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A set of customizable features for adaptable games

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Abstract

The popularization of digital games reaches a wide diversity of audiences and styles, but often do not take into account the accessibility context, which excludes a portion of the population, such as children with disabilities. There are studies presenting games with customized interaction options; however, generally thought for specific disabilities. The purpose of this research is to investigate customizing characteristics in games, allowing a specialized professional to tailor the game to a specific patient during their session. For this, we conducted a review of the literature on adaptable games and an empirical study where we investigated three games that were developed and tested with healthcare professionals specialized in the care of children with disabilities. The results generated a set of customizable features for adaptable games.

Keywords: *Adaptable Games, Customization of the Interaction, Accessibility, Adaptable Technologies, End-User Development*

1 Introduction

Digital games have become an important part of the culture, widely used by children and youth, and reach other population segments. However, many people with disabilities are excluded from this medium due to the lack of accessibility (Archambault et al., 2008). Accessibility is making a product or service usable for as many people as possible. Thus, accessibility in games can be defined as removing barriers for people with disabilities within the limits of the rules of the game (Westin et al., 2018).

To promote accessibility in digital games, several types of research propose guidelines or considerations that should be used to guarantee social inclusion. In this paper, we define as guidelines the instructions and guides that are already established and recognized in the literature, while the considerations are initial proposals.

Several studies found in the literature review in the area propose guidelines for digital games or considerations about accessibility for games in general (Cheiran, 2013; Grammenos et al., 2009; Miesenberger et al., 2008). However, there is a research gap on specific guidelines or considerations for adaptable games. Adaptability allows a system to be configured by its users according to their needs and creativity. Adaptable technologies and games, also called customizable or personalized, follow the same premises (Oppermann, 1994a; de Souza and Diniz Junqueira Barbosa, 2006).

This paper presents a set of interaction customization characteristics for adaptable games[1]. The main objective is to help people interested in developing adaptable games through the characteristics presented and how they are used according to the intended audience. In this research, three groups of users are involved: adaptable game designers, health professionals, and children with disabilities. The idea is that designers will benefit from the features in the game creation process, which health experts will use according to the needs of the people served in their offices, in this case, the end-users of the games.

Initially, a literature review was carried out to find publications that describe adaptable systems, seeking to identify the most common personalization characteristics, the audience with which they are used, and the results generated. The review pointed out that the existing systems have brought good results, including when treating people with disabilities. Subsequently, a set of adaptable games was built: a memory game, a puzzle game, and an auditory memory game. These games have in common the ability to customize settings such as colors, audios, degree of difficulty of tasks, among other features. The features were chosen considering the opinion of a specialist in occupational therapy who works with children with disabilities in a specialized reference center, which will be designated in this work as ”Shelter”. This specialist acted as a research partner and requirements supplier.

Tests were carried out with health professionals from Shelter to empirically verify the value of the customization proposal present in the games. In that reference center, several professionals such as psychologists, occupational therapists, speech therapists, and physiotherapists care for children with delayed neuropsychomotor development, cerebral palsy, autism spectrum disorder, among other specificities linked, mainly, to communication difficulties. The tests indicated a good acceptance of the games as a tool to help the specialists. Due to the ethical issues involved in conducting tests with human beings, this research was submitted to the Ethics Committee and approved according to the following CAAE number: 14177018.3.0000.0018.

In the next sections of this paper, we will cover: the methodology of this research; the theoretical background of the work; the protocol used during the literature review; the adaptable games developed, focusing on their personalization characteristics; an analysis of the characteristics found both in games and in the literature review; the final considerations of the work and future stages of the research. We believe the contributions present in this paper help advance

[1]This paper is a revised and extended version of de Carvalho et al. (2019), published in Portuguese.

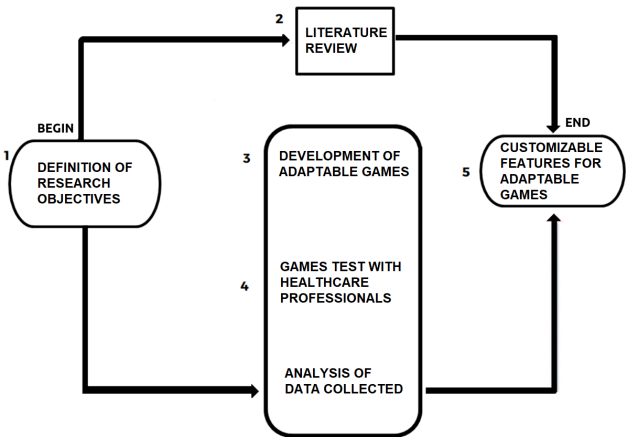
the knowledge in End-User Development and Games, addressing social issues present in the Sustainable Development Goals proposed by the United Nations.

2 Methodology

The research methodology adopted involves the following steps:

1. Define the research objectives.
2. Conduct a Literature Review to identify the personalization characteristics present in adaptable or adaptive systems and understand how these personalizations help the target audiences.
3. Develop a set of adaptable games based on the demands made by a specialist in the area of Occupational Therapy who works at the Shelter.
4. Evaluate adaptable games built with health specialists in Reference Centers through testing steps to verify that the personalization characteristics present are adequate and to collect new suggestions of functionalities to be implemented in the games.
5. Combine the knowledge acquired in the previous steps to develop a set of interaction customization features for adaptable games. This process is illustrated in Figure 1.

Figure 1. Research Methodology



Although all the tests were carried out with professionals from the same place (Shelter), they took place on different occasions and did not follow the same methodology. Specialists were recruited according to their availability during their work breaks, which sometimes were stricter depending on the day. When we tested Cuca Fresca game, for instance, it was possible to collect data about the Experts Profile using a questionnaire. However, when we tested the Puzzle Game there was not enough time to employ that questionnaire. Lastly, we had to test Auditory Memory Game with the professionals in the same room because it was not possible to perform individual tests.

In the following sections of this article are presented: the theoretical background of the work; the protocol used during the literature review; the adaptable games developed, focusing on their personalization characteristics; an analysis of the features found both in games and in the literature review; the final considerations of the work and future stages of the research.

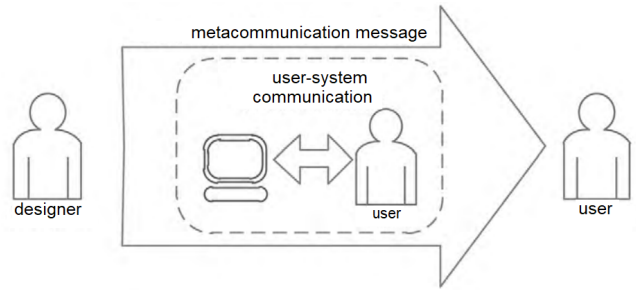
3 Theoretical Background

This section presents the theoretical foundation of this research, detailing Semiotic Engineering, End-User Development, Adaptable Systems, and Adaptive Systems. Finally, we present related works.

3.1 Semiotic Engineering

Semiotic Engineering is an HCI theory centered on communication. It characterizes human-computer interaction as a particular case of human communication mediated by computer systems. Its research focus is on communication between designers, users, and systems. The communication processes investigated are carried out at two different levels: direct user-system communication and metacommunication (i.e., communication over a communication) from the designer to the user mediated by the system, through its interface, as shown in Figure 2 (Barbosa and da Silva, 2010).

Figure 2. Designer–user metacommunication and user–system communication.



Computer systems are characterized as metacommunication artifacts, that is, they communicate a message from the designer to users about user-system communication, about how they can and should use the system, why and with what effects (de Souza, 2005a; de Souza and Leitão, 2009). The content of the metacommunication message, or metamessage, can be paraphrased in the following generic model (de Souza, 2005b):

> Here is my understanding of who you are, what I have learned you want or need to do, in which preferred ways, and why. This is the system that I have therefore designed for you, and this is the way you can or should use it in order to fulfill a range of purposes that fall within this vision.

In this research, each adaptable game developed aims to convey the message that the health professional can customize the game's characteristics according to their patients' needs.

Another important concept of Semiotic Engineering is that of communicability. Communicability can be defined

as the "capacity of the designer's representative to achieve complete metacommunication, communicating to users the essence of the designer's original message" (de Souza, 2005b), thus allowing users to generate meanings compatible with those encoded by the designer (Barbosa and da Silva, 2010).

In this research, tests were carried out with health specialists using the adaptable games developed. Although the methods of inspection and evaluation of communicability foreseen in Semiotic Engineering, SIM and CEM (Leitão and de Souza, 2009) have not been carried out, the experts' opinion was collected to verify if the games transmit the messages that we intentionally try to communicate through the developed adaptable games. We discuss the results of the tests with the experts in section 5.

3.2 End-User Development

End-User Development (EUD) is a set of methods, techniques, and tools that allows users of software systems, who are acting as non-professional software developers, to create, modify or extend a software artifact at a given time (Lieberman et al., 2006). In this work, this occurs when health professionals personalize the game according to each patient's needs, individually. The professionals then fit in as programmer users and children with disabilities are the system's end users.

A significant challenge in this area is developing environments that allow users without programming experience to develop or modify their own applications to enable people to use advanced information and communication technologies flexibly. More precisely, a system must offer a range of different modification levels with increasing complexity and power of expression. This flexibility ensures that users can make small changes in a simple way, while more complicated changes will only involve a proportional increase in complexity (Lieberman et al., 2006).

As an example, a system can offer three levels of complexity in flexibility (Lieberman et al., 2006):

- At the first level, the user can define parameters and make selections. All adaptable games reach this level, as they allow the health specialist to choose settings such as the number of pieces, colors, timers, and other settings in a game.
- At the second level, the user can rewrite existing components. The developed memory and puzzle games partially fit into this category, as they allow the user to create personalized themes with the images they want.
- At the third level, the user can extend the system when programming new components. None of the adaptable games developed fall into this category. To reach this level, it would be necessary to allow the user to program a new game mode within the memory game, for example, with the rules that the user wanted to invent, and not just a selection between predefined parameters.

3.3 Adaptable and Adaptive Systems

A system is adaptable if it provides users with tools that make it possible to change the system's characteristics. This type of individualization gives the user control over the adaptation. It is up to the user to start the adaptation and use it (Oppermann, 1994b).

In this research, the adaptable games developed are categorized as adaptable systems for providing personalization characteristics to health specialists (programmer users). Also, adaptable systems were investigated as part of the Literature Review carried out throughout the research.

A system is adaptive if it can automatically change its characteristics according to its users' needs. The self-adapting system is the most common concept of an adaptive system. Changes in the presentation of the interface or the system's behavior depend on the way the user interacts with the system. The system initiates and makes the appropriate changes to the user, their tasks, and specific demands (Oppermann, 1994b).

Some adaptive systems were found in the literature review. Although this research focuses on adaptable games, we sought to investigate both adaptable and adaptive systems' customization characteristics.

3.4 Related Works

This section details some research related to the research topic, but they follow different approaches.

3.4.1 Research on Guidelines for Accessible Games

Cheiran and Pimenta (2011) investigated different proposals for accessibility guidelines for digital games, such as: the document proposed by the organization IGDA (International Games Developer Association), which was a pioneer in describing the characteristics of disabilities and in evaluating a vast collection of games for identifying accessibility requirements and mechanisms; the GAG (Game Accessibility Guidelines), a set of guidelines made in a continuous effort between a group of studios, specialists and academics, presenting a detailed description of accessibility guidelines for digital games that cover different groups of special needs and classify, for each need addressed, the priority level of the guidelines; among other guidelines. Then, each of these proposals' limitations was illustrated, and the researchers suggested a new set of guidelines. Compared to the guidelines mentioned above, the proposal for this new set of guidelines was verified empirically through a case study with five students from an Information Systems course. The results indicated a more significant agreement of the proposed guidelines than those pointed out in the literature, but suggestions for improvement were also made (Cheiran, 2013).

Grammenos et al. (2009) introduce the concept of universally accessible games, games designed to be played by people with different skills without the need for adjustments or modifications. They argue that games developed specifically for people with disabilities have a high cost, reach a small number of users, and can generate social exclusion, segregating players with disabilities. As a result, the research proposes a structured design method for universally accessible games, corroborated using four games presented both as a case study and as a proof of concept.

Miesenberger et al. (2008) presented considerations about accessibility in games, composed of: 1) guidelines, 2) assistive interfaces, 3) coding and documentation standards. The guidelines proposed by the authors were based on the guidelines of the organizations W3C Web Accessibility Initiative (WAI) and IGDA. Regarding assistive interfaces, the authors state that they must ensure that games and scenarios can be adapted to the end user's skills in terms of knowledge, motor, and cognitive skills, among other aspects. Finally, coding and documentation standards are examples of good documentation practices, tutorials, and open-source, guiding developers and facilitating the inclusion of accessibility elements in various game genres, such as action, simulation, and strategy.

The work proposed in this paper is related to the research Cheiran (2013); Grammenos et al. (2009); Miesenberger et al. (2008) for being inserted in a context of accessibility. However, the purpose is not to generate considerations or guidelines about accessibility in general games, but to list a set of characteristics of personalization of the interaction, which can be incorporated in adaptable games.

3.4.2 Research on the Use and Design of Therapeutic Digital Games

A significant problem in the health area is the patient's lack of adherence to therapy. It is difficult to maintain the patient's attention when performing "boring", repetitive or tedious exercises. In these situations, the tendency is for them to exercise less frequently or even give up treatment. Mader et al. (2016) list therapeutic games as a promising solution to motivate patients. The authors define "therapeutic games" as those that produce a direct, expected, and intended therapeutic effect in patients who play them. This therapeutic effect can alleviate, improve or cure a patient's specific condition.

Designing therapeutic games is a challenge due to the following factors: (1) the gameplay is mainly restricted, as the game has to motivate the patient and at the same time provide the therapeutic effects; (2) the game must be evaluated in both medical and motivational terms and (3) it is difficult to share relevant health knowledge among health experts and game designers (Mader et al., 2016). Maia de Souza et al. (2019) realized the research gap on a formal approach to designing these types of games in a multidisciplinary team. The authors then proposed SemTh, a semi-participatory approach to the design of therapeutic digital games. This approach was based on: (1) data obtained in the literature; (2) reports of experiences of professionals who have already designed therapeutic games; (3) an evaluation by researchers in the fields of computing and health. SemTh was then used to design a therapeutic game for children diagnosed with cancer. The approach was then evaluated by the professionals involved in creating the game and obtained favorable results, mainly about understanding the domain, the needs of the intended users, and the therapeutic aspects of the game (Maia de Souza et al., 2019).

In this research, we developed adaptable games, which have a therapeutic purpose. However, differently from Maia de Souza et al. (2019) research, the focus is not on proposing an approach to the design of therapeutic games but on detailing the characteristics of personalization of the interaction and how these characteristics can be helpful for different audiences.

4 Literature Review

In the Literature Review, we sought to identify recent works that studied personalization features in tool construction. Two researchers from UFPA carried out the process, one being a Master's student in Computer Science and an undergrad student in Computer Engineering. The search bases used in the search were: The ACM Digital Library (ACM, 2019), IEEE Xplore Digital Library (IEEE, 2019) and ScienceDirect (ScienceDirect, 2019). The Search String used was as follows: ((“customizable games” OR “customizable game” OR “adaptable games” OR “adaptive games”) OR (“game” AND (“End-User Programming” OR “End-User Development”))). The string was adapted according to the syntax of each base searched.

The following Research Questions (RQs) guide this review:

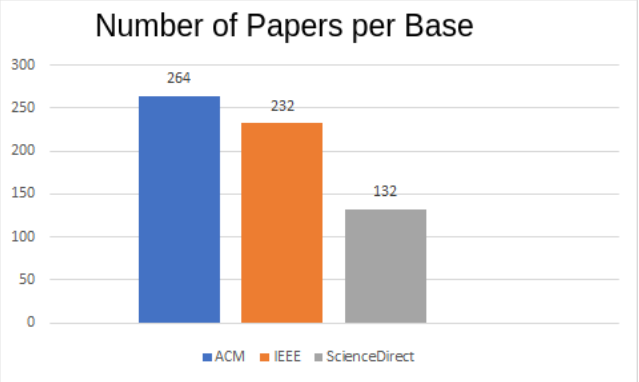
RQ1: What are personalization features present in literature games and systems?

RQ2: What are the benefits of each of these characteristics for the target audiences?

When running the protocol, a total of 628 works were found (Step 1), 264 on the ACM database, 232 on the IEEE database, and 132 on the ScienceDirect database, illustrated in Figure 3. We applied the following inclusion criteria:

- IC1: Papers must deal with games or digital systems.
- IC2: Papers must be written in English or Portuguese.
- IC3: The papers must have been published between 2009 and 2019.

Figure 3. Number of Papers per Base



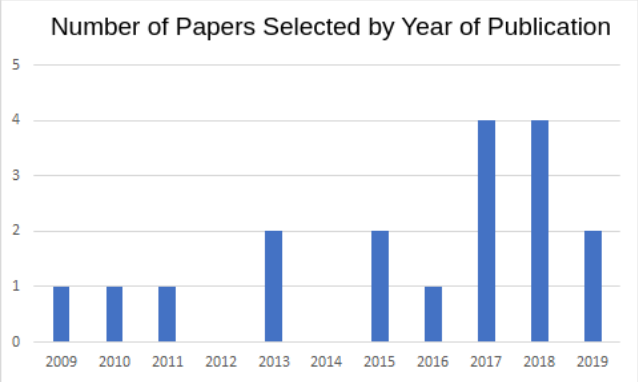
The following exclusion criteria were applied:

- EC1: Keynotes, Tutorials and any study not reviewed by peers.
- EC2: Papers in which the abstract don't mention the possibility of adapting their systems.
- EC3: Papers not available free of charge within the institutional network of UFPA.

In the second stage, we kept 50 articles. These articles were read completely as part of the third and final stage of

the Review. Of the 50 articles, 18 are related to the research proposal. In Figure 4, the number of selected works per year of publication is illustrated.

Figure 4. Number of Papers Selected by Year of Publication



In Table 1 the number of papers selected in each stage of the Literature Review is illustrated.

Table 1. Number of papers selected at each stage of the Literature Review

Database	Step 1	Step 2	Step 3
ACM	264	18	9
IEEE	232	21	6
ScienceDirect	132	11	3
TOTAL	628	50	**18**

In Table 2 is illustrated the name of the selected studies, the authors and the source.

4.1 Answering the Research Questions

In this section, we provide results to answer the research questions posed in this literature review.

4.1.1 What are personalization features present in literature games and systems?

The personalization features extracted from the 18 papers selected in the Literature Review are presented in Table 3.

The Movement Type (MT) and the Level of Difficulty (LD) were the most recurrent characteristics, having 11 and 9 occurrences. The Type of Movement is related to the popularity of the so-called "exergames" (games with a rehabilitation purpose). Difficulty Level is essential to keep a player entertained on a task and stimulate physical or cognitive skills.

Custom Audio (CA) and Colors (C) were less recurrent characteristics, perhaps because the works selected in the review were not focused on working aspects related to these characteristics.

4.1.2 What are the benefits of each of these characteristics for the target audiences?

Alankus et al. (2010) use games adapted for stroke patients according to their movements and cognitive skills. The games are a fun alternative to encourage and motivate the patients during the rehabilitation process. Javed and Khan (2018), Agres and Herremans (2017), Fikar et al. (2013), González González et al. (2019), Omelina et al. (2016), Tetteroo et al. (2015), Afyouni et al. (2019), Omelina et al. (2016) also research games intended to help the rehabilitation process, but with different approaches and audiences.

Tumlin (2017) use COPPER (CustOmizable Puzzle Programming Environment) to increase student interest and engagement by allowing teachers to customize levels for classes or individual students. Teachers can create characters for puzzles, upload photos to customize their appearance, and use block language to design the character's behavior. Also, teachers can specify the goal of each coding puzzle and restrict the blocks a student can use, allowing for the gradual introduction of programming concepts.

Salah et al. (2018) built adaptive educational games using subjective measures, where adaptive characteristics were manipulated based on the emotions reported by the participants. A study was carried out with 30 university students, using the adaptive and non-adaptive versions of games to assess the effectiveness of the adaptive aspects proposed in the learning experience: the learning gain and the level of involvement. The results were better with participants who used the adaptive version based on use and with the aid of Artificial Intelligence techniques. Clark et al. (2011), Ibáñez and Delgado-Mata (2013), Ivan et al. (2017) also researched the usage of educational games with personalized features, but with different approaches and audiences.

Blom et al. (2018) proposed a custom framework for crisis management training through a game. The framework focuses on monitoring and handling player stress levels during training and evaluating player performance, providing personalized feedback. The project was developed in close collaboration with real experts in crisis management, and its target audience is interns who can simulate real crises through game scenarios. Thus, they can train the efficiency of their decisions in situations of high cognitive effort and time limit.

Wilson et al. (2018) investigated the use of MyWord, an audio-visual dictionary app aimed at children. The aim is to support the child in creating their own personalized catalog of favorite words, images, and audios over time. A field study was carried out in two school periods in an autism-specific primary school, with 12 minimally verbal children aged 5 to 8 years old and their teachers and speech therapists. Findings indicate that the use of personal and contextually relevant words improved engagement, interaction, and self-expression.

5 Adaptable Games Plataform

We developed three adaptable games as part of this work: (1) the memory game, (2) the puzzle game, and (3) the auditory memory game. All games were developed in partnership with an occupational therapist who was a partner in the research, who acted by providing each game's requirements. Each of the games will be presented as a case study in which we report the process of building and evaluating the games, explaining their customization characteristics.

In general, the metacommunication message present in

Table 2. Primary Studies Selected

Codes	Papers	Author/Year	Source
PS1	Towards Customizable Games for Stroke Rehabilitation	Alankus et al. (2010)	ACM
PS2	Teacher Configurable Coding Challenges for Block Languages	Tumlin (2017)	ACM
PS3	Judged by the Cover: Investigating the Effect of Adaptive Game Interface on the Learning Experience	Salah et al. (2018)	ACM
PS4	Personalized crisis management training on a tablet	Blom et al. (2018)	ACM
PS5	MyWord: enhancing engagement, interaction and self-expression with minimally-verbal children on the autism spectrum through a personal audio-visual dictionary	Wilson et al. (2018)	ACM
PS6	Analyzing the quality of experience of computer games in rehabilitation: the therapist's perspective	Omelina et al. (2016)	ACM
PS7	RehaBot: Gamified Virtual Assistants Towards Adaptive TeleRehabilitation	Afyouni et al. (2019)	ACM
PS8	A Comparative Study on the Effectiveness of Adaptive Exergames for Stroke Rehabilitation in Pakistan	Javed and Khan (2018)	ACM
PS9	Lessons Learnt from Deploying an End-User Development Platform for Physical Rehabilitation	Tetteroo et al. (2015)	ACM
PS10	Music and motion-detection: A game prototype for rehabilitation and strengthening in the elderly	Agres and Herremans (2017)	IEEE
PS11	An adaptive framework for the creation of bodymotion-based games	Grammatikopoulou et al. (2017)	IEEE
PS12	Modular educational game system: A customizable framework for learning	Clark et al. (2011)	IEEE
PS13	The Sorcerer's Apprentice A serious game aiding rehabilitation in the context of Subacromial Impingement Syndrome	Fikar et al. (2013)	IEEE
PS14	Design of adaptive social ball games with both physical actions and reactions	Ibáñez and Delgado-Mata (2013)	IEEE
PS15	COL.diesis: transforming colour into melody and implementing the result in a colour sensor device	Rossi et al. (2009)	IEEE
PS16	Serious games for rehabilitation: Gestural interaction in personalized gamified exercises through a recommender system	González González et al. (2019)	ScienceDirect
PS17	Help The Math Town: Adaptive Multiplayer Math-Science Games using Fuzzy Logic	Ivan et al. (2017)	ScienceDirect
PS18	Validation of the Educational Game for Seniors: "Live Well, Live Healthy!"	Sauvé et al. (2015)	ScienceDirect

games is as follows:

> This is the adaptable game I designed for you, the healthcare professional. My understanding is that you need a system that is flexible in customization features. As the tool's end-user group includes children with disabilities, I designed a system with as few distracting elements as possible.

5.1 Case 1: Memory Game

The memory game, called Cuca Fresca, aims to explore cognitive aspects such as attention, memory, and concentration. It is available for computers running Windows OS and mobile devices running Android. It is expected to assist in the specialist's work to promote the social inclusion of individuals who have some deficit in cognition, stimulating mental skills to reach their full potential. The difference between this product and other memory games is that it allows the specialist to configure timers, colors, audios, and game themes. It also enables the creation of custom themes, that is, the specialist can create specific cards with photos of a child's family members, for example.

In the settings menu you can choose the game theme (default or custom), the number of pairs of cards, the initial display time of the cards (in seconds), the status of the card label (enabled or disabled), the game's background color (black, white, green, blue, silver, yellow and red), and other options. The settings menu is presented in Figure 5.

A game in which a custom theme was created, with four pairs of cards and the text of the activated labels in white

Figure 5. Cuca Fresca settings menu screen

color is presented in Figure 6. Unlike other memory games, card images continue to appear face up, even when the user selects two unpaired cards, which would be wrong. Cards are only turned face down after a new attempt has been made. This is important so that the specialist has time to talk to the child, explaining the content of the letters. The game ends when all pairs have been found. The number of attempts, time, or ranking the child obtained is not shown as this could discourage him, but this information is saved in a text file so that the specialist can view reports and follow the children's progress later.

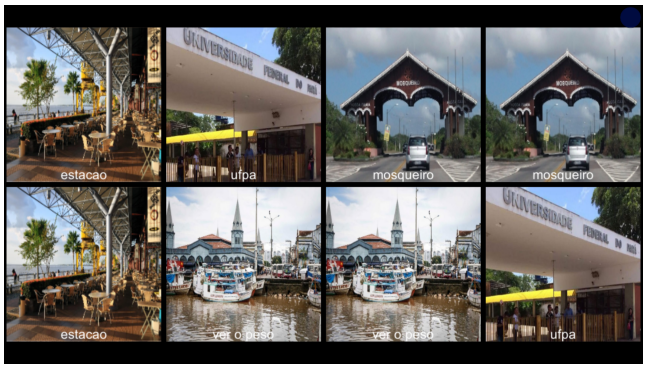
5.1.1 Expert Tests

Eight specialists in areas such as psychology, occupational therapy, social work, physiotherapy, and speech therapy

Table 3. Features found in Literature

	Features										
Primary Studies	Custom Audio	Colors	Timer	Custom Theme	Sound Feedback	Visual Feedback	Textual Elements	Game Mode	Difficulty Level	Movement Type	**Total**
PS1								x	x	x	3
PS2				x					x		2
PS3		x	x								2
PS4			x	x			x		x		4
PS5	x			x			x				3
PS6										x	1
PS7									x	x	2
PS8									x	x	2
PS9					x	x				x	3
PS10										x	1
PS11										x	1
PS12			x				x				2
PS13						x				x	2
PS14						x		x	x	x	4
PS15		x			x					x	3
PS16								x		x	2
PS17								x	x		2
PS18	x				x	x	x	x	x		6
Total	2	2	3	3	3	4	4	5	8	11	

Figure 6. Custom Themed Match Screen



were selected to obtain opinions from different perspectives on the proposal and accessibility of the game. To maintain participant privacy, they are identified from P1 to P8. Table 4 presents the profiles of the specialists, extracted from an initial questionnaire carried out before the beginning of the test. In the questionnaire they informed their age, occupation and which types of education apps they already used.

Table 4. Experts Profile

ID	Age	Occupation area	Educational apps
P1	35 - 44	Physiotherapy	Just games
P2	25 - 34	Speech Therapy	Games and tools
P3	18 - 24	Psychology	Games and tools
P4	25 - 34	Psychology	Just games
P5	35 - 44	Psychology	Games and tools
P6	35 - 44	Social Service	Just games
P7	25 - 34	Occupational Therapy	Just games
P8	35 - 44	Occupational Therapy	Games and tools

First, the participants signed the Informed Consent Form. During the test, participants interacted with Cuca Fresca performing five tasks that contained the main customization features initially present in the game. For this step, each task was read by a researcher. The method Thinking Aloud (Someren et al., 1994) was used so that the researcher encouraged the participants to express their thoughts and opinions when performing the tasks.

The proposed tasks are listed in the order they were requested, below: [T1] Change basic game settings; [T2] Play game with label text and labels sound enabled; [T3] Create custom theme; [T4] Play custom theme; [T5] Editing and deleting a custom theme.

5.1.2 Data Analysis

While collecting information relevant to the application's proposal, we only analyzed data related to the personalization features available to the experts. The application's overall proposal was well accepted by the test participants, who supported a configurable solution according to the needs of the people served in the sessions.

When asked about the good points of the game, P6 says: "*It pulls your attention. You have the playful piece and the technological piece, and they catch your attention. So you strive to develop that task, and it doesn't matter if you hit or miss. But just the way of being, digital communication, is already very good because we also see the commitment of children with disabilities, who sometimes only through speech, trying to communicate only through speech, ends up not generating as much attention*". The use of digital platforms to achieve this goal can stimulate individuals with cognitive problems such as autism, as studied by Shane and Albert (2008).

About using customizable applications, P7 argues that: "*She (the child) is in the learning phase, so we have been putting this on the agenda a lot, the issue of attention. This is a facilitator, really, into the school. When the child seeks treatment outside, it is to have this monitoring together, to be included. Then comes the question of the speech therapist, some phonemes to be worked on. So when we play the memory game with the child, and ask - What letter was that? B (on a theme of letters) - for us, occupational therapists, it also ends up having attention, recognition and identification*". The pedagogical purpose of providing the application as an auxiliary tool through a memory game can be achieved by facilitating the child's learning, serving as an intermedi-

ary between the therapeutic care environment and the school environment.

Among the features most highlighted among participants as necessary is the customization of themes. P7 emphasizes the importance of the possibility of creating themes, saying that: "*This issue of [being] customizable is very cool, because you can use what he actually uses. For example, we use the PACS [Image Archiving and Communication System], then normally what we use are pictures, so it's the child's photo, with the child's toy, so there is that association of equals*". P1 also commented on how the customization of themes is necessary, saying: "*It's quite clear, and it's a game that interests children, that is, we have a lot of options to work with. This personalization is very good, because sometimes we need to work with images that are already intimate with the child, so this is very important.*".

In addition to custom themes, standard themes are available in the app as options with photographs of animals and objects and drawings. P7 believes that the presence of different representations allows the child to associate what they know visually with what is being displayed in the game: "*The objects are very nice, because you put real images of the objects and not their drawings . If you ask if there is a difference, sometimes there may be, because of the lack of recognition of the figure, which is not always visible, legible for the child*". For a child with cognitive problems or an intellectual disability, the lack of similarity between the drawing representations and the actual object present in educational applications aimed at children can cause problems.

P2 and P8 highlight the use of voice resources, highlighting how the voice of the labels makes the child associate the word with the image displayed. To improve, P2 suggests: "*Put some option for the child to record her voice when playing the audio of the labels, because then you can work on other things besides memory. You can work on the issue of speech, so that she can hear herself speaking that word*". P8, in turn, says: "*An option to record with the child's or family's voice would be interesting, so if I wanted to make some communication board related to the family, I would ask the family to record the voice* ". Communication boards are commonly used with children who have speech problems and need to express themselves (Dorneles, 2015). To facilitate the child's association, the sound of a voice he is already familiar with can help him focus on the activity and stimulate his emotional side. Recording the child's voice speaking the word in the image can also help the specialist to analyze the performance in pronunciation and speech, allowing to compare the audio already recorded with the current pronunciation.

P7 also talks about the possibility of changing the background colors of the cards and the board, and says: "*Each of these items is important, for example, the background, the letter [of the labels]. For from that, we can identify the person's favorite topic. For example, if the blue background performed better, it might be because it is the preferred color. There are colorblind children too, so I have to know what is the best [background] for him, the issue of attention and preference for objects, colors and sounds, because not every sound is pleasant*".

Trial participants provided several additional suggestions. Among the main recommendations are:

1. Create options with lower values for the time the cards are displayed, as the disability will not always require such a long time, and the child may be anxious, wanting the image to close, to play as much before.
2. Propose a new stage of the game, providing additional activities. For example, the child played with the theme 'clothes', so when he finished the game, he could form sentences with the pieces used in the theme.
3. Display the cards even after pairing so that you can view the image. In addition, add a button so that the specialist can redisplay the cards at the end of the game.
4. Allow choice of font size for letter labels, with at least three size options: small, medium, or large.

5.2 Case 2: Puzzle Game

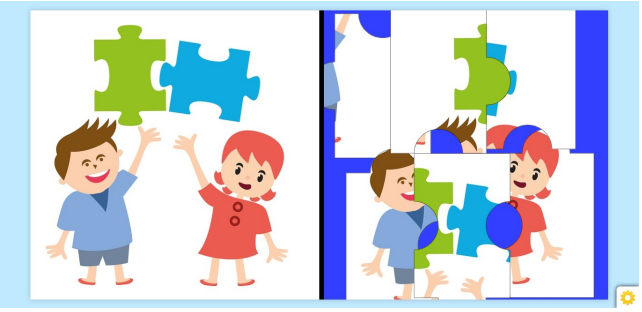
AdaptaQuebra-Cabeça is an adaptable puzzle game. It is available on the web and therefore can be used on devices such as desktops, notebooks, tablets, and cell phones, providing they have internet access and any application with web page browsing capability. The game's configuration interface is illustrated in Figure 7, where the expert can customize a match by configuring the following options: number of rows and columns, degree of difficulty, initial time of image display, theme, background color, among other options (da Cruz Júnior, 2019). The game also has expert login screens and child registration, enabling the storage of multiple profiles that are saved on a web server.

Figure 7. AdaptaQuebra-Cabeça's configuration menu screen

The number of rows and columns determines the total number of parts, allowing the specialist to configure the most suitable quantity for the assisted child. The "Degree of difficulty" item selects the degree of proximity necessary for the pieces to fit correctly. There are four options: very easy, easy, normal, and difficult. At the very easy level, the user clicks on the piece, automatically moving it to the correct position. In contrast, in the difficult level, the piece must be dragged until it is very close to the correct position. The

”Show Temporary Image” item selects how long the image of the complete puzzle will be displayed at the beginning of a game, which can be zero (represented by the option ”Don’t Show”), five, ten, fifteen, twenty, or thirty seconds. The ”Select Theme” item allows the choice of the puzzle image among the themes available by default, whereas in the trial version of the game, only the ”Kids” theme was available. In the item ”Background color”, it is possible to choose the background color of the screen to generate a contrast between the background and the colors of the figure chosen for the match. The ”Upload Image” item allows the user to upload a custom image to the game. In Figure 8, a section of the game is illustrated in which the following settings were chosen: three rows and two columns, normal difficulty level, temporary image in 5 seconds, Kids theme, and blue background color.

Figure 8. AdaptaQuebra-Cabeca’s startup screen with preview of the image and available buttons



5.2.1 Expert Tests

After developing the stable version of the game, tests were carried out with eight professionals from the Shelter. The study was carried out individually, with participants identified from P1 to P8. The activity lasted about 25 minutes and was divided as follows:

1. Presentation of the AdaptaQuebra-Cabeça, together with the Informed Consent Form.
2. Start of testing.
3. Request for a record of the specialist’s profile and record of the child’s profile in the application (fictitious data).
4. Changing basic game settings, such as number of pieces and degree of difficulty.
5. Request for a match with 8 pieces and normal difficulty level.
6. Request for a match using a custom image.
7. Conducting a semi-structured interview with qualitative and quantitative questions about the experience with the game and the customization options available.

5.2.2 Data Analysis

Regarding the configurable elements of the game, the highlights were: the possibility of customizing the game’s image, the game’s background color, and the degree of difficulty. About customizing the image, P5 says *“I liked the option to load image from the gallery so that we can choose associative images”*. About customizing the background color, P2 says *“By customizing the background color, I will be able to customize the puzzle board to work with visually impaired children”*. About the degree of difficulty, P8 says *“This degree of difficulty changes the ’magnet’ of the pieces, it is interesting for children with small motor difficulties”*.

Regarding the application’s interface, their opinion was that it is simple to use. You can see all the customization options as soon as you open the settings menu, which is easy to understand even for a new user. The only feature that raised some doubt during the testing round was the customization of rows and columns. Some participants got confused when multiplication between rows and columns to define the number of pieces in a session.

In addition to the praise, the participants gave several suggestions to expand the application’s functionality. The main ones are:

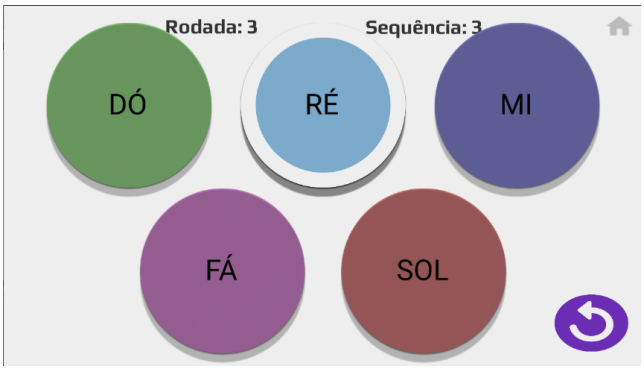
- Sound reinforcement during the movements of the pieces and adjusting the type of music according to the selected theme, thus giving clues to the child about which image should be assembled.
- An adjustable timer, where the professional can determine the time the child has to assemble the image.
- Addition of a difficulty level that, in addition to changing the attraction between the pieces, changes the shape of the pieces and fittings.
- Generation of a report in graph form to analyze the child’s time in executing the assembly of the image pieces.
- Addition of a Watermark Image Mode. In this mode a transparent image of the theme will be displayed as a way to help children with greater difficulties during the sessions.

5.3 Case 3: Auditory Memory Game

Ritmo Mania is an auditory and visual memory game designed to help cognitive development, specifically in memory capacity, pattern recognition, and attention stimulation. In this game, there is a configurable number of pieces of different colors. When starting the session, the user hears a sequence of sounds on a musical scale, which lights up a sequence of pieces. The player must repeat the same sequence that was presented to end the match successfully. Upon successful completion of a sequence, the game features positive feedback represented with applause sound and celebration effects, encouraging the child to continue to the next stage. Its operation is similar to classic Simon/Genius games. A game match with five round pieces and white background can be seen in Figure 9.

Figures 10 and 11 show the Settings screen with the options implemented up to the project’s current stage. The present functions aim to allow the customization of the game experience to cover the needs of each player. Therefore, among the options available are: the number of pieces (maximum 7, representing the musical notes); initial sequence size (difficulty level); sequence speed (timer); background color; and type of sound played (digital, flute, and piano options).

Figure 9. Game Match Screen "RitmoMania"



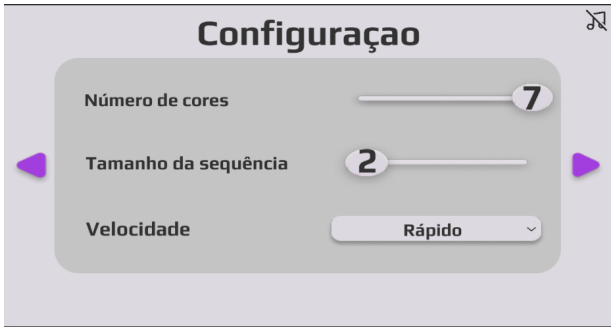


Figure 10. Ritmo Mania settings screen

5.3.1 Interview with experts

On two separate occasions, Ritmo Mania was presented to experts. On the first occasion, the game was still a prototype developed on another platform (Ionic Framework). We applied a test scenario and an interview with an occupational therapist to collect analyzes and suggestions about the game. During the interview, we asked what issues were identified, what improvements were needed, and what other features could be implemented in the game. The data collected lead to a lot of changes and new features developed.

The latest version of the game was presented at a second meeting with professionals specializing in child health, occupational therapy and psychology. The game received positive feedback from all experts when presented with its basic features and customization options.

5.3.2 Data Analysis and Interpretation

There were bugs such as sound delay and visual feedback desynchronization, issues fixed with the switch from the Ionic Framework development platform to Unity. Several suggestions were made to improve the game, such as improving the difficulty progression, which should increase with the hits and go back with the mistakes, thus finding the appropriate level for the child. According to the therapist's considerations, this is beneficial for children with disabilities. Another suggestion was to change the shape of the buttons from the square to the circle because it would be more attractive to children. More clarity was also needed in the feedback of actions in the game and how the rules work. This could be done by increasing the feeling of reward after winning, with sounds of applause and celebration and visual effects of congratulations and increasing clarity after the sequence error, with automatic repetition preceded by clear error feedback.

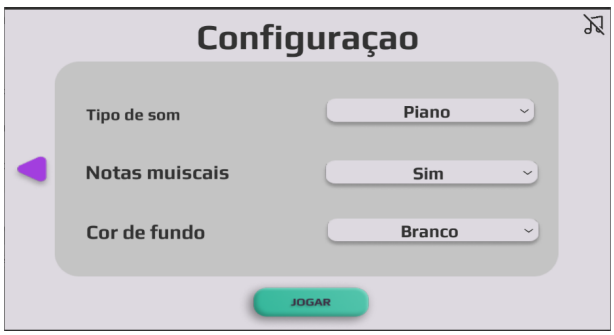


Figure 11. Ritmo Mania settings screen

Other changes were: adding choice options for different shapes of buttons and sounds; awareness to the musical part of the game, implementing real music, thus linking musical learning to the game; adding different game forms such as "random"; play with existing songs and discover the musical notes where the player will play the songs from the notes list; put different configuration options for the functioning of the game designed for two situations: being worked in the Shelter with the professional with total control of the configurations and the child playing alone at home.

The meeting with the specialists had initial positive feedback. The suggestions received were: reduce the minimum length of the sequence from 3 to 1; define a configurable number of chances of error; keep the melody at each round, adding notes at the end of it. The game used a random sequence of musical notes to be memorized by the user, but they requested that could be a song known by the children to be played for easier memorization.

5.4 Customization Features in Developed Games

The Table 5 presents the customization characteristics present in the games developed so far in the research. The features present in all developed games were Colors, Timer, Number of Pieces, and Visual Feedback. The Custom Audio and Difficulty Level only appeared in one game each.

The features "Movement Type" and "Game Mode" appeared in the Literature Review but are not found in any developed adaptable games. The "Type of Movement" is a characteristic related to physical rehabilitation, which does not fit with the proposal of the developed games. The "Game Mode" does not fit because the games were designed to be used by a child at once, in sessions with health specialists.

6 Results

The customization characteristics present in the adaptable systems highlighted in the literature as well as in each adaptable game developed are presented in Table 6. Of the 50 works found during the literature review, we selected 18 that fit the research proposal and present personalization characteristics in the paper text.

In the Table 6, the first column contains the selected works in the literature, named from EP1 to EP18, and the developed games, named from C1 to C3. Game features appear in

Table 5. Customization features present in developed games

	Features									
Case Studies	Custom Audio	Colors	Timer	Custom Theme	Sound Feedback	Visual Feedback	Textual Elements	Difficulty Level	Number of Pieces	**Total**
C1	x	x	x	x	x	x	x		x	8
C2		x	x	x		x		x	x	6
C3		x	x		x	x	x	x	x	7
Total	1	3	3	2	2	3	2	2	3	

C1: Case 1, Memory Game

C2: Case 2, Puzzle Game

C3: Case 3, Auditory Memory Game

the following columns, and the total number of features each work has and the total number of works each feature appears.

6.1 Customization Features

In this section we list and describe the characteristics collected in the selected works and in the developed games.

6.1.1 Number of Pieces

The Number of Pieces is the number of configurable elements of the game, such as cards in the memory game, pieces in the puzzle and in the auditory memory game. This customization is essential in order not to "overload" some children in early sessions. One of the Shelter therapists reported that she started using the memory game with only 2 or 3 pairs of cards in sessions with a child with cerebral palsy. As the child adapted to the specialist, the number of letters increased during the sessions.

NP was the only feature that did not appear in any of the selected works in the literature, perhaps because it did not fit the mechanics of these games.

6.1.2 Custom Audio

In the memory game, the Custom Audio is the card's name's sound. The CA can be customized when the user creates a theme and types the text they want as the card's labels. This configuration is essential as an alternative way of associating the object's name and its image. Children with low vision may have difficulty seeing the text on labels, for example.

In the work of Wilson et al. (2018), CA is the child's option to record audios with the words they want within the dictionary application. Sauvé et al. (2015), use CA as a virtual voice capable of reading the game's questions, rules, and instructions for older people with vision problems.

6.1.3 Colors

Color customization is present in the memory game with the following options: game background color, card background color, and card label color. In other adaptable games, only the background color is configurable. In Salah et al. (2018)'s work, it's about the color of the game's theme, automatically changed according to the player's performance and affective state. In the work of Rossi et al. (2009) it is the color corresponding to a given melody.

6.1.4 Custom Theme

The use of custom themes is found in Cuca Fresca, with the possibility for the user to create a custom memory game theme by adding the images they want. In AdaptaQuebra-Cabeça and Tumlin (2017) it is the image that forms the puzzle's pieces. In Wilson et al. (2018), these are custom images children can save in the application. In Blom et al. (2018) is the chosen setting for training.

6.1.5 Game Mode

The Game Mode, present in the works of Alankus et al. (2010), Ibáñez and Delgado-Mata (2013), González González et al. (2019), Ivan et al. (2017) and Sauvé et al. (2015) is the possibility of playing with other people (multiplayer mode). According to Alankus et al. (2010), multiplayer games, both competitive and collaborative, can be quite motivational. However, it should be considered that if one of the players has a physical or cognitive disability, there may be a disadvantage.

6.1.6 Visual Feedback

Visual Feedback, present in many works, is an image that serves as a resource to indicate whether an action taken by the user was successful or failed. In the memory game and the auditory memory game, this is the display of balloons when the user ends a session successfully. In Fikar et al. (2013), it is an image indicating whether the patient is performing the exercise correctly or, if he is exercising the limb incorrectly, an image is displayed showing the correct way to achieve the activity.

6.1.7 Timer

The Timer customization concerns the display time of visual elements in the memory game and the auditory memory, being the initial display time of the cards in the former and the time the pieces remain illuminated in the latter. In the work of Salah et al. (2018), it is the time available to finish the games.

Table 6. Personalization features present in the works of the Literature and in the games developed

	Features											
Primary Studies	Custom Audio	Colors	Timer	Custom Theme	Sound Feedback	Visual Feedback	Textual Elements	Game Mode	Difficulty Level	Movement Type	Number of Pieces	**Total**
PS1								x	x	x		3
PS2				x					x			2
PS3		x	x									2
PS4			x	x			x		x			4
PS5	x			x			x					3
PS6										x		1
PS7									x	x		2
PS8									x	x		2
PS9					x	x				x		3
PS10										x		1
PS11										x		1
PS12			x				x					2
PS13						x				x		2
PS14						x		x	x	x		4
PS15		x			x					x		3
PS16								x		x		2
PS17								x	x			2
PS18	x				x	x	x	x	x			6
Case Studies	Custom Audio	Colors	Timer	Custom Theme	Sound Feedback	Visual Feedback	Textual Elements	Game Mode	Difficulty Level	Movement Type	Number of Pieces	**Total**
C1	x	x	x	x	x	x	x				x	8
C2		x	x	x		x			x		x	6
C3		x	x		x	x	x		x		x	7
Total	3	5	6	5	5	7	6	5	10	11	3	

6.1.8 Sound Feedback

The Sound Feedback, present in all adaptable games, is the user's option to hear (or not) positive stimuli when they complete a task and negative stimuli when they make a mistake.

6.1.9 Textual Elements

In the memory game, the Textual Elements are the card label texts of the theme selected for a match. In the auditory memory game, it is the display of musical notes represented by each piece of the game. In the first game, it allows the therapist to work with the child to learn the names of objects and figures, while in the last game, it enables the therapist to work on learning the musical notes represented by each piece. In the work of Wilson et al. (2018), this is the catalog of favorite words that the child can store in the application. In the research done by Sauvé et al. (2015) it is the text used in the game, which must be readable considering the target audience of older people.

6.1.10 Difficulty Level

In AdaptaQuebra-Cabeça, the Difficulty Level corresponds to the ease with which a piece can be correctly positioned. For example, in the easy level, the piece is just close to its correct position for the fitting to occur. In researches for Alankus et al. (2010), Tumlin (2017), Blom et al. (2018), the level of difficulty consists of the intensity of the cognitive challenge chosen for the session. In the research of Ivan et al. (2017), it consists of the complexity of the proposed math exercises, being chosen automatically by the system. In the works of Afyouni et al. (2019), Ibáñez and Delgado-Mata (2013) and Javed and Khan (2018), it is about the difficulty involved in the rehabilitation exercise, which is automatically adjusted by the system.

6.1.11 Movement Type

The Movement Type, present in 11 works found in the literature review, is the exercise of the body muscles in physical rehabilitation. Games of this type are called "exergames" due to the physical exercises intrinsic to these games.

7 Discussion

By analyzing the adaptable games developed, it was possible to observe the following customization settings present in all of them: colors, number of pieces, timers, and sound feedback. Customizing the number of parts is essential as it allows for a gradual increase in the difficulty of tasks during service sessions. For example, one of the therapists at Shelter reported that she started using Cuca Fresca with children with cognitive disabilities with two pairs of cards and gradually increased it to nine pairs over time.

Customizing the timer is also essential for children with some cognitive impairment, who may need more time to complete tasks. One of the therapists interviewed corroborated this information, stating that she uses Cuca Fresca, configuring a longer initial display time of the cards during sessions with a child from the shelter who has cerebral palsy.

Color customization is present in the three games developed as well as in the work of Salah et al. (2018) and Rossi et al. (2009). The choice of color is vital as a given color can minimize the distractions of a user with attention difficulties and help them focus on the activity, while another color can distract them. There is also the case of colorblind users who

can be harmed if the game represents important information in colors that the user cannot distinguish. The work of Rossi et al. (2009) emphasizes the combination of color and sound for the formation and association of melodies.

The difficulty level of a game, present in several works found in the review and the puzzle game, is essential to keep a user entertained in a session. A level of difficulty that is too high or too low can demotivate the player. The correct level of difficulty can keep the player concentrated in a state of flow, a concept in psychology coined by Csikszentmihalyi and Nakamura (2002) in which the user is completely focused on a task to the point of losing track of time. In the works of Alankus et al. (2010), Tumlin (2017), Blom et al. (2018), as well as in AdaptaQuebra-Cabaça, this setting is chosen by the user, while in the researches of Ivan et al. (2017), Afyouni et al. (2019), Ibáñez and Delgado-Mata (2013) and Javed and Khan (2018) is automatically adjusted by the system.

The use of personalized audio, present in the work of Wilson et al. (2018), is imperative. It allows children with disabilities to create customized sound catalogs according to their interests, an important instrument of self-representation. In the work of Sauvé et al. (2015), it is an alternative way to assimilate the rules and instructions of the game through the sound emitted by a virtual assistant.

Other settings highlighted by experts are sound and visual feedback. It is important not to frustrate children who can make mistakes in early care sessions, so the feedback that can be turned off is important. Suppose the child is performing the tasks correctly. In that case, he must hear positive reinforcement sounds or visualize motivational images, such as the balloons displayed at the end of a successful match in the memory game.

The possibility of using custom themes is crucial to bring users closer to their reality. Allowing the choice of familiar images such as people and places known, for example, can arouse more significant interest in the player.

A feature present in Cuca Fresca and AdaptaQuebra-Cabeça, and that the professionals asked to be included in the auditory memory is the use of hidden buttons on the game's starting screens, which allow the player to return to other screens, such as the main menu or the settings menu. These return buttons should be hidden as their visibility would hinder the attention of some users with disabilities. Game mode and movement type are not present in adaptable games, but there is a concern to add support for unconventional interaction types, such as eye and head tracking, as future works.

7.1 Limitations and threats to validity

One of the limitations of this research is the lack of tests with children with disabilities. Tests were scheduled for 2020 but were postponed due to the Covid-19 pandemic. Another limitation was the lack of resources for purchasing Apple computers. Computers from this brand are needed to generate native applications for the iOS platform, the most used operating system on mobile devices after Android. Due to this limitation, Cuca Fresca and RitmoMania games cannot be used on macOS or iOS devices.

Another threat to this study validity concerns the literature review performed. Although some steps were executed to ensure the rigor and reproducibility of the study, we didn't use a data extraction form, and there was no quality assessment checklist to evaluate the studies selected in the review. For those reasons, the literature review performed didn't fulfill all the requisites of a Systematic Literature Review, according to the guidelines proposed by Kitchenham (2004).

7.2 Future Work

New adaptable games are planned to improve other physical and cognitive aspects of children with disabilities. An example would be the construction of games in which the type of movement would be a customization feature, considering it was the most recurrent feature in the works found during the review. We want to provide an adaptable gaming platform, making several games available to support health specialists as programming users.

It is also intended to record match information in all game sessions of the future platform. This information is vital so that specialists can visualize the evolution of patients over time and, for example, which customization options are most related to their improvement. For this, Information Visualization techniques will be implemented, which allow adequate analysis of each parameter.

Tests of the games will be carried out with their end-users, children with disabilities, using the Research-Action methodology. This technique foresees the observation of the main difficulties that children have when interacting with games. Thus, new options for customizing the interaction will be created, more suited to each specificity.

Another future work is the construction of a socially aware model for adaptable game design, based on the work of Baranauskas (2009). This model will consider a wide range of technical, social, and cultural aspects for the development of accessible games in a participatory and socially responsible way, given the complexity of the topic. This paper focuses on the possible deficiencies the target audience may have, but accessibility goes beyond that. For example, it is necessary to consider aspects such as the software and hardware required to run the games, the language used, and whether it needs an internet connection.

Currently, a Systematic Mapping Study is being performed to identify and describe studies that investigate the adaptation of digital games for the users' needs. The Mapping is going to help identify aspects that must be included in the Socially Aware Model.

8 Final Remarks

This paper presented a set of features obtained from the literature review together with the development of a set of adaptable games. The main objective of this research is to propose a set of personalization features to help people interested in building adaptable games in the context of accessibility. To achieve that:

1. We conducted a survey on existing accessibility guidelines, new proposals, and a literature review on customizable systems.

2. We developed adaptable games with the support of the specialist providing requirements for the systems. Expert tests were then conducted to identify the potential benefits of each customizable feature.
3. We mapped the main characteristics of customization present in both adaptable games found in the literature and the developed ones, correlating each customization with the benefits they can provide to their users.

To corroborate this information, test stages of the games were carried out with health experts, who highlighted the importance of the various personalization features available. For example, we can mention creating themes and voice options that help children associate familiar elements with those graphically represented, generating stimuli for memorization and logical reasoning.

The main contribution of this research is the detailing of a set of personalization features extracted from both the developed adaptable games and the papers found in the literature review. We hope that the details of these features will serve as a guide to help designers interested in designing adaptable games to choose which features to use. Another contribution is the availability of adaptable games that support health specialists as programming users, making adaptations according to the needs of their patients.

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