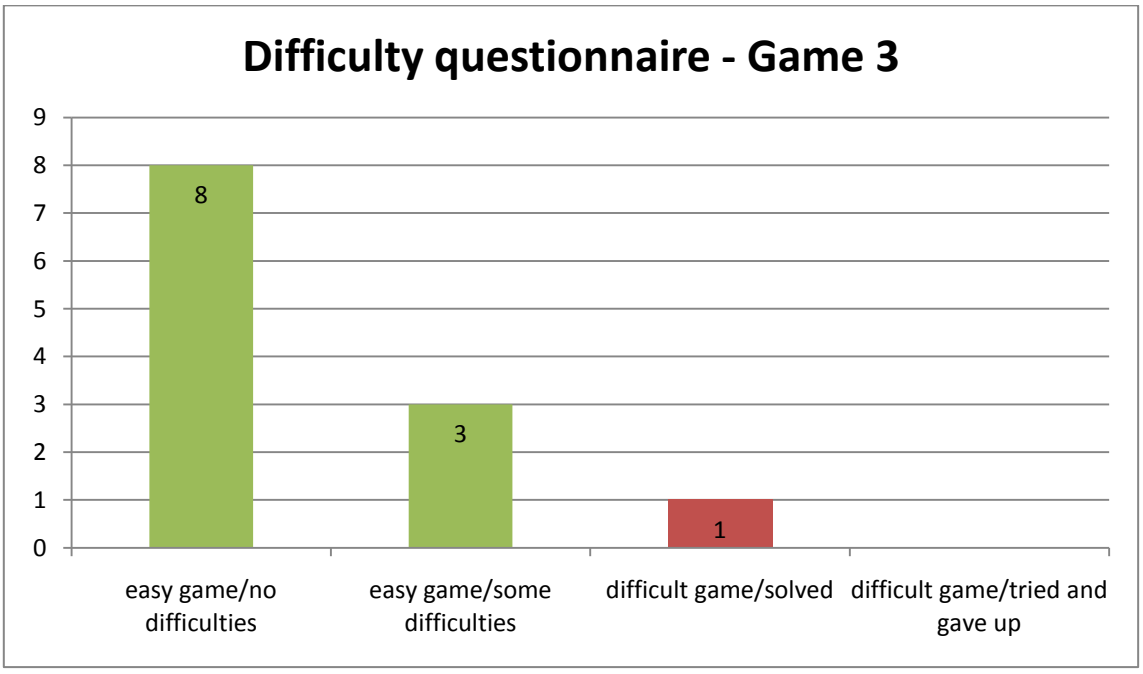


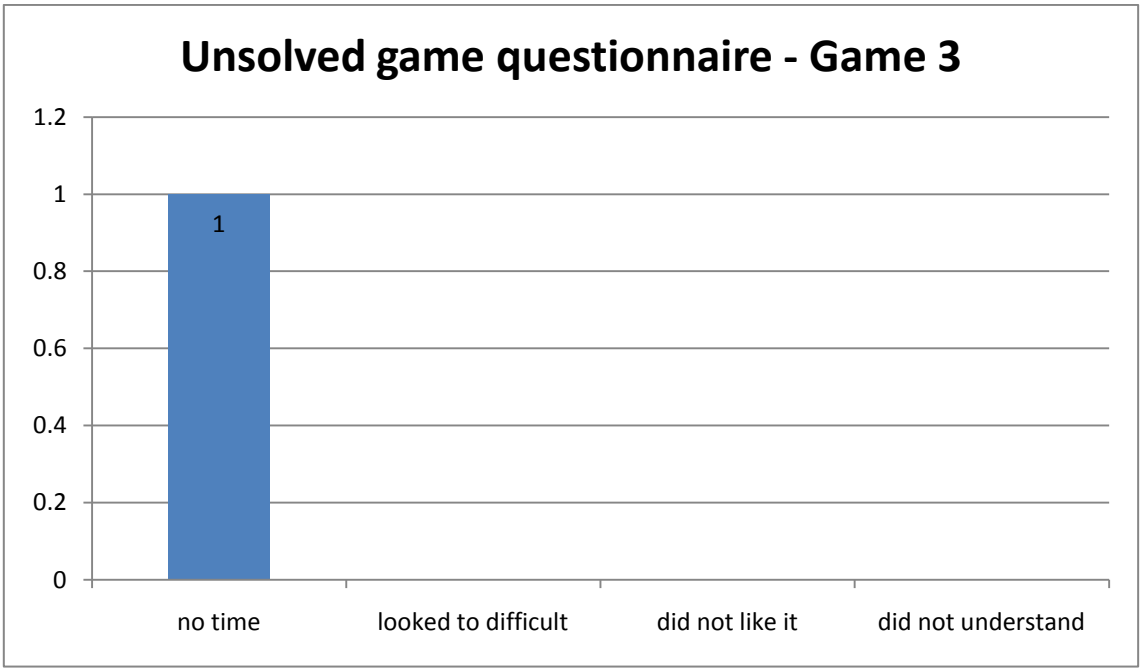
- **<u>Game 2 – Find 9 differences between two similar images (Find Differences Game)</u>**


Difficulty questionnaire - Game 2
8
7
6
5
4
3
2
1
0
7
4
easy game/no difficulties
easy game/some difficulties
difficult game/solved
difficult game/tried and gave up

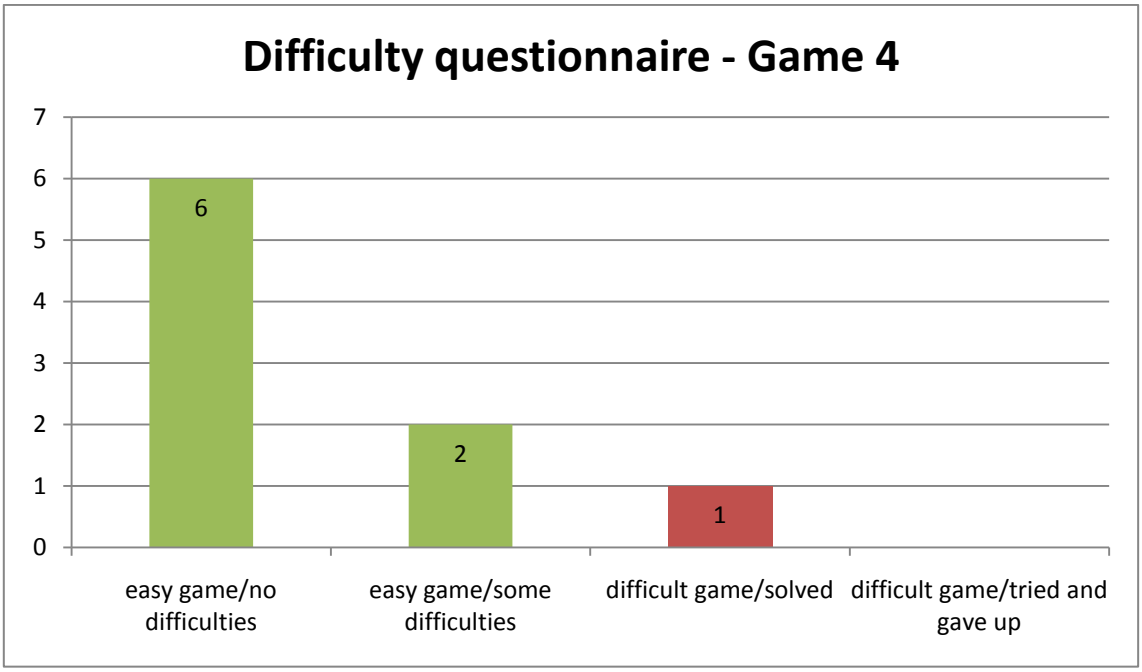

Unsolved game questionnaire - Game 2
1.2
1
0.8
0.6
0.4
0.2
0
1
1
no time
looked to difficult
did not like it
did not understand

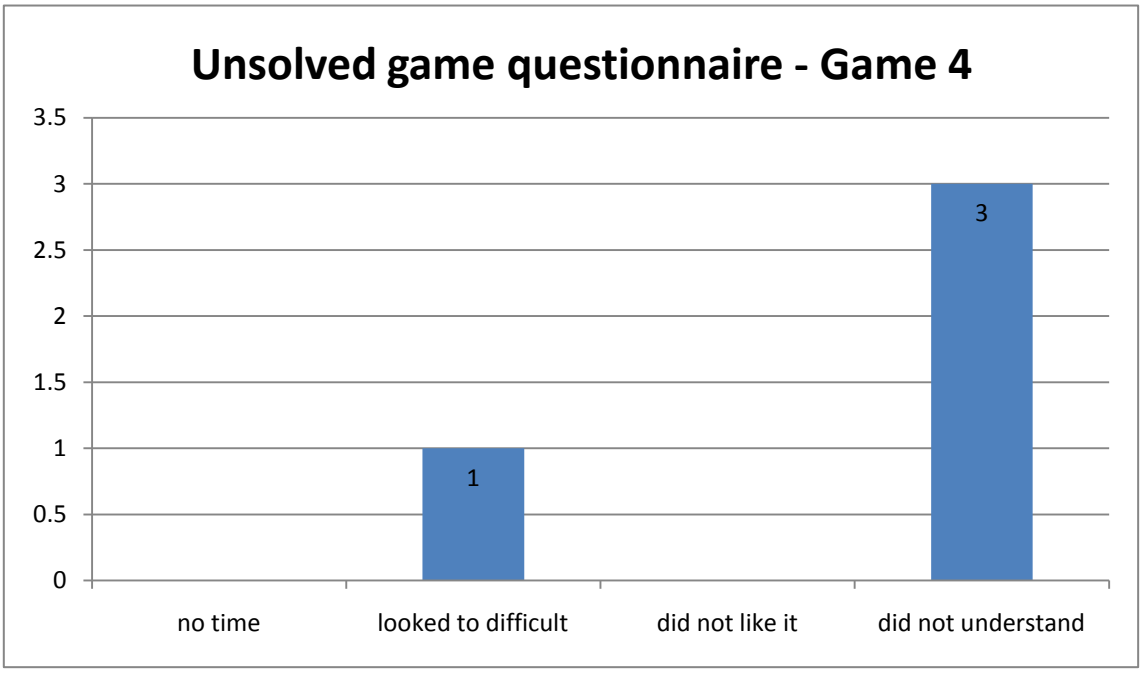
- **Game 3 – Match 3 letters to a picture, following a maze (Maze Game)**



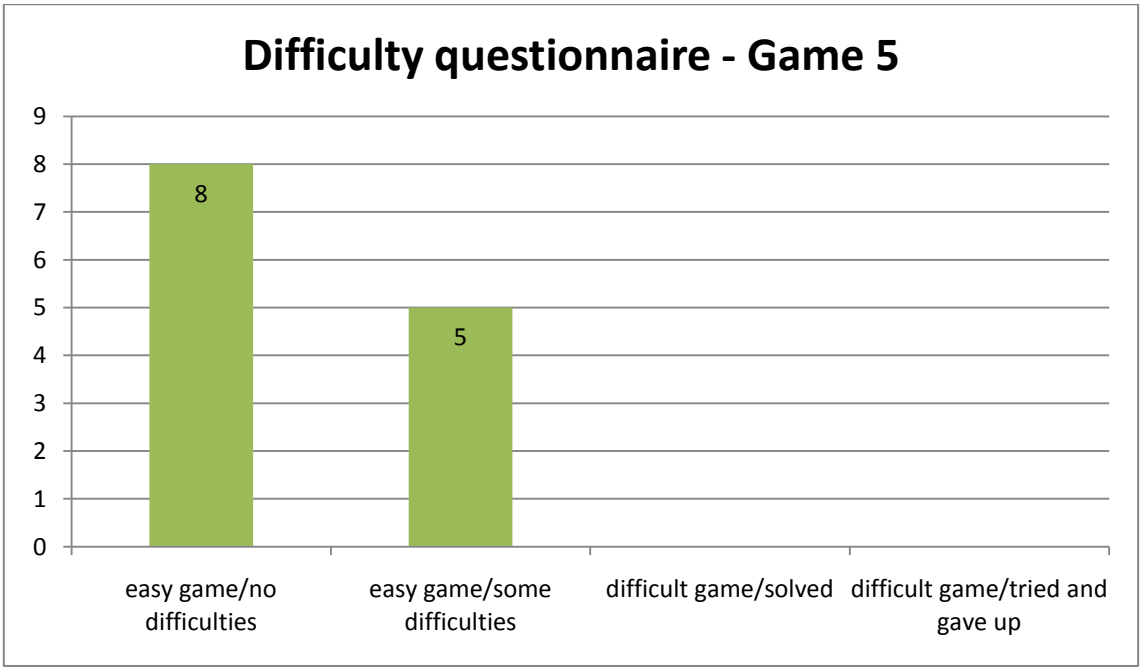


- **Game 4 – Order syllables to form 8 words (Word Game)**

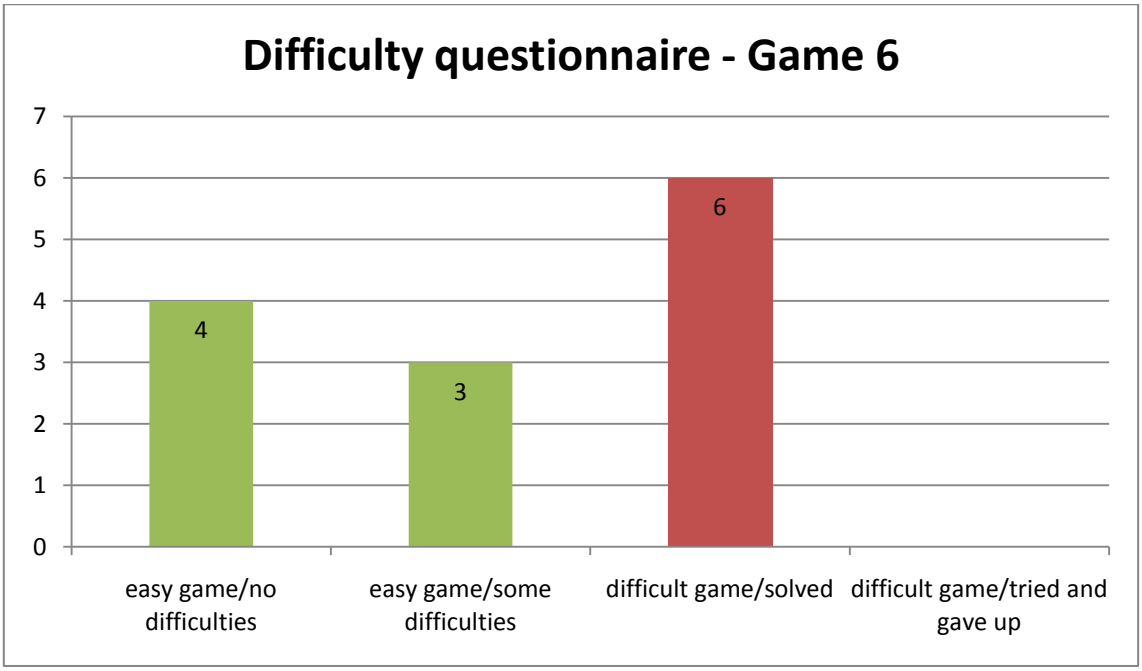

Difficulty questionnaire - Game 4
7
6
5
4
3
2
1
0
6
2
1
easy game/no difficulties
easy game/some difficulties
difficult game/solved
difficult game/tried and gave up


Unsolved game questionnaire - Game 4
3.5
3
2.5
2
1.5
1
0.5
0
1
3
no time
looked to difficult
did not like it
did not understand

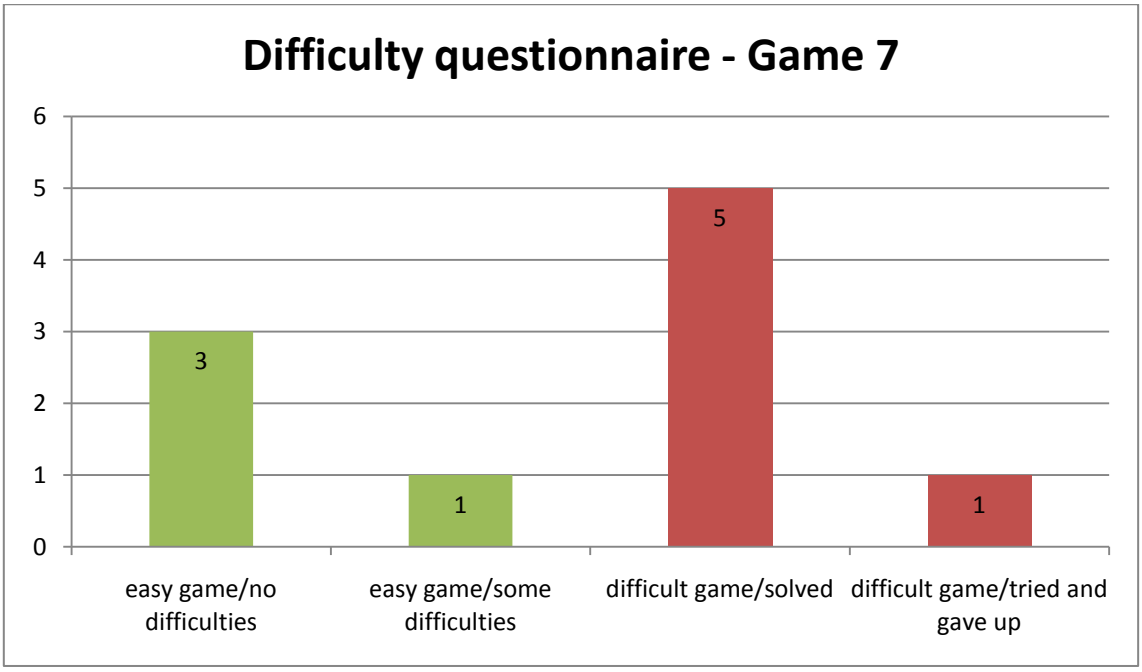
- **Game 5 – Write, by memory, 10 bathroom objects (Word Game)**

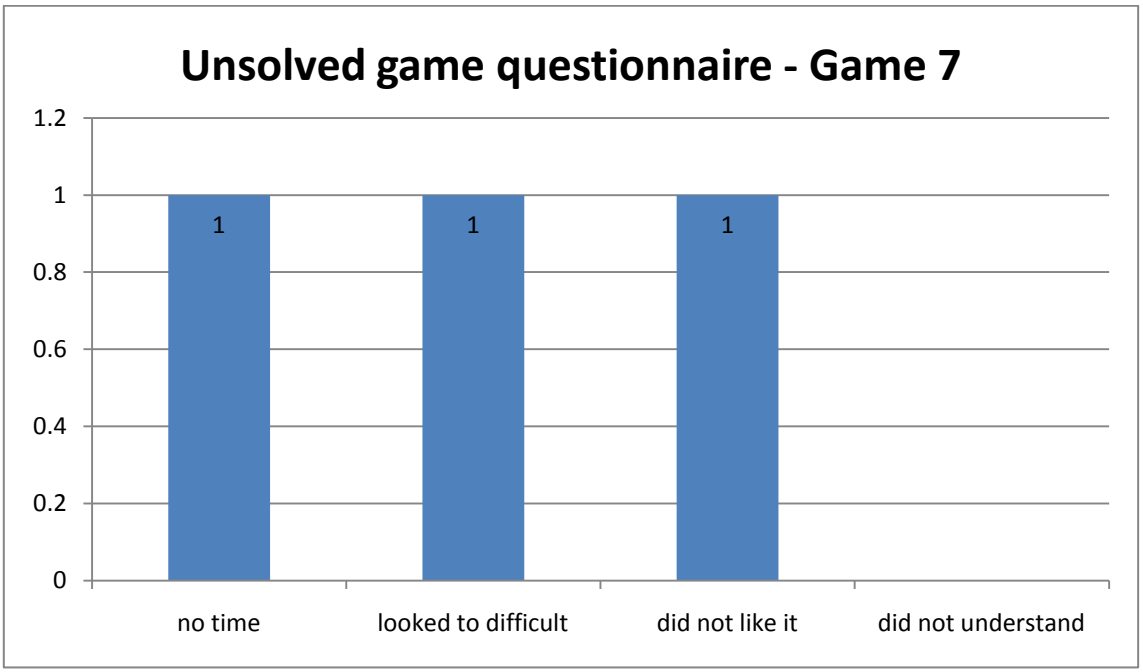


- **Game 6 – Answer 5 enigma questions (Enigma Game)**

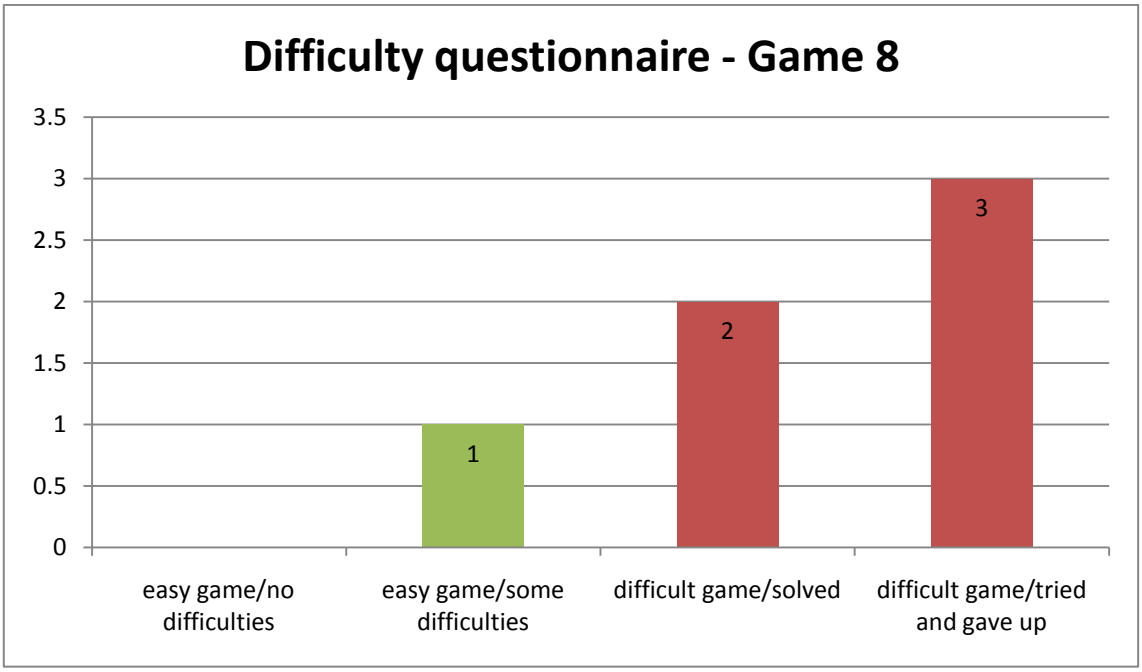


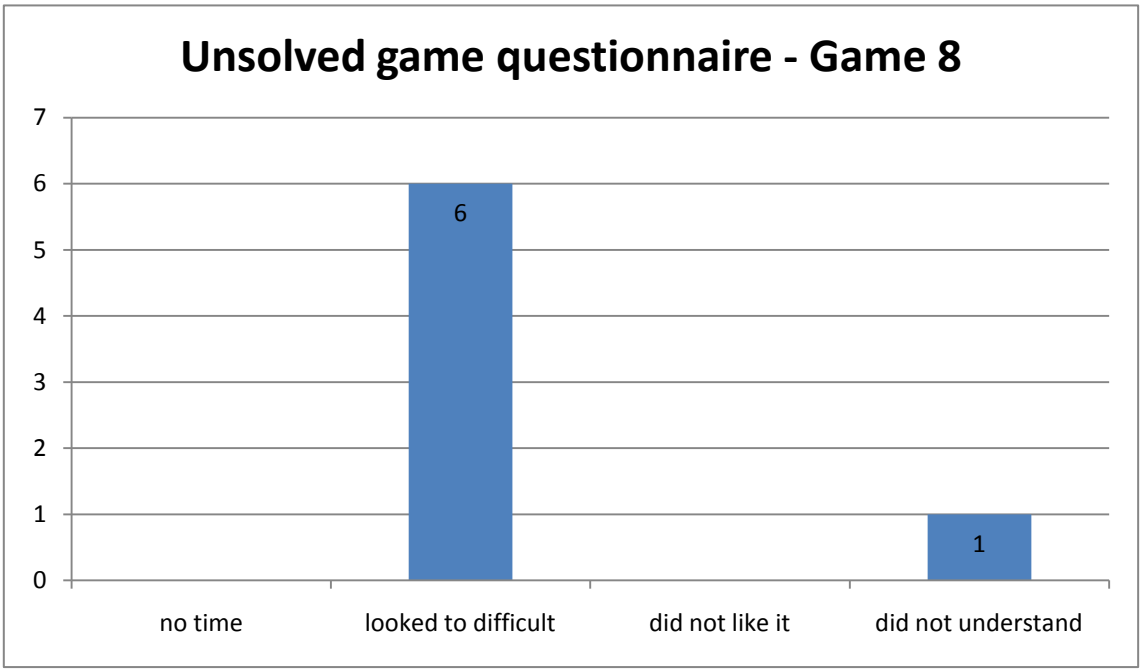
- **Game 7- Find 17 words hidden in a letter s grid (Word Game)**



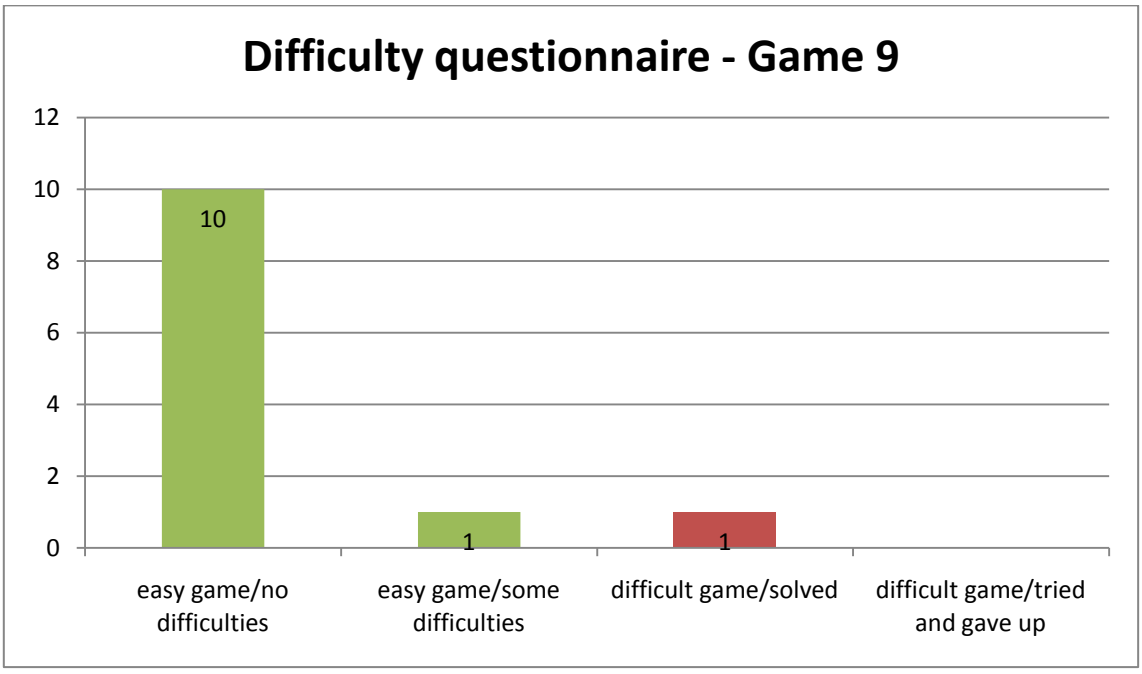


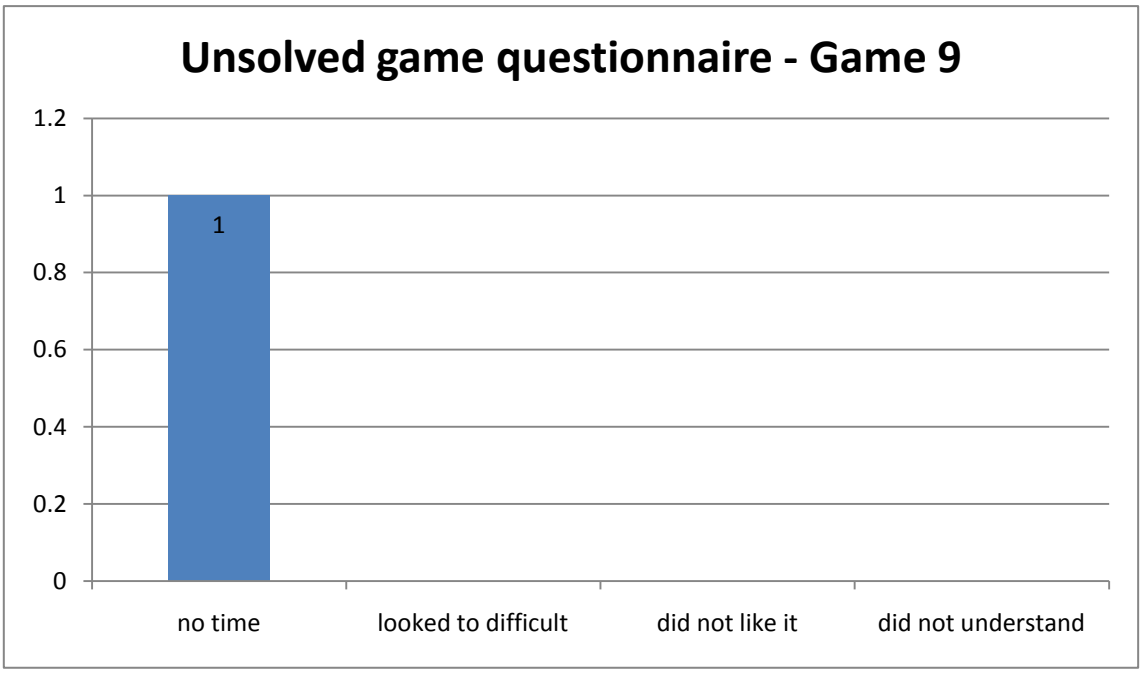
- **Game 8 – Find the path between two points, through a maze (Maze Game)**


Difficulty questionnaire - Game 8
3.5
3
2.5
2
1.5
1
0.5
0
1
2
3
easy game/no difficulties
easy game/some difficulties
difficult game/solved
difficult game/tried and gave up

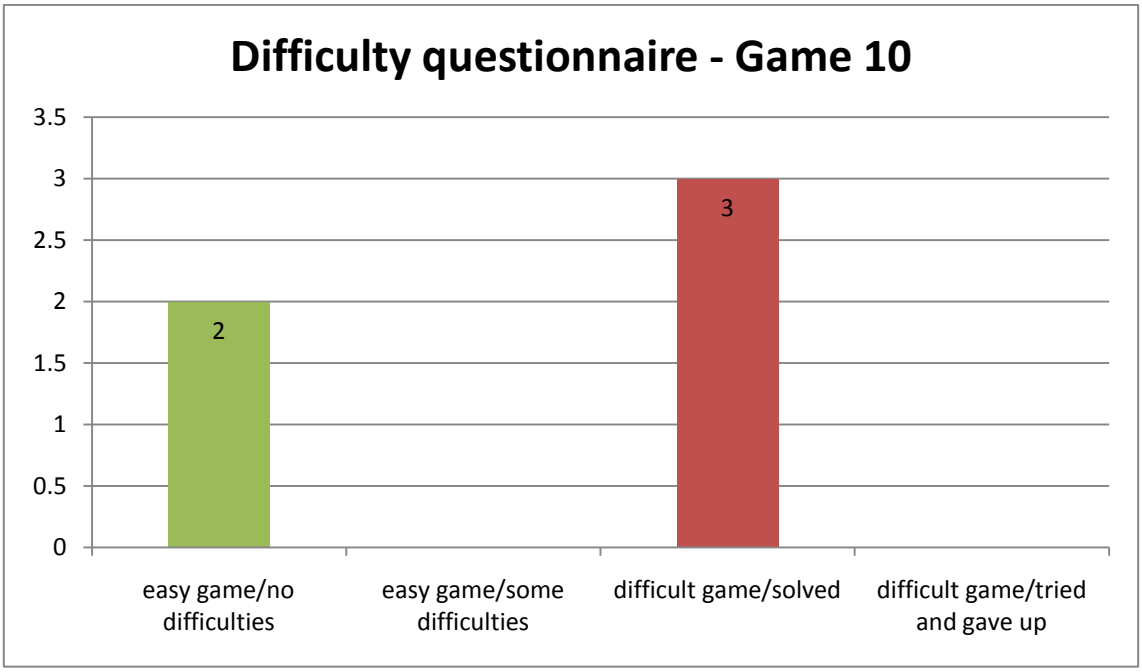

Unsolved game questionnaire - Game 8
7
6
5
4
3
2
1
0
6
1
no time
looked to difficult
did not like it
did not understand

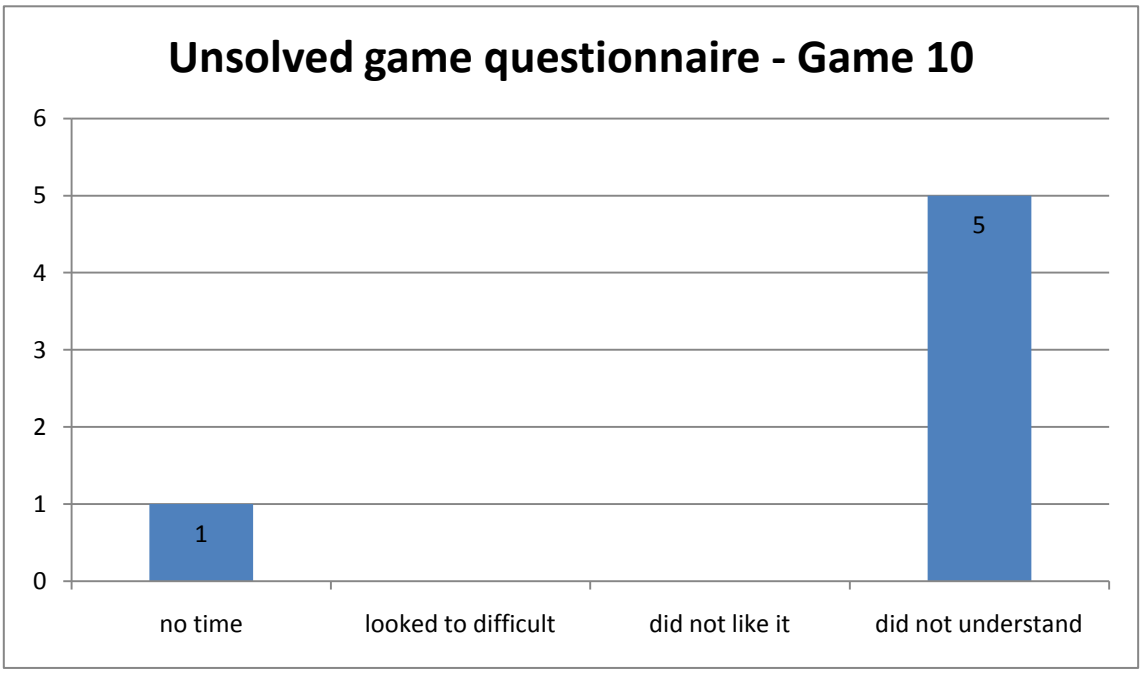
- **Game 9 – Find 3 similar objects (Find Differences Game)**

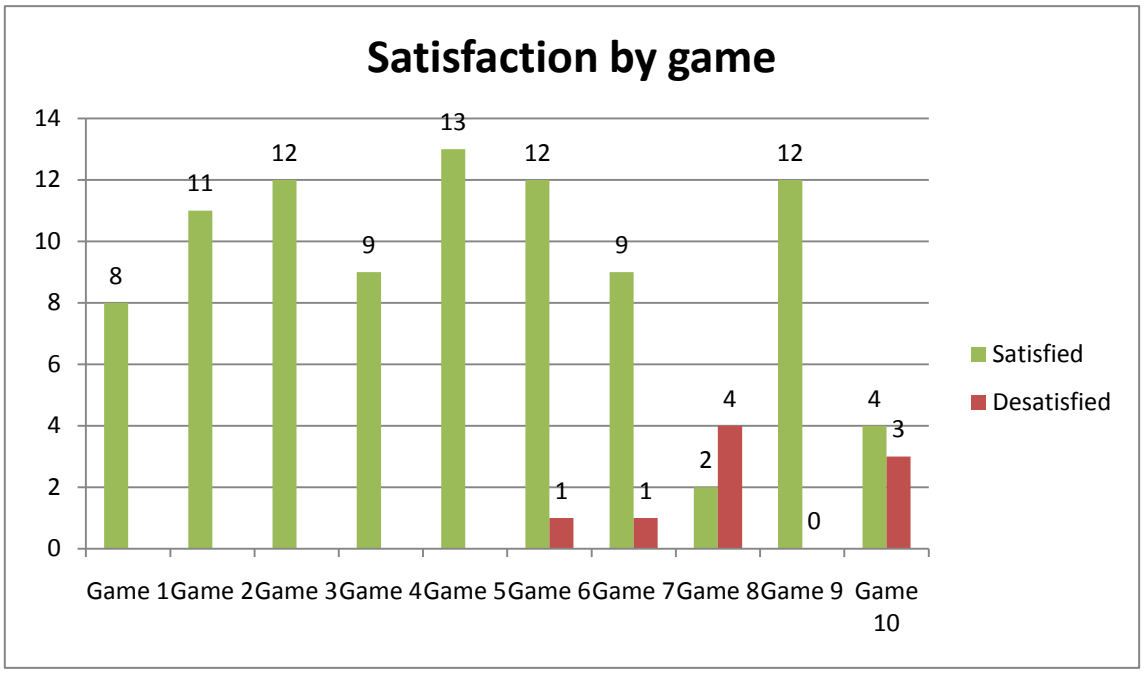


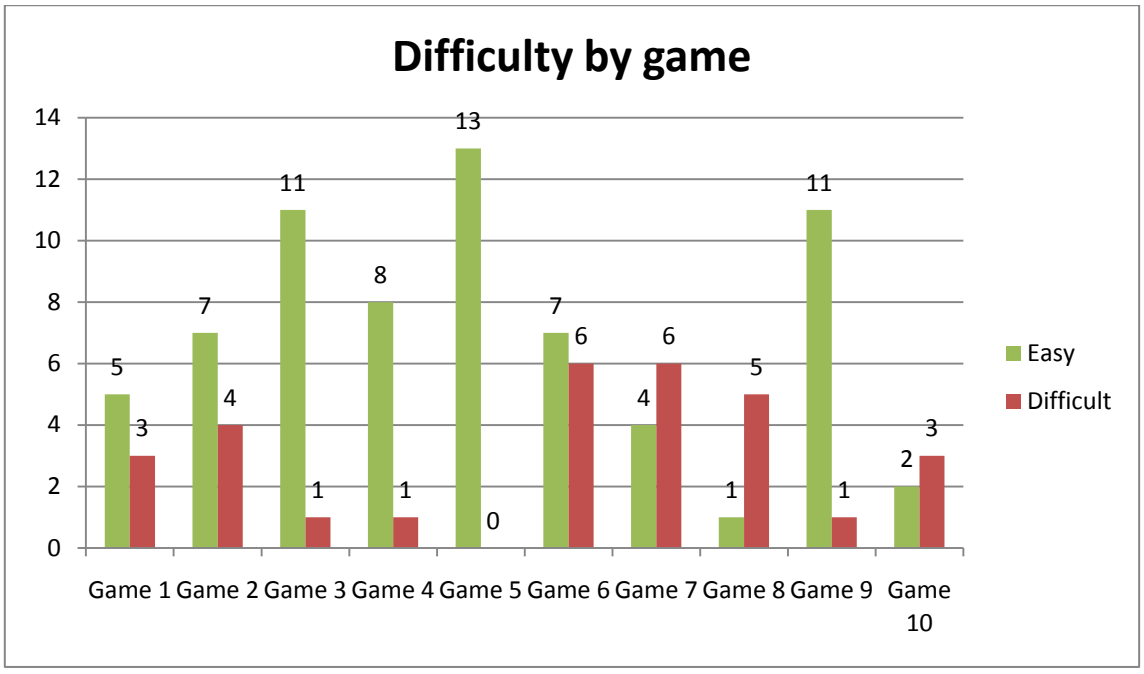


- **<u>Game 10 – Complete 4 sequences of symbols (Sequence Game)</u>**


Difficulty questionnaire - Game 10
3.5
3
2.5
2
1.5
1
0.5
0
2
3
easy game/no difficulties
easy game/some difficulties
difficult game/solved
difficult game/tried and gave up


Unsolved game questionnaire - Game 10
6
5
4
3
2
1
0
1
5
no time
looked to difficult
did not like it
did not understand


Satisfaction by game
14
12
10
8
6
4
2
0
8
11
12
9
13
12
1
9
1
2
4
12
0
4
3
Game 1
Game 2
Game 3
Game 4
Game 5
Game 6
Game 7
Game 8
Game 9
Game 10
Satisfied
Desatisfied


Difficulty by game
14
12
10
8
6
4
2
0
5
3
7
4
11
1
8
1
13
0
7
6
4
6
1
5
11
1
2
3
Game 1
Game 2
Game 3
Game 4
Game 5
Game 6
Game 7
Game 8
Game 9
Game 10
Easy
Difficult

Participants' Comments

"My daughter helped overcome my challenges. I enjoyed the games and would play more."

M.F. (F), 85

"I like to play alone and with other people."

D. (F), 77

"I solved it while I was keeping company to my husband who is sick and in bed. Is was quite good because he saw I was busy and tried not to bother me so often, only when it was really necessary."

M.A. (F), 79

"I like to play with my friends because we help each other."

M.A. (F), 78

"I don't play that often, but when I do I usually need help."

A. (F), 77

"I always need help to solve these puzzles. I become very tired and I lose my patience."

A. (M), 77

"I solved the book while I was with my grandchildren. They were doing their homework and when I needed I asked them to help me."

L. (F), 74

"I play to entertain myself and I usually play when I wake up in the middle of the night and I can't go back to sleep. I also prefer to play alone so I can concentrate."

F. (F), 82

Chapter 8

Appendix B

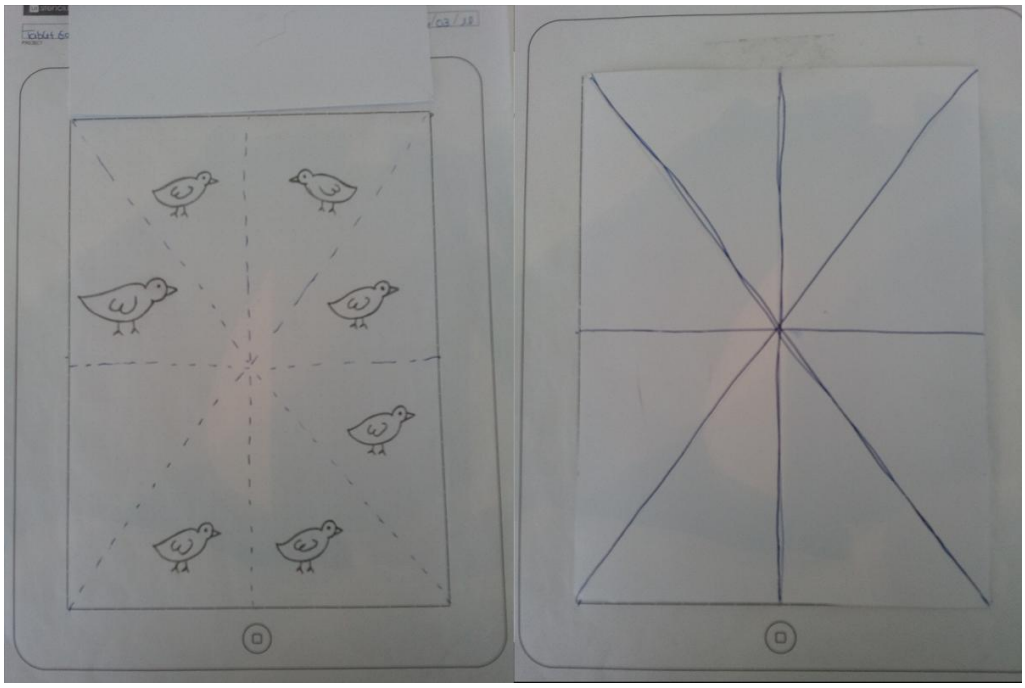
This appendix contains the protocols and results of the user tests as well as the results from the game book experience.

8.1 Usability Test 1 Protocol

Usability Test Nº 1 24-03-2011

Prototypes:

- 24-P: Memory Attention Mini game
  - Screen divided into 8 equal areas.
  - 1 empty area
  - 1 bird bigger than the others
  - 1 bird symmetric to the others
  - Remaining birds are all alike
  - 1 blank screen divided in the same 8 equal areas



Objectives:

- Understand if they are able to recognize the bigger bird, the symmetric bird and the empty space.
- Understand if they are able to memorize the location of the different elements.
- Understand it they can identify the areas of the bird screen on the blank screen.
- Assess the number of elements that they can identify and memorize.
- Identify difficulties in the comprehension of game rules and adapt their explanation.

Protocol:

1. **Introduction**

    a. "Hi, my name is Ana and I am developing games for cognitive stimulation. Here I have an example of what I am developing, it's just a mini game and I need your help to understand if you enjoy the game and if it is appropriate for you. Would you like to play with me?
    Don't worry if you find the game too difficult or if you answer incorrectly, it is not your fault. We want to evaluate the game and not your answers; it is the game that needs to be adapted to your needs."

2. **Playing the game**

    a. "Now I need you to look at this screen with the birds and tell me if you find any differences among them. If you do can you please point them out for me?"

    b. "Now I will cover the screen with this blank screen that is divided just like the one with the birds."

        i. **Scenario 1: The participant only recognizes the bigger bird**
            - "Can you please point to the area on this screen where the big bird was?"

        ii. **Scenario 2: The participant only recognized the empty space**
            - "Can you please point to the area on this screen where the empty space was?"

        iii. **Scenario 3: The participant recognized the symmetric bird**
            - "Can you please point to the area where the symmetric bird was?"

        iv. **Scenario 4: The participant recognized more than one element.**
            1. We asked them where the elements were, one question at a time, always in the following order: bigger bird, empty space, symmetric bird, limiting the questions to the elements they found.

3. **Thank you**

Results:

Participant	Bigger Bird	Symmetric Bird	Empty Space
1	V	-	-
2	V	-	-
3	V	-	-
4	V	-	-
5	V	-	-
6	V	-	-
7	V	-	-
8	V	-	-
9	V	-	-
10	V	-	-
11	V	-	-
12	V	-	-
13	V	-	-
14	V	-	-
15	V	X	X
16	V	V	-
17	V	-	V
18	X	-	V
19	V	V	X

V: Identifies the difference and answers correctly

X: Identifies the difference but answers incorrectly

- : Doesn't identify the difference

Conclusions

Facts:

- 19/19 identified the bigger bird
- 3/19 identified the symmetric bird
- 4/19 identified the empty space
- 14/19 identified 1 difference
- 3/19 identified 2 differences
- 2/19 identified 3 differences

- All the elderly who only identified one difference answered correctly.
- 2/3 of the ones who identified two differences answered correctly, 1/3 failed one question.
- 1/2 of the ones who identified three differences answered two questions correctly, and 1/2 only answered one correctly

Conclusions:

- The bigger bird was the most recognizable difference, with all participants recognizing it. This indicates that different sizes are a characteristic that is easier to find and grabs their attention.
- Older adults had difficulties in recognizing the symmetric bird. This indicates that the difference was not substantial or that other differences were more likely to attract attention.
- They had difficulties in memorizing the position of more than one different element, which suggests that one difference at the time if a more suitable choice and not so demanding for this audience.
- Older adults that only answered to one question always answered it correctly.

TODO:

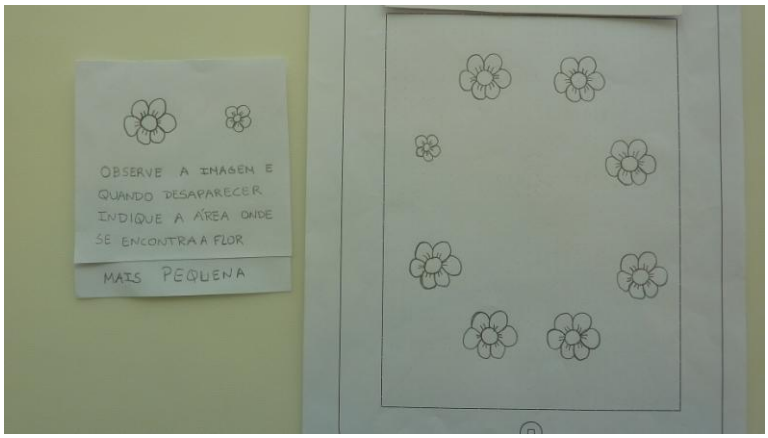
- Test game with only one difference to memorize.
- Test the time older adults need to look at the screen to memorize element's positions.
- Test the importance of screen guidelines.

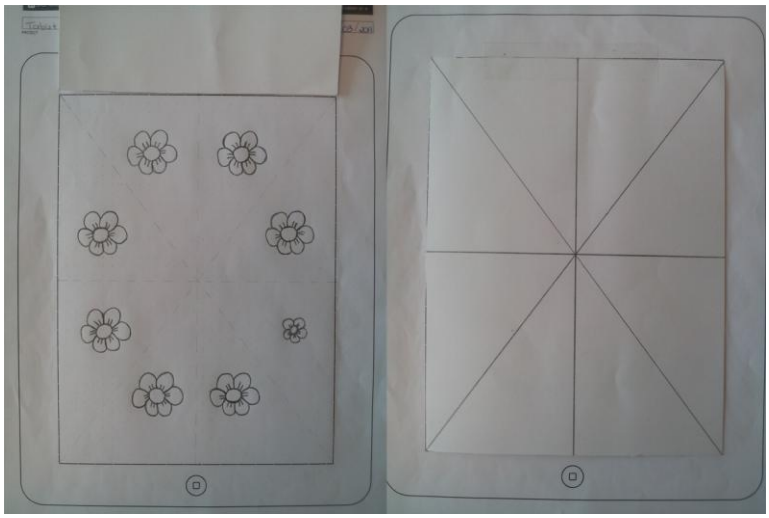
8.2 Usability Test 2 Protocol

Usability Test Nº 2 29-03-2011

Prototypes:

- Game Instructions
- 29-5S: Flower Game (5 seconds)
  - Screen divided in 8 equal sections with on-screen guidelines
  - Each section contains a flower
  - One of the sections contains a flower that is smaller than the others
  - Blank screen divided in the same sections as the flower screen
- 29-2S: Flower Game (2 seconds)
  - Same as the previous, but the flower is in another location
- 29-SL: Flower Game (without guidelines)
  - Same as the previous ones but with no on-screen guidelines





Objectives:

- Assess if 5 seconds is enough time for the older person to identify the smaller flower and memorize its position.
- Assess if 2 seconds is enough time for the older person to identify the smaller flower and memorize its position.
- Assess if the on-screen guidelines are important for them to localize the elements in the screen.

Protocol:

1. **Introduction**

    a. "Hi, my name is Ana and I am developing games for cognitive stimulation. Here I have an example of what I am developing, it's just a mini game and I need your help to understand if you enjoy the game and if it is appropriate for you. Would you like to play with me?
    Don't worry if you find the game too difficult or if you answer incorrectly, it is not your fault. We want to evaluate the game and not your answers; it is the game that needs to be adapted to your needs."

2. **Playing the game**

    a. "These are the game instructions. You can see here two flowers and one is smaller than the other, can you tell me which one is the smaller one?"
        - Show the game instructions.

    b. **"**Now I will show you a screen with 8 flowers and one of them is also smaller than the other ones. I will show you the screen for a limited time and in the end I will cover it and you will need to tell me the area in which the smaller flower was."
        - Show prototype 29-5S for 5 seconds.

    c. "Now I will show you another similar screen but you will have less time to look at it and then you do the same, just point to the area where the smaller flower was."
        - Show prototype 29-2S for 2 seconds.

    d. "Now I will show you another one, but the first screen will not have the lines that limit the areas and then you just have to do the same as in the previous ones."
        - Show prototype 29-SL.

3. **Thank you**

Results:

Nome	Idade	Flower Game (5 sec.)	Flower Game (2 sec.)	Flower Game (no guidelines)
A. (F)	84	V	V	V
A. (M)	77	V	V	V
M. (F)	70+	X	X	V
R. (M)	79	V	V	V
J. (M)	75	X	V	X
X. (M)	78	V	X	V
L. (F)	75	V	V	V
R. (F)	?	X	X	V
A. (F)	77	V	V	V
D. (F)	77	V	V	V

V – Answered correctly

X – Answered incorrectly

Facts:

- All participants were able to identify the smaller flower on game instructions and understand the game concept.
- 7/10 users answered correctly after watching the screen for 5 seconds.
- 7/10 users answered correctly after watching the screen for 2 seconds.
- 9/10 users answered correctly after watching the screen with no guidelines.

Conclusions:

- The difference between 5 and 2 seconds is not significant since the same amount of participants were able to answer correctly.
- The guidelines are not important since only one participant answered the question incorrectly.
- Having a limited amount of time to look at the screen made the game more challenging since more participants answered correctly when the time was not limited.

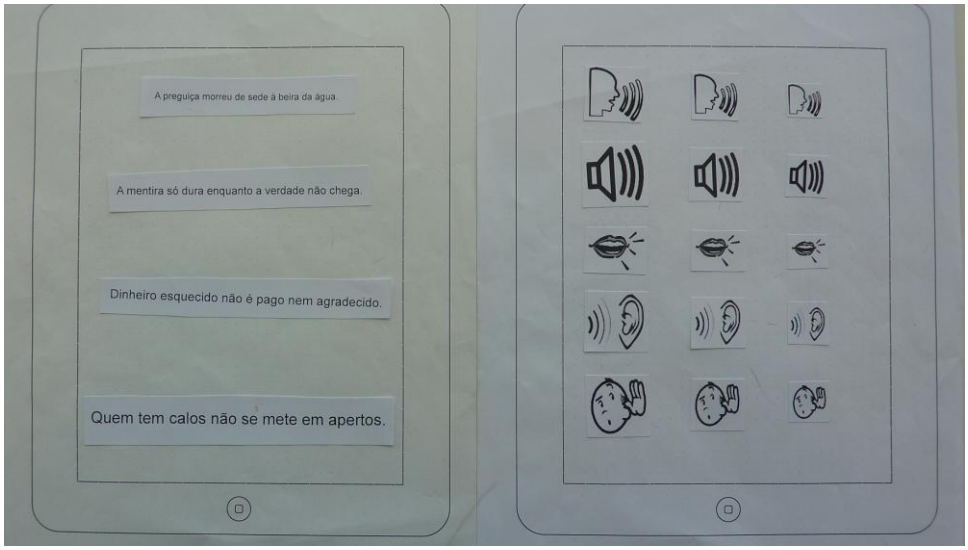
TODO:

8.3 Usability Test 3 Protocol

Usability Test Nº 3 31-03-2011

Prototypes:

- 31-TL: Screen with four phrases with different sizes:
  - 12pt Arial
  - 14pt Arial
  - 16pt Arial
  - 20pt Arial
- 31-S: Screen with the symbols of the cards in three different sizes:
  - 1,5x1,5 cm
  - 2x2 cm
  - 2,5x2,5 cm
- 6 Cards with different symbols regarding the action of “Listen”



Objectives:

- Understand which is the appropriate font size that should be used in interfaces for older adults.
- Understand which symbol should be used to illustrate the text-to-speech functionality and which is the minimum size it should have.

Protocol:

1. **Introduction**

    a. "Hi, my name is Ana and I am developing games for cognitive stimulation. Here I have some elements that I will be using in the games and I need to evaluate if they are appropriate for you.
    Don't worry if you can't do something of what I ask you to do, it is not your fault. We want to evaluate these elements and not your answers; they are the ones who should be adapted to your needs."

2. **Questionnaire**

- **If the person is not wearing glasses:** "Do you wear glasses to read?"
- Do you know how to read?

3. **Test Procedure**

    Scenario 1: The participant knows how to read

    a. "Can you please read these sentences for me?"
        - Present prototype 31-TL.

    b. "Now let's pretend that you don't know how to read or that you don't have your reading glasses with you (in the case the participant wears glasses) but you really want to know what these sentences mean. I will give you these cards that have images on them and you will give me one that represents "I want to listen to these sentences" to you."
        - Give the 6 cards to the participant.
        - The participant gives me a card back

    c. "Ok, good choice. Now, can you identify this image in this paper and point it to me?"
        - Keep the image at sight.
        - Show smaller symbols in prototype 31-S. Show bigger size if the person cannot see them.

    Scenario 2: The participant doesn't know how to read

    a. "I have these sentences here and let's pretend that you really want to know what these sentences mean. I will give you these cards that have images on them and you will give me one that represents "I want to listen to these sentences" to you."
        - Give the 6 cards to the participant.
        - The participant gives me a card back.
        - Read sentences to participant.

    b. "Ok, good choice. Now, can you identify this image in this paper and point it to me?"
        - Keep the image at sight.
        - Show smaller symbols in prototype 31-S. Show bigger size if the person cannot see them.

4. **Thank you**

Results:

Reading Test

Name	Wears Glasses?	Knows how to read?	12pt Arial	14pt Arial	16pt Arial	20pt Arial
L. (F)	Yes	Yes	Difficulties	Yes	Yes	Yes
A. (F)	Yes	Yes	Yes	Yes	Yes	Yes
X. (M)	Occasionally	Yes	Yes	Yes	Yes	Yes
T. (A)	Yes	Yes	Difficulties	Yes	Yes	Yes
A. (M)	Yes	Yes	Yes	Yes	Yes	Yes
MF. (F)	Yes	Yes	Yes	Yes	Yes	Yes
MR. (F)	Yes	Yes	Difficulties	Yes	Yes	Yes
D. (F)	Yes	Yes	Yes	Yes	Yes	Yes
M. (F)	Yes	No	-	-	-	-

Symbols

Name	Profile	Volume	Mouth	Ear	Hand	Music
L. (F)					X	
A. (F)			X		*	
X. (M)		#	#	#	X	
T. (F)		X			*	
A. (M)		X				
MF. (F)			X			
MR. (F)					X	
D. (F)			X			
M. (F)					X	

***** - clearly misinterpreted the symbol

\# - indicated the symbol as a possible choice

Symbol Size Test

Name	Small	Medium	Large
L. (F)	Difficulties	Yes	Yes
A. (F)	Yes	Yes	Yes
X. (M)	Yes	Yes	Yes
T. (F)	Yes	Yes	Yes
A. (M)	Yes	Yes	Yes
MF. (F)	Yes	Yes	Yes
MR. (F)	Difficulties	Yes	Yes
D. (F)	Yes	Yes	Yes
M. (F)	Yes	Yes	Yes

Facts:

- 9/10 participants knew how to read
- 3/9 participants had difficulties reading 12pt Arial
- 9/9 participants read 14, 16 and 20pt Arial

- 2/10 participants chose the volume symbol and 1 indicated it as a possible choice
- 3/10 participants chose the mouth symbol and 1 indicated it as a possible choice
- 1/10 participants indicated the ear symbol as a possible choice
- 4/10 participants chose the hand symbol, however 2/10 misinterpreted its meaning
- None of the participants chose the profile or the music symbols

- 2/10 participants had difficulties identifying the chosen symbol at 1.5x1.5cm size
- All participants identified the symbols at 2x2cm and 2.5x2.5cm sizes

Conclusions:

- Participants only showed difficulties reading font sizes smaller than 14pt which indicates that this should be the minimum size used in the prototypes.
- The symbols should not have less than 2x2cm since some participants had difficulties in recognizing symbols with 1,5x1,5cm.
- The preferred icons to illustrate the text-to-speech functionality were the mouth and the hand ones.

TODO:

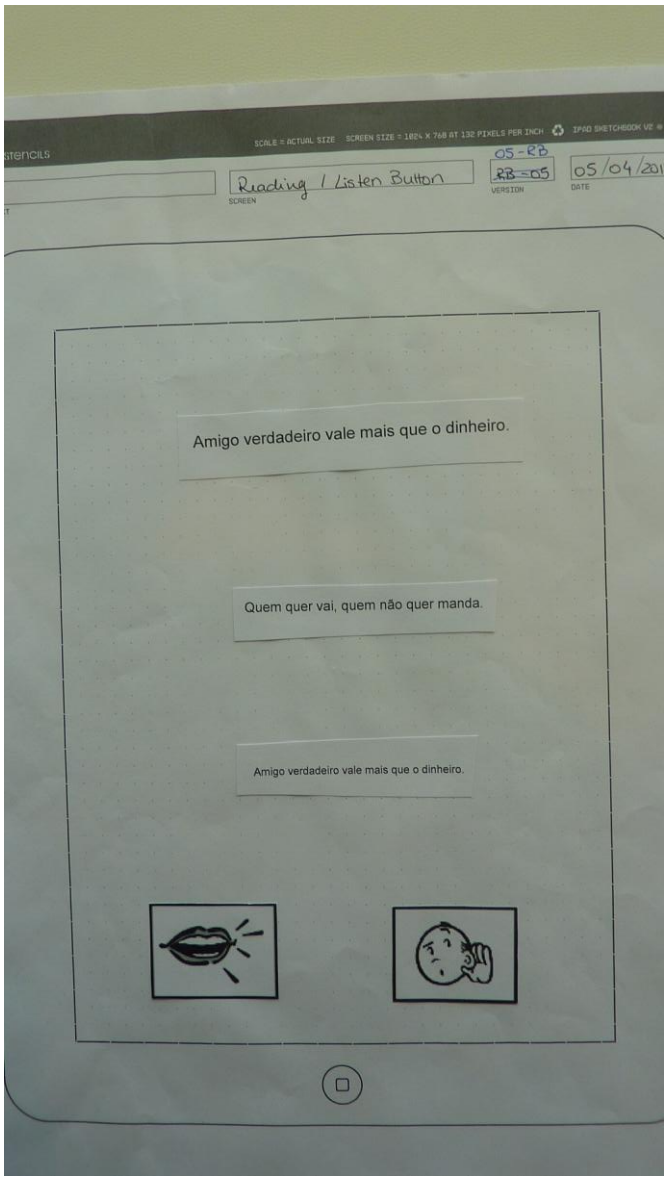
- Improve the mouth and hand symbols and re-test the two, to see which one they choose.

8.4 Usability Test 4 Protocol

Usability Test Nº 4 05-04-2011

Prototypes:

- RB-05: Screen with three sentences and two buttons
  - Arial 12pt
  - Arial 10pt
  - Arial 8pt
  - Mouth Button
  - Hand button (improved from last prototype)



Objectives:

- Understand if older adults can read small letter sizes.
- Choose between the two buttons the one that should be used when the text-to-speech option is needed.

Protocol:

1. **Introduction**

    a. "Hi, my name is Ana and I am developing games for cognitive stimulation. Here I have some elements that I will be using in the games and I need to evaluate if they are appropriate for you.
    Don't worry if you can't do something of what I ask you to do, it is not your fault. We want to evaluate these elements and not your answers; they are the ones who should be adapted to your needs."

2. **Questionnaire**

    - Do you know how to read?

3. **Test Procedure**

    Scenario 1: The participant knows how to read

    a. "Can you please read these sentences for me?"
        - Present prototype.

    b. "Now let's pretend that you don't know how to read or that you don't have your reading glasses with you (in the case the participant wears glasses) but you really want to know what these sentences mean. See these two images here at the bottom? Let's pretend they are buttons and you have to press one of them to ear the sentences. There is no right or wrong, I just want to know which one do you think means that."
        - Let the participant choose the button.
        - Read sentences aloud.

    c. "Ok, good choice. Now, can you tell me why you chose that button?"
        - Keep the button at sight.

    Scenario 2: The participant doesn't know how to read

    d. "I have these sentences here and let's pretend that you really want to know what these sentences mean See these two images here at the bottom? Let's pretend they are buttons and you have to press one of them to ear the sentences. There is no right or wrong, I just want to know which one do you think means that."
        - Let the participant choose the button.
        - Read sentences aloud.

    e. "Ok, good choice. Now, can you tell me why you chose that button?"
        - Keep the button at sight.

4. **Thank you**

Results:

Name	Knows how to read?	12pt	10pt	8pt	Mouth	Hand	Reason of choice
F. (F)	Yes	Yes	Yes	Yes		X	Ear = listen
R. (F)	No	-	-	-	X		Mouth = speak
I. (F)	Yes	Yes	Yes	Yes		X	Ear = listen
F. (F)	Yes	Yes	Yes	Yes		X	Ear = listen
R. (M)	Yes	Yes	Yes	Difficulties	-	-	Didn't choose but didn't understand the hand symbol
MC. (F)	Yes	Didn't had her reading glasses			X		Mouth = speak
D. (F)	Yes	Yes	Yes	Yes	X		Mouth = speak
T. (F)	Yes	Yes	Yes	Yes	X		
A. (M)	Yes	Yes	Yes	Difficulties		X	
MI. (F)	Yes	Due to health reasons couldn't read			X		
M. (F)	Yes	Yes	Difficulties	Difficulties		X	Liked the face
S. (F)	Yes	Yes	Difficulties	Difficulties		X	Ear = listen
M. (F)	Yes	Yes	Difficulties	Yes	X		
MR. (F)	Yes	Yes	Yes	Yes		X	

Facts:

- 13/14 knew how to read
- 14/11 people could read Arial 12pt
- 8/11 people could read Arial 10pt, 3/11 had difficulties
- 7/11 people could read Arial 8pt, 4/11 had difficulties

- 6/13 people chose the mouth symbol
- 7/13 people chose the hand symbol

Conclusions:

- All participants could read size 12pt as expected, however some began to have difficulties in reading smaller sizes.
- Although more participants chose the Hand symbol it was clearly misinterpreted by at least one participant and several more couldn't indicate the reason why they had chosen that symbol.

TODO:

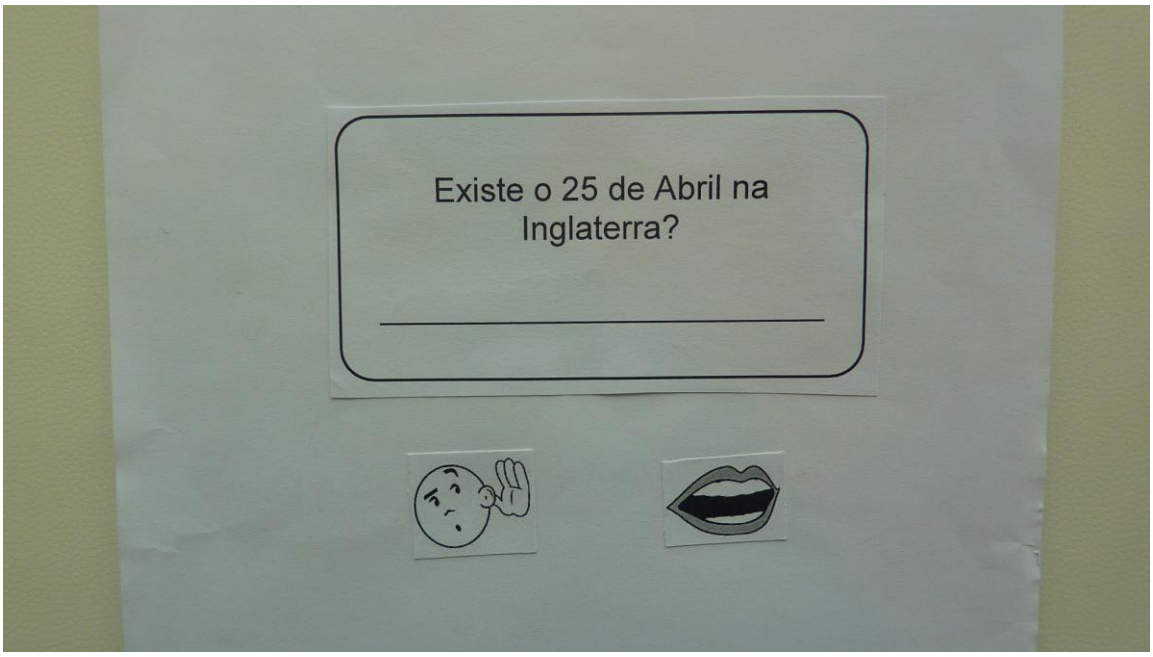
- Improve the mouth and hand symbols to perform a final test and choose the most suitable one.

8.5 Usability Test 5 Protocol

Usability Test Nº 5 12-04-2011

Prototypes:

- 12-S: Screen with one sentence and two buttons
  - Mouth Button (improved from last prototype)
  - Hand button (improved from last prototype)



Objectives:

- Make the final choice between the two icons and choose the one that should be used in the text-to-speech button.

Protocol:

1. **Introduction**

    a. "Hi, my name is Ana and I am developing games for cognitive stimulation. Here I have some elements that I will be using in the games and I need to evaluate if they are appropriate for you.
    Don't worry if you can't do something of what I ask you to do, it is not your fault. We want to evaluate these elements and not your answers; they are the ones who should be adapted to your needs."

2. **Questionnaire**

    - Do you know how to read?

3. **Test Procedure**

    Scenario 1: The participant knows how to read

    a. "Can you please read this sentence for me?"
        - Present prototype.

    b. "Now let's pretend that you don't know how to read or that you don't have your reading glasses with you (in the case the participant wears glasses) but you really want to know what this sentence means. See these two images here at the bottom? Let's pretend they are buttons and you have to press one of them to ear the sentence. There is no right or wrong, I just want to know which one do you think means that."
        - Let the participant choose the button.
        - Read sentence aloud.

    c. "Ok, good choice. "

    Scenario 2: The participant doesn't know how to read

    d. "I have this sentence here and let's pretend that you really want to know what it means. See these two images here at the bottom? Let's pretend they are buttons and you have to press one of them to ear the sentence. There is no right or wrong, I just want to know which one do you think means that."
        - Let the participant choose the button.
        - Read sentences aloud.

    e. "Ok, good choice."

4. **Thank you**

Results:

Name	Knows how to read?	Hand Symbol	Mouth Symbol
R. (F)	No		X
MJ. (F)	No		X
H. (F)	Yes		X
I. (F)	Yes	X	
H. (F)	Yes		X
T. (F)	Yes	X	

Facts:

- 2/6 participants didn’t know how to read

- 2/6 participants chose the hand symbol
- 4/6 participants chose the mouth symbol

Conclusions:

- After the improvements, the majority of the participants chose the mouth icon, including both participants that didn’t know how to read, therefore this is the icon that we should use in the text-to-speech button of our system.

TODO:

8.6 Usability Test 6 Protocol

Usability Test Nº 6 19-04-2011

Prototypes:

- Matching game with unknown faces – 6 pairs
- Matching game with known faces – 6 pairs
- Identify the faces

Objectives:

- Understand if participants enjoy the game.
- Assess their difficulties in playing the game.
- Assess the minimum image size for which they can still recognize the photos.
- Understand if they can identify two equal images.
- Understand if they recognize people and know their names.

Protocol:

1. **Introduction**

    a. "Hi, my name is Ana and I am developing games for cognitive stimulation. Here I have an example of what I am developing, it's just a mini game and I need your help to understand if you enjoy the game and if it is appropriate for you. Would you like to play with me?
    Don't worry if you find the game too difficult or if you answer incorrectly, it is not your fault. We want to evaluate the game and not your answers; it is the game that needs to be adapted to your needs."

2. **Playing the game**

    a. "This is a matching pairs game. You will point me two cards and I will turn them for you, if they have the same image then you make a pair and the cards leave the board, otherwise they will stay in the board and I will turn them back."
        i. Show prototype of matching game with unknown faces.

    b. "Now we will play the same game but with different pictures, and you will tell me if you recognize them."
        i. Show prototype of matching game with known faces.

    c. "Now can you tell me the name of these persons?"
        i. Show pictures used for the matching game with known faces.

3. **Thank you**

Results:

Name	Unknown (time/min)	Known (time/min)	Which one do you prefer?	Names of people	Would you like to play with friend's pictures?	Would you like to play with family's pictures?
F. (F)	3:43.63	4:13.35[1]	Indifferent	2/6	Yes	No answer[3]
D. (F)	2:35.50	2:07.62	Indifferent	3/6	Yes	Yes
A. (M)	3:34.54[2]	1:07.10[2]	Known	1/6	Yes	Yes
J. (M)	2:57.54	2:34.07	Known	2/6	Yes	Yes
C. (F)	3:17.45	2:13.39	Indifferent	3/6	Yes	Yes

1. Took longer because when she recognized the faces she spent some time talking about the people in them.
2. Didn't finish the games because he was too tired.
3. This participant had a difficult relationship with her family, hence the absence of answer.

Facts:

- 1/5 participant took longer to solve the matching game with known faces because she got distracted and started talking about the people she recognized in the pictures.
- 4/5 participants took less time to solve the matching game with known faces.
- 1/5 participant didn't finish the games because he was tired and thought that the games took too long.
- 3/5 participants said that it was indifferent to play the game with known or unknown faces.
- 6/6 participants stated that they would enjoy a game with pictures of their friends.
- 5/6 participants stated that they would enjoy a game with pictures of their family and 1/6 participant didn't answer the question.
- In average the participants were able to identify 2 out of the 6 names.

Conclusions:

- The majority of the players took less time to solve the game with known faces which indicates that it is easier for them to memorize familiar faces.
- Although the majority of participants said that it was indifferent to play the game with known or unknown faces, all of them said that they would enjoy a game that had pictures of their friends or family.
- Participants had some difficulties in recognizing the faces at first, but after we asked them if they knew the person in the pictures they were able to identify it. The reasons for that were the size of the photos and their complexity since the participants needed to bring the pictures closer to their faces to see them and the background of the photos were too complex and dark, which confused them, as they stated.

- We can conclude that a matching game with known faces is easier for older adults to solve. However, the pictures should be bigger and less complex as they had some difficulties to recognize the people in the pictures, due to vision problems.

TODO:

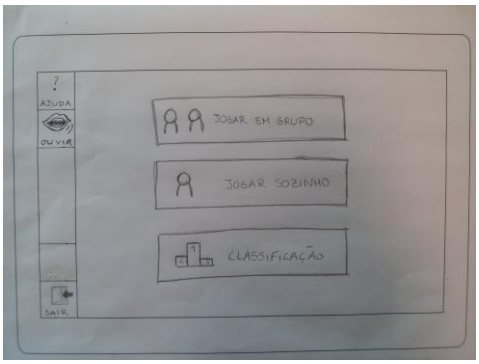
- Test the game with bigger and less pictures.

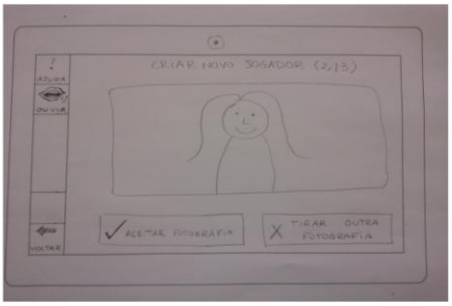
8.7 Usability Test 7 Protocol

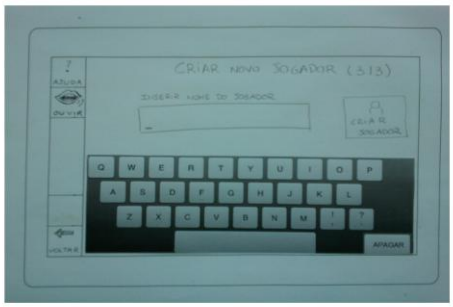
Usability Test Nº 7 10-05-2011

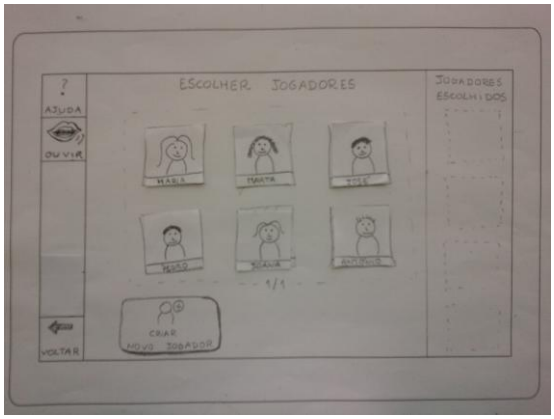
Prototypes:

- Game platform menus
    - Playing alone, creating a new user and selecting the player using two types of interaction









Objectives:

- Assess the overall usability of the menu interface for the game platform.
- Understand if the functionalities of the platform are necessary or sufficient.
- Asses which one is the best option to use when selecting a player.

Protocol:

1. **Introduction**

    a. "Hi, my name is Ana and I am developing games for cognitive stimulation. Here I have an example of the system that will allow you to play the games. I will guide you to some scenarios and I will ask you to perform some tasks. Would you be able to help me with that?
    Don't' worry if you find the tasks challenging or you cannot perform them, I am evaluating the system, not you. Besides feel comfortable to tell me if you want to stop for any reason and if you need help, please search and use the interface button that serves that purpose. "

2. **Menu navigation**

    a. "This is the main menu of the system, and I want you to start a game in which you will be playing alone. Can you press the button that you think is the right one?"
    b. "Here you have a list of players that already used this system. Let's create a new player. Do you see that option and can you choose it?"
    c. "Here you can see the person's face as if they were being seen through a camera. Let's choose the option to take a picture."
    d. "Here is the final picture. Let's accept it."
    e. "Now let's give him the name Tiago. Type it on the keyboard and finally create the player."
        i. Scenario 1
            1. "Can you see now your player listed here? Now you have to select the player's photo and click on the button that selects that person as the player"
        ii. Scenario 2
            1. "Can you see the new player listed here? Now click on his photo to select him as the player."
            2. "Now select "Yes" on the pop-up menu to confirm that he is the player that you wish to choose."
    f. "Now let's just see your scores and information on the player menu. Can you see where it is and click it?"
    g. "To finish can you go back to the previous screen?"

3. **Thank you**

Results:

Name	Used hand	Time (1st scenario)	Time (2nd scenario)
F. (F)	Right	3:13	1:57
LI. (F)	Right	3:25	2:37
B. (M)	Right	3:10	1:53

Facts:

- All participants took less time to perform the tasks with the 2nd scenario.

Conclusions:

- These preliminary tests indicate that the second scenario is easier to use by the participants.

TODO:

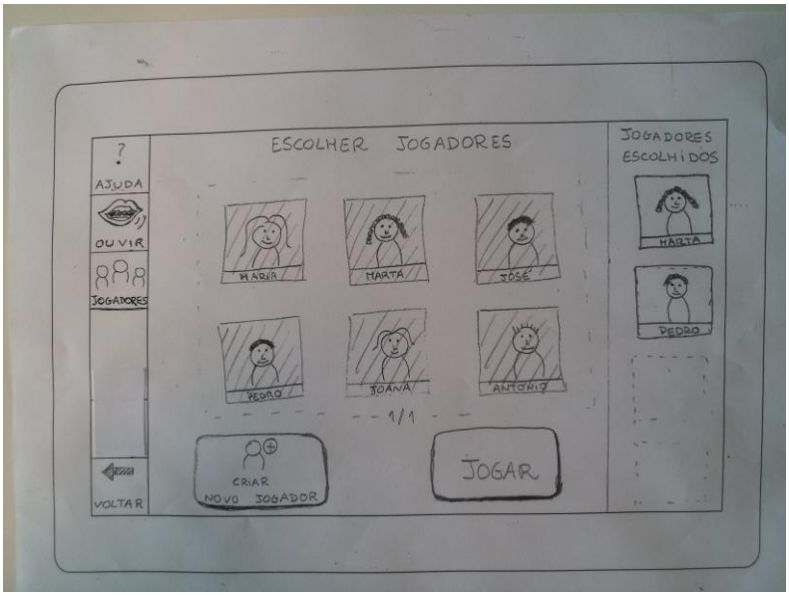
- More tests are needed to validate this test's results.

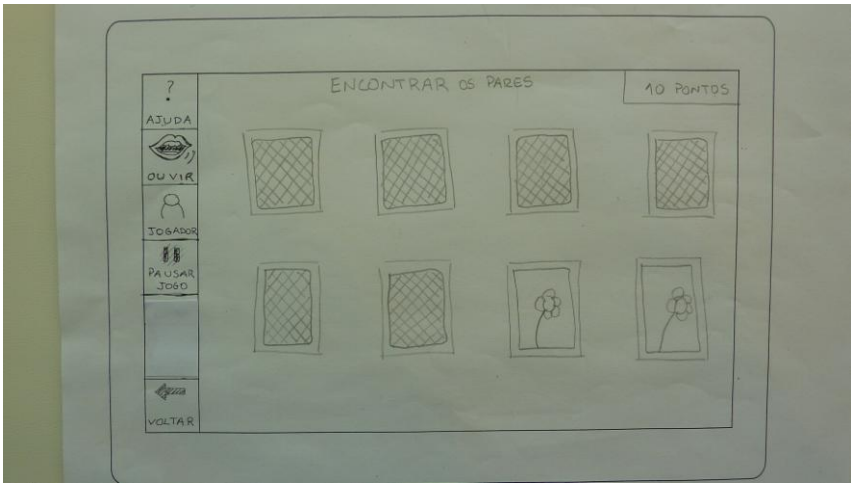
8.8 Usability Test 8 Protocol

Usability Test Nº 8 12-05-2011

Prototypes:

- Selecting users for a group and remove one
    - Click and pop up method
- Selecting users for a group and remove one
    - Drag and drop method
- Identifying the player during a game and recognizing the points system





Objectives:

- Assess the overall usability of the menu interface for the game platform.
- Understand if the functionalities of the platform are necessary or sufficient.
- Asses which one is the best method to use when selecting a group of players.
- Understand if the participants recognize the functionalities and systems used.

Protocol:

1. **Introduction**

    a. "Hi, my name is Ana and I am developing games for cognitive stimulation. Here I have an example of the system that will allow you to play the games. I will guide you to some scenarios and I will ask you to perform some tasks. Would you be able to help me with that?
    Don't' worry if you find the tasks challenging or you cannot perform them, I am evaluating the system, not you. Besides feel comfortable to tell me if you want to stop for any reason and if you need help, please search and use the interface button that serves that purpose. "

2. **Selecting users for a group – Click and Pop-up method**

    a. "This is the main menu of the system, and I want you to start a game in which you will be playing in a group. Can you press the button that you think is the right one?"
    b. "Here you have a list of players that already used this system. We want to form a group with Marta and Pedro. Let's start with Marta. Can you click her picture?"
    c. "Now the system is asking you if you want to add Marta to the group. Let's say "Yes". Can you click that button?"
    d. "Here you can see that Marta's picture is under the selected players, well done. Now let's do the same for Pedro."
    e. "Now let's imagine that Marta does not want to play and wants to be removed from the group. Where would you click to do that?"

3. **Selecting users for a group – Drag and drop method**

    a. "This is the main menu of the system, and I want you to start a game in which you will be playing in a group. Can you press the button that you think is the right one?"
    b. "Here you have a list of players that already used this system. We want to form a group with Marta and Pedro. Let's start with Marta. Can you drag her picture to the selected players' area?"
    c. "Now let's do the same for Pedro."
    d. "Now let's imagine that Marta does not want to play and wants to be removed from the group. What would you do to make that happen?"

4. **Questionnaire**

    a. "As you saw, we used different methods to perform the same action. Which one do you feel was easier to you and that you would prefer to use more often?"

5. **Player button and points system**

    a. "In this screen you can see that there is a find pair's game that is unfinished. Someone started it and found a pair but we don't know who. Can you find a button that will tell us who was playing the game?"
    b. "Now we can see here this label that says "10 points" what do you think that means?"

6. **Thank you**

Results:

1. **Select group users – method click and pop-up**

Name	Time	Can identify how to remove?
- (F)	02:02	Yes
L. (F)	0:39	Yes
F. (F)	1:35	Yes
A. (F)	1:04	Yes (with help)
A. (F)	1:13	Yes

2. **Select group users – method drag and drop**

Name	Time	Can identify how to remove?
- (F)	0:34	Yes
L. (F)	0:35	Yes
F. (F)	0:45	Yes
A. (F)	0:39	Yes
A. (F)	0:38	Yes

3. **Questionnaire – Which method do you prefer?**

Name	Click and pop-up	Drag and drop
- (F)		X
L. (F)	both	
F. (F)	both	
A. (F)		X
A. (F)	X	

4. **Find player button and identify point system**

Name	Finds player button	Identifies points system
- (F)	Yes	Had difficulties
L. (F)	Yes (with help)	Yes
F. (F)	Yes	Had difficulties
A. (F)	Yes	No
A. (F)	Yes	Yes

Facts:

- All participants took less time to perform the tasks with the drag and drop method.
- All participants were able to understand how the players should be removed from the system; however one of them needed help with the click and pop-up menu.

- 2/5 participants preferred the drag and drop method.
- 1/5 participant preferred the click and pop-up method.
- 2/5 participants were not able to decide which method to choose and said that both of them were easy to use.

- All participants were able to find the player button; however one of them needed help.
- 2/5 participants were able to understand the points system.
- 2/5 participants had difficulties in understanding the points system.
- 1/5 participant did not understand the points system.

Conclusions:

- If we consider the time needed to perform the tasks, the drag and drop method would be the most suitable; however when asked about their preferences their opinions were not conclusive.
- Regarding the remove player from group action, all participants were able to recognize how to do it therefore we can assume that, as long as we use the same method for performing the add and remove action, participants will be able to perform that action.
- The player button was recognized by all participants so we can conclude that its use and position is appropriate.
- The point system was not recognized by the majority of the participants, who struggled to explain what it meant. Therefore improving and re-testing is needed.

TODO:

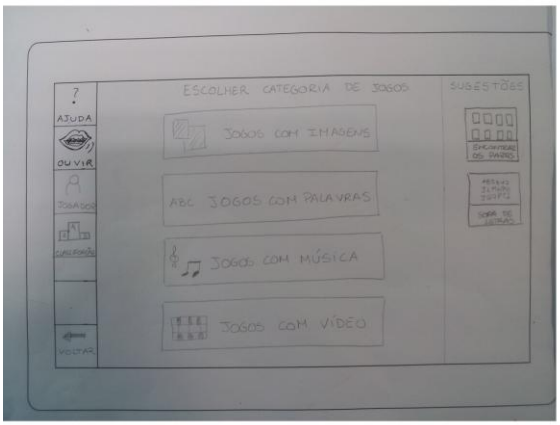
- Improve point system and test.

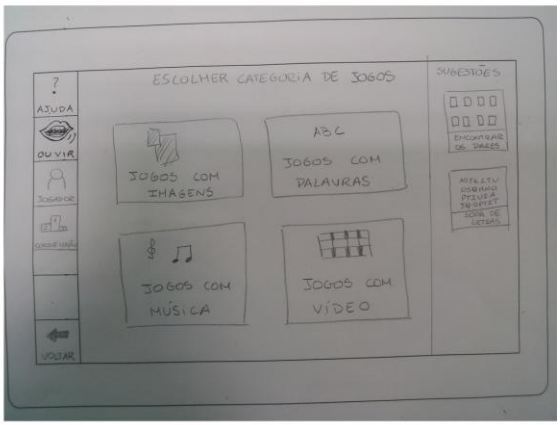
8.9 Usability Test 9 Protocol

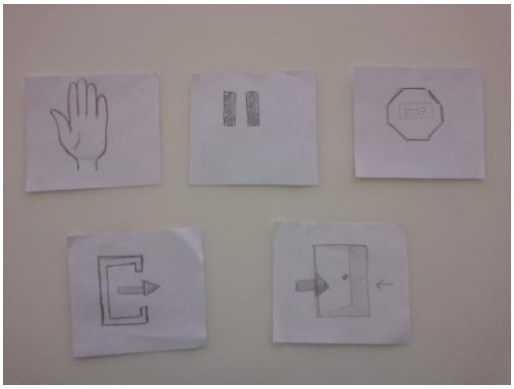
Usability Test Nº 9 17-05-2011

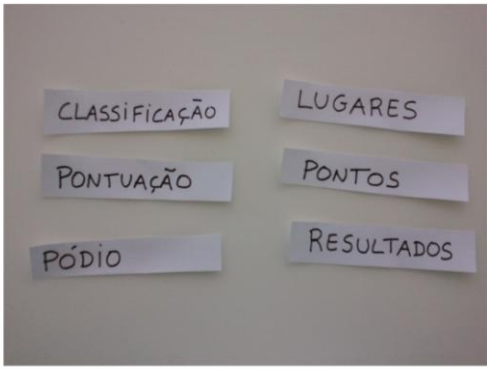
Prototypes:

- Game platform menus
    - Select category menu – Two layouts
- Exit icon
- Pause game
- Points system icon and label









Objectives:

- Assess the overall usability of the menu interface for the game platform.
- Assess the perception participants have of the points systems and which is the best icon and label to illustrate it.
- Select the best icon to illustrate the exit button.
- Select the best icon to illustrate the pause game button.
- Assess the best layout for the “choose game category” menu.

Protocol:

1. **Introduction**

    a. "Hi, my name is Ana and I am developing games for cognitive stimulation. Here I have an example of the system that will allow you to play the games. I will ask for your opinion regarding some icons and names for buttons and to click in some specific buttons in an interface. Would you be able to help me with that?
    Don't' worry if you find the tasks challenging or you cannot perform them, I am evaluating the system, not you. Besides, feel comfortable to tell me if you want to stop for any reason and if you need help, please search and use the interface button that serves that purpose. "

2. **Menu navigation**

    a. "Let's imagine a button in a system that allows you to exit and finish all your tasks. I have these two icons here that could illustrate that button, which one do you think is better?"
    b. "Now let's do the same thing but with this three pictures for a button that lets you put a game on hold for a while and then return to it and resume the gameplay. Which one would you choose?"
    c. "Now let's think of a button that allows you to see the ranking of all the players in the system. Which icon would you choose to illustrate it? And which label would be more appropriate?"
    d. "Finally I will show you two screens that have the exact same four buttons but with different layouts. I will ask you to click a specific button in both of them."

3. **Thank you**

Results:

1. **Exit Icon**

Name	Door Icon	Arrow Icon
A. (F)	X	
F. (F)	X	
L. (F)		X
C. (F)	X	
J. (M)	X	

2. **Pause Icon**

Name	Pause Icon	Hand Icon	Stop Sign Icon
A. (F)		X	
F. (F)		X	
L. (F)			X
C. (F)			X
J. (M)		X	

3. **Points System Icon**

Name	Graphic Icon	Medal (neck) Icon	Medal Icon	Star Icon	Podium Icon	Trophy Icon
A. (F)	X					
F. (F)					X	
L. (F)					X	
C. (F)	X					
J. (M)					X	

4. **Points System Label**

Name	“Classificação”	“Resultados”	“Pontos”	“Pódio”	“Pontuação”	“Lugares”
A. (F)	X					
F. (F)		X				
L. (F)					X	
C. (F)	X					
J. (M)						X

5. **Game Category Menu Layout**

Name	L1 - Music	L2 - Music	L1 - Words	L2 - Words	L1 - Images	L2 - Images	L1 - Video	L2 - Video
A. (F)	4.95	3.59	3.27	1.72	4.18	2.90	3.27	1.45
F. (F)	17.46	6.40	3.98	4.45	4.72	3.54	2.63	2.36
L. (F)	4.45	3.03	2.36	3.27	2.29	2.63	2.09	2.09
C. (F)	8.36	5.29	4.72	2.63	11.36	4.18	1.92	5.09
J. (M)	2.93	1.45	4.82	2.90	12.30	1.45	2.09	1.72
Average	7.63	3.95	3.83	2.99	6.97	2.94	2.40	2.54

Time in seconds

Facts:

- 4/5 participants chose the door icon to illustrate the exit button
- 1/5 participant choose the arrow icon to illustrate the exit button
- 3/5 participants choose the hand icon to illustrate the pause button
- 2/5 participants choose the stop sign icon to illustrate the pause button
- 3/5 participants choose the podium icon to illustrate the points system button
- 2/5 participants choose the graphic icon to illustrate the points system button
- 2/5 participants choose the word “Classificação” as the label to the points system button
- 1/5 participant choose the word “Resultados” as the label to the points system button
- 1/5 participant choose the word “Pontuação” as the label to the points system button
- 1/5 participant choose the word “Lugares” as the label to the points system button

- In average, participants took less time to choose the same button with the second layout, except for the video button, however for the latter the difference between layouts was not significant.

Conclusions:

- These tests indicate that:
    - The door icon is the most suitable one to use for the exit button.
    - The hand icon appears to be the most suitable one for the pause button.
    - The podium icon appears to be the most suitable one for the point’s system button.
    - The word “Classificação” appears to be the best label for the point’s system button.
    - The second layout is more appropriate to the system.

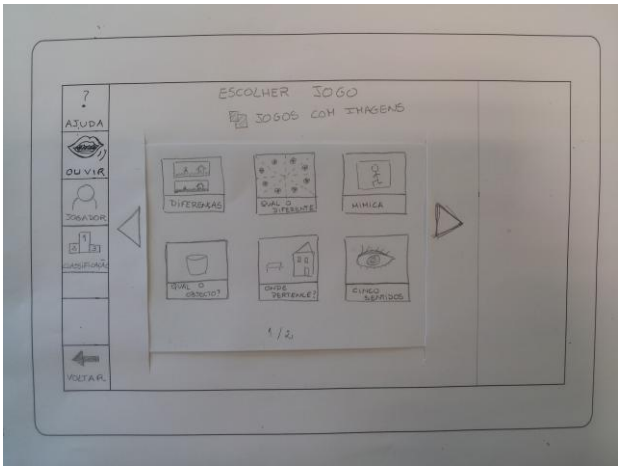
TODO:

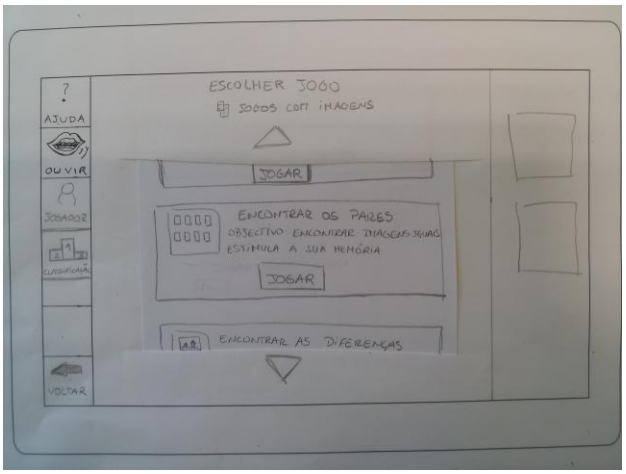
8.10 Usability Test 10 Protocol

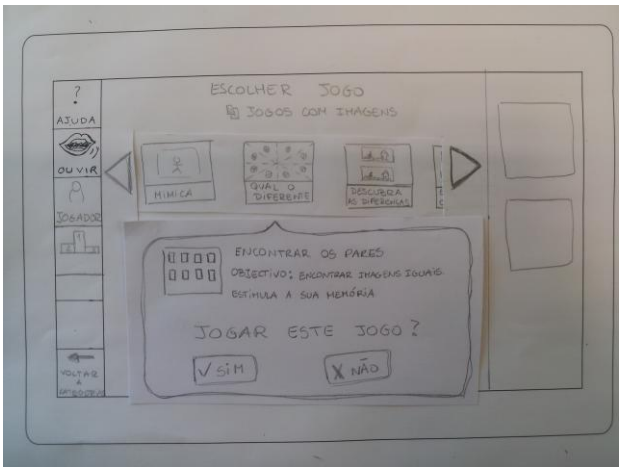
Usability Test Nº 10 19-05-2011

Prototypes:

- Choosing game menu
  - Click and pop-up method
  - List method
  - Balloon method







Objectives:

- Assess the overall usability of the menu interface for the game platform.
- Understand if the functionalities of the platform are necessary or sufficient.
- Asses which one is the best option to use when selecting a game.

Protocol:

1. **Introduction**

    a. "Hi, my name is Ana and I am developing games for cognitive stimulation. Here I have an example of the system that will allow you to play the games. I will guide you to some scenarios and I will ask you to perform some tasks. Would you be able to help me with that?
    Don't' worry if you find the tasks challenging or you cannot perform them, I am evaluating the system, not you. Besides feel comfortable to tell me if you want to stop for any reason and if you need help, please search and use the interface button that serves that purpose. "

2. **Menu navigation**

    a. "This is the game menu of the system, and I want you to choose the matching cards game. Here you have the game buttons that allow you to choose a game, and there you have the arrows that let you change the page and see more games. Can you for it?"
    b. "Now select the game, and say that you want to play it."

3. **Thank you**

Results:

Name	Click and pop up	List	Balloon
L. (F)	15:30	25.03	23.56
F. (F)	11.96	19.81	23.14
J. (M)	15.43	20.29	14.89
C. (F)	20.55	33.52	>List

Time in seconds

Facts:

- 3/4 participants took less time to select the game using the click and pop-up method
- 1/4 participant took less time using the balloon method

Conclusions:

- This test indicates that the best method to choose a game is the click and pop up. All the participants that took less time using this method had already tested the choose player menu using it. This may indicate that there is a process of learning and that using the same method for both menus has advantages.

TODO:

8.11 Trial Protocol

Final Trial 30-05-2011

Prototypes:

- High-fidelity prototype of the platform, tested on the tablet

Objectives:

- Assess the overall usability of the menu interface for the game platform.
- Understand if the functionalities of the platform are necessary or sufficient.
- Observe elders interaction with the tablet
- Recognize potential improvements to the prototype

Protocol:

1. **Introduction**

    a. "Hi, my name is Ana and I am developing games for cognitive stimulation. Here I have an example of the system that will allow you to play the games. I will guide you to some scenarios and I will ask you to perform some tasks. Would you be able to help me with that?
    Don't' worry if you find the tasks challenging or you cannot perform them, I am evaluating the system, not you. Besides feel comfortable to tell me if you want to stop for any reason and if you need help, please search and use the interface button that serves that purpose. "

2. **Single Player Mode (create new player)**
    a. "Let's start a single player game now, can you choose that option on the main menu of the system?"

3. **Create new player**
    a. "Since you have never played with this device before, you have not a user created for you. Can you choose the "Create new player option"?
    b. "Now you have to take you picture to be your profile image. Point the screen towards you and when you feel that the picture is ok for you, press the "Take Picture" button."
    c. "Here you have the final picture. Do you like it? If so proceed and press the "Accept picture option", if not choose the "Take another picture" option"
    d. "Now that you have your picture please write your name?"

4. **Select player**
    a. "Now you already have your player here? Can you select it and confirm the selection?"
    b. "Now just press the "Play" button"

5. **Select Game Category**
    a. "Today we will play an images game. Can you select that option in the select game category menu?"

6. **Select Game**
    a. "You can see here that there are two available games. Let's choose the pairs game and confirm that we want to play it"

7. **Play Game**
    a. "Now let's play the game"
    b. "Congratulations, you completed the game and scored X points"

8. **Thank you**

Questionnaire:

1. Did you enjoy this experience?
   Yes/No
2. Did you find it challenging to complete the tasks?
   No/1-2 tasks/3-4taks/all task
3. If there was a tablet available here at the centre how often would you use it?
   Never/ Seldom/ Often/ Very Often

Results:

Participant	Start Single Player Mode	Create new player	Select player	Select game category	Select game	Play game
Ana	Completed	Problems writing name	Completed	Completed	Completed	Completed
Fernanda	Completed	Problems writing name	Completed	Completed	Completed	Completed
Andreza	Completed	Problems writing name	Completed	Completed	Completed	Completed
João	Completed	Problems writing name	Completed	Completed	Completed	Completed
Adriana	Completed	Problems writing name	Completed	Completed	Completed	Completed
Laura	Completed	Problems writing name	Completed	Completed	Completed	Completed

Questionnaire:

Participant	1	2	3
Ana	Yes	No	Often
Fernanda	Yes	No	Very often
Andreza	Yes	1-2 tasks	Seldom
João	Yes	No	Often
Adriana	Yes	No	Often
Laura	Yes	No	Very often

Facts:

- All players had challenges when writing their names using a regular tablet keyboard
- All participants completed the tasks
- All participants stated that enjoyed the playing experience
- 1/6 participant had some challenges while performing 1/2 tasks
- 3/6 participants would use the platform often
- 2/6 participants would use the platform very often
- 1/6 participants would use the platform seldom

Conclusions:

- Regarding the completion of the proposed tasks we concluded that the platform was indeed easy to use for the older adults; however the use of the default keyboard was not the best option
- All participants enjoyed the experience and the majority did not find the tablet challenging to use and would use it again often
- Furthermore during the tests we observed that:
    - Participants would press the buttons using more strength than necessary and for more time than needed
    - Participants would press buttons unintentionally with their hands or wrist and were not aware of that
    - In the choose game screen it was not clear that the game images were buttons and some elders took longer to understand that they had to click the image to select the game

TODO:

- Study an alternative keyboard
- Disable the home button on the android default bar
- Enhance the choose game buttons

Appendix B

Chapter 9

Appendix C

In this appendix is the paper submitted to the 8th International Conference On Advances in Computer Entertainment Technology (ACE 2011).

Tablets as a Gaming Platform for Older Adults

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ABSTRACT
The number of games specifically designed for the older population is scarce to inexistent. One of the reasons that contribute to this situation is the stereotype that seniors cannot and do not want to use computers. However, this is not the case, and more and more, elders use technology in their daily life. Older adults are a segment of the population with very different characteristics from the mainstream users for whom most games are designed. Disregarding those differences in the design of the game can make the gaming experience challenging, if not completely impossible for the older adult. This paper describes the research process for the development of a tablet-based gaming platform for older adults. This platform provides a series of casual games that aim at promoting the quality-of-live and well-being of seniors by making available different types of cognitive games. 10 features are identified as good rules of thumb for this platform and the games included in it. The low- and medium- fidelity prototypes of this platform were systematically tested with older adults, and a high-fidelity implementation is undergoing.

Categories and Subject Descriptors
H.5.5 [Information Interfaces and Presentation]: HCI

General Terms
Design, Human Factors.

Keywords
Human-Computer Interaction, Games, Tablets, Older adults, Elderly Entertainment.

1. INTRODUCTION
Older people (65+) are likely to encounter computers and other forms of technology in a large number of settings. However, and despite the trend of an increased use of computers, it is still lower among older adults as compared to younger ages [1]. One commonly held belief is that older people are resistant to change and unwilling to interact with computer systems, however the majority of studies that examined the attitudes of seniors towards computers indicated that "older people are receptive to using computers" [2]. Therefore there is no valid reason for not considering seniors as a potential target audience for computer applications; on the contrary developing software with these users in mind has the potential to provide them with a wide range of benefits that would otherwise be unreachable.

During the past decades the 'games for adults' industry has suffered a tremendous growth as a consequence of the population ageing and its impact in the economy [3]. This demand on entertainment mechanisms for retirement-age adults has already caught the attention of many researchers who have studied games potential in providing not only enjoyment but also well-being related improvements [4-10]. Their conclusions are optimistic and provide valuable information for future projects within the field.

Furthermore, novel devices that incorporate touch and gesture-based interaction "may afford an alternative and more natural interaction method" [11], easing the use of technology by older adults.

With these premises in mind the authors believe that studying the combination of games with touch-based devices, such as a tablet, can result in a suitable product for older adults, diminishing the current gap between this audience and technology thus promoting its use and the wide range of benefits that it can provide.

Section 2 makes an overview of the changes older adults experience as they age. Section 3 explains how older adults approach games, and start to describe the focus of our project. Section 4 discusses some aspects on the technology used for this project. Section 5 and 6 detail the characteristics and features of the platform that we are developing. Finally, section 7 discusses the research carried out and outlines aspects for future research.

2. OLDER ADULTS
The ageing process is responsible for changes at several levels, from biological to psychosocial. These age-related changes may impact a number of different aspects of older adults' lives and limit the extent to which they are able to perform certain activities. These constraints can also be observed in their ability to interact with computer systems, which are yet to be prepared to accommodate seniors capabilities and limitations. In this section the authors document a number of age-related changes in motor, perceptual, cognitive and psychosocial skills that can impact the user interaction with a tablet device.

8th International Conference on Advances in Computer Entertainment Technology'11, November 8–11, 2011, Lisbon, Portugal.

2.1 Motor and Perceptual Changes

Age-related changes affecting perceptual capabilities (e.g. vision and hearing) and motor skills are especially problematic for older adults when trying to interact with computer systems.

Older adults can experience challenges while reading at close distances in result of a condition known as *presbyopia*, "the inability to focus effectively on near objects" [12]. Transitioning from light to dark environments or performing visual tasks under dim light condition at night, can also introduce challenges [13]. Generally, seniors also experience a loss of static and dynamic visual acuity and yellowing of the lens that makes the perception of short wavelength light harder, diminishing the colour sensitiveness in the blue-to-green ranges [12].

Regarding hearing, many older adults, especially men, suffer from *presbycusis* – the reduced ability to hear high-frequency sounds – which challenges the hearing of certain sound such as the 's' sound, causing problems in correctly understanding speech [12]. These changes should also be considered in the design of computer systems as older people may find it challenging to perceive synthetic speech or hear alert sounds such as "beeps or pings" [1].

Age-related changes in motor skills include slower response times, declines in ability to maintain continuous movements, disruptions in coordination, loss of flexibility and variability in movement [1]. The haptic processes, which involve the use of touch to obtain information about the features of an object, can also suffer some changes, specifically the loss of sensitivity in the hands [14]. These motor skills can greatly influence the perception the user gets from interacting with a system, especially when manipulating devices that require great precision.

2.2 Cognitive Changes

Many computer tasks are characterized by having high cognitive demands [1] and for this reason it is important to consider any age related changes on cognitive skills when designing for older adults.

Memory and attention are some of the most important cognitive abilities that may suffer decline with age. The capacity of short-term memory shows signs of decline with age and is known to affect many complex everyday tasks such as decision-making, problem-solving and the planning of goal-directed behaviours [15]. This is mainly due to the difficulty of older adults to store and manage large amounts of new information [12]. However, unlike working memory, long-term memory is largely preserved in old age [15].

In general, attention is also affected by age. Older adults have shown to have more difficulty in tasks that require divided attention across multiple input channels and are also more prone to being distracted by irrelevant information [12]. These two cognitive constructs – memory and attention – should be highly considered when presenting information to older adults, since they may find challenging to absorb and process large quantities of new information at a time.

Two other relevant skills are spatial cognition and language comprehension. The first is related to the ability of mentally manipulating images or patterns whereas the latter is the ability to interpret verbal information [16]. Both these cognitive skills have shown to decline with age and they can, along with memory and attention, affect the way elders perceive and interpret information.

2.3 Psychosocial Changes

Even though people are in general more aware of the physical age-related changes due to their external visibility, psychological and social changes that occur in elders' lives are equally important to consider.

One of the main triggers to social or psychological changes is retirement. Being retired is many times associated to a loss of social importance and power due to the disengagement of an active social role, and presents itself as an open door to old age [17]. This perceived lack of responsibilities towards the society may incite an identity crisis and consequently a loss of self-esteem [18]. At the same time, physical and cognitive changes begin to be more noticeable, affecting one's independence and autonomy, diminishing the performance of daily life activities which can also be psychologically distressing by posing a threat to one's ability to live safely and independently [19].

The above-mentioned problems are yet aggravated by the reduction of the elder social network. For the older individual, the social component is one of the most important means towards well-being, however in old age there is a series of barriers that difficult the maintenance of relationships such as the death of friends and family, personal vulnerability, environmental and contextual obstacles, stress and conflict [17].

While these changes may not seem important for a computer system design, they are indeed worthy of reflection if we wish to design an artefact that appeals to this audience. As an example, older adults that experience feelings of abandonment may recognize the importance of a system that fosters social interaction that will consequently increase its acceptance rate.

3. GAMES AND OLDER ADULTS

A game, as defined by Juul [20], 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".

Understanding and considering all the mentioned game elements as well as their impact in the gaming experience should be done at an early stage of a project, in order to carefully incorporate them into the game design. In this section we discuss the relationship between older adults and games, their scope and potential impact and then study the above-mentioned game elements and their design to better adapt to this specific audience.

In many situations, after retirement, leisure activities represent a big part of elderly daily life [21]. There is a wide range of motivations that compel seniors to engage in these activities, like keeping themselves busy and mentally alert, being socially included or just having some fun [5]. Playing is already part of many older adults' routine and even though it is true that the majority of older adults solely play non-digital games, thinking that the games' target audience only consists of children and teenagers is a misconception. In fact, in 2010, the average age of the American player was 34 years old and 26% of game players were over the age of 50 [22].

Games are known to provide fun and enjoyable experiences, through a wide range of different mechanisms that usually appeal to the emotional connection that players feel towards games [23] and are also a way of communication that enables people to relate to each other, interact and spend time together [24]. Their scope

of benefits is actually broad and their use as a tool to increase seniors' well-being is starting to gain a significant importance.

A recent example of these benefits is the Wii platform and the spread of 'exertion games'. Jung et al. [9] have studied the effects of Wii games on elders' quality-of-life and their results showed that the overall well-being of Wii players was significantly improved, demonstrating the potential of the Wii to impact on the diverse aspects of elders' lives.

Another aspect in which games can contribute to older adults' well-being is in the area of cognitive stimulation. Increasing attention is being paid to the cognitive effects of playing games, on older people [25][26][7][6][8]. Not all studies were conducted with games specifically developed to older adults, however, even with regular games, results show that seniors who played them were faster in their reaction time [25][26], significantly improved their performance on tests of visual fluency and visual perception ability [8], improved cognitive skills and maintained their self-concept and quality-of-life [6]. Moreover a recent study reported that, in fact, these benefits remain for weeks and can be transferred to everyday tasks [27], indicating that games can help older people to stay mentally fit, thus contributing to their well-being.

3.1 Designing a tablet-based cognitive gaming platform for older adults

Combining tablets' characteristics with the aforementioned research results, we recognize an opportunity to study a solution that uses games as a cognitive stimulation tool for older adults. 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 older adult into the gaming experience.

The first step to develop the best possible solution was studying the relevant cognitive changes that take place with age and that were already described in section 2. Subsequently, it was crucial to understand how to stimulate the affected cognitive constructs. As to do so we analysed cognitive stimulation exercises provided by literature on ageing [28][18] from which we were able to extract patterns of gaming elements, and to relate them with the cognitive construct they intend to train.

Table 1 shows the matrix with the result of this analysis, which acted as a guide for the possible elements to include in a game that aims the stimulation of a specific cognitive construct.

Table 1. Cognitive Exercises Elements and Stimulated Cognitive Constructs

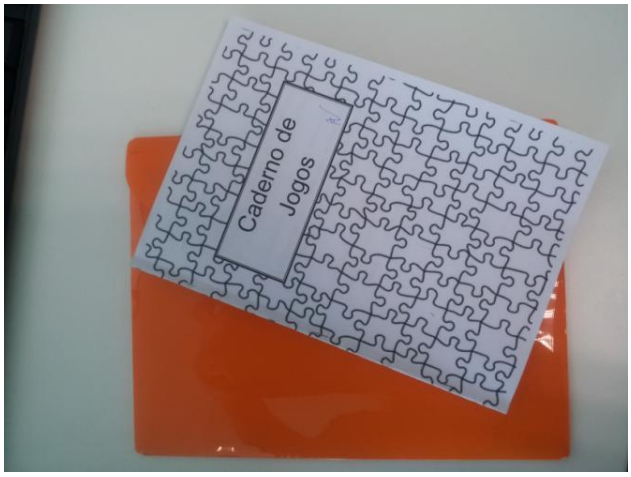
	Cognitive Constructs					
	Working memory	Semantic memory	Attention	Spatial cognition	Language comprehension	Problem Solving
Trivia		X			X	
Mimic	X	X	X		X	X
Patterns	X		X		X	X
Enigmas		X	X		X	
Find Differences	X		X	X		
Word Puzzles	X	X	X	X	X	
Sequences	X		X			X
Mazes			X	X		

Even though all these categories could be applied to games, we further performed a critical analysis of this matrix, along with a review of the literature, to settle on the most suitable ones for our platform and for older adults. We concluded that trivia and mimic games should not be considered in a first stage, since trivia games have the main purpose of stimulating semantic memory, which is not primarily affected by age. 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.

3.2 Gaming Platform Requirements

Gathering requirements for games designed for older adults may be more demanding than the usual process for a more conventional software artefact. On the one hand, game "requirements like *fun* and *absorbing* are not well understood from the perspective of requirements engineering" [29] and, on the other hand, "user requirements are usually elicited by a way of focus group, which is often difficult when working with older people" [30]. Thus, some reflection on the traditional methodologies was needed in order to overcome possible difficulties in the requirements elicitation phase of this project.

To understand games' context of use by older adults we resorted to natural observation in elders' usual get together sites and day care centres as well as informal conversations with them and their caregivers. These steps gave us a deeper insight on older adults' preferences – e.g. group games – and we also received some advices from the caregivers – e.g. if possible provide them with a variety of games. However, to obtain more formal and accurate results, we developed a *game book* to better assess seniors' preferences and difficulties regarding games, in particular games that were designed with the purpose of stimulating cognitive skills. This *game book* concept was developed considering the idea of games as research proposed by Nathan Shedroff [31] and was distributed among the elderly using the same method as the one of cultural probes [32].



Picture 1. Game Book

The *game book* consisted of 10 different games distributed over the following categories: 2 sequence games; 1 enigma game; 3 word puzzles; 2 labyrinths; 2 find differences games.

The *game book* was distributed to a group of older adults consisting of 13 individuals (10 female/3 male) with an average age of 80 (74-88) who were asked to solve the games and return the book to us within a week. When collecting the *game book* we

performed a questionnaire to evaluate their level of satisfaction, difficulties encountered or reasons for not solving a game. This questionnaire was carried out during an informal conversation.

Results showed that older adults felt more engaged in word puzzles and find differences games. This was mainly due to two factors: these games are more familiar to them, as they are usually available in magazines or newspapers (and for some of them these consist of regular activities); and because when assessing game difficulties, they pointed these two categories as the easier ones. This indicated that there might be a correlation between game preference and difficulty, as they tend to favour games that do not imply a great effort to solve.

3.3 The Gaming Experience

Our main concern in this project was to develop a product that users will want to use [33] and will be able to effectively use [34]. Thus, one of most important aspects of the solution is its usability – the ability that a specific user group has of using a product to achieve specified goals with *effectiveness*, *efficiency* and *satisfaction* in a specified context of use. [35] While all of these characteristics are of utter importance, the user satisfaction aspect is crucial if we aspire to develop a product that appeals to an older audience. The perceived usefulness of a system highly relies on the experience the user has when using a product and this is an essential aspect that dictates the acceptance of the final product.

The experience of use is related to the usability of the system, however in games this aspect extends beyond that. Games are about providing fun and enjoyable experiences [20] hence there is a need to understand which are the needed elements and mechanisms to support that, as well as the approach needed to assess their efficacy.

Gámez et al. [36] studied the gaming experience and proposed CEGE (Core Elements of the Gaming Experience) as the necessary, however not sufficient, elements that should exist in a game in order to provide a good user experience. According to their theory "a positive experience (enjoyment) while playing games is achieved by the player's perception of the game and the interaction with it". Furthermore, they specify that the game perception is given by the environment and the game-play, whereas the interaction depends on the player's sense of control, ownership and through the 'facilitators': aesthetic value, time and previous experiences.

From literature research on games, we learnt that the 'casual games' category endues some of the game elements that we believe are more suitable for the older user and that can be related to the ones of enjoyment above-mentioned. Trefry [37] defines the characteristics of a 'casual game' as:

"(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."

The sense of control in a game is given to a player as soon as he learns how to manipulate it. For this reason, and because older adults may find decision making more challenging due to their cognitive impairments, game rules and goals must be clear enough for them to understand (as in Trefry definition 1). Moreover, the existence of goals by itself creates motivation and ultimately provides the feeling of accomplishment, which may also influence the value of the game, as perceived by the older adults. In fact, is this rewarding sense that they may experience that produces ownership, when players understand that their actions in the game have results and a positive (or negative) outcome. Logically a positive outcome will keep the player engaged whereas a negative feedback can lead to frustration. Although a game should be challenging it is important to clearly understand what the player's skills level is in order to adapt the game level of difficulty to it. If that balance is achieved a user should be able to quickly reach proficiency (as in Trefry definition 3) which will reduce the risk of user dissatisfaction. This is especially important when designing for older adults, as they are more unwilling to learn via trial and error and get frustrated more easily [5]. These two characteristics are also connected to the time factor because, contrarily to what one may think, after retirement seniors do not have more free time. In fact they tend to engage in specific routines and have all their activities scheduled in advance [38]. For this reason they are not willing to spend their time in an activity that is unknown to them, thus requiring that the game adapts to their lifestyle (as in Trefry definition 2) and not being time-consuming. Finally, as elders of today do not have previous experiences with games, they tend to misinterpret some game concepts – such as the use of weapons – and favour games that portrait real stories or realistic activities [5][6] (as in Trefry definition 4).

In essence, we consider that 'casual games' provide a simple framework of game characteristics that, according to Gaméz's theory [36], has a number of necessary elements to provide an enjoyable gaming experience to an older audience.

4. USER INTERFACES TODAY

How users interact with technology has a huge impact on the way they feel about that experience [39]. Up until some time ago, to interact with computers, users had to use 'indirect' input devices, such as the mouse and keyboard. This kind of input devices is normally associated with WIMP (Window, Icon, Menu, Pointing device) user interfaces and is still widely used in desktop computers.

However, we see now a different range of input devices becoming available. These devices are not necessarily new, but they have reached a point where affordability, availability and consumer acceptance converge to make the devices reach a huge number of users [39]. These alternative devices are called 'direct' input devices, and they allow the user to have a more direct interaction with the device. Contrarily to 'indirect' devices, they are characterized by not requiring any transformation between the actions of the user and the action performed by the device. Because of this characteristic, their use requires little hand-eye coordination, little training and has minimal spatial demands [42]. Touch screens, touch pads, voice recognition, wearable interfaces are examples of this kind of devices. They open a new range of possibilities for designers to expand the way people interact with technology, creating richer experiences for users. Some studies suggest that gesture recognition through touch may be an alternative and more natural interaction method to indirect pointing devices [40].

A comparison between direct and indirect methods performed by Rogers et al. [41] from which we may conclude that while direct devices generally need less training and are better suited for novice users or those that do not want to memorize commands, indirect devices are more precise and users with more experience prefer them for longer periods of use. Direct devices are also considered to be easier to use because of their reduced cognitive and coordination demands.

As they age, seniors may experience a reduction in dexterity and motor coordination. And since most of them have never had contact with computer technology, and with the input devices being used, they may experience greater cognitive demands to execute tasks. These two factors can combine and make the seniors' first interaction particularly challenging [42]. Since direct devices have reduced cognitive and coordination demands when compared to indirect devices, they appear to be more adequate for the interaction with older adults. There are some age-related studies showing that older adults have problems when interacting with a computer using traditional 'indirect' devices, especially when they have some kind of disability such as Arthritis or Parkinson [11]. In a study by Wood et al [42], the performance of young and older adults, when using a mouse to interact with the computer was compared and it was found that the senior participants experienced difficulties when the task they were performing involved clicking or double clicking the mouse.

4.1 The Tablet

Tablets have recently risen in popularity. A Tablet can be defined as a device, in the form of a notebook that uses a touch screen as its main input method. The tablet's dimensions are normally bigger than the smartphone's and smaller than the laptop's. It is important to distinguish between two kinds of Tablets: the convertible and the slate. Much like the name implies, the slate looks like a writing slate and doesn't have a dedicated keyboard. Convertibles, on the other hand, resemble modern laptops with the difference that the screen is a touch screen. The screen can also be rotated and hide the dedicated keyboard to expose only the screen, which doesn't happen in normal laptops. For this project, we will only consider slate tablets since they are the format that we believe better adapt to our project. Slate tablets do not possess a physical keyboard but they have software capable of simulating a virtual keyboard on the screen that can be used like a physical one. This has the great advantage that the keyboard is still available when needed, but remains hidden the rest of the time. Not having a physical keyboard also means that the display screen can be bigger and more flexible [39]. So, slate tablets are usually smaller and lighter than convertibles [43].

4.2 The Selection of the Tablet for this Project

We chose to use the tablet for this project because of its mobility. This device is relatively small and can be transported nearly everywhere and used when necessary [43]. This is important when dealing with older adults since most of them experience some degradation of their motor skills and may be more inclined to use a device that does not weigh a lot and has reduced dimensions. The tablet also possesses an autonomy that is bigger than the one of a laptop, and yet smaller than the one of a smartphone. Finally, the tablet has a touch screen that can provide the novice user with a more natural way of interaction since he can interact with items on the screen by just touching them [39].

5. COGNITIVE GAMES PLATFORM

Throughout the process of research and requirements elicitation we became aware that our solution needed to take into account a number of characteristics. Besides the existing guidelines for developing games for older adults [16] and the above-mentioned results regarding the *game book*, we came across additional information that we consider to be an important contribution to this area and that will allow the development of more suitable products in the future.

Our solution is based on a gaming platform that will incorporate a series of mini-games, distributed into the categories that most appeal to the seniors. It has two playing modes: single player and collocated multiplayer. Since the games are expected to be played during a short period of time we decided to incorporate the multiplayer mode as a tool to manage player turns instead of allowing two or more players to use the tablet simultaneously. Although that could indeed be an option, when considering that cognitive games can enhance seniors' abilities it is important to note that such effects only take place if a game is played by a single individual at a moment in time. Nevertheless elders can still collaborate to solve a game if they wish to do so.

5.1 Platform Description and Prototypes

During our initial observations at the day care centres and other get together sites where older adults usually meet we observed that they favour games that promote social interaction, i.e. games that require more than one player. Along with that, competition seemed to be a big part of the gaming experience since both game participants and observers commented on the game progress and winning/losing strategies during the game development. When we conducted the *game book* experience we also verified 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, which also indicates an acute sense of competition among them. For those reasons we incorporated the multiplayer mode described earlier as well as a reward system so that users are able to keep record of their performance and compare game results.

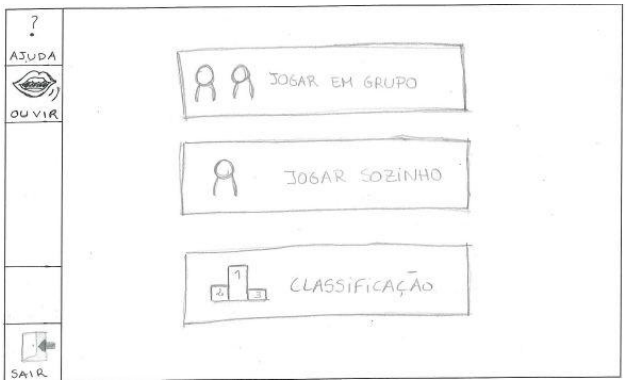


Figure 2. Paper prototype of the main menu with "play in group", "play alone" and "view scores" options

During the interviews with the caregivers at the day care centre we were told that non-digital games were already part of older adults' routine and that providing variety was a very important aspect. With the exception of some games that seniors play more regularly (e.g. cards, dominoes), they tend to get easily tired of playing the same game for an extended period of time. Further more the caregivers emphasized the importance of stimulating elders through the use of different games. For that reason we developed a gaming platform providing its user with a variety of different mini-games, such as demonstrated in Figures 3 and 4.

Figure 3. Choose Game Category Menu

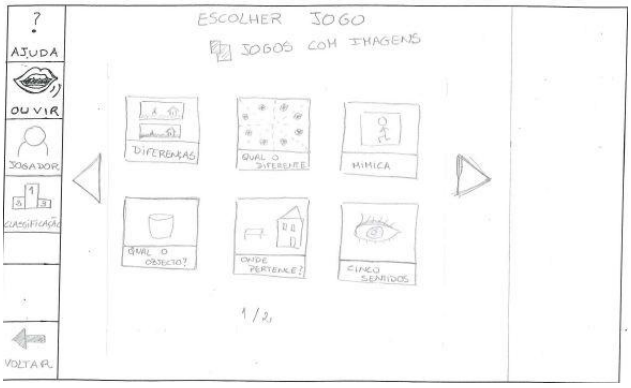


Figure 4. Choose Game Menu

Until now we have designed and tested two different games to be added to the platform. Both aim at stimulating cognitive constructs, in particular semantic memory and attention, and draw their characteristics from the 'casual game' category discussed in section 3.3. In the first one the older adult is presented with a set of similar images for a limited period of time during which he has to identify the one element that is different from the others (in our test this element was smaller than the others, but the differences may vary). Afterwards the screen is cleared and the elder is asked to identify the area in which the different element was located.

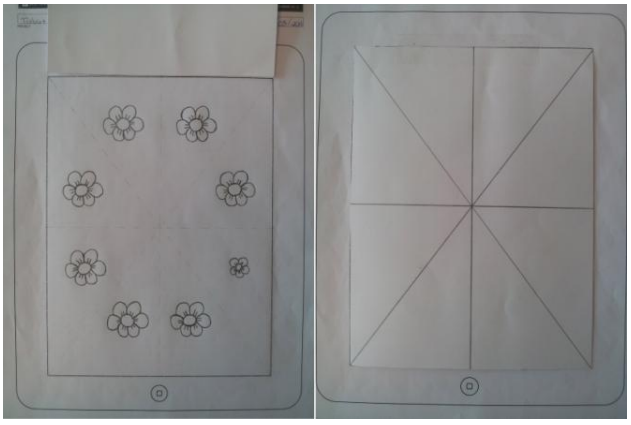


Figure 5. Game Prototype

The second game that was tested was a matching cards game. The player had to turn two cards at a time in order to find a matching pair. The major particularity of this game was the use of pictures of people that were known to them from their everyday life, such as the caregivers from the day care centre they attend to. We tested the game with both unfamiliar and familiar faces and concluded that elders not only preferred pictures from their acquaintances but also were faster in finishing the game.

Figure 6. Game Prototype with day care centre caregivers' photos

As argued in section 2, there are several age-related changes that may limit the extent to which an older user is able to interact with a system. All through the platform's design process we took those constraints into consideration and assured that fonts and icons were readable and understandable by people with vision impairments, buttons and other touch-based actions were accurately performed by seniors with motor impairments and that accessibility options like *Help* and *Text-to-speech* functionalities were implemented.

So far we have developed low-fidelity prototypes, which have been systematically evaluated with a group of seniors at a day care centre. These tests focused on assessing the overall usability of the system, as well as icons and naming conventions in order to be recognizable by older adults. The implementation phase of the project is in progress and after we have a fully functioning prototype we will run a trial to validate its acceptance by our target audience.

6. 10 RULES OF THUMB FOR OUR GAMING PLATFORM

It was our main concern to develop an artifact that holds the needed characteristics for providing an enjoyable experience to our audience. The overall specification and design of the platform, as shortly described in the previous section, considered their characteristics and needs. But there are a number of features we considered of paramount importance, which are as following:

1. Usage of direct input devices, to make the interaction as easy as possible and reduce the anxiety of elders towards technology;

2. Mobile platform, so it can be transported and played anywhere;

3. Unique interface, with a design that accommodates the changes elders experience as they age;

4. Expandability, so that new games can be created, made available and downloaded and play by elders;

5. Variety, by providing more than one game in each category enabling elders to choose their favourite;

6. Customization, since the games can be adapted to a specific individual through the use of pictures, videos or sounds that are familiar to him;

7. Feedback, for the user to know about his actions in the game, so that he knows where he was correct, where he failed and how;

8. Goals, to keep the user's focus on the objective of the game and that can act as challenges to keep the user engaged;

9. Rewards, to immediately award the user for his performance since the benefits of cognitive games might only be noticeable in the long run; the rewards can also be used to show to friends and keep track of the user's progress.

10. Social interaction, promoted by the multiplayer mode and through the reward system as it provides a conversation theme among elders while enabling a friendly competition.

7. DISCUSSION AND FUTURE WORK

Due to its expandability, this platform can be complemented in the future with more games and relevant levels of difficulty, so it adapts to a wider group of users. Furthermore, we prepared it to save a series of parameters regarding user performance that may be used not only to track an individual's progress but also as monitoring tools, similarly to the ones studied by Jimison and Pavel [7].

Another aspect that is yet to be fully explored is the cognitive improvements that games can in fact have on older adults. Although games have proven to have that potential, "currently little is known regarding how the schedule of video game practices affects transfer to other perceptual and cognitive abilities" [44]. However, despite the conclusions that future research may reach on the subject, a game should always be a fun and free activity, and imposing schedules could possibly negatively influence the user experience. For this matter a solution that motivates users, opposing to obligate them to play a game is needed. We are currently studying a mission/goals mechanism that would reward users that engage in a specific game playing routine, which could potentially be a solution for this issue.

Finally, however preliminary results have already indicated that the platform satisfies the various aspects of usability as well as its great acceptance by older adults, these results still need further formal validation.

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