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# Design and evaluation of mobile game for older people: an empirical study*

Projeto e avaliação de jogo para pessoas mais velhas: um estudo empírico

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**Resumo**

Em uma sociedade pouco adaptada às pessoas com 60 anos ou mais, os jogos digitais podem ser uma opção de lazer e cultura. Contudo, para que os usuários mais velhos possam jogar confortavelmente, os designers de jogos devem considerar as restrições decorrentes da idade. Este artigo apresenta os resultados de um processo de design de um jogo digital móvel focado em pessoas com mais idade. 30 pessoas mais velhas participaram da avaliação da primeira versão do jogo desenvolvido e 25, da segunda versão. Os resultados indicam que esse público-alvo dá importância a imagens, cores, sons e trilhas sonoras. Além disso, concluímos que um jogo projetado para pessoas mais velhas também deve ter recompensas simples, mensagens de reforço e linguagem adaptada ao público-alvo, considerando suas preferências e baixa experiência com o uso da tecnologia.

**Palavras-chave:** Design de interface com o usuário. Game design. Smartphones. Idosos.

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**Abstract**

In a society that is not well adapted to people aged 60 and over, digital games can be an option of leisure and culture for them. However, to achieve this benefit, game designers must consider age-related constraints so that older users can play comfortably. This paper presents the results of a process of designing a mobile digital game focused on older people. 30 older people participated in the evaluation of the first version of the developed game and 25 in the evaluation of the second version. The results indicate that, despite having visual and auditory restrictions, this target audience gives importance to images, colors, sounds and soundtrack. In addition, we conclude that a game designed for older people should also have simple rewards, reinforcement messages and language adapted to the target audience, considering their preferences and low experience with the use of technology.

**Keywords:** User interface design. Game design. Smartphones. Older people.

## 1 INTRODUCTION

Digital games may bring many benefits for older people (people aged 60 or over). Playing games can delay memory decline and other cognitive impairments and even improve cognitive abilities that are declining due to the ageing process (ZELINSKI; REYES, 2009). Besides that, as a leisure option, digital games have the potential to improve well-being (IJSSELSTEIJN et al., 2007).

In order to make these benefits a reality, there is the need to develop digital games focusing on the special needs of the older adults. In addition to the reduction of their cognitive abilities, older adults also suffer a decline in their motor skills and response times, auditory acuity, visual acuity and visual sensitivity (IJSSELSTEIJN et al., 2007).

According to the Entertainment Software Association (ESA)(Entertainment Software Association, 2014), 53% of the gamers play games on their mobile devices, mainly on smartphones. In developed nations, the number of mobile phone subscriptions is greater than the population (120.8%), which means that many people have two or more subscriptions. In developing countries, this number is smaller but even so, there are about 90 subscriptions per 100 people (MOBITHINKING, 2014). In Brazil, a survey conducted by the Center for Research on Information and Communication Technology (CETIC.BR, 2014) revealed that only 15% of people aged 60 or more used a computer in the last three months, and in some regions of the country only 23% of the houses have a computer. Moreover, 64% used a mobile phone in the last three months and 64% already had a mobile phone. These results indicate that mobile games for smartphones can reach a larger number of old people than games for computers

Mobile games for older people are a great challenge because of the small screens of mobile devices, mainly those of smartphones. In spite of being a very important topic of research, due to the increasing number of the population of older people all over the world (IJSSELSTEIJN et al., 2007; ZELINSKI; REYES, 2009; United Nations, 2014), there are still few published results about mobile games with focus on them. Based on this information, and given that there are few games developed with the focus on older people (GERLING et al., 2011), we sought to develop a mobile game that would meet the characteristics and needs of this audience. The results of the evaluation of this game are presented in this work, so they can be replicated and extended in future works. The game was appreciated by the old people who have participated in this work, indicating that the decisions we took should be considered in the design and development of other mobile games geared towards older people. These decisions consider physical, psychomotor (cognitive, sensoriomotor and psychic) skills restrictions and also low experience with technology and preferences, as this can impact the use of the game and also the vocabulary used in it. In addition, at the end of the paper, a list of recommendations for the design of mobile games for this public is presented.

This paper is organized as follows. Section 2 presents some related work. Section 3 presents the methods we adopted. Section 4 presents the main design decisions and also the evaluation of the first and second versions of the game developed. Section 5 presents our main

conclusions, a list of recommendations for the design of mobile games for the old people and also suggestions for future work.

## 2 RELATED WORK

In literature, we can already find some work related to the design of games and applications for older people, as well as discussions about the adoption of games in their lives.

Considering the adoption of mobile phone by seniors, Dyk et al. (2012) propose three major categories: (1) Physical characteristics : the device must have a big screen, must be easy to understand, with large fonts and high contrast, and must have a good speaker and buttons that provide adequate feedback when pressed; (2) Device complexity : the system should use a self-explanatory terminology and each button of the keyboard must control at most one extra function; (3) Functionalities : the device must have the two main functions (make and receive telephone calls) and also non-essential, but desirable ones, such as the functions of emergency, alarm, scheduling, text messages and audio input and output.

Several papers discuss factors that can hinder the adoption of mobile phones by older people, such as: lack of experience using computers and mobile devices (FISK et al., 2009), bad usability (KURNIAWAN, 2008) and perceived utility (MAGUIRE; OSMAN, 2003). However, the reality has changed in recent years. According to Conci et al. (2009), older users also own mobile phones as a tool for social interaction.

Regarding digital games, Ijsselsteijn et al. (2007) emphasized the importance of encouraging feedback, even in very simple levels so that the elderly feel more confident to play.

Strengers (2012) presented some design requirements for smartphone interface used by seniors, which should be considered when designing a game geared for this group of users. According to the author, the results showed that the interface requirements for smartphone are mostly similar to desktop interface design: colours should be used to highlight relevant information; screens should avoid animations or moving texts to avoid confusion; buttons, icons and font sizes should be larger than in applications for youth; text entry should not be by keyboard.

Nap et al. (2009), in turn, identified some of the preferences, motivations and needs of the senior gamers, such as: they prefer familiar games; they do not like violent games; they get too frustrated when they fail to achieve the goal of the game; one of their main motivations to play is to escape from reality; for them, games are a means to exercise cognition and reactions.

In another study of mobile games usability with a focus on seniors, Santos et al. (2013) identified that a game that is enjoyed to be played on paper can not always be easily adapted for mobile devices. This is the case of, for example, crossword puzzles, which are traditional games that are enjoyed by many older people, but are difficult to be played on smartphones for different reasons such as the fact that the virtual keyboard to enter letters is small, tips for guessing the words are hard to read, and finally, depending on the number of words in the game, full-screen viewing is inadequate.

Santos et al. (2013) also stressed the importance of defining a small number of game rules, since memory is one of the cognitive constraints that increases with age. Other features identified as important are: facility to learn, to exercise the mind and to provide tasks that are not performed in daily life. The elderly also expressed what characteristics they consider unimportant. Among them we can highlight: sound setting, soundtrack, competition.

Some researches in the area of mobile applications for older people are specifically tailored to meet psychomotor restrictions or lack of ability to use mobile phones. Mol e Ishitani (2010) identified that, as old people are more used to physical buttons than touch screen buttons, they usually press the touch screen with a lot of strength and for a longer time, which may cause unexpected responses from the device, such as the opening of the operating system menu.

López-Martínez et al. (2011) presented a computer game for the elderly, focusing on the exercise of cognitive functions. The results of their research indicate that developing a game adapted to the restrictions that come with age contribute to motivate the elderly and to make them feel cognitively stimulated too. Among the adaptations, we can highlight the high contrast between text and background, the simple screens and the content with short texts. However, the authors showed to be against the development of games for mobile devices due to small screen size.

Unlike the recommendation of López-Martínez et al. (2011), there are already successful experiments in the specific area of mobile games for seniors. One of these experiments is the game *MoviPill* (OLIVEIRA et al., 2010), which aims to help patients to remember to take medicine by means of social competition.

Within the scope of mobile games for seniors, (VASCONCELOS et al., 2012) developed a game for tablets. This work was based on the use of a gamebook that promotes the stimulation of cognitive functions, such as games of questions and answers, riddles, puzzles of words and differences between two images (5 errors). This gamebook was made available in printed format for evaluation by 13 seniors, with average age of 80 years. The findings identified ten guidelines for developing a game for tablets to be played by older adults. Some of these guidelines, such as the need for proper interface to the elderly, are already well known. Others, such as immediate rewards and variety of games, are innovative. In particular, according to the authors, it is important to offer a variety of games to be played, like mini-games or variations on the same theme, amplifying the actions of the elderly on the same activity options, preventing tiredness and keeping them interested in playing.

Given the restrictions that come with age, it is also worth highlighting the guidelines presented in the international accessibility guidelines W3C WCAG 2.0 (W3C, 2008), which include, among others: to associate text to non-text content, to facilitate listening and viewing content, to increase the contrast of colours, to give enough time for reading, to avoid the use of jargon, to help the user to avoid mistakes.

Because of visual impairments, some precautions should be taken during game design process. For example, colour should not be used alone to convey information (RIDPATH, 2000) because people with visual impairments or who do not correctly perceive colours will not un-

derstand well the information that is transmitted. Besides that, for the correct reading of a text, the font size must be equal to or greater than 12 pt (LÓPEZ-MARTÍNEZ et al., 2011). It is also recommended to allow the user to easily control font, colour and contrast setting and scroll rate (IJSSELSTEIJN et al., 2007).

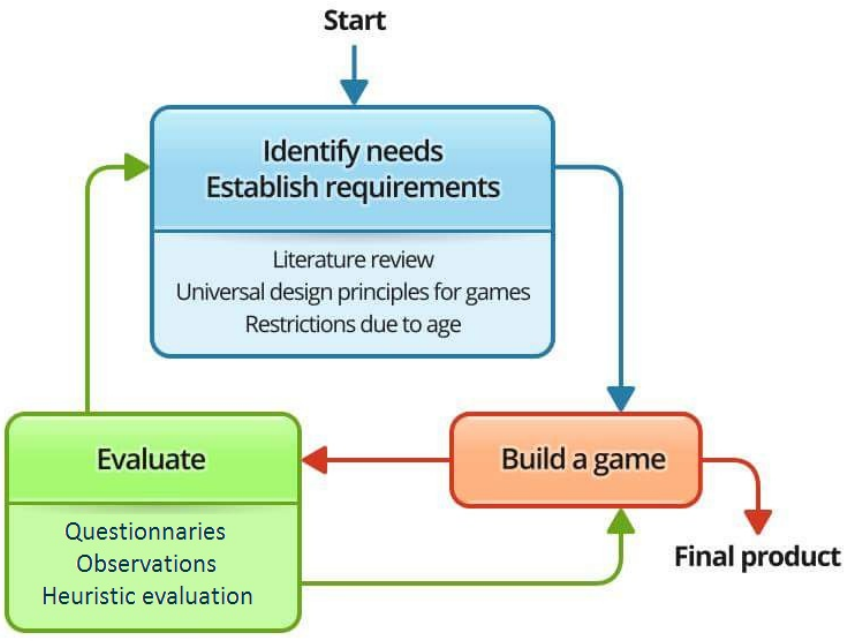
In addition to these guidelines, it is important to consider what motivates older people to play. Within this aspect, Carvalho e Ishitani (2012) recommended that a game should have a context or story that motivates players to keep playing and challenges that are not related to time limitation, which can create tension and a sense of failure, due to a typical characteristic of old people: increase of time response.

Besides those results, Cota et al. (2015) also recommended that a game for older people "should be acknowledged as a tool to aid cognitive diseases and to improve quality of life" .

## 3 METHOD

The methodology was based on the simple design model proposed by Rogers et al. (2012) (Figure 1). This model emphasizes the importance of a user centered design, evaluation of the developed versions and interaction between activities.

**Figura 1 – Design process model**




**Source: Adapted from Rogers et al. (2012).**

The following subsections describe each of these activities.

### 3.1 Identify needs/establish requirements

In general, a project begins with the identification of users' needs. In this phase, the set of guidelines identified in the literature review (SANTOS et al., 2014) (Table 1) was considered for the development of a mobile game for older people, called *Viajando pelo mundo*, which means "Traveling around the world".

The game design of *Viajando pelo mundo* also sought to include preferences and characteristics considered important by older people, such as card games and virtual world tourist trip (GERLING et al., 2011; CARVALHO; ISHITANI, 2012).

In the following subsections, topics on the human development in adulthood as well as the universal design principles for games are presented and discussed.

**Table 1 - Usability heuristics for the evaluation of mobile games for the elderly**

| |
|---|
| H1: The controls should be clear, customizable and physically comfortable; their respectiveresponse acti-ons must be immediate |
| H2: The player should find a tutorial/help to get familiar with the game |
| H3: The player should be able to customize the audio and images of the game, according to his/her needs |
| H4: The player should be able to easily obtain information about everything in the game,including his/herscore |
| H5: All visual representations and messages should be easily understood by the player |
| H6: Layout and menus should be intuitive and organized so that the player can keep his/herfocus on the game |
| H7: The aesthetics of the screen should be good, with visible content, enabling the identification and understanding of its components |
| H8: Game sessions/matches should allow quick start |
| H9: The player should be able to save the current state to resume the game later |
| H10: The main objective of the game must be presented to the player since the beginning of the game |
| H11: Graphics and soundtrack should catch the interest of the player |
| H12: The player should be rewarded for his/her achievements in a clear and immediately way |
| H13: The challenge of the game can be adjusted according to the player's skill, and it should not be repetitive and boring |
| H14: The game should allow the player to develop skills that will be needed in the future |

**Source: Santos et al. (2013).**

### *3.1.1 Human development in adulthood*

Human beings suffer physical, psychological and cognitive changes during their lives. This development process has been organized in phases, based on age, which are commonly referred to as: childhood, adolescence, adulthood and old age. It is during old age that people actually face loss of their physical and cognitive abilities (PAPALIA et al., 2009).

It is known that health, activities and habits influence the ageing process. So, it is important to think about the practices to adopt for this process to occur more slowly (WILLIAMS; KEMPER, 2010).

The physical capacities that are reduced with ageing include those related to vision, hearing, motor control and dexterity. Nielsen (2013) presented the results of a study involving 75 old people, in which 82% of the participants reported difficulties related to visual problems, 73% related to lack of dexterity and 49% related to oblivion.

Reduction of visual acuity is perhaps the best known impairment among older people problems. Visual restrictions may vary from the inability to focus on objects that are close, due to presbyopia (VASCONCELOS et al., 2012), to other more serious diseases such as macular degeneration, glaucoma and cataract (HEITING, 2017). Independent of disease, vision undergoes restrictions due to age which include (IJSSELSTEIJN et al., 2007; HEITING, 2017) decreased visual acuity; loss of near vision; reduced field of vision; reduced colour, depth and contrast perception; decreased adjustment to the dark. This makes it difficult for the elderly to perceive and locate small elements on the screen and to read text with small letters. Lopez-Martinez et al. (2011) clarify further that the elderly have limited perception of small details.

Over the years, hearing is also compromised on some frequencies (LÓPEZ-MARTÍNEZ et al., 2011). Many older people, especially men, suffer from presbycusis, or the reduced ability to hear sounds at a very high frequency, which, for example, makes it difficult to hear beeps (VASCONCELOS et al., 2012).

The reaction response time also increases due to the reduction of psychomotor skills, such as motor coordination, which makes it difficult to perform actions that require precision (VASCONCELOS et al., 2012). In general, the elderly also suffer cognitive constraints such as (BORG et al., 2014; LÓPEZ-MARTÍNEZ et al., 2011; VASCONCELOS et al., 2012): reduced attention to details in the presence of distracting information; reduced shortterm memory; difficulty to learn and to perform new activities or old activities in a new way; reduced spatial cognition, or the ability to mentally manipulate images and patterns; inability to remember the goals of a task to be performed. These impairments can be caused by diseases such as Alzheimer's but also by the natural ageing process.

According to Papalia et al. (2009), people approaching retirement often wish to expand their minds and their skills to make a more productive and interesting use of leisure. Some adults simply enjoy learning and want to continue learning throughout life. Then, learning activities, work and leisure should be available for people of all ages. This possibility can help older people to slow the impact of ageing on their physical and cognitive abilities, which often

determines their emotional state.

### *3.1.2 Universal design principles for games*

Usually, the design of a game is based on certain principles or approaches, such as those presented by Despain (2012) and Schell (2008), but another dimension in the construction process must be considered: the so-called value-based thinking or design values. Instead of thinking about the design of a game through classical principles, it must be designed considering the desired values (KULTIMA, 2009). This becomes appropriate when considering cultural differences, whether ethical, regional, related to belief or age, which in the latter case, is the focus of this work.

The development of a game must consider four design values (KULTIMA, 2009): acceptability, accessibility, simplicity and flexibility.

Acceptability means that games must be accepted by a large group. The acceptability occurs when games avoid the use of offensive topics (value judgments, race, beliefs, violence, sexuality), are built using simple puzzles, make use of abstract topics, reproduce themes of universal appeal (as gardening, travel, cooking), evoke positive emotions, exploit simple and easy to understand mechanics, and modify the real life of the player, involving learning or allowing social interactions among others.

In its turn, accessibility enables different people, with varying disabilities, to play the game. It is achieved through the use of topics which are mentally or cognitively common and recognizable by the audience, concise and contextualized content, simple design, easy purchase and installation and also when it considers the preferred options of the player (social networks, mobile phones, tablets, computers or game consoles) and requires little or no investment to be played.

Simplicity is what makes the game easier to be understandable so the player can quickly start playing. Minimum interface elements should be used in the construction of the game. In addition, simple interactions maintain cognitive effort of the player focused on the game, and not on the interface, which is critical when considering the restrictions due to age (Section 3.1.1).

Finally, flexibility enables the player to change settings or situations in the game. For example, a casual game can be played while traveling, eating, reading, practicing a sport or doing many other activities. Thus, the game must offer very flexible options, allowing the player to, for example, pause a game and resume any moment.

### 3.2 Build a game

Based on the conducted literature review, whose results are presented in sections 2 and 3.1, two versions of the game were built. The following subsections describe each of these versions.

#### *3.2.1 First version of Viajando pelo mundo*

For a digital game with focus on older people, it is desirable to select a theme that is not part of their everyday life (MOL; ISHITANI, 2010; SCHELL, 2008). One of these themes is a trip around the world, due to their physical or financial difficulty to travel. Making virtual tours also contribute to broaden general knowledge.

Thus, a virtual world tourist trip was selected as a main theme and we chose three countries (Brazil, France and Japan). In a playful manner, players could learn or exercise their country knowledge through mini-games. The game design was defined as follows: the player chooses a country to be explored and, for each one, there are four mini-games which follow the Flow (CSIKSZENTMIHALYI, 1990) and the Fun (KOSTER, 2005) theories.

Considering the needs of older people and features (Sections 2 and 3.1.1), we selected the following mini-games: 1) Memory – exercises memory; 2) 5 errors – exercises attention; 3) Guess the word – exercises language; 4) Jigsaw puzzle – exercises memory and visual perception.

The selected games have the following advantages: they are well-known by older people and their design is well-defined, which means the rules and mechanics are already created and tested by other game designers, which is one of the crucial steps for a successful digital game development (RABIN, 2010).

For a proof of concept, only the memory and the 5 errors mini-games were included on *Viajando pelo mundo* first version. As they are well-known games, the project could focus on the production of a friendly, clear, visually interesting and easy to handle interface.

The memory mini-game, entitled *Memória* (Figure 2(a)), is quite simple: during three seconds, cards containing different country context images are presented to the player; after that, they are turned over in order to hide the images. The player must match pairs of cards with the same image and wins the game if all pairs are correctly matched. In *Viajando pelo mundo*, this mini-game has increasing difficulty levels, with 12, 16 and 20 cards.

In the 5 errors mini-game, entitled 5 *erros* (Figure 2(b)), two nearly identical images are presented side-by-side to the player who must try to indicate the differences between them, touching the screen. The player wins the game when all five errors are discovered.

A virtual postcard, from the selected country, is given as a prize to the player when he/she concludes all levels of a mini-game. Each postcard also has the tourist attraction name and the name of the city where is located.

**Figura 2 – Screenshot of the mini-games on the first version of Viajando pelo Mundo**


(a) Memory mini-game (b) 5 errors mini-game

**Source: Elaborated by authors.**

*Viajando pelo mundo* shows players how to select a country beginning with a spinning 3D-Earth model with waving flags from Brazil, France and Japan properly placed on each country. The planet stops slowly, a short text instruction appears ("Swipe the screen and select a flag") and an iconic hand repeatedly shows the right action to be performed, indicating what the player should do. The planet reacts according to the speed and direction of the player's finger movement. The waving flags draw user attention to select one of them.

Considering the design values presented in Section 3.1.2, the interface respects: the acceptability value, because the game does not present any violence and offensive content, has no mechanical competition between players and does not have a time limit to complete tasks; the accessibility value, as the mini-games are quite familiar to the general public, the icons and words are simple, the application installation is via a single file that is self-installing and free;the simplicity value, since the entire interface is minimalist, more complex functions are hidden and grouped into a single menu (such as the settings menu) and all the interface follows the same pattern of functioning; and flexibility value, because the game can be installed on any mobile device running Android. The navigation system was designed to have at most three navigation levels: country, mini-game and phase. Two buttons are always visible: the *Opções* (Options) menu button and the "Back" button (except on the first screen, because there is no screen to return to).

### *3.2.2 Second version of Viajando pelo mundo*

The second version of *Viajando pelo mundo* aimed to treat the problems identified previously (subsections 4.1 and 4.2), and then to improve game usability and playability. In addition, all mini-games proposed initially were developed and other cultural aspects were included, such as typical musics, new images and other achievements.

The four mini-games were called *Memória, 5 Erros, Adivinhe!* (guess the word) and *Quebra-cuca* (jigsaw puzzle). Figure 3 shows a screenshot of each mini-game.

In *Memória*, we have changed the position of the cards from horizontal to vertical. We have also changed their number (6, 8 and 10 cards) for two reasons: first, 12 cards were too difficult for many older people, according to their complaints; at last but not least, visual im-

**Figura 3 – Mini-games screenshots of the second version of Viajando pelo Mundo. From left to right, top to bottom: Memória, 5 Erros, Adivinhe! and Quebra-cuca**


**Source: Elaborated by authors.**

pairments of older people showed that this number of cards was the largest possible number of cards to show in vertical position.

In *5 Erros*, we included more pictures.

In *Adivinhe!*, the player must complete a word taking a corresponding image as a hint. For this reason, several shuffled letters are available, and the player selects them touching on the screen or dragging the letter to the correct position in the incomplete word. The success and error indications are made by different colours, respectively green and red. Moreover, it is possible to remove a placed letter touching on it or dragging it, so the letter goes back to the set of available letters.

Finally, the jigsaw puzzle *Quebra-cuca* begins with an entirely-solved image being displayed, divided in some pieces according to the game level (9, 16 or 25 pieces distributed in a square-matrix way). After a few seconds, those pieces are shuffled on the screen. The player acts moving each piece, or previously grouped pieces, trying to joint them where connections are possible. The game ends when the player joins all pieces. Intending to improve the user experience, only the grabbing action is allowed (i.e. pieces do not suffer rotation).

Because of the four mini-games simplicity, an improvement was made to enhance fun and engage players (ROGERS, 2010): for every mini-game won in each country, the player receives a typical souvenir as achievement. The achievements created for the project are shown in Figure 4. In the first line, Brazilian souvenirs: coconut tree, Cristo Redentor miniature, jaguar puppet, Namoradeira miniature and a yellow-green soccer ball. In the second line, French souvenirs: Arch of Triumph miniature, perfume, Eiffel Tower miniature, beret hat and a bottle of wine. In the last line, Japanese souvenirs: Maneki Neko, geisha puppet, japanese clutery, typical fan and geta footwear.

According to Huhtala et al. (2010), animations are recommended to highlight transitions between environments and elements insertions on interfaces. On our environment, all interface

**Figura 4 – Achievements of the second version of Viajando pelo Mundo**

**Source: Elaborated by authors.**

elements "come in and out of the screen": they appear quickly zooming in to draw user attention, and reverses the process when quitting or backtracking.

Considering the usability evaluation results on the game first version, the following design aspects have been improved: simplicity and flexibility. For simplicity, all interface is minimalist with simple and understandable icons; all buttons come with text and, when necessary, with an image to help understanding its function; more complex functions are hidden and grouped into a single menu (such as the settings menu) and all the interface follows the same motion pattern and organization. To improve flexibility, the game allows the player to set some options, such as audio removal as well as restart the player progress or select difficulty levels for each game, which gradually increase its complexity.

For the design of the new buttons, it was considered the needs of the target audience previously advised. We changed their size, improved the colour contrast and included texts and some iconic representation. Thus, both image and text contributed to a better understanding of each button function.

The vocabulary used was chosen carefully, avoiding computer jargon. For instance, instead of requiring a "click" on the screen, we asked them to touch the screen (*Toque aqui*, in Portuguese). The word "achievement" was replaced by gifts (*Lembranças*, in Portuguese) and the word "menu" by the word "options" (*Opções*, in Portuguese) and so on. As the game was developed for Brazilians, we also avoided the use of words in English.

The menus of countries, mini-games and their levels are organised as a horizontal circular sliding list (CSL) which responds to the user action of sliding his fingers (Figure 5). This interface behaviour uses a natural and common movement accepted in any smartphone. The CSL partially shows the other semi-hidden options in the left and right, highlighting in colour, opacity and size, and the currently selected option.

The CSL solution is better than a traditional menu, which keeps all options on the screen at once. This causes a button size reduction to maintain all of them on the same screen, compromising their readability and preventing the inclusion of informational text in large typefaces,

**Figura 5 – Initial screen to select countries on the second version of Viajando pelo Mundo**


**Source: Elaborated by authors.**

which is a need of older people. The CSL allows many modifiers over the unchosen options, such as size reduction and colour/opacity, which is in accordance with the visual constraints, the need for simplification and the reduction of attention shifts. The options of the menu has a different background colour (black instead of blue), in order to demonstrate the special screen meaning. It presents all the basic game settings in a vertical CSL, such as audio control, a text tutorial for each mini-game and the exit game option. There is also the option to restart the entire system, in which all completed levels and unlocked achievements are reset, after player confirmation.

To be more understandable and easy to use, a help for the interface appears whenever the player starts the application. To show that there are several CSL semi-hidden options, the list of current options is displayed using a sliding animation to help the player understand that the menu can be accessed by swiping. Finally, this menu organization method is scalable, once new countries, games and levels can be easily included, without redesigning the entire interface.

Touch screen sensitivity was also an important aspect to be considered. Unlike other users, older people tend to press the screen too hard and for too long. Because of this, some design decisions were taken, such as increasing the size or changing the colour when a button is pressed and including inertia in the menus movements (according to the speed of the touch movement, the buttons move slowly or quickly by following the user command) (MOL; ISHITANI, 2010).

### 3.3 Evaluate

The first version of the game was evaluated in two steps: the first one was attended by 30 people with 60 years or more, and the second by four specialists from the field of humancomputer interaction. In the evaluation with users, data were collected through observations and questionnaires (Section 3.3.1). The second evaluation was carried out as a heuristic evaluation of the game (Subsection 4.2), and its results were compared with the ones from the evaluation made by the elderly.

The second version of the game was evaluated by 25 people with 60 years or more. Once again, data were collected through observations and the same questionnaires used in the evaluation of the game first version.

The next subsections detail the research tools and the process of game evaluation.

### *3.3.1 Questionnaires developed for the evaluation of the games*

We developed two questionnaires to be used in our evaluations with older people. The first one aimed to collect demographic information about the participants, in order to check if results were influenced by characteristics and previous knowledge of the participants of the evaluation. Information collected concerned age, gender, level of education and previous use of technology.

The second questionnaire aimed to collect the evaluation of the participants about the game *Viajando pelo mundo*. Most of the questions were based on the usability heuristics presented in Table 1. The other questions asked about clear rewards, easy help, pleasing colours and soundtrack. To answer each question, each participant could choose one of the following options (Likert scale): 1 - Strongly disagree, 2 - Disagree, 3 - Neither agree nor disagree, 4 - Agree or 5 - Strongly agree. Besides these closed questions, two open questions were proposed to the participants: what they liked most and what they disliked most in the game.

### *3.3.2 Evaluation of the game by older people*

User evaluation involved the participation of seniors with 60 years or more. All the participants were invited from the circle of friends and acquaintances, following the recommendation that volunteers who belong to a personal or family sphere enable good results (MONTEIRO, 2011; ALMEIDA et al., 2011). The tests were performed in a familiar environment for the participants, such as their own residence or other known environment.

First of all, the participants were instructed about the purpose and the importance of the research. After the initial presentation, participants were asked to sign a free informed consent. Then, they received and filled in the first questionnaire with demographic information, as described in the previous section.

Before playing *Viajando pelo mundo*, the participants received some orientations about the operation of the basic functions of the smartphone, as most of them had never used a touch screen or a smartphone before. The participants played the game without any time limit. The survey data were collected through annotations made by the researchers, and recorded by the application SCR Free Root (Available at http://www.scr-screen-recorder.com/), which captures the screen image and also the audio of the environment. The tests were carried out on a smartphone Google Nexus 4 with a 4.7-inch touch screen and 318 pixels per inch.

After playing *Viajando pelo mundo*, the participants were asked to fill in the second questionnaire.

#### *3.3.3 Heuristic Evaluation*

In addition to the evaluations with older people, four professors from the field of human-computer interaction conducted a heuristic evaluation of the game. As defined by Desurvire and Wiberg (DESURVIRE; WIBERG, 2009), a heuristic evaluation is an inspection method for usability evaluation and has been expanded to more specific assessments such as the one of mobile games.

The physical and motor limitations of older people were considered for the heuristic evaluation. This evaluation considered the same heuristics that served as the basis for the questionnaires used in the tests.

In the end, we analysed all the obtained results and elaborated a set of recommendations for the development of mobile games for older people.

## 4 RESULTS

The development of a new game was motivated by the fact that most of the available games don't consider the specific characteristics of older people (CARVALHO; ISHITANI, 2012), as presented in sections 2 and 3.1.1.

The following subsections present the main results of the two evaluations with older people and also the results of the heuristic evaluation.

### 4.1 Evaluation of the first version with older people

The evaluation of the first version of *Viajando pelo mundo* followed the procedure presented in Section 3.3.2. The participants of the evaluation were 30 people aged 60 years or over. 73% of the sample were 75 years old or younger and 60% of them were women. With regard to the Education Level, there was no incidence of participants with graduate, master or doctoral degree.

Regarding physical and cognitive limitations, nobody had an impairment which negatively affected their activities.

Among the participants, 53% owned a traditional model of mobile phone, 37% had no mobile phone and only 10% had a smartphone. Regarding the participants' experience with the use of the mobile games, 90% had never played before the tests.

None of the characteristics examined (Subsection 3.3.1) were scored by the participants

of the evaluation with grade less than 3 and most of them were scored with grades near 5, which was the best possible score.

The characteristic that was not well-evaluated (presented in Table 2) was associated with the need to memorize the game commands – it was observed that this characteristic occurred mainly because of the difficulty in using the mechanism of transition among the mini-games and the countries.

Additional considerations were recorded during evaluation sessions. The memory mini-game showed all the images of the cards before turning them down, but the participants complained that the time to see all the images of the cards was too short.

> *"The cards are turned over very quickly. The time is not enough to try to memorize the pairs."*

Considering the audio features of a game, despite the loss of hearing being a common deficiency of older people, and against previous results (SANTOS et al., 2013), we cannot disregard the importance of the sounds and songs of a game.

> *"I liked a lot the sounds of the game. They are very clear."*
> *"I liked a lot the sounds of the game. They are very clear."*
> *"The music should be different for each country, and typical songs should be used."*
> *"This song... It seems that I am dreaming."*
> *"I liked the song. It is calm."*

A similar conclusion concerning vision impairment can be reached.

> *"The pictures are very beautiful, clear, colourful."*

Rewards showed to be important, but there is no need to propose innovative or very creative ones.

> *"I found the postcard interesting, but I liked it more when the game showed 'Congratulations'."*
> *"I liked the 'Congratulations' because even having spent much time, the message showed me that I have managed to finish."*

The comments of the participants also reinforced the importance of giving older people the opportunity to learn more and also to exercise their mind.

> *"It is interesting to see the culture of other countries, such as the cultivation of rice in Japan."*

*"I was in need of a game like this to exercise my memory"* (talking about the memory game).
*"This game is very good to exercise my mind."*
*"When we arrive at a certain age, we need to exercise the mind: the game is very good and fun."*

It is also worth to mention some notes made by the researchers during the evaluation process. These are shown in Table 2, where Pxx indicates a participant of the evaluation process. In general, they emphasize the need to make things as simple as possible.

**Table 2 – Observations of the participants (First version)**

| **Observations related to usability problems** |
|---|
| P05 and P13 did not know what to do after choosing the country. They did not realize that they had to choose the icon of one of the mini-games.<br>P07 did not understand that the flags shown in the globe should be tapped in order to choose a country.<br>P13 was not able to return to the main menu after seeing the rewards.<br>P16 did not identify that the button with an arrow to the left was to return to the previous screen of the game.<br>P17 and P22 did not understand that they should choose one image to start playing.<br>P08 did not understand that the postcards were a prize/bonus.<br>P07 and P12 thought that the marks on the mini-game *5 Erros* were the total number of errors found. They did not realize that the game marked the differences on both images at the same time.<br>In *5 erros*, P24 and P25 did not understand that the six mini-game options were related to the six available images of the country. |
| **Some difficulties related to motor impairments** |
| P12 and P14 found the choice of a country a bit tricky, because they had spun the globe very fast.<br>P03, P15, P18 and P27 found it difficult to settle differences in the mini-game *5 Erros*. Sometimes, they pressed the screen several times until they hit the exact spot. |

**Source: Elaborated by authors**.

It is also important to show motivating messages: P21 and P23 liked to be congratulated when completing a level. Some of the participants preferred messages than other prizes. For example, P19 had no interest in seeing the postcards.

### 4.2 Heuristic evaluation

The evaluation of the first version of *Viajando pelo mundo* by game designers was held by four evaluators. During the process, the evaluators considered the physical and motor limitations of older people due to age.

From the analysis of the identified problems and also the solutions proposed by the evaluators, it was possible to organize a set of changes necessary for the game to become more suitable for older people. These suggestions are presented in the following paragraphs.

1. There is no visual feedback of a selection. In order to make older people feel more secure of their actions, and as touch screens are not familiar to some of them, the game should vibrate the mobile phone or show a mark, like a circle, indicating that the screen was touched.

2. For older people it is important to repeat some instructions. For example, what they must do when the game returns to the main menu.

3. After choosing a country, there is nothing in the game that confirms or remembers the user which country he/she has chosen.

4. The country selection is made by clicking on the flag of the country on a globe that spins. The player must swipe his/her finger across the screen to make the globe go round, so that the flags of the countries are displayed for selection. There are many problems associated with this mode of interaction and the first two of them were confirmed during evaluation with older people: players not used to touch screens may find it difficult to control the speed and the direction that the globe will rotate and also to select a flag, while the globe is spinning; regardless of age, there is no easy way to know the number of available countries in the game and as so, this kind of interaction should be replaced; even by showing the flags instead the respective country, the user may not know which country the flag is associated to, so it is important to show the name of the country.

5. As, in general, older people are not heavy users of technology, the X icon to exit the game is not intuitive and it should be replaced by a better metaphor for exiting the game or by an explicit question, such as “Do you want to exit the game?”.

6. Images should always be displayed vertically because the images in the horizontal force the user to change the mobile phone position to use the game comfortably.

### 4.3 Evaluation of the second version with older people

Unfortunately, five participants of the first evaluation could not participate again due to illness or death. So, the second version of the game was tested by 25 people aged between 67

and 96 years. 16% of the participants said they play on mobile phones every day or almost every day (Earthworm, Pou, Solitaire, sudoku, among others). The game evaluation process lasted 30 days.

In general, users liked very much the new version of the game, which was observed by their comments.

*"The game stimulates and exercises the mind."*
*"The game helps to relax."*
*"The game is very challenging."*

Despite having enjoyed all the mini-games, the participants showed a higher preference for mini-games *Memória* and *5 Erros*. For these two games, users have expressed many positive comments.

*"The places and landscapes are beautiful!"*
*"The memory mini-game aids to exercise the mind."*
*"I loved the game because it is colourful!"*

And despite presenting a jigsaw puzzle with few pieces, there is still the need to reduce this number to increase the size of the pieces.

*"The jigsaw pieces are very small."*

There were also statements that demonstrated that older players pay attention to the soundtrack.

*"I did not like to hear a single song for all games of a country." "In the 5 Erros game, we hear always the same song for the same country".*

There were no negative comments about the menus, which may indicate that our design option is adequate for older people.

As in the presentation of the first evaluation results, some notes made by researchers during the evaluation process deserves particular mention. In Table 3, P2xx indicates a participant of the evaluation process of the second version of the game.

**Table 3 – Comments of the participants (Second version)**

| **Comments of the participants regarding sound and visual resources of the game** |
|---|
| P210 said the game is beautiful and dynamic.<br>P202, P203, P204, P206, P212, P213, P216, P218, P223 and P224 said the colours are sharp and nice.<br>P203, P210, P212 and P215 stated that though they liked the songs, they thought it was kind of boring having only one song per country. |
| **Comments concerning the rewards** |
| P210 appreciated the system of rewards, but he did not like the rewards (souvenirs).<br>P224 said he was expecting a reward for each completed level of the game, in spite of winning only one, after completing all the levels.<br>P213 said he wished a scoring system that allowed him to play the game again to improve his previous score. |
| **Some participants demonstrated difficulties in using the jigsaw puzzle mini-game** |
| P209, P210, P213, P223 found a problem in the pieces of the game: too small or confusing, and overlapping. |

**Source: Elaborated by authors**.

**Table 4 – New recommendations for the design of mobile games for older people**

| **Recommendations** |
|---|
| Menus with semi-hidden options allow the display of all options without having to reduce their size |
| Soundtrack is important and as so, must be included. Despite of the hearing impairments, many older people can hear well and like good songs. If possible, vary them throughout a game session |
| Icons and vocabulary must be well-chosen to be understood by older people, which includes avoiding the use of jargon |
| Drag–and–drop interaction must be avoided due to possible motor impairments |
| Congratulations are important Rewards must have value for older people |
| Display time of messages and other elements of the game must be greater than in games for young people |

**Source: Elaborated by authors**.

## 5 RECOMMENDATIONS AND CONCLUSIONS

According to the results of the evaluations of the game *Viajando pelo Mundo* we could organize a set of new recommendations for the design of mobile games for older people. These recommendations are presented in Table 4.

Regarding the game *Viajando pelo Mundo*, the results indicate that despite having a small screen in relation to desktop computers, smartphones can be used by older people as a de-

vice for playing games, even considering their visual impairments. The mobile game *Viajando pelo Mundo* was well evaluated by all the participants of the evaluation of the two versions of the game, who aged 60 years and over. There was no manifestation against the use of games in smartphones, by the group that, though small, covered various levels of education, professions, ages and genders.

This result contradicts some previous studies which indicated that mobile devices were not suitable for older people (FISK et al., 2009; KURNIAWAN, 2008) and opens a wide space for further research and for the gaming industry. From the development and evaluation of the two versions of the game we could extract several features for visual and gameplay improvements (Table 4). Although some adjustments are still needed as discussed in the evaluation of the second version of the game, we came to a very appropriate game to the needs of the target public of this work.

These results motivate the development of mobile games for older people, aiming at specific fields of knowledge, such as education and health.

Future extensions of this study should include tests with a larger group of old people, after improving the game with more countries and levels for each mini-game. It is also necessary to increase the test period, to confirm the fact that the game is not repetitive or monotonous. A longitudinal analysis may contribute to understanding the characteristics of a mobile game which are very important to improve user experience.

One important aspect to be studied is level design for older players, given the restrictions that come with age, including motor and cognitive difficulties. The authors also want to evaluate competitive and cooperative games.

It was also observed, during the tests, that sometimes older people do not play by not knowing the available options of games. Interestingly, the initial participation restrictions were, in most cases, due to the fear of doing something wrong or of damaging the device that was being used, since, in general, participants did not have a smartphone and therefore had no experience using the features available on this type of device.

As a future work we also propose conducting assessments with seniors from higher social classes, with more user experience of mobile devices to see if the recommendations for game design focused on older people remain the same. Besides, we propose to perform tests using devices with larger screen, such as tablets, which would allow checking if the screen size and consequent size of the components on the screen interfere with the results obtained in this research.

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