Mobile Audio Games Accessibility Evaluation for Users Who Are Blind

6 authors, including:

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[Draft Version] Mobile Audio Games Accessibility Evaluation for Users Who Are Blind

Maria C. C. Araújo[1], Agebson R. Façanha[1] Ticianne G. R. Darin[1], Jaime Sánchez[2], Rossana M. C. Andrade[1]⋆, and Windson Viana[1]

[1] Federal University of Ceara, Graduate Program in Computer Science, Brazil,
`mariaaraujo@great.ufc.br,agebson@ifce.edu.br,`
`ticianne@virtual.ufc.br, rossana@ufc.br, windson@virtual.ufc.br`
[2] University of Chile, Department of Computer Science, Chile
`jsanchez@dcc.uchile.cl`

Abstract. Digital games have become increasingly popular for both entertainment and education purposes. However, making these games universal and accessible poses a challenge for interface designers and game developers, since they are usually unfamiliar with the peculiarities of gamers who are blind. More effort is necessary for contributing to a universal game design and, ultimately, helping to promote the inclusion of people with disabilities to take full advantages of digital games. In this research, we present a study concerning existent guidelines and recommendations for accessibility in digital games. As a result, we propose ten recommendations for the design of mobile audio games, targeting gamers who are blind. We also present an evaluation instrument assembled from the recommendations we propose. We used this instrument to assess ten audio games labeled as inclusive. Results indicate that only three from a total of ten games were considered "good", which means they met the fundamental aspects of the guidelines.

1 Introduction

During the past decades, the way of enjoying the playful universe of digital games evolved regarding style, meaning, and available platforms (e.g., arcades, consoles, PCs, mobile devices). In turn, the purpose of games has been widened beyond sheer entertainment. For instance, we can find games as learning support software (edugames), marketing tools (advergames), or even games for improving physical conditioning (fitness games) [19][22]. Digital games are now more socially relevant than when they were conceived. Despite performing a significant social role in many sectors and communities, most games do not contribute to the inclusion of people with disabilities. In fact, the majority part of digital games has not design, user interface, or mechanics adapted to gamers who have some disability [32][12].

According to the United Nations (UN), there are more than 600 million people with some physical, cognitive, hearing, or visual disability in the world. The World Health

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Organisation estimates 285 million inhabitants with visual impairments. 40 million of them are totally blind. The majority (90%) live in developing countries such as Brazil and India [1]. Game designers and developers devote feeble efforts for implementing accessibility in their games despite this significant number of people with disabilities [25][12].

Groups of researchers, game communities, and specialized game companies have mobilized themselves to develop games targeting users with disabilities in various platforms [3] [32]. Some communities compile and make available such games, such as the Game Accessibility Web sites [3] and Audiogames.net [4]. Another notorious initiative is the proposal of accessibility guidelines and recommendations for designers and game developers. However, the most important guidelines available nowadays are scattered in many works and demand compilation.

In this research, we present a study concerning these guidelines and recommendations for accessibility in mobile games. The research focused on accessibility recommendations for gamers who are blind. As a result, we propose ten recommendations for the design of mobile audio games, which are a set of games in which the primary interaction occurs through audio.

In the first phase of this research, we gathered and studied six collections of guidelines. Then, we resumed these guidelines focused on the most relevant accessibility characteristics provided in mobile audio games for users who are blind. Based on this study, we identified ten recommendations that can be considered recurrent or minimal requirements to meet in the design and development of a mobile audio game. These recommendations contain simple considerations and design decisions that apply to most game mechanics. However, these are the recommendations that benefit the biggest number of players and are easy to implement.

Moreover, we developed an evaluation instrument based on the Web Content Accessibility Guidelines (WCAG) 2.0 classification and organization [24]. The assessment instrument offers a simplified way to evaluate the minimal accessibility requirements that a mobile audio game should meet. To validate the instrument, we applied it to the evaluation of ten mobile audio games (e.g., Nebula, Inquisitor, GBraille Hangman). Finally, we implemented an evaluation process with the assistance of two individuals who were blind. Results indicate that only three from a total of ten games were considered "good", i.e., met the fundamental aspects of the guidelines. Two games were found unsatisfactory, and three games were insufficient mainly due to the absence of an audio tutorial and no level configuration available to the gamers.

The remainder of the paper is organized as follows: Section 2, after the introduction, gives an explanation about accessibility in games in a broader context and also discusses the audio games available for mobile devices. Next, Section 3 presents the study of the Recommendations for Accessibility in Digital Games. Section 4 details the assessment of ten audio games implemented using our instrument. It also presents the results ob-

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[3] http://game-accessibility.com/game/

[4] http://audiogames.net/

tained by this evaluation. Section 5 takes up on related works and, finally, Section 6 closes the paper showing final considerations and future work.

2   Game Accessibility

"Accessibility for games can be defined as the ability to play a game despite limiting conditions. Limiting conditions can be temporary functional limitations or permanent disabilities – such as blindness, deafness or reduced mobility" [14].

Accessibility features in digital games are often limited to change of resolution, volume adjusts, subtitles activation, and remapping of game controllers [25]. These mechanisms promotes on some level the universal design of the games, but several limitations are still unaddressed. Game audio is an important immersion aspect. However, rarely, it receives the same attention received by the game visual project. Frequently, sound feedback provided by games is not enough to indicate all the essential information for understanding the scene or the possible navigation paths. Players who are blind also experiment a generalized incompatibility of screen readers and games since these systems require access to hidden text descriptions in each element of interaction. Also, even players with low vision need options for increasing the size or contrast of game elements [32][31].

2.1   Audio games accessibility

Audio games are focused on an audio-based gameplay. These techniques allow a user to play a game without the need for a graphical user interface to understand the game context or to interact with the application [7]. It is also important to emphasize that these audio-based games are not always accessible due to its target audience. For example, the game Zombie, Run! [29] is an immersive running audio game in which users are put into zombie's universe focused on a street running.

Accessible audio games have as target audience people with visual impairments. These games reinforce audio solutions to guarantee the interaction. Originally, amateurs have developed the majority part of the accessible audio games. They started with adaptations from existing games, trying to make them partially or entirely accessible. Nevertheless, they also aroused the interest of sound artists, researchers, developers, and gamers [16]. Most of the audio games don't have a graphical interface. In some cases, a primary visual interface is available since games can also aim at universal design. Then, people who are blind can also play with or against people who are sighted.

The main characteristic of accessible audio games is the treatment of routines and narrative in games through sound resources. Games use both recorded sounds or TTS (Text-To-Speech) techniques to generate audio from text information. In these games, the player can differentiate several sound patterns quickly. Additionally, audio games could include tactile and haptic feedback (e.g., feedbacks with vibration or sound). With this

approach, a complete game atmosphere can be built, offering to individuals who are blind a good level of interaction [26][32][12].

Audio Quake, *Serialization*, and *Audio Icons* are the most commonly used techniques to provide accessibility in audio games [3][33][26].

- **Audio Quake** – It simulates a radar and uses sound metaphors to indicate the position of mobile and fixed objects. For example, sounds are emitted from the enemy's position. They gain intensity (or alarms) according to the approximation of the opponent [4]. Some authors indicates Audio Quake as the first adaptation technique produced [33]

- **Serialisation** – This technique treats game priorities in the sound playing. Distinct levels of information (e.g., enemies, obstacles, etc.) have different levels of priority concerning sonorization time. Therefore, the correspondent sounds should be serialized according to this priority, which indicates its importance for the game comprehension. In that sense, several paradigms of priority might be used in this technique [5][33].

- **Audio Icons and Audio Cues** – This technique proposes adding sound effects to the game (audio icons) or sound clues for promoting the object identification or for describing actions in the game [33][26]. For example, the game plays a collision sound, and, just a few seconds later, it executes other audio indicating that there is a wall in front of the gamer's avatar [12].

- **3D Audio Cues** - 3D audio cues use sound levels and sound source position (e.g., sound from the north, from behind the user) for directional guidance. Nowadays, smartphones and PCs have binaural audio, which reproduces 3D effect to systems that have 5.1 sound (5 channels for simple sounds - medium and acute sounds - and a channel for deep sounds) in stereo headphones or speakers. Frequently, this technique is combined with the other ones to provide a fully immersive 3D game. Nevertheless, games incorporating 3D audio and directional simulation may not always provide high-quality experience, since it also depends on the user's device audio system (speakers position, headphone quality) [12].

There are several academic work related to developing of audio games that incorporate these techniques [27][28][8][18][7]. For example, Audiopolis [28], a game focused on stimulating navigation and orientation abilities in a virtual city by interaction with audio and tactile interfaces.

Web repositories maintained by users communities contains a list of accessible audio games. Take as an example the website Augiogames.net, an international repository with more than 100 games (http://www.audiogames.net/). The available games range from adaptations of board games (e.g., chess) to RPG (Role Playing Games) and action games. For example, "Nicolas Eymerich, Inquisitor" is a PC adventure game, in which Eymerich is called to investigate a complex case that reveals a new face of Evil. The player finds and collects objects through sound feedback of scenery elements.

2.2 Mobile Audio games

Audio Games may also be developed for mobile platforms. It is similar to any other digital game with audio and video output. In other words, it has a narrative, and the player interaction uses audio and other native resources of the mobile device. For instance, sensors and gestures may also be used to guarantee and improve player's immersion. Audio games that are in a mobile context present the same gender variety that console-based or PC games, such as adventure games, action, terror, running, RPG, among others [6] [23].

Mobile game developers also work with binaural audio. Sound effects provide an identification of where the player is, and device gestures can be translated into game commands. These sound effects allow them to build an immersive world around the player, making him able to identify direction and distance from game objects. Besides, the mobile game could take advantages of the resources available in Smartphones and tablets as the a compass, GPS, accelerometer, and other sensors [20][26][12].

Accessibility implementation in mobile games involves several specific issues. Mobile devices provide freedom to the user, which can play games everywhere using a multitude of input methods (text, gestures on the screen, gesture with the mobile phone, etc.). However, these characteristics imply more interaction limitations for players with disabilities.

While designing games for mobile devices, game designers and developer must consider items related to alternative inputs (e.g., "buttons" configuration, controlling customization). Some games include a capacity of spinning the device in space by using a gyroscope to control the game avatars. Other games require interaction with the device's touchscreen. In both situations, developers must provide alternative controllers. For instance, the game should have alternative buttons in the interface, allowing those that cannot properly hold the device to be able to play the game by using the screen buttons [17][12]. High contrast and design options for color-blind people are important for players with low vision or color blindness so they can distinguish critical areas related to the game menu and navigation.

Web repositories also contain a list of mobile audio games that are accessible for people who are blind. Papa Sangre, Blind Legend, VBHangman, and GBraille Asteroids are examples of these audio games. Their download is available at the virtual stores of Android and iOs. For instance, Papa Sangre is an audio-based navigation game with a terror thematic. Gamers walk or run by tapping left and right on the bottom of the screen. Sliding gestures on the screen will turn the user's virtual "avatar". The game plays 3D audio cues for directional guidance. It is available for both Android and iOS. Another example is VBHangman, in which the user plays the game and tries to determine what word is dictated, given its length and a limited number of guesses [18].

3 Methodology

The methodology followed in this research followed four phases: Analysis of Accessibility Guidelines, Proposal of Guidelines for Audiogames, Development of Evaluation Instrument, and Evaluation of Audiogames. The starting point of the work was the search and studying of papers concerning accessibility in both digital and audio games. This study also includes the investigation of the main accessibility guidelines for digital games. In the beginning, the goal was to find a guide or group of patterns, such as WCAG 2.0, that could help in the design of mobile games for people with visual impairment. However, the first searches and readings indicated an inconsistency in the guidelines and recommendations, which led to the decision of carrying this research out.

The research second stage consisted of the study, classification, and compilation of the guidelines and recommendations. We focus on the accessibility features for people who are blind. We adapted these guidelines for an evaluation performed, focused on the most relevant accessibility characteristics provided in mobile audiogames for people with visual impairment and blindness. Based on this study, we identified ten recommendations that can be considered recurrent or minimal requirements to meet in the design and development of a mobile audiogame. We then create an evaluation instrument that allows the assessment of these recommendations in mobile audio games. This guide was used throughout the whole process of design and development of an accessible audio game. In the fourth part of the study, we applied the instrument in the evaluation of ten mobile audiogames (e.g., Nebula, Inquisitor, GBraille Hangman). This evaluation was held with the assistance of two individuals who were blind. The results and their analysis are shown in Section 4.

3.1 Accessibility Guidelines Investigation

In the first phase of this research, we gathered and studied six collections of guidelines:

– Accessibility in Games: Motivations and Approaches - IGDA (International Game Developers Association) [14];

– Game Accessibility Guidelines *Top Ten* - IGDA GASIG - Game Accessibility Special Interest Group [14];

– Guidelines for the development of entertaining software for people with multiple learning disabilities - UPS Project [23];

– Guidelines for the Development of Accessible Computer Games - Roland Ossmann [20];

– Blind Computer Games: guidelines for building blind-accessible computer games - J. Bannick [15];

– A Pratical Guide to Game Acessibility (Includification) - The AbleGames Foundation [17]

These guides present – through similar structure and points of view – recommendations and accessibility guidelines focused specifically on the assessment and support for the development of accessible digital games. These six guidelines are the most cited by the game development community.

The guidelines deal with the relevance of game items that maximize the accessibility, considering aspects concerning the user, the game theme, and the characteristics of the interactions. For example, the IGDA Game Access SIG (Game Accessibility Special Interest Group) proposed, in 2004, nineteen accessibility guidelines. The group derived the guidelines from a research of 20 accessible games. Most games included applications for blind users, individual with a motor disability, and games for users who are hearing impaired.

Norwegian organization Medialt has sponsored the UPS project aim at creating guidelines to adjust existing games to become more accessible to a larger audience. They propose a set of 34 accessibility recommendations.

A group of developers, specialists, and scholars published two guidelines: the *Guidelines for the Development of Accessible Computer Games* and *Blind Computer Games: guidelines for building blind-accessible computer games*. In both cases, the authors gathered efforts to increase the number of recommendations available. The last guide studied, called Includification, brings definitions and approaches that developers must implement to promote accessibility in digital games. They propose guidelines for the general themes of visual impairment, cognitive disability, motor disability, and hearing impairment. English organizations created a Web portal [5] with an illustrated version of the Includification guidelines.

3.2 Top 10 Recommendations

There is a variety of possible approaches that game designers and developers can follow considering the main items in accessibility that are applicable for mobile platforms. The set of recommendations in the guidelines studied deals with all types of disabilities. However, our focus is game accessibility for gamers who are blind. To do so, we made a simplification of the recommendations having in mind the assessment of mobile audio games. Hence, after the study of the six guidelines, we identified the ten most relevant game accessibility characteristics that must be provided for gamers who are blind.

These ten recommendations can be considered recurrent or minimal requirements to meet in the design and development of a mobile audio game. These recommendations contains simple considerations and design decisions that apply to most game mechanics. However, these are the recommendations that benefit the biggest number of players and are easy to implement if they are taken into account since the Game Design Document (GDD) creation. The following list detail each of the ten recommendations and tests to identify their correct application:

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[5] http://gameaccessibilityguidelines.com

– **R1 - Game level and speed adjustments.** The game should allow players to choose between a wide range of challenges and speeds.

  Goal: People might benefit from slower and easier versions to adjust the game, adapting to their needs.

  Test: Does the game allow these settings to be changed? If yes, can the title be adjusted to a mode in which is much harder to fail or to be hit?

– **R2 - Free exploration and tutorial modes.** The game should offer a way in which the player can explore the game without failures. Another possibility includes a tutorial mode that explains how to play the title.

  Goal: This game feature helps in the understanding, control adjustment, skill development and to offer a fun way for those who interact with the standard game while playing alone.

  Test: Is the game free exploration mode easy to enable? Does it have attractive commands to catch the players attention? Is the player free to try and learn on his/hers own pace?

– **R3 - High contrast interfaces.** The game should offer high contrast color schemes. Essential items and the menu selection must follow the same approach. Also, the game should allow background deactivation in 2D/3D games.

  Goal: It increases the visibility of text items that are important for players who are visual impaired.

  Test: First, the tester should run the game on a low-resolution computer screen. Is it possible to read and navigate by its menu or is it too difficult? If it is hard to navigate, the game is not following this recommendation correctly.

– **R4 - Friendly design for people with color blindness.** Game developers should avoid color combinations that are hard or impossible for a person with color blindness to distinguish.

  Goal: The goal is to allow access to information in all color shapes and also offer alternative configurations to transmit the meaning of the color combination.

  Test: How is the color information in the display? Are only two colors being used to give options? Is there a color palette showing all colors in a way that allows color-blind people to change it?

– **R5 - Accessible menu.** Game interface customization should be ease to access by people who are blind. For this, the menu should have fast starting modes, alternative texts, and navigation for the menu entry (e.g., text-to-speech and a description of symbols).

  Goal: For a game with a complex interface, the goal is to provide a simplified interface that shows only the most common used controls. All the resources will continue available. However, they are hidden from the users in a first place.

Test: Do the players face difficulties when navigation through the menu? Is there a way to access most of the game functions in 3 menu options or less?

– **R6 - Standard presentation of texts.** Game messages and labels should be compatible with screen readers. Gamers should be able to use simple gestures to access the majority of the text messages, which should be read by the screen readers. When the game shows a visual message, it should be recommended to present an equivalent audio message to indicate what has been done.

Goal: Users with visual impairment will be able to identify and understand texts presented in the game.

Test: Use a screen reader provided by the mobile operational system or one that is compatible with it. Are the items and descriptions read correctly by the tool?

– **R7 - Speech-generating features.** This recommendation is a derivation of R6. The main idea is to use text-to-speech technologies to improve the user immersion. Texts can be presented in different languages and be correctly read by game-integrated voice synthesizers, even there is no screen reader installed.

Goal: R7 allows users with visual impairment situate themselves in the game dialogues and the sequence of narrative texts.

Test: Navigate through the game with a personal with no visual impairment and an another one with visual impairment. Do the navigation of all control combinations properly return visual and hearing feedback for both users?

– **R8 - Accessibility resources easily found.** Developers should implement features that assure easy access to accessibility configurations. Gamers should access and understand in the first contact with the game where are the accessibility features (e.g., color customization, audio cues enabling, additional audio feedback).

Goal: The goal is to permit players to know that they will be capable of enjoying the game before purchasing the title or start playing. This information must be mainly in the dissemination platforms of these games on the web, for example.

Test: Is there a way to quickly check the accessibility features, options and requirements of the game right in the first contact with the title?

– **R9 - Game tutorials and help.** Developers should hierarchize game tutorial and helps to guide the gamer through the help items, providing feedback. This resource would be useful for almost all players, especially, for people with learning disabilities that have low attention span or lack lasting attention to focus on a long instruction guide.

Goal: Following R9, the game provides the players with objective indicators assisting the players in situations of bewilderment.

Test: Is the player forced to read long information passages? Can he properly continue with his game through fast orientation?

– **R10 - Orientation** Players should be able to use the physical keyboard or the touch-screen to guide the avatar in many directions and receive feedback about its direction. For example, using the sliding gesture to the right the avatar will turn its face to the right in a standard angle (e.g., turn 45 degrees). An audio feedback will be played describing the users orientation (e.g., North).

Goal: To guide specific avatar movements and receive orientation feedback.

Test: Is there a way to offer the player to be guided based on the cardinal points, for example?

4 Accessibility assessment instrument for mobile audio games

From the top ten recommendations, we created an assessment instrument to help game developers in the testing of the mobile audio games. The questionnaire comprises a total of 32 questions distributed in six categories. These categories are inspired by WCAG 2.0, which is a W3C stable and referenceable technical standard for accessibility assessment. The six categories are:

– **[C1]-Alternative texts**: The game mobile interface should provide textual alternatives for non-textual content. The idea is to map visual elements to speech and textual messages. This additional information should be available as text, aiming the proper use of screen reader programs that provide a sound return of textual information.

– **[C2]-Adaptability**: Game interfaces and contents should be adaptable according to the mobile device characteristics. So, they could be presented in many forms on the mobile devices (for example, in minor resolution or only audio), without losing essential information.

– **[C3]-Atmosphere**: Navigating in the mobile interface, players should be able to comfortably situate themselves in the scenery from the content, including through separate sound return.

– **[C4]-Operability**: Interface, Interaction, and navigation components should be operable, easy to understand, and intervene by players. Fast start options should be included for avoiding multiple levels of information overloading the players. Players should have appropriate times of interaction with game features.

– **[C5]-Configuration Facility**: the game should allow the player to adjust, simplify, and change controls and game settings. Language issues, screen resolution, speech resource, screen readers, volume, among others features should be properly addressed in this category.

– **[C6]-Assistance and Tutoring**: Provide documentation, tutorial mode, and help features to assist the player in the understanding of the gameplay.

All 32 questions are classified as **A**, **AA** and **AAA**. Level attendance suggests effort in support of game accessibility features for people who are blind.

- **Level A**- 17 questions: The conformity level A (minimal level) comprises satisfactory criteria that could be implemented with low or moderate technical effort. This level includes most of the part of game mechanics and interface.

- **Level AA**- 12 questions: The conformity level AA guarantees that the game attends a more accurate list of successful criteriums. However, the technical effort to implement these features may be high. Some mobile devices and platforms may not support these features, which implies in an extra implementation effort.

- **Level AAA**- 3 questions: AAA ensures that the game contemplates satisfactory criteria that widen game experience. However, meeting the criteria is so specific that recommendations apply to a limited game list. This level will not be easily accomplished by games targeting a large audience, being suitable for games developed focusing on a particular player profile (e.g., totally blind users).

We attribute one point for all 32 questions. But, each level (A, AA or AAA) has a distinct weight, being 3 to level A, and 2 to level AA, and 1 to AAA. In this sense, the assessment can attribute to level A (the most critical one) a maximum of 51 points, level AA 24 points, and level AAA 3 points. Therefore, a game can reach the maximum of 80 points. Then, a game is going to be evaluated as *insufficient* when the score is from 0 to 39 points; *unsatisfactory*, when is from 40 to 60 points; and *good* when the score is from 61 to 78 points.

The assessment instrument is available on https://goo.gl/np7PrR.

5 Mobile Audio Game Evaluations

The final step of our study consisted of accessibility tests by using the proposed assessment instrument. Tests have evaluated ten audio games aiming at better refine the investigation of accessibility features found in mobile audio games recurrently. The assessment also tried to measure the conformity level of these applications according to the top ten game accessibility recommendations. Tables 1 and 2 show a summary of the evaluation results.

5.1 Users

We carried out the evaluation process with the assistance of two individuals who were visually impaired and collaborated with the research group. One user was 26 years old, and the other was 32 years old. Both users receive scholarships and work in the IFCE research center. They assist accessibility tests of the prototypes and software developed by the research group. They have great knowledge and experience using touchscreen mobile devices.

5.2 Audio Games

We evaluated eight distinct games and two versions of a ninth game:

- **Mine Sweeper Accessible - BFG.** The aim of this freeware game [6] is to find and mark all the hidden bombs on the game board map. The game includes many accessibility resources and uses tactile feedback for interaction (screen vibration).Blind Faith Games has developed this arcade game for Android Platform 2.2 or superior versions.

- **Golf Accessible - BFG.** This arcade and freeware game [7] works on Android 2.2 or superior versions. It provides a Golf game experience in an accessible format. The Blind Faith Games has created a Golf game with many game modes and levels.

- **Zarodnik - BFG.** The aim of this strategy game [8] is to collect rewards while defending and avoiding an attack from an ocean monster. Also developed by Blind Faith Games, this freeware Android game uses audio effects by implementing 3D binaural sound, and it also provides tactile feedback during the game interaction.

- **GBraille HangMan v3.0 and 3.1 - GREat Lab.** Itś an educational quiz game based on the hangman game [9]. It runs on Android 4.0 and uses GBraille Keyboard data entry. The game requires a previous installation of a voice synthesizer for its full functioning (e.g., eSpeak or Acapela). GBraille Hangman Version 3.1 has added new game features, corrected some accessibility problems, and included more language options.

- **Nebula.** Gray Company developed this action and strategy game [10] for iOS. Nebula has an arcade style of spatial battles. It targets as players both people with or without visual impairment. Players need to trust their hearing to move forward and win. The game also offers a multiplayer mode.

- **Inquisitor Audio Game Adventure.** An inquisitor, Eymerich, is called to investigate an unclear case of heresy, which can reveal a new face of Evil. The game is available for both Android and iOS platforms [11]. It can be played by blind, myopic, visually impaired, and sighted people.

- **Flarestar.** The mission is to discover Icarus spaceships, fly to explore deep space, avoiding collisions, fighting training drones, and trained strikers. Audiogame.it developed this arcade game [12] for iOS 8.1.

- **GBraille Asteroids v.6.0 - GREat Lab.** The goal of the game [13] is to practices Braille characters by using a Braille-based virtual keyboard. In this battle arcade

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[6] https://play.google.com/store/Apps/details?id=es.eucm.blindfaithgames. minesweeepe

[7] https://play.google.com/store/apps/details?id=es.eucm.blindfaithgames.golfgame

[8] https://play.google.com/store/apps/details?id=es.eucm.blindfaithgames.zarodnik

[9] https://play.google.com/store/apps/details?id=com.gbraille.forca

[10] http://www.applevis.com/forum/ios-gaming/nebula

[11] http://www.eymerich.it/index.php?center=audiogame

[12] http://www.applevis.com/apps/ios/games/flarestar

[13] https://play.google.com/store/apps/details?id=com.gbraille.asteroids

game, players are in a spacecraft and have to avoid hits from asteroids. To do so, users must destroy the asteroids by firing missiles. To trigger them, the user uses gestures on the screen that correspond to the writing of Braille characters.

- **Papa Sangre II - the museum of memories.** This paid iOS app is a first person adventure game [14]. The player is in a posthumous world and the game atmosphere makes him access memories to evolve. He has to find a way back to the living world. For this, the player explores a museum of memories, the Papa Sangre's Museum, a place where his existence depends on the knowledge of the living world. In the museum, there is a danger of being lost forever as a spirit without purpose or memories of his origin.

5.3 Materials

Users have played the games in two mobile devices: i) Apple iPhone 5S with iOS 8.13 system, and ii) Motorola MOTO G 2nd generation with Android 4.4.4 operational system (KitKat).

5.4 Procedures

Section 5.2 describes in detail all the games evaluated. They are available in Web repositories, such as Audiogames.net, Grey Company, Google Play Store, Universal Access, and Audiogame.it. We selected these games based on their popularity. We also evaluated three games developed by our research group.

The evaluation lasted four days. Each user has tested two games per day, and in the fourth day, they evaluate the last one. Each game evaluation section lasted for 50 minutes. One assistant filled the assessment instrument according to the answers given by each user.

5.5 Results

Tables 1 and 2 present an evaluation summary, as well as the scores obtained for each game. Results indicate that only two from a total of ten games have a right level of accessibility meeting the top ten recommendations. Two games were considered unsatisfactory and three presented insufficient results mainly concerning questions of level A, which are those indispensable in the implementation of game accessibility features.

Test results also indicate the categories of recommendations identified as critical for each game. The most common errors are related to operability category [C4]. Minor errors are related to Alternative Texts [C1]. It means that these ten games have basic accessibility levels, but features that are more complex are not receiving the same attention.

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[14] https://itunes.apple.com/br/app/papa-sangre/id407536885

Tabela 1. Accessibility Evaluation Results - Part 1

Game	Critical Categories	Score	Evaluation
 BFG- Mine Sweeper	[C4] Configuration presents problems related to memorization and lack of agility when accessing rules, commands, and game objectives; [C5] Some Incompatibilities with screen readers;	Level A: 12 pts (x3) Level AA: 7 pts (x2) Level AAA: 2 pts (x1) Final Score: 52 pts	**Unsatisfactory**
 Accessible Golf	[C2]- The game has simple versions of menu options and interfaces, but it not has options for enabled/disabled them; [C3]- The audio descriptions of some commands are not executing correctly;	Level A: 8 pts (x3) Level AA: 6 pts (x2) Level AAA: 1 pt (x1) Final Score: 37 pts	**Insufficient**
 Zarodinik BFG	[C4] Time to read, understand, and use content is insufficient [C4] In order to start a new game, user must navigate- through multiple levels of screens and menus	Level A: 8 pts (x3) Level AA 6 pts (x2) Level AAA: 2 pts (x1) Final score: 38 pts	**Insufficient**
 GBraille HangMan v.3.0	[C3] Sound feedback is not enough to indicate all essential information for the understanding of the game scenes. Audio descriptions are not sufficient to orient the navigation in menus and input/output screens; [C6] The game does not have a tutorial mode.	Level A: 8 pts (x3) Level AA: 6 pts (x2) Level AAA: 1 pts (x1) Final Score: 37pts	**Insufficient**
 GBraille HangMan v.3.1	Gbraille Hangman 3.1 improved some interaction problems (e.g., navigation, menu, audio feedback, speed) of the 3.0 version, but the game is still not meeting [C4] and [C6] adequately.	Level A: 11 pts (x3) Level AA: 6 pts (x2) Level AAA: 1 pts (x1) Final Score: 46 pts.	**Unsatisfactory**

6 Final Considerations

The focus of this paper was a preliminary proposal of structuration and organization of the main guidelines of accessibility for audio games in mobile platforms. As the first contribution, the research produced a simplified list of ten accessibility recommendations focused on gamers who are blind. Second, we offer a WCGA-style manual test instrument to assess these recommendations in mobile audio games.

Tabela 2. Accessibility Evaluation Results - Part 2

Game	Critical Categories	Score	Evaluation
 Nebula	[C2] Low vision players need options that widen the size or the contrast of elements; [C4] The game has some problems with screen readers settings. It does not warn users whether the screen reader is disabled or enabled;	Level A: 15 pts (x3) Level AA: 10 pts (x2) Level AAA: 2 pts (x1) Final Score: 67 pts.	**Good**
 GBraille Asteroids	[C3] Sound feedback is not enough to indicate all essential information during game sessions; [C6] The game does not have a tutorial mode.	Level A: 14 pts (x3) Level AA: 6 pts (x2) Level AAA: 1 pts (x1) Final score: 56 pts	**Unsatisfactory**
 Inquisitor	[C2] Low vision players need options that widen the size or the contrast of elements;	Level A: 14 pts (x3) Level AA: 9 pts (x2) Level AAA: 2 pts (x1) Final Score: 62 pts	**Good**
 Flarestar	[C5] Incompatibilities and configuration problems with screen readers; [C1] Many alternative texts are absent;	Level A: 13 pts (x3) Level AA: 8 pts (x2) Level AAA: 2 pts (x1) Final Score: 57 pts	**Unsatisfactory**
 Papa Sangre II	[C5] Incompatibilities and configuration problems with screen readers; [C1] Some alternative texts are absent;	Level A: 16 pts (x3) Level AA: 12 pts (x2) Level AAA: 2 pts (x1) Final Score: 74 pts	**Good**

We implemented an initial evaluation with ten mobile audio games. The results suggest a low level of accessibility in a part of the mobile audio games investigated. From this research, we noted how complex is to trace profiles or evaluation patterns for accessible games in the mobile context because of the mobile device heterogeneity. For this study, we did not take into account the many device screen sizes, the standard gestures on the touchscreen, and also the use of device sensors in the games. Recommendations to deal with these issues should be further investigated.

The tested samples of this work are not sufficient to obtain more precise information about the mobile gaming scenery. Due to this factor, we consider this as an initial study on the identification of necessary refinements for the group of proposed guidelines and recommendations. However, the study provides evidence that the instruments and com-

piled recommendations are a good starting point for game designers and developers seeking a way to make their games more accessible in mobile platforms.

7   Acknowledgments

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