Game Accessibility Guidelines for People with Sequelae from Macular Chorioretinitis

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ABSTRACT

Macular chorioretinitis is an ocular inflammation that may cause the permanent loss of the central vision. Researches indicate that the formation of macular scars, the potential sequela of that inflammation, is the leading cause of low vision in children. As we found no game accessibility guidelines in the literature that were specific to users with central vision loss in a preliminary search, this study thus aimed at surveying those targeted at players with low vision. The guidelines were extracted through a systematic literature review conducted on digital libraries and also with the manual selection of other relevant sources. In total, we identified 25 more general game accessibility guidelines, for people with low vision, and 19 of them were considered applicable to people with macular scars. Afterward, we assessed the feasibility of each guideline according to their impact, reach and cost. The survey also confirmed that no guideline existed that was specific to players with central vision loss. We expect the results of this research to serve as a starting point for the definition of new guidelines specific to players with sequelae of the macular chorioretinitis.

Keywords: game accessibility, macular chorioretinitis, visual impairment, low vision, central vision loss.

1 INTRODUCTION

Macular chorioretinitis is an inflammation in the eye [25] that can lead to permanent loss of the central vision [19]. People who do lose their central vision go through several limitations on daily activities, such as a difficulty in recognizing faces not so frequently seen, the need to approach others closer to identify facial expressions and a higher propensity to visual fatigue while reading [19].

There are different causes to macular chorioretinitis, but the most common one is the congenital toxoplasmosis [10], a disease resulting from the infection from a protozoan, transmitted through the ingestion of contaminated food and that can be acquired during gestation, from mother to fetus. A possible sequela is the formation of scars is the eyes' macula (i.e., an anatomic structure situated in the retina central region [16] that is responsible for the vision of details and the perception of colors [4]). The formation of macular scars leads to the permanent central vision loss. Proper treatment with antibiotics when conducted during the first year of life of a child can significantly decrease the damage caused by congenital toxoplasmosis [24], but that depends on the timely diagnosis of the disease, as early as the first days of life [9].

Similarly to other visual impairments, the macular scar caused by the chorioretinitis impacts heavily on the gaming experience, as in the case of games not made accessible, players are presented with barriers imposed by the developers and need to adapt to overcome the artificial conditions they implemented. The peculiarity of the macular scars is that players cannot use the central vision [19], which frequently prevents them from having a good gaming experience.

Accessibility is a concept that defines the participation of people with some disability in diverse activities [7], and the same notion applies to digital games, such that game accessibility defines that individuals with some impairment have the option of having a satisfactory gaming experience no matter their conditions.

In Brazil, disregarding myopia, hypermetropia, astigmatism, and presbyopia, which are visual impairments easily treated with the use of glasses or lenses, about 4 million people have some visual disability, of which approximately 100 thousand are children [5].

A study conducted at Laramara, the Brazilian Association of Assistance to the Visually Impaired, between 1998 and 2003, identified that chorioretinitis is the third leading cause of visual degeneration in children, being responsible for 8.4% of the registered cases during that period [15]. Another study, conducted at the clinical hospital of Campinas State University (Unicamp) between 2003 and 2007, verified that macular chorioretinitis is the one leading cause of subnormal vision in children [22].

As the macular chorioretinitis is one of the main causes of low vision in children, it is important that game developers have the concern to develop games that do not unnecessarily impose artificial barriers to those potential players, in such a way to ensure they have a good gaming experience.

The goals of this research included (a) identifying game accessibility guidelines that were specific to people with loss of the central vision, as well as (b) analyzing if those targeted at individuals with low vision, more generally, could also be considered adequate to improve the game experience of people with sequelae from the macular chorioretinitis; and lastly, (c) analyzing the feasibility of implementing those guidelines. We conducted the survey of the existent guidelines through a systematic literature review (SLR) [17] and by manual selection of other relevant sources. Posteriorly, we analyzed the applicability of the identified guidelines considering the literature on game accessibility as well as macular chorioretinitis. On that analysis, we also leveraged the knowledge and experience of a group of 4 professionals from the areas of ophthalmology, psychopedagogy and occupational therapy who were either involved with the sequelae from the macular chorioretinitis or that, for one of them, is the parent of a child that has macular scars due to congenital toxoplasmosis. Afterwards, we classified each applicable guideline regarding the viability of its implementation, using as baseline the experience of the authors as developers and the classifications available at [11] and [2]. That analysis of the applicability and feasibility of the guidelines might be the starting point for new studies in the game accessibility field for people with sequelae from the macular chorioretinitis.

The remainder of this study is organized such as following. Section 2 defines what is macular chorioretinitis. Section 3 describes the methodology employed to survey the accessibility guidelines for players with low vision. Section 4 presents the results obtained from the survey, the study of their applicability to the specific case of people with macular scars caused by chorioretinitis and an assessment of their feasibility. The last section presents our conclusions and some future work.

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2 MACULAR CHORIORETINITIS

Chorioretinitis (or retinochoroiditis [26]) is a term that references an inflammation in the retina (i.e., a thin layer of tissue which is responsible for catching light [8]) and the choroid (i.e., a layer of blood vessels that feeds nutrients to the retina [21]). The macula is the central part of the retina. When the chorioretinitian inflammation reaches the macula in the eye, it is denominated macular chorioretinitis. Figure 1 depicts a schema that identifies different parts of the human eye.

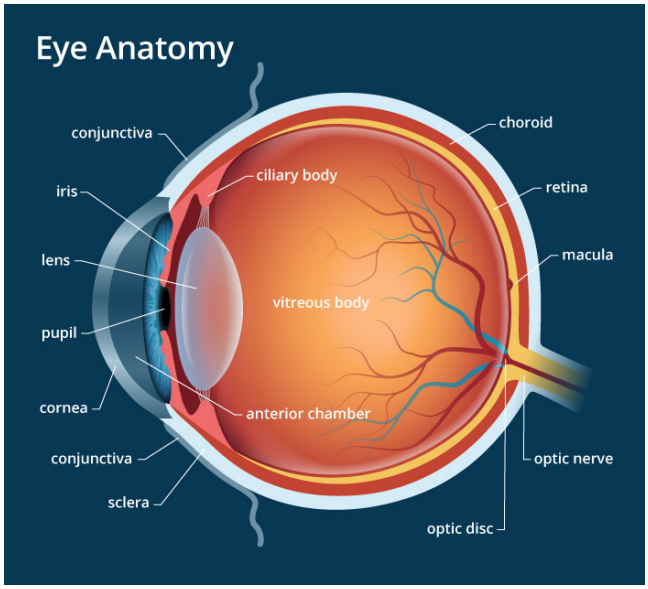

Figure 1: Human eye structure [1]

There are two types of receptors in the retina: cones and rods [12]. The cones, which concentrate in the region of the macula, are capable of detecting the details and colors of an image [12]. The rods, which lie on the periphery of the retina, are capable of detecting the luminosity of a picture [12].

The evolution of the inflammation caused by the macular chorioretinitis might lead to the formation of scars in the macula, which provoke the loss (partial or integral) of the central visual acuity. In this way, the person can only see the periphery of an image. Figure 2 illustrates how that person's vision is affected by the sequelae of the macular chorioretinitis.

The sequelae from macular chorioretinitis affect the daily activities of people in different ways, and that makes some adaptations to the environment and utensils necessary so they can execute those activities the best and least costly way possible. One example of such adaptation is usually needed for reading, as it is helpful for the text to have a larger size and to be formatted in block letters instead of cursive. In the case of printed text, it is important to have a vertical support for the material to avoid neck pain, as the person usually tilts per head sideways to be able to read [19]. Lastly, in the case of reading on digital devices, it is important that they have higher resolution, so letters are depicted very sharply [18].

3 METHODOLOGY

To identify which game accessibility guidelines apply to people with sequelae from macular chorioretinitis, it was necessary to survey existent, more general, guidelines for players with low vision. We conducted a study of the applicability of the found guidelines to the specific case of people with macular scars due to chorioretinitis. Lastly, we analyzed their viability by evaluating their impact on the gaming experience, their reach, and their implementation cost.

Figure 2: Impact of macular scar caused by macular chorioretinitis on vision

3.1 Literature survey

We conducted, in the literature, a survey of the game accessibility guidelines for low vision through a procedure called Systematic Literature Review (SLR), which is a research method that enables the detection of the highest number of publications that are relevant to the subject of interest. Also, its searching strategy must allow the repeatability and the evaluation of the integrity of the research [17].

To execute the SLR, we defined the review protocol, which is a document that establishes the scope and guides the researcher in the whole process. It specifies the research questions being investigated, the libraries considered for examination, the selected time frame, query strings, inclusion and exclusion criteria for the publications, the quality evaluation criteria and the data which was collected from the selected publications [17].

The process consists of three main phases: preparation, execution, and analysis. The first phase comprises the elaboration of the protocol, the second phase is the actual conduction of the review, and the third one is the report of the findings. During the conduction, we selected the publications in a process that comprises four steps:

1. Selection by title: consisted in the elimination of the publications whose titles were unrelated to the theme.

2. Selection through the abstract: consisted in the selection of

the publications whose abstracts related to the theme.

3. Selection through diagonal reading: consisted in the selection of the publications that had introduction and conclusion that related to the theme.

4. Data collection: consisted in the selection of the publications by the quality criteria and their adequacy to the theme, and later on the data collection itself.

After the conclusion of those four steps, we analyzed each of the selected articles that remained by answering some specific questions (SQ) stated in the review protocol. Those responses led to the answer of the research question (RQ).

In this research, we conducted the survey during May 2017, and we used the digital libraries ACM, ScienceDirect, and IEEE. The time frame for the selection of the publications comprised between 1992 and 2017.

As the end goal of this study was to determine applicable accessibility guidelines for people that have been affected by macular chorioretinitis, the research question (RQ) of the SLR was "What are game accessibility guidelines for people with sequelae from macular chorioretinitis?".

In the specific questions (SQ) we also included the accessibility guidelines for players with low vision, as in preliminary searches we found no guidelines specific to individuals with macular scars due to chorioretinitis. Thereby, we defined the following list of specific questions:

SQ1 What are some accessibility guidelines (**in general**, not just in games) for people with sequelae from macular chorioretinitis?

SQ2 What are some **game** accessibility guidelines for people with sequelae from macular chorioretinitis?

SQ3 What are some game accessibility guidelines for people with **low vision** (more generally)?

We defined three query strings (QS) to guide the search on the digital libraries and therefore answer those questions. The first one aimed at surveying accessibility guidelines, both in the context of games but also related to daily activities, targeted at people that had been affected by macular chorioretinitis. The second one involved the term macular scars, which is the main sequela from macular chorioretinitis. Lastly, the third query string aimed at searching for game accessibility guidelines for individuals with low vision (a broader term). All QS included terms in English and Portuguese, and they can be seen next:

- game accessibility macular chorioretinitis OR *acessibilidade jogos coriorretinite macular* OR game accessibility macular retinochoroiditis OR *acessibilidade jogos retinocoroidite macular* OR accessibility macular chorioretinitis OR *acessibilidade coriorretinite macular* OR accessibility macular retinochoroiditis OR *acessibilidade retinocoroidite macular* OR games macular chorioretinitis OR *jogos coriorretinite macular* OR games macular retinochoroiditis OR *jogos retinocoroidite macular*

- game accessibility macular scar OR *acessibilidade jogos cicatriz macular* OR games macular scar OR *jogos cicatriz macular* OR accessibility macular scar OR *acessibilidade cicatriz macular*

- game accessibility low vision OR *acessibilidade jogos baixa visão* OR game accessibility subnormal vision OR *acessibilidade jogos visão subnormal*

For the data collection step, when we evaluate the quality of the publication and its adequacy to the theme, we defined three questions regarding quality, each one worth 1.0 point. To consider a publication approved on this step, it should score the minimum of 2.0 points (approximately 67%).

Besides that, we defined four questions regarding the adherence of the publication to the theme, each worth 1.0 point as well. On those, the publication should reach the minimum of 1.0 point (25%) to ensure the article could answer at least one question completely, or two partially (by scoring 0.5 points in each). That minimum score allowed us to state that the publication is indeed related to the proposed theme. Next, we present the questions related to the adequacy to the topic:

- Does the study define or present accessibility guidelines for people with macular chorioretinitis or macular scars?

- Does the study define or present ways for individuals with macular chorioretinitis or macular scars to improve the execution of everyday activities?

- Does the study define or present some means to improve the quality of life of people with macular chorioretinitis or macular scars (i.e., it defines ways to simplify some of their daily activities?)

- Does the study define or present game accessibility guidelines for people with low vision?

After all steps for selecting the publications had been performed, it was possible to answer the specific questions. From the selected articles, we could extract 16 game accessibility guidelines for people with low vision. That satisfied [SQ3], which aimed at identifying game accessibility guidelines for players with low vision. However, we could not identify any guidelines through [SQ1] or [SQ2], which aimed to determine those that would be specific to individuals with sequelae from macular chorioretinitis.

3.2 Surveying other sources

During the execution of the data collection step, we identified two other sources that contained relevant accessibility guidelines. More than one publication pointed them as sources of game accessibility guidelines, albeit they had not been contemplated on the SLR, as they were absent from the inspected digital libraries. Upon the conclusion of all phases of the SLR, we opted to include those other sources in the investigation as well.

Thereby, we handpicked [11] and [2] and applied the same process and criteria from the SLR on them. Neither had been published in scientific vehicles, but they were still solid inclusions because they contained many game accessibility guidelines that proved helpful for the goals of this research.

One of them [11] is a web page with a list of game accessibility guidelines presented in a developer friendly way, as it allows filtering by different types of impairments and also by an index of impact, reach, and cost of implementation. Several people connected to game accessibility contributed to the generation of its content – studios, specialists, and researchers.

The other work [2] is a white paper from the AbleGamers foundation, and it presents game accessibility guidelines that had been defined by developers and players with different types and levels of impairment.

By surveying those sources, we could identify 22 guidelines targeted at individuals with low vision. The next section presents the results.

4 IDENTIFIED GUIDELINES

We divided the process for determining accessibility guidelines for people with sequelae from macular chorioretinitis in two sequential steps: first, we identified the guidelines for people with low vision that the different research sources presented or defined and, second, we analyzed their applicability for the specific situation of people with macular scars due to chorioretinitis. Thereafter, we also assessed the feasibility of implementation of the applicable guidelines.

4.1 Consolidation of the guidelines

As a partial result of the SLR, considering all three query strings (QS) we defined, we found 28 publications. At the end of the fourth step of the selection process (data collection), only two publications were selected, as can be seen in the graph of Figure 3.

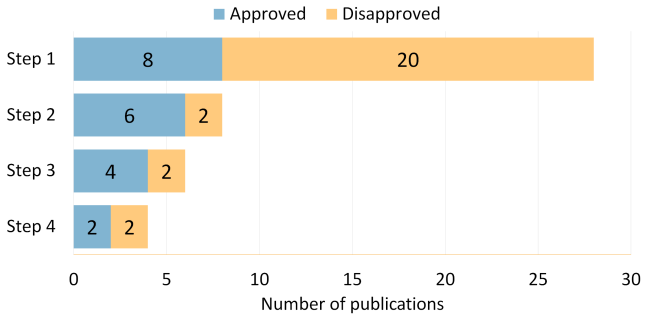

Figure 3: Amount of publications – partial result from the SLR

One of the selected publications is [13], which presents the big picture of the necessity of developing games accessible to people with any type of impairment and discourses about the importance that games can have in the life of an individual. The other publication is [3], which is a theoretical study about game accessibility and it talks about the need for developing games accessible to people with visual impairment in particular.

We consolidated the guidelines we found on the different selected sources in a single list to better visualize and analyze the results. In the process of consolidation, we removed repeated items and merged those which were sufficiently similar or related.

As the result of the survey, we found 25 game accessibility guidelines for people with low vision, as presented next:

G01 **Utilize high contrast between the background, text and other elements on the screen**
Usage of high contrasting images allows people with lower sensitivity to contrast to discern the game elements visually.

G02 **Ensure that relevant information is not uniquely conveyed through color**
Allow people that cannot differentiate colors to identify the information on the screen through other forms besides colors (eg., text or symbols).

G03 **Utilize easy-to-read fonts**
Choose fonts that do not design their letters too similar to each other – for example, some fonts draw 'u' as a rotated 'n' and that might confuse players with reading issues such as dyslexia.

G04 **Scale text large enough**
Text with small font sizes hinders players with low vision to read the information and instruction presented in the game.

G05 **Allow the customization of fonts (eg., size and style)**
The fonts and formatting of the text in the game should be configurable to fulfill the needs from different types of impairments, making it necessary to allow players to customize the fonts, sizes, and colors according to per needs and preferences.

G06 **Allow the rearrangement of the interface (eg., colors, sizes and item positioning)**
Some visual impairments prevent players from seeing regions of their field of view, making it necessary to enable the rearrangement of the items in the interface. Colors and sizes of the interface elements should also allow customization.

G07 **Utilize redundancy in the visualization of information (eg., text and symbols)**
Some players might have trouble identifying information in a certain format, and the use of redundancy in other formats allows them to choose the one that best suits their needs or preferences.

G08 **Allow adjustment of the speed (eg., game, text and speech)**
Players with different conditions might take more time to receive the visual stimuli so games should allow the reduction of their speed.

G09 **Provide separate volume controls for sound effects, speech and background sounds/music**
It must be possible to prioritize sounds that are more relevant to the gameplay by having separate volume controls for sound effects, background music, ambient sound, and voiceovers.

G10 **Ensure interactive elements and virtual controls are large and well-spaced, including on touch or small screens**
Small interface elements and controls are hard to see and, when too close, are also hard to interact. Games need to scale and position elements appropriately considering different types of screen sizes too.

G11 **Utilize several forms of distinction (eg., color, sound and symbol) for different elements and events in the game**
People with low vision might have difficulties in distinguishing the game elements and events, making it necessary to use more than one form of distinction for each one.

G12 **Provide subtitles and closed captions, with the transcription of sounds**
Despite the difficulties in receiving visual stimuli by people with low vision, having text associated with every speech and sound effect might help them associating the game events both in the visual and auditory channels complementarily.

G13 **Utilize good audio techniques (eg., sourround sound and binaural recording)**
The use of audio techniques such as spatialization enables the transmission of relevant information through the auditory channel, which can complement the visual stimuli that might not be fully received.

G14 **Provide voice reproducers for all text (including menus and installers) or ensure support for screen readers in different devices**
Games should include speech synthesis or allow screen readers to speak the text present in all elements of the interface.

G15 **Allow players to communicate using different forms (eg., voice and text messaging)**
Multiplayer games should allow players to communicate with each other in different ways to prevent the communication

from being hampered due to their distinct needs and preferences.

G16 **Allow players to use the numeric keyboard to control the movement of characters**
Players with partial or total loss in their vision might prefer using the numeric keyboard for character control as they may have trouble identifying which keys need to be pressed if they are spread over the whole keyboard.

G17 **Identify and describe the nearest objects by using audio**
Use voice to describe the surroundings and the nearest objects to facilitate navigation in the game as is usually done with GPS navigation systems.

G18 **Ensure that all key actions can be realized through digital controls rather than very complex input**
Analog input is more complex to interact than digital. For instance, as it may be harder to track the cursor position for people with visual impairments, digital controls should be an alternative option.

G19 **Allow adjusting the screen configuration (eg., contrast, brightness and zooming)**
Games should choose good default values for screen color settings, but they should also allow players to customize them. A player with some visual impairment might want to change the contrast or increase the brightness to identify the game elements better.

G20 **Allow the customization of the cursor**
Due to the difficulty that players with low vision may have in pinpointing the cursor, it is important to include customization options to it to facilitate its identification.

G21 **Provide a three-dimensional audio navigation map with the positioning of enemies in 3D games**
Players with difficulties to see the enemies on the screen in 3D games should be able to use a navigation map that depicts the position of the sound sources near the player.

G22 **Allow the configuration of the field of view in 3D games**
The angle that determines the field of view in 3D games should be bounded by what is expected to be seen by the player in the real world, because it might cause visual fatigue and even nausea if too high or too low, respectively. The value chosen as a default should consider the screen size and its distance to the player, but the game should also allow players to change it according to their needs or preferences.

G23 **Allow the removal of differences between the character control and the camera movement in 3D games**
If the camera movement is not synchronized with the character control, especially in first-person games, players might feel motion sickness. Some games feature that as immersion resources by having, for instance, detached head/weapon bobbing and involuntary camera movements.

G24 **Allow disabling the background movement**
Background movement may distract players' attention by presenting less relevant information, and that is a problem for players with low vision, as they might have difficulties identifying game elements on the screen. Thus, it is important to allow players to disable background movement.

G25 **Allow easy orientation/navigation through the game environment between the compass points in 3D games**
Allowing players to navigate in the game world through cardinal points aids in players orientation and localization.

Next, we detail the criteria adopted to determine if a guideline can be considered applicable to improve the game experience of people with sequelae from macular chorioretinitis.

4.2 Study of the applicability of the guidelines

After the consolidation of the identified guidelines, we studied their applicability to the case of people with sequelae from macular chorioretinitis. We based our analysis on the literature regarding game accessibility, the experience of professionals in the field of ophthalmology, psychopedagogy, and occupational therapy and on input we received from the parent of a child that has macular scars due to chorioretinitis caused by congenital toxoplasmosis.

Table 1 presents the criteria used for classifying the identified guidelines.

Criterium	Description
I	Difficulty in detecting colors and details
II	Higher propensity to visual fatigue during reading
III	Difficulty in visualizing items positioned in the central region of images
IV	Based on report, unrelated to the literature

Table 1: Criteria used for analyzing the guidelines applicability

G01 (high contrast) and **G02 (conveyance of information through color)** were considered applicable because of the difficulty people with macular scars have in detecting colors and details from images. The use of high contrast diminishes the need for differentiating colors too, which aids in the visualization of the items on the screen. For the same reason, **G19 (adjust screen configuration)** and **G20 (cursor customization)** were also considered applicable as they state the player must be able to adjust graphical configurations as deem fit.

Regarding text in games, the guidelines **G03 (easy-to-read font)**, **G04 (large enough text)**, **G05 (font customization)**, **G14 (speech synthesis or screen readers)**, and **G15 (communication among players)** were all considered applicable, as players with macular scars tend to get visually fatigued with reading more easily. Similarly, we also regarded **G07 (redundancy in information transmission)** applicable, as it consists of transmitting game information redundantly in textual, graphical and symbolical ways. The reasoning of the guideline is that in doing such, reading text becomes optional or, at least, less frequent. On the other hand, as the guideline **G12 (subtitles and closed captions)** consists of providing textual alternatives to all of the audio, it was considered not applicable to the public concerned.

We considered **G06 (interface rearrangement)** applicable as it states that the game must allow players to have freedom in positioning items on the screen. As such, players with sequelae from macular chorioretinitis can redistribute the interface elements to the screen edges to prioritize those more relevant to the game. That way, they avoid losing valuable information that would be visualized on the central region of the screen otherwise. Besides, this guideline also states that players should be able to change colors and sizes of the interface elements, making it doubly suitable because of the fact the public concerned having trouble detecting colors and details on images.

Due to the difficulty in identifying details, we considered the guideline **G08 (speed adjustment)** applicable, as the player might have trouble to read textual information or identify items on the interface quickly enough.

We deemed **G09 (separate volume controls)** applicable too because some types of sounds might be more relevant to the player than others and it might be helpful to prioritize those. According to the statement of this guideline, game elements which play-

ers have more trouble identifying visually could be better distinguished through audio. The desired scenario should allow players to increase the volume of sound effects and lower the background music, for instance.

The guideline **G10 (large and well-spaced elements)** was regarded applicable because of the fact people with sequelae from macular chorioretinitis might have trouble identifying game items that are too small or too close to each other. As those players might not detect specific visual details too well, there is more probability of mistaken clicks or interactions.

The guideline **G11 (elements and events distinctiveness)** was also considered applicable, as making game characters, items and events more easily distinguishable aids players in their correct and efficient identification. For instance, quickly identifying the threat a player is subject to because of an enemy might be crucial to succeeding in a game [6, 23]. If the game provides enough distinctiveness for the enemies, the player can analyze his threat level faster. A famous example of how important this guideline can be is that the developers of Team Fortress 2 designed its nine characters so distinctively from each other to the point players could identify them just by their silhouettes [20]. As the game is very action-packed and players have to make split second decisions while playing, the development team intended to allow the distinction of other players' characters as soon as their initial glimpse in a scene [20], even in less illuminated areas in the game world.

For the same reasons, we regarded **G13 (good audio techniques)** applicable because audio is essential in making the game elements distinctive. Additionally, binaural sound recording, together with spatial sounds, allow players to approximate the position of sound sources in the game world [6], which can be used to augment the visual stimuli in case of players with trouble to identify game elements visually.

Regarding movement in the games, we considered the guidelines **G23 (match camera and character movement)** and **G24 (disabling background movement)** applicable because of the difficulty in identifying details on images. The camera and background movement in games cause a lot of visual stimuli, which is usually conveyed in short time intervals, and that might hinder the ability for players to identify more relevant game elements. The guideline **G22 (configurable field of view)** was also deemed applicable in the case of games with 3D cameras. A scene projected with a field of view higher than desired might depict a view with a vast region of the world, cramming too many details in a single image, whereas one that is too low can also cause nausea in some players [11]. Thus, the guideline claim proceeds: the field of view in 3D games should be configurable.

Guidelines **G16 (movement through numeric keyboard)**, **G17 (identify near objects through audio)**, **G18 (digital controls for key actions)**, **G21 (enemy positioning through audio)**, and **G25 (easy navigation through compass)** are too specific and we evaluated their impact for players with sequelae from macular chorioretinitis to have just a marginal gain or even none. For that reason, we regarded them as not applicable.

Table 2 consolidates the results of the applicability of the guidelines we identified. For each one, it shows its classification and the criteria used to determine if it applied to improve the gaming experience of players with sequelae from macular chorioretinitis or not.

The results indicate that from the 25 guidelines that had been identified, 19 can be considered applicable to games to improve the gaming experience for the public concerned. Criterium I (difficulty in detecting colors and details) was the most frequently used to evaluate a guideline as positively impacting, whereas criterium IV was the most used when classifying a guideline as just marginally helpful, or not applicable.

Guidel.	Description	Applicable	Criteria
G01	High contrast	Yes	I
G02	Conveyance of information through color	Yes	I
G03	Easy-to-read font	Yes	II
G04	Large enough text	Yes	II
G05	Font customization	Yes	II
G06	Interface rearrangement	Yes	I, III
G07	Redundancy in information transmission	Yes	II
G08	Speed adjustment	Yes	I
G09	Separate volume controls	Yes	I
G10	Large and well-spaced elements	Yes	I
G11	Elements and events distinctiveness	Yes	I
G12	Subtitles and closed captions	No	II
G13	Good audio techniques	Yes	I
G14	Speech synthesis or screen readers	Yes	II
G15	Communication among players	Yes	II
G16	Movement through numeric keyboard	No	IV
G17	Identify near objects through audio	No	IV
G18	Digital controls for key actions	No	IV
G19	Adjust screen configuration	Yes	I
G20	Cursor customization	Yes	I
G21	Enemy positioning through audio	No	IV
G22	Configurable field of view	Yes	I
G23	Match camera and character movement	Yes	I
G24	Disabling background movement	Yes	I
G25	Easy navigation through compass	No	IV

Table 2: Classification of the identified guidelines regarding their applicability to people with central vision loss

4.3 Discussion regarding viability

After analyzing the identified game accessibility guidelines, we found that 19 of 25 might benefit the gaming experience of people with sequelae from macular chorioretinitis. Next, we scrutinized each of the suitable ones with regards to the viability of its implementation in games. The arguments used to sustain our views stem from the experience of the authors as programmers and on the classifications of some of the guidelines available on [11] and [2]. Both works classify the guidelines according to the number of players that might benefit from them, the positive impact they might cause and the effort to implement them. In determining those factors, those sources had as inputs interviews with gamers and professional game developers.

Guidelines **G01 (high contrast)**, **G02 (conveyance of information through color)**, **G03 (easy-to-read font)** and **G04 (large enough text)** were considered basic, as many people might benefit from them and, even if not made during the initial phases of development the implementation is still simple.

G05 (font customization) states that even if an easy-to-read font is used, players should still be able to change the text size and style,

as too heavily styled text can hinder reading and the size of the font may be inadequate for some impairments or types of screen. By allowing players to adjust the fonts freely, it might be necessary to rearrange the whole interface to fit the content when the font sizes get bigger than some threshold. For that reason, this guideline was considered advanced. Besides, for games that are localized to multiple regions, tests need to be thoroughly performed for each language.

We classified **G06 (interface rearrangement)** as intermediate, as it has a somewhat difficult implementation, yet a high positive impact for people that cannot see some parts of the screen, such as those with macular degeneration or macular chorioretinitis.

The guideline **G07 (redundancy in information transmission)** was considered basic, as during the initial phases of development there is a low cost of implementation and a positive impact for people with trouble in identifying one of the forms the information is being conveyed.

G08 (speed adjustment) was considered advanced for elements that involve the game mechanics, as the control of time might have a critical impact on gameplay. Moreover, in action multiplayer games, it could generate discrepancies in the competitiveness when a player with a certain speed plays against another with a different setting. Adjusting text and speech, on the other hand, has a lower cost, especially if planned since the beginning of development.

The guideline **G09 (separate volume controls)** has a positive impact on the gaming experience and has a low cost if implemented early. However, if a customization is made *a posteriori*, the cost of implementation is high. For that reason, this guideline was considered intermediate.

We deemed the guideline **G10 (large and well-spaced elements)** to be basic due to the high number of people that might benefit from it and the significant improvement in the gaming experience. The absence of what this guideline proposes in a game might preclude the game from being played on some devices, as well as prevent players with low vision from having a satisfactory experience because of their difficulty in identifying elements on the screen.

G11 (elements and events distinctiveness) implies a high cost involved with the creation of graphical and auditory assets, especially on games with a greater number of elements, such as characters, enemies, items, weapons, events, spells. However, the impact for players is very positive. As a matter of fact, in 2011, Terry Garrett, who became blind as a child, was able to finish the game Abe's Odyssey solely through the auditory stimuli [14]. That was possible due to the very distinct sounds for players actions (and, of course, his great will power). Considering the higher implementation cost and the positive impact, we classified this guideline as intermediate.

G13 (good audio techniques) was classified as advanced because of its higher implementation cost. However, in 3D games, the suggested techniques are typically already expected from most players due to the realism and immersion they provide.

The guideline **G14 (speech synthesis or screen readers)** was considered very advanced because there are no general purpose screen readers that can read the games' source code. In that case, the game developers themselves would need to implement or reuse some speech synthesis tool.

G15 (communication among players) consists of providing multiple communication channels for players and was considered advanced, as it might require a dedicated set of hardware and software resources to allow voice communication, for example. Besides the complexity, the infrastructure to enable the transmission of voice data over the network also has a regular financial cost to maintain.

G19 (adjust screen configuration) also has a higher implementation cost, but as it has a highly positive impact on the game experience for the public concerned, it was considered an intermediate guideline. Besides, this guideline also allows people without any visual impairment to tweak the graphics to have a higher contrast or brightness, which contribute to the visualization and identification of the elements on the screen.

The guideline **G20 (cursor customization)** was considered an intermediate one, as the implementation of setting the cursor appearence is rather simple, but it also involves a new screen for players to configure it with its size, color and their own images and the impact on the game experience is not so expressive.

G22 (configurable field of view) was deemed a basic guideline as it is simple to set the field of view in 3D games with some configured value. The interface to allow players to adjust it does not require complex controls. However, the field of view value might impact the gameplay, as players with a higher value can see a larger area of the world than players with lower ones and they can be in advantage because of that. So, for multiplayer games, developers need to evaluate the impact on the the competitiveness.

Lastly, we classified the guidelines **G23 (match camera and character movement)** and **G24 (disabling background movement)** as intermediate due to their reasonably complex implementation and their moderately positive impact on the gaming experience caused by the removal of unnecessary graphical effects.

Table 3 summarizes the classification of the applicable guidelines for people with sequelae from macular chorioretinitis regarding how viable is their implementation.

Guidel.	Description	Viability
G01	High contrast	Basic
G02	Conveyance of information through color	Basic
G03	Easy-to-read font	Basic
G04	Large enough text	Basic
G05	Font customization	Advanced
G06	Interface rearrangement	Intermediate
G07	Redundancy in information transmission	Basic
G08	Speed adjustment	Advanced
G09	Separate volume controls	Intermediate
G10	Large and well-spaced elements	Basic
G11	Elements and events distinctiveness	Intermediate
G13	Good audio techniques	Advanced
G14	Speech synthesis or screen readers	Advanced
G15	Communication among players	Advanced
G19	Adjust screen configuration	Intermediate
G20	Cursor customization	Intermediate
G22	Configurable field of view	Basic
G23	Match camera and characters movement	Intermediate
G24	Disabling background movement	Intermediate

Table 3: Classification of the applicable guidelines for people with central vision loss regarding the feasibility of their implementation

5 Conclusions and Future Work

This research aimed at surveying which game accessibility guidelines for low vision would apply for a more specific visual impairment that causes the central vision loss. That condition can be a permanent sequela from the inflammation called macular chorioretinitis, which can be caused by untreated toxoplasmosis.

We surveyed the guidelines through a systematic literature review which revealed some academic publications that were analyzed jointly with other non-academic works that were sources of game accessibility guidelines.

After consolidating the guidelines identified for people with low vision, we studied their applicability to the case of players with sequelae from macular chorioretinitis. To evaluate them, we used as criteria what the literature exposed about the impairment, input from a group of professionals involved with ophthalmology, psychopedagogy and occupational therapy and the reports from the parent of a child with sequelae from macular chorioretinitis about the effects the condition causes on his daily activities. We identified 25 guidelines for players with low vision and 19 of them apply to the public concerned.

Next, we analyzed the viability of each of the applicable guidelines based on their impact on the gaming experience, their reach, and their implementation cost. We classified them as basic (7 guidelines), intermediate (7) and advanced (5).

Considering the results from this work and that we found no related work on game accessibility for people with this specific kind of low vision, we expect this research to be an initial step towards the study of how gaming experience can improve for people with sequelae from macular chorioretinitis.

As macular chorioretinitis is the leading cause of low vision in children, it is necessary to include the sequelae from this inflammation in the game accessibility field. This work did not involve the evaluation of the guidelines from the perspective of players with macular scars due to chorioretinitis. Naturally, future work includes (a) evaluating the impact of the guidelines on the gaming experience through user tests and (b) assessing if their gaming experience can be improved in ways that are absent from the 19 identified guidelines.

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