

A study on the interaction of the elderly with digital games through usability and user experience evaluations

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Abstract

The growing number of the elderly and their potential use of technological products requires understanding the interaction between these users and technology to develop appropriate products that include them. Accordingly, this article focuses on studying the interaction between older people and digital games to provide strategies for digital game developers to create inclusive games for these users. Thus, usability and user experience evaluation sessions were performed to achieve these objectives, and the older generation's acceptance of technology during interaction with digital games was verified. The data collection methods were observation and the application of questionnaires, one before the tests to evaluate the profile of the public and another afterward to assess usability, experience and technology acceptance. The test was applied to 36 people aged 60 and over. The results showed that the elderly prefer mobile devices and use them more often. Despite their lack of experience with digital games, the test participants had a good experience, even with difficulties such as game time management and perception of screen elements.

Keywords: Elderly, Digital Games, User Experience, Usability, Technology Acceptance.

1 Introduction

According to the World Population Prospects report, by 2050, one-sixth of the world's population will be over 65 years old [1], highlighting a transformation in the demographic pyramid. This increase in life expectancy is due to advances in medicine and economic and social development in developed and developing countries. The Brazilian Institute of Geography and Statistics (Instituto Brasileiro de Geografia e Estatística - IBGE) confirmed the same prediction in Brazil. In 2023, people aged 60 or over represented 33 million, which means 14% of the population, and estimates indicate that this number will be 60 million by 2050 [2].

Aging is an irreversible social and emotional process that affects biological aspects. The biological dimension is expressed through structural changes and the depreciation of functional capacity, not caused by diseases but by changes that occur gradually throughout life. Thus, aging is a series of changes accompanying an individual over the years, involving physical losses such as the human being's vision, hearing, motor and sensory coordination [3]. Consequently, aging generates a slowdown in cognitive processing, reduced attention, difficulty retrieving learned information, and decreased prospective and contextual memory, leading to problems in older people's everyday tasks and socializing [4].

However, activities that stimulate cognitive abilities can minimize clinical manifestations related to dementia, for example [4]. Playfully, board games, hangman, word searches, and memory games, among others, promote these cognitive stimuli. Many games can be easily accessed on a computer, via the Internet, or through mobile applications (smartphones and tablets).

Considering digital games used by the elderly, it is clear that there are functional barriers related to this technological innovation and the elements implemented in the interfaces, which often do not consider the physical and cognitive restrictions arising from age, such as the size of the displayed elements which makes viewing difficult [5]. Therefore, when developing technological products that include older people, it is necessary to consider these users' physical and cognitive characteristics to provide a quality of inclusion, socialization and independence. So,

this research aims to understand the interactions of these users with digital games based on usability assessments, user experience and acceptance of the use of technology.

Usability allows verifying the ease of use of a product as well as the ability to support users' real work in an effective, efficient way and promoting subjective satisfaction [6] and [7]. User experience highlights users' perceptions while using the product [6]. Exploring the acceptance and use of technologies allows us to verify whether the individual believes technological devices are useful and can be used independently. Besides, understanding the reasons for accepting or refusing to use these technological products provides clues on improving the acceptance [8] and [9]. From this, the practices of older people were identified, considering vulnerabilities acquired with age. These characteristics should not be obstacles to interacting with technology. Therefore, the need for special configurations to serve this audience is emphasized. These adaptations are specific to them and any group to provide a more inclusive and comprehensive experience.

Then, physical and cognitive limitations acquired due to aging were studied to achieve this research's objective: usability, user experience and acceptance of technology for developing data collection tools and understanding the digital barriers that the elderly face when interacting with digital games. Five existing digital games to collect study materials were selected from the game collection provided by ProBrain (<https://www.probrain.com.br/>). This company develops interactive and educational games to stimulate communication, memory and attention skills. These games were subjected to tests with users from the target audience, and then two questionnaires were made available, one pre-test and the other post-test, where the data were analyzed. With the data collected, it was possible to identify strategies so that digital game developers could create more inclusive games for older people. Consequently, this will give this age group a more engaging, efficient, effective and satisfying experience when using these games.

Five sections structure this paper. In addition to this Introduction, section 2 presents the theoretical framework and related works to support the research. Section 3 outlines this study's methodology, test planning, and collection methods. Section 4 discusses the analysis of the results obtained after performing the tests. In the end, Section 5 addresses final considerations and future work.

2 Theoretical Reference

This theoretical framework presents some characteristics and limitations acquired throughout life to understand the interaction needs of the elderly. It presents the concepts of usability and user experience, focusing on older people and their interactions with digital games to clarify the differences between these concepts. It also presents concepts about technology acceptance models that were used to collect data on the acceptance of technology by the elderly when using digital games. Finally, it shows some related works found in the literature.

2.1 The elderly – lifelong cognitive and physical losses

The human body and mind can undergo changes related to motor, cognitive and perceptual functioning problems throughout a person's life [10]. Aging is a complex process that involves multiple endogenous and exogenous factors. According to reference [11], endogenous factors, such as genetics, anatomy, and physiology of the human organism, determine individual receptivity. This process does not begin in people over 60, but it is a persistent degenerative process of varying degrees that affects everyone's lives [12]. A gradual decrease in functional reserve characterizes such changes. That is, an organism under normal circumstances, the older will be able to survive adequately. However, they may experience difficulties due to physical and emotional stress, among others [13].

Over the years, the senses lose their intensity. Thus, the brain still interprets nerve signals translated from environmental stimuli (light, sound, taste and touch sensations) less intensely. From the age of 60 onwards, issues related to vision loss become more visible [14]. In addition to vision, there is loss of hearing and motor coordination. That is why the elderly need more time to perform complex tasks. They lose skills with delicate movements, which makes their movements less precise [15].

Cognitive function is linked to perception, learning, memory, attention and reasoning. Furthermore, this concept often includes psychomotor functions (reaction time, movement, performance speed). During the natural aging process, some changes occur in the body of individuals, and some of these cognitive abilities begin to manifest their decline mainly in slow processing, reduced attention and memory [16]. However, these losses can be minimized when there are opportunities for cognitive stimulation, caregiver support and possibly assistive technologies to improve safety and independence.

Fortunately, most of the time, cognitive decline is due to disuse (lack of practice), illness (such as depression), behavioral factors (such as alcohol and drug use), psychological factors such as lack of motivation, lack of confidence and low expectations and social factors (such as loneliness and isolation) more than aging itself [17]. The

speed at which information is processed represents more cognitive change. It is evident in the older that the cognitive delay affects other functions and may be responsible for cognitive deficits, the difficulty in understanding texts, the need for a richer and broader explanation and more time to perform calculations [18].

2.2 Usability and usability evaluation methods

According to ISO 9241-110:2020, usability concerns the extent to which specific users can use a system, product or service to achieve particular goals with effectiveness, efficiency and satisfaction within a specific context of use [6]. In this sense, it can be considered that the important characteristics of the interaction are:

- Efficiency: The resources needed and consumed to achieve the objective;
- Effectiveness: The quality with which the user achieves the objectives;
- Satisfaction: How the user feels when using the system.

Usability is typically measured by testing the system with some representative users performing a predetermined set of tasks. The measurements obtained from a set of usability metrics are calculated to determine the system's overall usability or recognize that users are different considering the entire distribution of usability metrics [19].

According to [19], the following components should constitute the focus of the interface designer's attention:

- Ease of learning: The system must be easy to use, allowing even inexperienced users to perform the supported tasks quickly;
- Efficiency: The system must be efficient in its use so that, once learned, it allows a high level of productivity to be achieved;
- Memorability: The system must be easy to remember, allowing casual users to reuse the system without having to relearn its use;
- Error prevention: The system must prevent users from making errors, in particular, those that cause damage to the work. The system must allow users to recover from errors. However, this attribute does not include system errors, only those committed by the user.
- Satisfaction: The system must be pleasant to use.

Usability evaluation can be undertaken with users (empirical models) or with usability experts (analytical models) [20]. Using these models, usability evaluation methods, such as testing, survey, controlled experience and inspection, were established. The first three are related to empirical models and involve users; the last is linked to analytical models and includes experts.

The test method involves observing users in the field, where individuals perform their daily tasks in the natural environment, or in a controlled environment, where individuals are observed executing specific tasks. The difference between observation in the field and a controlled environment occurs in the focus, as the first is interested in user interaction. At the same time, the other emphasizes what individuals do [21].

The survey method involves collecting qualitative data from users, which, although subjective, provides relevant information about desires and expectations.[22]. Data can be collected through focus groups, interviews, and questionnaires.

The controlled experiment method presupposes the application of the scientific method to test a hypothesis with real users in addition to measuring or observing certain behaviors. This method uses a sample size sufficient to determine statistical significance. Collections are conducted through usability tests and experiments [21] and [22].

Inspection involves the participation of experts to evaluate different aspects of the interaction through criticism and identification of usability problems. This includes heuristic evaluation, walkthrough, inspections, and analyses [21] and [22].

2.3 User experience applied to the elderly in games

User experience is defined as a person's perceptions and responses that result from the use and/or anticipated use of a product, system or service [6]. A complement to this definition is that user experience explores how a person feels when using a product. That means the experiential stage, affective, meaningful and valuable aspects of using the product [23].

The main objective and focus for designing accessible products is to ensure their universality, making the product more flexible and complete. The application of user experience aims to make interfaces more perceptible and understandable by users in various circumstances, environments and conditions. A concern at this level will benefit all people with cognitive or motor limitations related to the circumstances and the device used [24].

Older people represent potential users for the use of digital games. This statement is directly due to the benefits of some available game resources. However, some games were not developed or structured with the elderly in mind. Therefore, games are often not accessible to them.

Older people need more time and follow a slower pace. Learning to manipulate and absorb the working mechanisms of these artifacts is slow, whether for personal, everyday use or professional activities. Games do not always have an easy-to-use interface to adapt to the characteristics of the elderly. So, for example, considering font size and type, icon size, color contrast, and interaction design, aside from using sounds with a lower frequency [14].

Elderly people do not like playing complex games, with many rules to follow during the stages [25]. Several works have emerged to make digital games recreational and leisure. With researchers' interest in revealing cognitive potential, especially quality of life, studies on the target public stand out, some of which deal with losses of memory, hearing, vision and motor coordination, which are more prominent in the age group over 60.

It is then stated that older people do not use gaming technologies in general because there is no incentive, preparation and accessibility aimed at this audience. Furthermore, these characteristics are not always considered in gaming culture. Technology developed for the older must meet their essential expectations to accept and adopt it in everyday life [26].

It is necessary to use methodologies that can include characteristics of the older generation to mitigate this problem, such as user experience, which offers more appropriate solutions by understanding users' perceptions, feelings and emotions when using a product. To this end, the development process must focus on the target audience, from the requirements for an interaction design, the analysis of the user experience, and a study concerning the game's objective. This focus allows for constructing a standard design that is easy to understand, interpret, and usable according to the interaction between the user and the product.

2.4 Game Experience Questionnaire

The GEQ (Game Experience Questionnaire) is a data collection instrument to evaluate the user experience during the game. It has a modular structure consisting of a Core Module, Social Presence Module and Post-game Module. Modules are applied immediately after the game session ends in the order above. The first and second parts examine emotions and thoughts while playing. The last one evaluates how players felt after they stopped playing [27].

The Core Module is the central part and evaluates the gaming experience as points in seven components: Immersion, Flow, Competence, Positive or Negative Effect, Tension and Challenge. The Social Presence Module investigates the player's psychological and behavioral involvement with other social entities, whether virtual, that is, characters within the game, mediated (for example, others playing online) or co-located. This module should only be applied when at least one co-player is involved in the game. The Post-game Module evaluates how players felt after they stopped playing. This model is relevant to assessing naturalistic gaming when players voluntarily decide to play, but it can also be relevant in experimental research [27].

2.5 Technology Acceptance Model

The Technology Acceptance Model (TAM) explains the determinants of computer acceptance that are comprehensive enough to elucidate user behavior across a wide variety of end-user-oriented computing technologies and user populations while also being simple and theoretically justified [8].

TAM assesses the intention to use technology through perceived usefulness and ease of use. The former is defined as the extent to which someone believes using technology will improve their performance at work. At the same time, the latter is determined by how much a person believes that technology will be effortless [28].

The reference [29] proposed TAM2, which adds new elements to meet the needs of the first model. In this way, social elements (subjective norm, voluntariness and image) and cognitive elements (relevance for employment, demonstrated results and quality of outputs) were added to the first model. Then, reference [28] developed TAM3, which adds to TAM2 and considers the influence of other factors on technology acceptance, such as device self-efficacy, perception of external control, technophobia, device playfulness and objective usability.

2.6 Related work

This section will cite previous experiences related to this research topic. The reference [30] analyzed gamers' feelings while playing games, considering the developers' industry's needs and evaluating the users' general

experience. The authors also address interaction techniques as evaluative methods for enhanced user experience, such as gestures, eye tracking, and biophysiological inputs and feedback.

The reference [31] sought to discover the perceptions of older people in Florianópolis about the usability of the digital game SolitaireQuiz. To do this, they surveyed elderly people between 60 and 100. During the research, the authors noticed that the older had difficulty knowing gameplay and lacked time to understand the game's rules before it started. Another factor highlighted was the difficulty in identifying the numbers on the cards, which the researchers believe was due to the small size and lack of contrast between the elements on the screen.

Reference [32] presents a systematic mapping of accessibility and usability issues in the development of digital games for older users. The study found 46 publications on the subject. The results showed that accessibility in digital games for the elderly is only predominantly considered in the implementation and evaluation phases when combined with usability. Usability is considered a requirement for game accessibility. It was also found that the number of publications on usability was greater than the number of publications on accessibility in the development of digital games for the elderly. In this sense, the authors emphasize the need to address usability for the elderly population so that accessibility is also addressed consequently.

Reference [33] presents usability tests of a touchscreen puzzle game with elderly users. The authors observed some common behaviors as a result of the user tests, such as the difficulty of playing without prior instructions. It was also observed that the testers were unable to start the game using only trial and error.

Unlike the aforementioned studies, this research collects data on the interaction of elderly users with digital games through empirical usability, user experience, and technology acceptance evaluations. Usability testing allows for the verification of the efficiency and effectiveness of the technology during interaction. The user experience identifies comfort, satisfaction, and emotional sensations during interaction. Additionally, the acceptance of the technology by the elderly in the entertainment action of playing was evaluated. The articles mentioned played an important role in preparing this study, providing more in-depth knowledge.

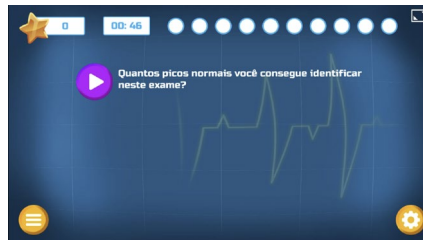
3 Methodology

A bibliographic survey was conducted to search for studies, research, applied methodologies and the results that served as the basis for developing this research. A study was carried out on the older population and its characteristics, usability concepts, user experience and metrics, focusing on developing and applying usability tests and analyzing data from them.

After theoretical research, five games made available by ProBrain were chosen on its platform that offer gamified solutions to stimulate brain skills related to communication, hearing and learning in adults and children. The games chosen were: "Find the Hat" (Ache o Chapéu), "Heart Monitor" (Monitor Cardíaco), "Lite Duration" (Duração Lite), "I found it,"(Achei) and Supermarket" (Supermercado), which target motor coordination skills, auditory perception and memorization stimuli. Even though these games were not developed specifically for the older, they are often used by them. Figure 1 shows an interface for each game.



(a)



(b)



(c)

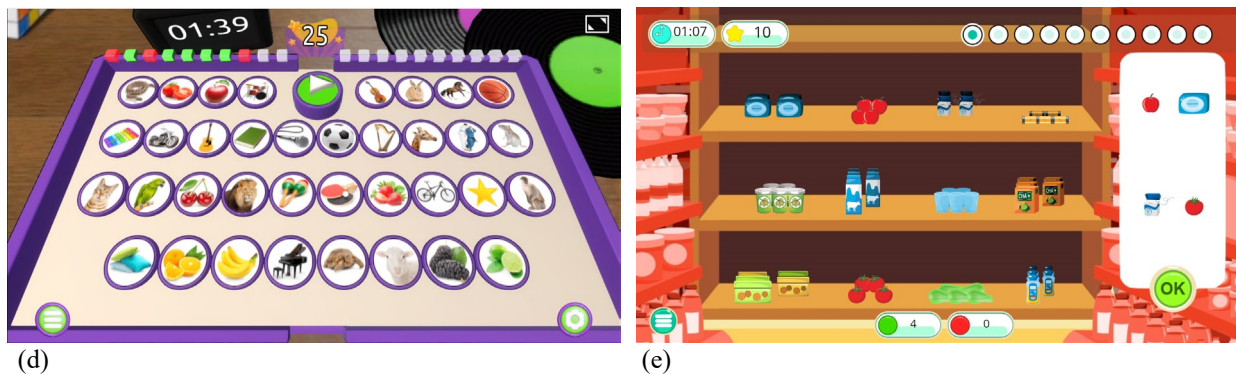


Figure 1: Game interfaces (a) Find the Hat, (b) Heart Monitor, (c) Lite Duration, (d) I found it and (e) Supermarket.
Source: <https://www.probrain.com.br/>

After selecting the games, the tasks to be performed during user testing were defined. Table 1 describes these tasks. The games were evaluated with the target audience twice: in April 2022 and August 2023. Each participant evaluated three games defined by the researchers.

Table 1: Tasks performed in each game during user testing

Find the Hat	Heart monitor	Lite Duration	I found it	Supermarket
Turn off the sound. Then activate it again	Read all instructions, then return to the menu	Read the instructions	Read the instructions	Read the instructions
Read all game instructions. After reading, close the instructions	Put the game in full-screen mode	Adjust the music and game volume to whatever level you think is best	Increase the game volume to 10dB	Decrease the music volume
Choose Level 1 and play as instructed	Mute the game music	Make music sound come out only through the right ear	Choose a game-level	Choose a game-level
When you finish Level 1, play Level 2	Silence the noise of people in the background	Play Level 1 as the given rules	Play the chosen level	Play the chosen level
When you finish Level 2, exit the game	Play Level 1 of the game Change the time interval between peaks to 500ms Turn the game music back on Replay level 1	When you finish Level 1, play Level 2 Send a suggestion and/or complaint about the game	When you finish the level, exit the game	When you finish the level, exit the game

Participants were selected by convenience and invited to participate voluntarily. The inclusion criteria of the sample were individuals aged 60 years or older who had the ability to interact with digital games. Individuals with physical or cognitive impairments that prevent them from using technological products and those who did not consent to the research were excluded from the sample. Participants were given the option to withdraw from the study at any time, either due to fatigue or inability to perform the planned tasks.

We observed users while performing the tests to collect usability data, as observation is essential to understanding interaction difficulties and errors. Besides observation, two questionnaires were administered: the pre-test questionnaire to obtain demographic information about the participants and discover their familiarity with technology and digital games; the post-test questionnaire collected data on the user experience and acceptance of using technology.

During the tests, participants performed the tasks previously defined for each game to interact. Then, through the post-test questionnaire, their perception of satisfaction and perceived ease of use were analyzed. To this end, the TAM3 questionnaire was used to assess user acceptance of the technology, and the GEQ was used to evaluate the users' experience based on how they felt after playing the games. The post-test questionnaire consists of 16 questions from the TAM3 questionnaire and 12 from the **GEQ post-game module**, and all questions were answered on a Likert scale from 1 to 5, ranging from "completely disagree" to "completely agree".

3.1 Test planning and execution

Test planning considered the equipment to be used, the navigator, the time spent on each stage of the test, the tasks to be performed by the testers, the tasks to be performed by the test observer and the collection tool. Pilot tests were undertaken to validate this plan, with two users who performed the tasks and answered the questionnaire, timing the time for each activity and considering an increase of 10% of this time spent to carry out the tests, which resulted in 45 minutes to take the entire test. But in practice, the testers took longer than expected, as they needed, on average, 1 hour and 40 minutes to complete all activities. Thirty-six older people, aged between 60 and 85, participated, with 12 (33%) taking part in the first round of tests in April 2023 and 24 (67%) in the second round in August 2023. Before starting the testing session, all users were informed about the research objectives by the applicators. The collection procedures were previously informed to the testers, as well as the time that would be spent on the entire testing session. It was made clear to the testers that the evaluation focused on interaction and not on the users' expertise, and they were also informed about the possibility of withdrawing at any time. It was also explained to the testers that the data collected would be anonymized and used for this research, guaranteeing privacy and confidentiality. Next, participants signed the Informed Consent Form.

The study was conducted in the testers' homes, with available notebooks belonging to the researchers with Internet access. The researchers previously opened the game pages in the Chrome browser so that the user could begin the experience of playing a level of each game. After trying out the games, a questionnaire was applied based on the GEQ post-module (for all participants) and TAM3 (only in the second round of tests; only 67% responded). Each user was evaluated individually, having the possibility to ask questions related to technology or the game with the applicators, which happened to some users who requested some help or questions regarding the game.

In total, there was, on average, 1 hour and 30 minutes of experience, divided into 15 minutes for contextualizing the research and guidance on the objectives of each game, 5 minutes for preparing the tool and opening the games in the Chrome browser, 50 minutes for users to perform tasks. During this phase, researchers observed and noted each user's behavior. At the end of the test, 20 minutes were available for each tester to answer the questionnaire. In the first round of testing, a post-test questionnaire consisting of 33 questions based on the GEQ Core Module was applied to evaluate the user experience. In the second round, a post-test questionnaire was answered, composed of 16 questions from TAM3 and 12 questions from the GEQ post-game module, evaluating acceptance of the technology and experience with the game.

This research was approved by the Ethics Committee of Universidade Presbiteriana Mackenzie on December 19, 2023, under Opinion No. 6.592.441 and CAAE: 73351923.4.0000.0084. All ethical precepts were fully respected.

4 Results and discussion

This section presents and discusses the data collected from users during the application of tests conducted by the authors of this work.

4.1 Interviewees Profile

Tests were performed with 36 users aged between 60 and 85, divided into two stages. Of the total, 36% of participants were male, while 64% were female. Initially, there were 38 participants, but two withdrew and were disregarded.

The pre-test questionnaire reported that among the older's favorite activities were: "talking to family and/or friends" (87.5%), "listening to music" (83.3%), "reading" (66, 7%), "performing physical activities" (66.7%), "going for a walk" (66.7%) and "dedicating oneself to religion" (66.7%). The least popular activities were "board games" and "card games". Furthermore, it was found that all the elderly in the research, except for two, use or have used electronic devices, with the majority of them, 87.5%, using them daily. Furthermore, some participants commented during the test observations that they preferred mobile devices, which aligns with the studies of reference [36].

The most performed tasks on electronic devices were: "sending messages" (87.5%), "social networks" (83.3%), "searching on search engines" (79.2%), making calls (70.8%) and "taking photos and/or recording videos" (70.8%).

The least common uses were: "taking notes" (12.5%), "food delivery app" (16.7%), "calendar and alarms" (25%), "online shopping app" (29.2%) and "games" (29.2%). Regarding the comfort level with technology, most responded that they felt more comfortable than uncomfortable. Only one said he felt uncomfortable, and none said he was completely uncomfortable. However, 41.7% reported they were neither comfortable nor uncomfortable.

About online games, 36% of the older had already played an online game. Among the most played types of games, the following stood out: "Puzzle" (29.2%), "Memory game" (25%), "Card games" (25%). However, the types "RPG", "Shooting games" and "Chess" games proved to be unpopular for this sample since only 8.3%, 0% and 8.3% of participants, respectively, answered that played them frequently. Furthermore, 54.2% of users choose to play alone, 25% prefer to play collaboratively with other players, and 20.8% prefer to play competitively.

4.2 Observation while interacting with games

It was observed during the tests that some participants confused the initial message of the game contextualization with the respective instructions with the play action. This corroborates the need for prior instructions for the elderly users on the game playing addressed by reference [33]. In games that had background animation, some participants thought that these animations were elements that could be manipulated during the game. A simpler interface, avoiding unnecessary elements, would have avoided these confusions. Despite this, participants could understand how the interface worked during the interaction.

In games with hamburger menus to access them, many participants thought it was a button to access the sound settings, as, according to them, the icon resembled a speaker. As a result, they had difficulty accessing the game menu and settings. These results denote that the interface components must be understandable.

Another confusion was regarding the colors. Many participants understood that the red color would be a button with a connotation of something that could not be clicked, and the green color would have a clickable connotation. They also had difficulty understanding that gray buttons were unavailable at that time. Testers were observed clicking gray buttons trying to perform some action. These observations indicate that the interface design must consider users' cultural issues.

Another situation noticed was that a user with a slight hearing impairment, when he was successful in one of the game's stages, the game sent a sound notification for the stage passage. Still, a visual or textual alternative was not presented on the screen, resulting in the tester's doubt about whether he had achieved the objective. Furthermore, if the sound had a low frequency, it could be heard, as mentioned in the reference [14]. It was also observed that the size of buttons, icons, clickable areas and fonts sometimes need to be enlarged, a recommendation already highlighted by the reference [14].

Within the game settings, users had difficulty changing the volume levels, as they were reported as being: "OFF", "-15dB", "-10dB", "-5dB", "ON", "+5dB", "+10dB" and "+15dB" from mute level to the highest level. One of the users suggested that there should only be "ON" and "OFF" levels to turn the game sound on or off.

4.3 TAM results

It is worth mentioning that the 16 TAM questions were applied to only 67% of the participants. The questions related to TAM demonstrated that most elderly people who answered these questions believe that games can improve their memory, localization and ordering performance (54.2% completely agree). Despite the usability problems and difficulties observed, most participants responded that the game interface was clear and understandable (45.8% agreed, and 33% neither disagreed nor agreed). In comparison, 33.3% of them agreed to use the games if they had access to them. However, users were more divided when asked whether games required much mental effort, but 33.3% completely disagreed. Half of the participants neither agreed nor disagreed that the games were easy to use, while 33.3% agreed.

Regarding the fear of using computers, 37.5% of older people disagreed or agreed that computers scared them, while 29.2% agreed. Users were divided when asked about the nervousness that using it can cause, but with a slight tendency to say that they completely disagreed.

4.4 GEQ Results

In the first round of tests, the GEQ Core Module was applied. Analyzing Figure 2, 98% of users enjoyed the experience, with 94% feeling challenged by the game. 94% found the game aesthetically pleasing, which aligns with the 96% who rated the experience as rich.



Figure 2: Positive aspects of the 12 participants in the first round of tests

Analyzing Figure 3, 67% of users who participated in the first round of tests had to make an effort to play. However, only 23% felt pressured. Adding to the 48% of users who reported difficulty, only 19% felt frustrated, with one of the users commenting on his frustration at not having a prize at the end of the game, showing only an achieved score.

The Post-game Module was applied in the second round of tests with 67% of the total sample. From Figure 4, it can be seen that 79.2% of participants felt satisfied, and 75% felt renewed after playing. Around 66.7% felt energized after the game. The feeling of winning was highlighted by 62.5% of respondents. However, only 45.8% felt proud and 16.7% empowered.

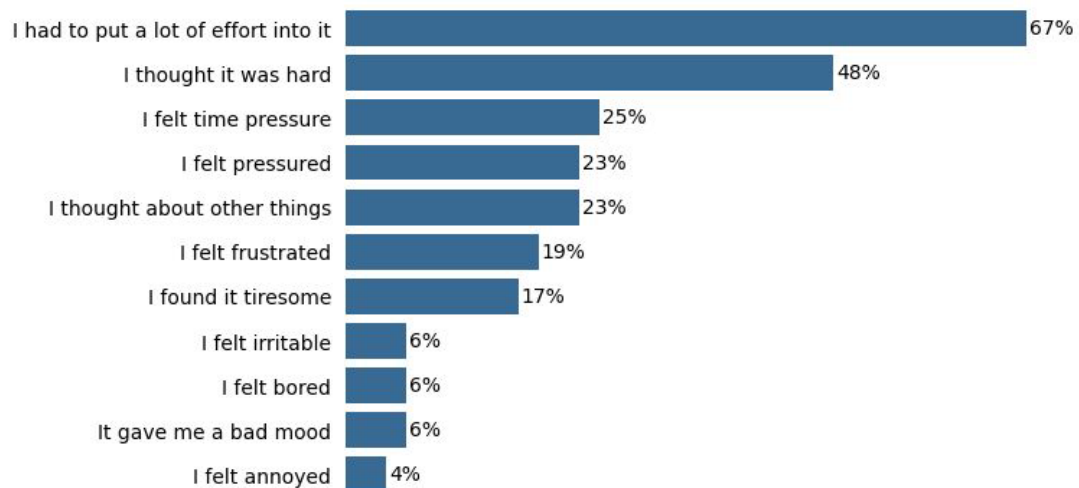


Figure 3: Negative aspects highlighted by respondents in the first round of tests

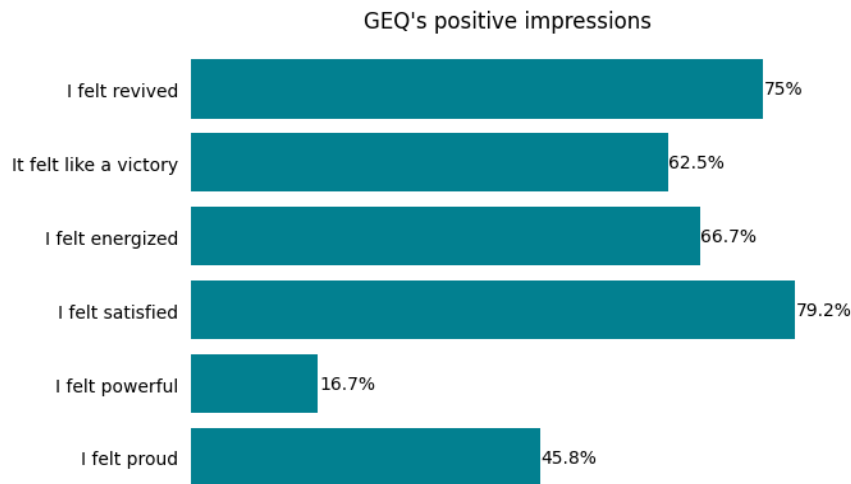


Figure 4: Positive impressions pointed out by participants in the second round of tests.

Figure 5 reveals that no participant felt bad when playing, but 29.1% thought they could do more useful things instead of playing games, and 8.3% felt they wasted time and regretfulness. 12.5% felt ashamed, and 4.2% felt guilty after the game.

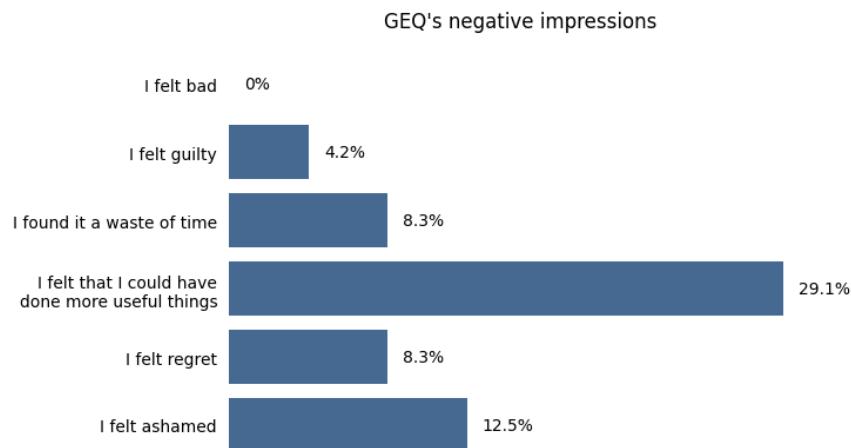


Figure 5: Negative impressions highlighted by participants in the second round of tests.

From the data collected on the positive points, it is possible to conclude that despite the challenges faced by users, there was a good experience, considering that 96% of respondents felt good and 79.2% were satisfied when playing. Regarding the negative points, it is possible to realize that although the user made an effort to achieve his goals and felt some difficulties during the experience, this was not a determining factor for him to feel irritated or in a bad mood, considering the 6% of each feeling. Still, some felt they were wasting time and could be doing other things. Effort and difficulty could be mitigated if players were informed about the objectives of the tasks in the game in clear and simple language, as pointed out in reference [30].

4.5 Recommendations generated from experiments

Based on the results obtained from the experiments, it was possible to define some recommendations that will provide strategies for digital game developers when developing inclusive games for older people. Table 2 shows the recommendations observed. As recommendations herein presented aim to improve usability issues, such as efficiency, effectiveness, and ease of use, and can be considered as accessibility requirements during the implementation of games for older users, as recommended by reference [32].

Table 2: Recommendations observed from the experiments undertaken in this research

ID	Recommendations
R1	The game should preferably be for mobile devices
R2	The game cannot be virtual reality, or that prevents the user from viewing the environment around him.
R3	Consider cultural aspects in the use of colors, icons and format of action buttons
R4	Present information in more than one media
R5	Allow increasing the size of screen elements, especially texts, action buttons, icons
R6	Reduce the amount of information on the screen to facilitate the understanding
R7	Make it clear to the user what each element on the screen represents
R8	The game must have a tutorial level that explains to the user how it works through brief texts

5 Final considerations and future work

This paper conducted evaluations to understand the interaction of the elderly with digital games, their experience and acceptance of technology and provide some recommendations for developing inclusive digital games. The research involved the participation of 36 people aged between 60 and 85, considering the physical and cognitive limitations arising from age. Five games made available by ProBrain were evaluated. The games were developed to stimulate motor coordination, auditory perception and memorization skills. Twelve (12) older users tested the games to collect information and identify their feelings from interacting with the digital games in the first round of tests. Another 24 participants, different from the first round, interacted with the games to collect information about technology acceptance and experience when playing. It was still possible to observe and infer, from the pre-test questionnaire, that the elderly prefer puzzle games, memory games or single-player card games as they are the most popular among them. The post-test questionnaires showed that the game tutorials were unclear, affecting users' understanding of the gameplay. Therefore, it is recommended that future games have an interactive tutorial in which it is possible to play the game and read brief texts containing explanations simultaneously. According to the results, these recommendations are necessary because older people have little experience with digital games. In this way, it will be possible to overcome the barrier of lack of training that some of them have, cited by reference [9].

Although the research achieved its objectives, some limitations were noted, such as using questionnaires composed of different questions between the first and second rounds of tests. This event occurred because the need to improve collection instruments was realized from the first round onwards.

In future work, we intend to validate the recommendations obtained from experts and increase data collection tools for testing games using thinking aloud and interviews about the experience immediately after executing the tasks, improving the fidelity of the results. The aim is to produce a guide of good practices and recommendations for developing and adapting accessible and inclusive games for the older generation, considering different forms of interaction and stimuli.

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