

# SOUNDS GOOD: AN INCLUSIVE GAME FOR VISUALLY IMPAIRED CHILDREN

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## ABSTRACT

Much work has gone into research on accessibility for people with disabilities and there is a clear demand for increased accessibility in commercial games. Modern video game developers have been making some efforts to increase accessibility for visually impaired people. While accessibility can be increased in commercial games so the VI can play with their fully sighted peers this becomes a bigger problem for fully blind people. In this research, we aim to add knowledge to the toolbox for improving the accessibility and enjoyment of blind video game players. To find out more about conveyed information and entertainment factors, we made and evaluated the rhythm-based fighting game, Sounds Good. The game can be played with or without rendering making it a good tool to study gameplay without vision. Using this game we conducted a study with n=32 participants to further our understanding of the experience of visually impaired players and how information conveyed as sound could be consistent with visual information. The participants were split into two groups, one playing with sound only and the other one only with visuals. Both quantitative and qualitative measures are used to analyze the results to compare the experience of the two groups and identify the successful and problematic elements of the auditory substitution.

## 1. TOPIC AND MOTIVATION

The aim of this research is to make games more enjoyable for visually impaired children and consequently improve their relationships with their families and friends. Visually impaired children can mainly experience the game through sound. We wanted to create a game that could be enjoyed by both visually impaired and sighted children. We wanted to find out how to adapt the sound so visually impaired children could access the same information as sighted children. At the same time, we wanted the game to be a bridge between visually impaired children and their peers and families. We aim to improve their experience as well as the experience of their sighted peers. Hopefully, this way the visually impaired people will feel that they are not alone.

Although it is intuitive to improve a game by analyzing the performance of the players, we hypothesized that analyzing the performance of players in a game for VI

players would not yield valuable results because different players perform differently.

In conclusion, our games and experimental designs are largely concerned with how to make the messages conveyed by sound more informative and how to make players more satisfied. By learning this, we can know which sound effects or designs stand out. And with such sound design, we hope that the results of this study will empower game companies in the community to design better games for children with visual impairment. Wishing every VI player could feel the love from every single beat of this game.

## 2. RESEARCH PROBLEM AND RELATED LITERATURE

Video games have revolutionized the entertainment industry. In their early days, they quickly became a social phenomenon that has now blossomed into an enormous industry. It is estimated that a quarter of the population plays digital games in some form worldwide [1] [2]. Originally, video games were meant solely for entertainment. Over time, digital games began to seep into areas outside entertainment and are now commonly used for serious purposes like education, advertisement, health, and other behavioral intervention [3] [4]. The prevalence of video games in society emphasizes the necessity of considering users with different needs in their design [1]. There is a wide variety of disabilities that hinder or prevent a large group of people from using this increasingly important technology.

Multiple users with disability play mainstream video games, even competitively, and a 2018 demographic survey showed a majority of players with a disability want to play commercial games. Another survey showed a common desire among visually impaired (VI) gamers to play games made for sighted people with sighted people [1] [5]. Accessibility for users with different needs is even more paramount when it comes to the serious use of games, to the point where it can be a legal obligation for educational games [2]. Accessibility in video games is described as the ease of using the game despite limiting conditions or disabilities. As digital games have generally been thought of as visual systems visual impairment can be a major obstacle [6].

Visual impairment is reduced vision that negatively affects everyday tasks and cannot be corrected with glasses or other measures [2]. The severity and type of visual impairment dictate what measures are required for increased accessibility in a video game. Color blindness has many variations that make it difficult to distinguish colors from different color schemes. Measures as simple as changing the color schemes accordingly or relying on symbols instead of colors can be enough to greatly improve accessibility [2]. For users with low vision, for example, tunnel vision or blurred vision accessibility could be increased with magnification on the screen, bigger icons and font sizes, and other similar modifications. The accessibility measures needed for color-blind and low-vision users can, and have been implemented in commercial games played by normally-sighted people [2]. This enables VI to play with and against normally sighted people on relatively equal ground.

Blindness, or the complete lack of vision, is the most severe of the visual impairments. While accessibility can be increased in commercial games so the VI can play with their fully sighted peers this becomes a bigger problem for fully blind people. Accessibility for blind people can be challenging to add to games developed focusing on visual elements. The games accessible for blind people are therefore often developed primarily with that in mind [6]. Although blind players cannot see what is going on in the game research suggests that other senses might be heightened [7]. There is good evidence for heightened tactile senses in blind people, especially those who have been blind for a long time. Blind people consistently outperform their non-blind counterparts on tasks studying the tactile acuity of the fingers [8]. It is still debated whether this acuity enhancement is directly affected by the lack of vision or indirectly by the increased practice and blind reading, but avid blind readers outperform their non-reading peers in this tasks [9] [8]. Enhanced auditory perception in blind subjects has similarly been thoroughly studied. Like tactile perception, it is still a subject of debate whether the improvements are merely the result of practice [7]. There is strong evidence for superior auditory perception in the early blind, which is especially true for spatial auditory processing and the ability to use subtle spatial cues for localization [10]. A reason for this enhanced ability in people that have been blind from very early in their lives is the neuroplasticity of brain areas that are input-deprived and research suggests that the occipital areas of the brain can be “recruited” or “rewired” for other sensory purposes [10] [11] [7]. These heightened sensory abilities of blind people open up an exciting venue for research on games for blind people and that the duration of their blindness can have an impact on performance.

Modern video game developers have been making some effort to increase accessibility for the VI and some of the most modern and popular games have an impressive amount of VI accessibility [12]. A good example here is

The Last of Us Part II, a game released in 2020 by the game development company Naughty Dog. The game has more than 60 accessibility settings for VI or blind people and uses both fine motor and hearing options. To name a few, the game has text-to-speech, navigation and traversal assistance, auto-aim and skip puzzle options to make the game playable for blind people [13]. Although Naughty Dog has made a great effort in blind accessibility this is not universal for AAA games and is commonly seen in less popular more specialized games, often for research purposes. Blind Hero was a research project and a game where the researchers developed a device that translated visual stimuli into haptic stimuli, allowing blind players to play a game similar to Guitar Hero. The game and method were rated fun and enjoyable by participants [2].

Audio games have sound as the main element of experience [6]. An example of an audio game is the horror game *Blindsight*, a game that takes place in a 3D audio world players traverse based on audio queues. A study on *Blindsight* showed that blind people usually finish the game faster than players with normal vision [14] [6]. Visual audio games emphasize both visual and auditory elements allowing sighted and blind people to play together through different senses. [6] *Terraformers* is a visual audio game that takes place in a 3d world that players traverse. The VI get instructions from a sound compass that leads them through the world and a specific sound that accompanies every object in the game [14]. *Terraformers* have a graphic 3D world and try to match the experience of visual players to that of VI players. Much research is needed to improve the balance between auditory and visual input so they can be equally enjoyable and useful. With the current research, we hope to add to and improve the knowledge needed to match the effects of auditory and visual stimuli on game enjoyment and accessibility. In the paper, we introduce and evaluate a rhythm-based fighting game, *Sounds Good*. The game can be played with or without rendering making it a good tool to study gameplay without vision, but can also be enjoyed with visuals. The game is simple and short and does not have too many elements or variability making it a good tool for research comparing the effects of sound and visuals. Using this game we will conduct a study to further our understanding of the subject by answering the following research questions:

- RQ 1 (Accessibility): Regarding games for VI children, how can the information conveyed by sound be made as consistent as possible with vision?
- RQ 2 (Entertainment): Which element(s) of the game make VI content? Which could frustrate them?

### 3. METHOD

#### 3.1 Sounds Good

To answer our research questions, we develop a 2D fighting game, *Sounds Good*. The game is designed to pro-

vide visually impaired children with an opportunity to play with their sighted family members and friends. It is a 2D rhythm-based fighting game where players stand on either the left or right side and engage in combat using musical instruments. The objective of players is to reduce the opponent's health points (HP) to zero. The game features three types of attack buttons, each representing a different instrument (flute, piano, and guitar), and the player can attack by pressing the corresponding button. Attacking on the beat of the background music will increase attack damage. Players can also defend themselves by pressing the correct parry button, which corresponds to the type of attack being used by the opponent. For example, a piano attack can only be defended with the piano parry button. A successful parry will decrease the attacker's HP.

To improve the game experience, we developed several graphical features to provide information related to battle. For example, a health bar shows how many health points a player still has. For visual impaired people, we developed sound effect features to convey the same information as we convey with the visual interface.

To accommodate the experiment, we developed two game mode options: vision-only mode and audio-only mode. The goal is to examine whether the information is properly conveyed from a single perspective. The visual-only mode only provides graphical indicators without any sound effects, while the audio-only mode is a blank screen with audio indicating player status and the events happening during the battle. To reduce the bias caused by a fight between two players with different skill levels, we developed an AI to combat the player.



**Figure 1.** The main menu of Sounds Good

### 3.2 Game interface and interactions

In Sounds Good, every event occurring during the fight is shown both in visual and in audio. Events consist of global events and individual events. To better convey the information of individual events in audio, we applied the features of directional sound. For information such as attack, parry and health status, the game plays the directional sound based on which side is the performer standing.

Before a battle starts, there will be a screen counting down numbers every second followed by a text with 'GO!'. Both events have corresponding audio.



**Figure 2.** A screenshot of a battle



**Figure 3.** An options panel for adjusting game mode

During the game there is no music. To not let players be distracted but still have a sense of rhythm a metronome was added. The metronome is ticking but is also shown at the bottom of the screen. This bar is shown in figure 5.

Both players can attack and parry. To show which attack is done, each attack has a different animation involving the instrument of attack. Each attack also has its own wind-up time. During the attack animation a sound is played for the duration of the wind-up time. The sound consists of 3 notes played of the instrument of the attack, and the pitch of each note increases to increase the wind-up effect. During the wind-up the color of the character also changes to red by 'filling' the character from the bottom-up (see figure 6).

When a player parries an attack successfully, and only then, a parry animation is played along with a parry sound. When a player fails the parry, the character gets damage and a hitting sound is played. To make a distinction between which player is attacking or parrying the sound of the attacks and parries is directional. If the character on the left attacks, players hear the sound to the left.

To inform the player how much health each character has left a health bar is displayed above each character. 'Health left' is the only information in which VI players have a disadvantage. To inform VI players of the HP of characters a sound is played at the moment players have 50% or 25% health left. VI players have no constant feedback of the current health of characters.

When one of the characters has no health anymore, the end screen is shown and a final celebratory sound is played. This informs players of the end of the battle. Players can then see how many of their parries were successful and

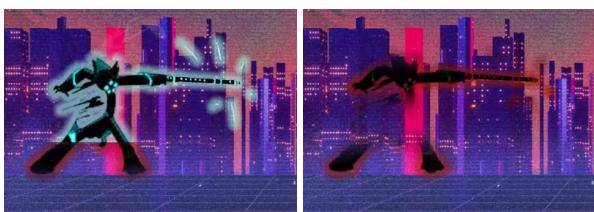
how many of their attacks where on the beat.



**Figure 4.** Count in



**Figure 5.** Visualized metronome



**Figure 6.** Windup animation

### 3.3 Preliminary evaluation and pilot study

A pilot study was conducted to get feedback on the game prototype and the questionnaire from seven participants. The information gathered from the evaluation was useful for refining the game and pointed out some problems with the research setup and questionnaire. The participants were overall fairly pleased with the game but pointed out some issues. For blind mode a “Better way to know how much HP you and the opponent have” was pointed out as well as the lack of a tutorial for it. Some people had problems with the “parry” feature which was that it was difficult to use: “There were a lot of sounds going on while also trying to attack or parry so this was confusing. Only used attack and not parry since I did not really understand when I should use that and did not seem very useful to me personally”. And that it was difficult to “learn to parry for a beginner and switching from the spacebar to the “G” button is just a bit to slow when also thinking about which instrument to guard with”. The participants praised the visuals and the audio as well as the concept of hitting the beat and using different instruments but pointed out that it was at times too cluttered and fast “A lot of sounds at the same time during attacking”. Finally an indicator for the health on blind mode was missing “Some type of sound to make clear how much health you have left”.

### 3.4 User research

To answer the research questions RQ1 and RQ2, we designed and conducted an experiment. Next, we will introduce it in detail.



**Figure 7.** Health bar

#### 3.4.1 Experimental setup

A between-group study was conducted, with two groups with different conditions. As the research questions imply the study is mostly qualitative in nature but quantitative elements were included in the questionnaire. The participants for the study were selected in a non-probabilistic way using convenience sampling. The participants were in the age range of 20-40 years old and none of them were legally blind. At the end of the study, we had  $n = 32$  participants evenly split into two groups of 16 with one result dismissed as it had filled out the survey in the most negative way possible making it a substantial outlier.

Each participant was asked to take part in the study and handed a randomly assigned information sheet assigning them to the vision-only or the audio-only group (Appendix A). Participants were assigned groups making sure the two groups would be similar in size. The information sheet explained the purpose of the research and explained the procedure. Participants were asked to download and install the game and follow the steps on the sheet. After installation, they were led through a tutorial explaining the mechanics of the game and then instructed to select a visual or audio-only mode per their group assignment. The tutorial included both visual and audio information allowing all participants to experience both before the experiment. The visual-only mode showed everything the tutorial had shown but muted the sound and the audio-only mode had no rendering of the graphics leaving the screen completely black while the audio was on. The participants were asked to play through their assigned game twice. A single play-through ends after the health of either the player or the opponent is reduced to zero. They were then asked to fill out a questionnaire concerning their game experience after playing. They were finally thanked for their participation and offered to own and play the game as much as they want.



**Figure 8.** A screenshot of tutorial

### 3.4.2 Informed consent

All participants would sign an informed consent form (Appendix B).

### 3.4.3 Privacy

All participants' data will be treated anonymously regarding privacy (Appendix B).

### 3.4.4 Questionnaire Setup

**Keywords of the questionnaire:** Four sections; Representation of the information; User satisfaction; User suggestions.

Players are supposed to answer a set of questions about the game design and quality, including quantitative and open-ended qualitative ones after playing the game. A quantitative question could be, how well you were aware of your health during the game. The answer to these kinds of questions should be a number, ranging from 1 to 5 or 1 to 10. Meanwhile, an example of a qualitative question is, please list the information in the game that you think is clear (Appendix C).

### 3.4.5 Result analysis

There are two groups to be quantitatively compared and we use an independent t-test to determine statistical significance. The qualitative results will be analyzed using a Straussian grounded-theory method to categorize the answers and derive theories from the data.

## 4. RESULTS

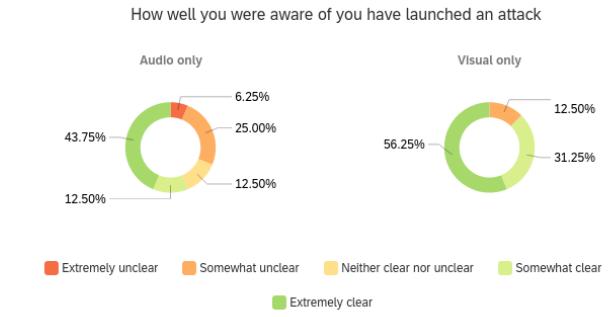
Our results were obtained from both qualitative and quantitative questions. As for the quantitative questions, besides 2 of them (Q4.1 and Q4.2) being scaled from 1-10, the others are scaled from 1-5. On the other hand, there are 4 True and False questions and 6 blank filling questions as the qualitative ones. Next, we are going to analyse the result.

### 4.1 Analyzing quantitative data

In this section, pie charts are shown comparing the 2 groups on three different aspects.

#### 4.1.1 Player's info

The results of questions 1.1 - 1.2 (Figure. 9) suggest that almost the same information was conveyed through audio and visual clues. Although the attack response is a bit vague, as observing half of the participants of the audio-only group voted 'somewhat unclear' in question 1.3. In summary, regarding players themselves, the information of 'player attack' and 'attack types' were consistently conveyed with the pictures, while the representation of the response of players' attacks is expected to be improved.



How well you were aware of you have launched an attack

How well you were aware of your own attack types

How well you were aware of your opponent has been hit

Extremely unclear      Somewhat unclear      Neither clear nor unclear      Somewhat clear  
Extremely clear

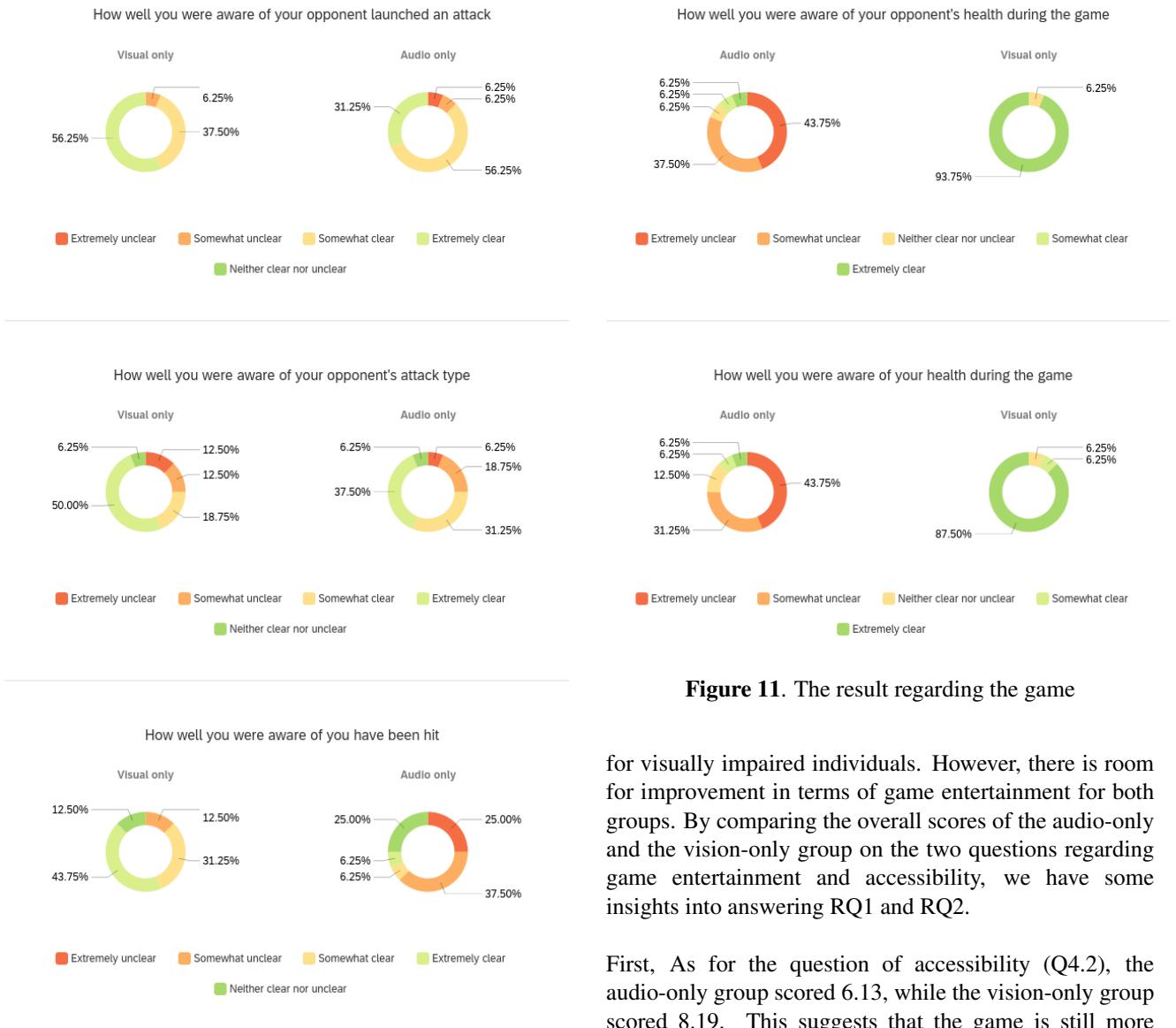
Figure 9. The result regarding player

#### 4.1.2 Opponent's info

The results of questions 2.1 - 2.2 (Figure. 10) illustrate that fairly coincident information was conveyed through sounds and pictures. However, the attack response is still concerning (question 2.3), as more than half of the participants voted 'Somewhat unclear' and 'Extremely unclear'. To wrap up, this situation corresponds to the previous section, VI people are able to receive the same information about their opponents' attacks as sighted ones, but they are still not very clear that whether the attack is effective or not.

#### 4.1.3 Game info

The audio-only participants (Figure. 11) rated their health awareness with a minimum score of 1.00 and a maximum score of 5.00, with an average score of 1.94. The standard deviation was 1.14, which indicates that the scores were widely spread out. The variance was 1.31, which in-



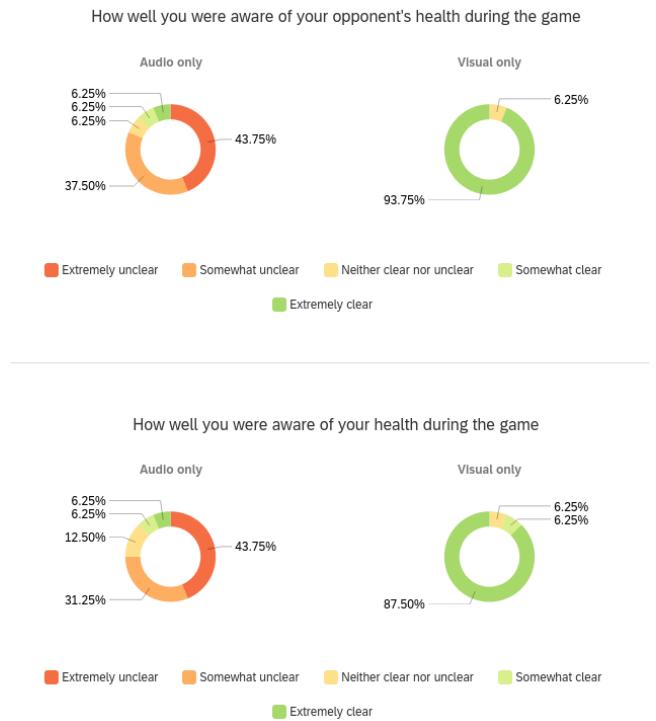
**Figure 10.** The result regarding opponent

dicates the amount of variation or dispersion of the data. On the other hand, the vision-only group rated their health awareness with a minimum score of 3.00 and a maximum score of 5.00, with an average score of 4.88. The standard deviation was 0.48, which indicates that the scores were relatively tightly grouped together. The variance was 0.23, which indicates the amount of variation or dispersion of the data.

In general, the results suggest that the vision-only group were more aware of their health during the game than another group. This is indicated by the higher average scores and lower standard deviation and variance in Group 2, showing that we should find a more appropriate way to deliver the messages about the health bar to VI people.

#### 4.1.4 Evaluation of game entertainment & accessibility

In summary, the game received above-average feedback from players and it did provide an entertaining experience



**Figure 11.** The result regarding the game

for visually impaired individuals. However, there is room for improvement in terms of game entertainment for both groups. By comparing the overall scores of the audio-only and the vision-only group on the two questions regarding game entertainment and accessibility, we have some insights into answering RQ1 and RQ2.

First, As for the question of accessibility (Q4.2), the audio-only group scored 6.13, while the vision-only group scored 8.19. This suggests that the game is still more accessible for the vision-only group. The lower score for accessibility among visually impaired participants indicates that the game has certain features or designs that still make it difficult.

However, the scores for the entertainment question (Q4.1) among the audio-only group (6.81) and vision-only group (6.25) are relatively close, indicating that the game is still enjoyable for VI individuals.

#### 4.1.5 Independent t-test

Here we use each participant's final score(sum scores of the information-related questions) in 2 groups (audio only & vision only) to do the separate variance t-test (welch two sample t-test) where H0: 2 groups have the same performance in information-related questions.

##### 4.1.5.1 Confidence interval

The mean of Group Audio Only minus Group Visual Only equals -15.3100. We have 95% confidence interval of this difference: from -22.2237 to -8.3963.

Group	Mean	SD	SEM	N
Audio only	47.38	12.08	3.02	16
Visual only	62.69	5.56	1.39	16

**Table 1.** Processing Data for T-test

#### 4.1.5.2 Intermediate values used in calculations

The intermediate value  $t$  equals 4.6052,  $d_f$  equals 21, and the standard error of difference equals 3.325.

#### 4.1.5.3 P value and statistical significance

The two-tailed  $P$  value equals 0.0002; By conventional criteria, this difference is considered to be extremely statistically significant.

## 4.2 Quantitative Results

According to the t-test results, there is a significant difference between Group Audio Only and Group Visual Only, which could answer RQ1. Besides that, Group Visual Only performs much better at the Game info sessions, and both players and their opponents attacking info. Then, we found the main factor of this distinction should be the sound design. Specifically, VI players had a hard time distinguishing the sound of successful parries from the sound of getting hit. Regarding RQ2, the results from the 2 groups were virtually the same, which demonstrates that the game's entertainment value was essentially equal in both groups. As a 1vs1 fighting game, if this can be achieved, it means that both players, regardless of visual impairment, can equally enjoy the fight with another player. This is really valuable for a competitive game, so we hope that game companies in the community can learn from this experiment about how to make games equally enjoyable without compromising the gaming experience for people with and without visual impairments.

## 4.3 Analyzing qualitative data

To analyze the data from the six open-ended questions from the questionnaire, we adapt the Straussian grounded method for coding. This will allow us to categorize the information and help make theories based on the data. The questions have people freely write about what they felt was clear or lacking in the information flow of the game and what they liked or didn't like. The answers to these questions will help form theories related to our research questions and help identify the flaws in how information is conveyed. To answer the research questions the main focus of this analysis will be on the audio-only group with some comparison with the vision-only group. The grounded theory includes three steps that will be briefly discussed here.

### • Open coding

We went through the whole set of answers and underlines the parts that would be helpful and informative for the research questions. This mainly concerned information flow, what was successful and what was not. We end up with a series of codes of similar responses.

### • Axial coding

The codes are grouped into categories. We grouped the codes into four clear and discrete categories that we could then break down further.

1. **Audio cues** is a category for sentences relating to the utility of the sound effects in the game. It includes sentences about the sounds that were too similar or confusing, but also the sounds that successfully conveyed what they were supposed to. Audio cues have two subcategories, helpful and confusing.
2. **Health indicator** is another category that consists of multiple comments made about how health information was conveyed to the audio-only group. Comments about the health indicator were frequent in the answers and were mainly concerned with it not being informative.
3. **Tutorial** was frequently mentioned and can be split into two subcategories, information and practice. Sentences about a lack of clarity of the interface go into this category as well as suggestions of longer practice time and the possibility of practising in a sound-only mode. The fourth category is
4. **Improvements** and it takes all the suggestions and ideas for improving the gameplay or information delivery the participants mentioned.

### • Selective coding

We go through the categories to find connections to develop a theoretical framework of how to improve the game and its accessibility. In the following section, we will briefly discuss the codes within each category and show some examples.

## 4.4 Qualitative results

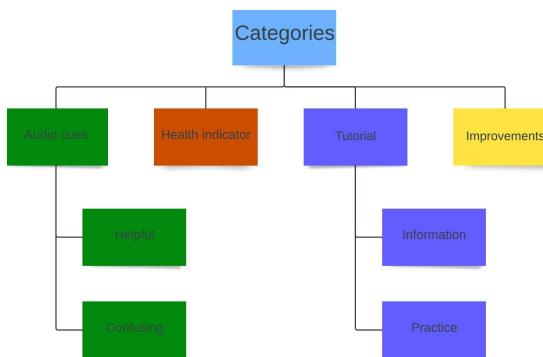
The audio cues in the game were frequently mentioned, some of them were praised for being helpful and intuitive while others were unclear and lacked information. The clear difference in sound from the instrument attacks gave the audio-only group a clear sense of what attacks were performed and having such a strong character for each instrument was considered helpful. This stood out to people and was the most common element people mentioned when asked what was clear about the game. On the other side, the vision-only group noted the lack of sound for the attacks and suggested adding colour to them to make the difference clear. Some of the sound cues, and their interactions, were confusing to people. There was a problem separating player attacks from the ones from the enemy underlining the importance of clearly different sounds for the two.

The sound that most confused people was the representation of the player's health. People had a hard time keeping track of their health in the sound-only group, "I

*don't like the half health sound effect. Multiple sound layers are overlapped so that it's hard to resolve them*". This suggests a better approach is needed to deliver the health information to blind players or at least make the sounds less "Ambiguous" or as another participant mentioned: "*Clearer sounds about my health and opponent's health*". It was noted that some of the complications were due to a lack of practice time. The tutorial should have been longer and "*The tutorial included too many auditory cues to remember in one go*". This is an understandable complaint since different players have different amounts of experience with video games. It was suggested that the tutorial should be audio-only to allow for practice with the sounds and while the sounds and information were clear more time was needed to memorize them. The sound information was too dense and "*The tutorial included too many auditory cues to remember in one go*".

#### 4.4.1 Theories formulated

- People appreciate a very strong difference in sounds for their actions in the game.
- Sounds from non-player characters or other opponents should be highly different from those of the player.
- Health indication by sound is problematic, especially in a sound cluttered action, and needs a very distinguishable sound to be informative.
- Different players have different experiences so the tutorial should offer more time to practice and memorize sounds.



**Figure 12.** A flowchart of the four categories and their respective subcategories.

## 5. DISCUSSION

The results show there is a significant difference in how well-informed players felt about the game state depending on whether they were lacking audio or vision. Although this in itself is not unexpected, we were able to identify some of the pain points in the game's design that most clearly added to the audio-only disadvantage. The

biggest complaint was the health indicator that most audio-only participants did not find helpful. The auditory substitution for the attack types was highly successful and both groups agreed that it was clear which attack was performed. As some participants mentioned, the tutorial was not sufficiently focused on the auditory stimuli and was, for some, too short to memorize the sounds related to actions. It is possible that a longer practice period is needed to play solely based on audio when compared to visual cues. It must also be taken into account that participants were much more likely to be used to playing games based on visual cues explaining the need for prolonged practice time. The attitude towards the game itself was highly positive and, in general, the participants enjoyed the gameplay and the graphic design.

### 5.1 Limitations

There were some limitations with the study procedure that will have to be addressed and that make room for improvements and future research on the subject. Mainly these limitations have to do with the generalizations of the results. As the study was conducted for a university project with limited time the participants in the study were mostly people in the age range of 20-40 years old with a large proportion of them being university students. It is unreasonable to assume the results can be generalized to children and the result would have to be conducted on a much younger age group. That was simply not feasible with a project of this size. The results can however be thought of as a trial run for the study and help refine the game and make some assumptions about its accessibility and entertainment value.

Another limitation that has to do with the generalizability is the fact that no blind participants took part in the study. The group of participants that served as the blind subjects tested the game without anything being rendered on the screen, they could, however, look at the keyboard and had already seen the rendered version of the game in the trial round. This has two main generalizability complications. First, the "blind" participants could envision the gameplay after having seen it and are therefore not a good measure of how a blind person would interact with the game for the first time, and what information they would have. Second, as mentioned in [8], [7] and [10] there is good evidence for blind people to have different and even superior sensory perception in other senses. This is especially true for early blind people and makes it problematic to generalize the results from normally sighted people, or even other blind people to the group as a whole. The purpose of the study was to identify and gather information on how to make the messages conveyed by sound more informative and enjoyable so the results gathered still have great value and can add to the knowledge on the topic.

Finally, there is a limitation in the procedure of the experiment which was conducted in the form of an online survey. The study was evaluated in a pilot study that took

place in a lab where researchers watched the subjects play the game and fill out the survey but to increase the number of participants an online variation was chosen for the main study. This method has two possible flaws. Firstly, there was no way of truly knowing if participants followed the procedure completely and truthfully. Secondly, a lack of control over the experiment. Different sizes in the screen and different headphones with different volume settings can all have an impact on the results. The research should be repeated in a more controlled setting to see if there is an impact on the results.

## 6. CONCLUSION

For this research, we made and evaluated the game Sounds Good, both as an enjoyable game and as a research tool. The game was used to gather insight into the mechanisms for visually impaired gaming and add to the knowledge of methods and tactics used to successfully convey information in audio form in a way that is consistent with visual information. We managed to improve the game and gather helpful information for further iterations to make the game better. We also identified successful methods of communicating information to visually impaired players. The field of research on accessibility for VI in video games is varied. There is an incredible amount of work to be done in developing games specifically for VI people and in fine-tuning and gathering data on the solutions already offered to make games more accessible. Different auditory representations to help identify the game characters are another area where research could help improve the accessibility of the game. Research comparing different auditory health indicator concepts and different methods of distinguishing characters would be a good start for improving the game and offer valuable information for the development or improvement of other games. Sounds Good was originally meant to be a player-versus-player game where people could compete against each other.

Implementation and evaluation of that feature would be an interesting addition. A study on a player's performance and enjoyment of competing against another player solely based on sound could be interesting and could even give some insight into possible advantages a VI could have in that scenario. Studying games where one person can see and the other one does not could improve our knowledge of which auditory aspects of the game should be tuned to tweaked to convey the information more clearly compared to their visible counterparts.

Future research should also include further iterations of the study described in this paper to increase its validity and reliability. With the correct license, it would add a great amount of value to conduct the study with child participants. This could give valuable information on their enjoyment of the game which might differ from the adult subjects in the current research. A study with visually impaired children with normal-sighted ones in the control group could point out some usability issues more specific

to children and is an interesting future improvement that would greatly increase the validity of the study. Future iterations of this research should be in a more controlled and supervised setting. Using the same computer, and headphones would increase the reliability of the results.

## 7. REFERENCES

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## A. INFORMATION SHEETS

### A.1 Information sheets - Blind group

#### Sounds Good: An Inclusive Game for Visually Impaired Children

We want to thank you for being willing to participate in our study. This study aims to evaluate the game Sounds Good and assess its accessibility for the visually impaired. We want to investigate the aspects of the game that should be improved to improve the performance and enjoyment of the visually impaired.

To obtain the game, please download via the following link:

PC:

<https://drive.google.com/file/d/1dmJtVTiIzQ229CbcT9H0KsfAZJrdB-wg/view?usp=sharelink>

Mac :

<https://drive.google.com/file/d/1hwdhoy4Uvv6ScDYhbVaUn4QJ7-A04uUz/view?usp=sharelink>

Note that sound is important to this study so we ask that you are wearing headphones and make sure everything is clearly audible. The study will take approximately 15 minutes and consist of playing the game, starting with the tutorial where you will learn the key bindings and mechanics of the game. After the tutorial, we ask you to go to the main menu and select options, under options we ask you to change the game mode to AUDIOONLY and select APPLY. Next select PLAY to start the game, this time the screen will be black and you will have to play by ear, other mechanics remain the same. We ask you to play through this game mode twice.

After the playthroughs, we ask you to follow the link below and complete a quick survey.

[https://qfreeaccountssjc1.az1.qualtrics.com/jfe/form/SV\\_6sssVcPiD01kdo2](https://qfreeaccountssjc1.az1.qualtrics.com/jfe/form/SV_6sssVcPiD01kdo2)

All your responses to our questions might be used for the project but they will be completely anonymous. Taking part in this study is completely voluntary and you are free to stop at any time and for any reason. If you have any questions you can ask them at any time and we will be happy to answer them. if any questions come up later you can email i.p.eiriksson@students.uu.nl

Now feel free to play the game as much as you want! :D

## A.2 Information sheets - Vision group

### Sounds Good: An Inclusive Game for Visually Impaired Children

We want to thank you for being willing to participate in our study. This study aims to evaluate the game Sounds Good and assess its accessibility for the visually impaired. We want to investigate the aspects of the game that should be improved to improve the performance and enjoyment of the visually impaired.

To obtain the game, please download via the following link:

PC:

<https://drive.google.com/file/d/1dmJtVTiIzQ229CbcT9H0KsfAZJrdB-wg/view?usp=sharelink>

Mac :

<https://drive.google.com/file/d/1hwdhoy4Uvv6ScDYhbVaUn4QJ7-A04uUz/view?usp=sharelink>

The study will take approximately 15 minutes and consist of playing the game, starting with the tutorial where you will learn the key bindings and mechanics of the game. After the tutorial, we ask you to go to the main menu and select options, under options we ask you to change the game mode to VISIONONLY and select APPLY. Next select PLAY to start the game, this time there will be no sound on the game, but other mechanics remain the same. We ask you to play through this game mode twice.

After the playthroughs, we ask you to follow the link below and complete a quick survey.

[https://qfreeaccountssjc1.az1.qualtrics.com/jfe/form/SV\\_6sssVcPiD01kdo2](https://qfreeaccountssjc1.az1.qualtrics.com/jfe/form/SV_6sssVcPiD01kdo2)

All your responses to our questions might be used for the project but they will be completely anonymous. Taking part in this study is completely voluntary and you are free to stop at any time and for any reason. If you have any questions you can ask them at any time and we will be happy to answer them. if any questions come up later you can email i.p.eiriksson@students.uu.nl

Now feel free to play the game as much as you want! :D

## B. CONSENT FORM

### Sounds Good: An Inclusive Game for Visually Impaired Children

Consent form for participation in the Study.

Please complete the form below by ticking the relevant boxes and signing on the line below. A copy of the completed form will be given to you for your own record.

- I confirm that the research project “Sounds Good: an inclusive game for visually impaired children” has been explained to me. I have had the opportunity to ask questions about the project and have had these answered satisfactorily.
- I consent to the material I contribute being used to generate insights for the research project “Sounds Good: an inclusive game for visually impaired children”.
- I understand that my participation in this research is voluntary, that it is not a requirement of my course, and that I may withdraw from the study at any time.
- I consent to allow the fully anonymised data to be used for future publications and other scholarly means of disseminating the findings from the research project.
- I confirm that I am 18 years of age or over.
- I understand that the information/data acquired will be securely stored by researchers, but that appropriately anonymized data may in the future be made available to others for research purposes only.
- I understand that I can request any of the data collected from/by me to be deleted.
- I agree to take part in the above study on “Sounds Good: an inclusive game for visually impaired children”.

## **C. QUESTIONNAIRE**

Which playing mode do you experience? Audio only/Visual only

### **Section 1. Knowing your character**

Q1.1 How well you were aware of you have launched an attack (1 to 5)

Q1.2 How well you were aware of your attack types (1 5)

Q1.3 How well you were aware of your opponent has been hit (1 5)

### **Section 2. Knowing your opponent**

Q2.1 How well you were aware of your opponent launched an attack (1 5)

Q2.2 How well you were aware of your opponent's attack type (1 5)

Q2.3 How well you were aware of you have been hit (1 5)

### **Section 3. Knowing the game process**

Q3.1 How well you were aware of your opponent's health during the game(1 5)

Q3.2 How well you were aware of your health during the game(1 5)

Tips: The following are true or false questions

Q3.3 Can you realize that the game has started (T/F)

Q3.4 Can you realize that the game is running (T/F)

Q3.5 Can you realize that the game is over (T/F)

Q3.6 Can you realize that you win or lose (T/F)

### **Section4. Your overall opinion**

Q4.1 How much do you like the game (1 to 10)

Q4.2 How much do you think that you get enough information to play during the game? (1 10)

Tips: \*Optional means the answer could be empty

Q4.2.1 (optional) If applicable, please list the information in the game that you think is clear

Q4.2.2 (optional) If applicable, please list the information in the game that you think is redundant

Q4.2.3 (optional) If applicable, please list the information you think is missing

Q4.3 (optional) If applicable, what is your favourite part(s) of the game?

Q4.4 (optional) If applicable, which part(s) were you not satisfied with?

Q4.4.1 (optional) If your answer was positive, which would be a more appropriate representation of those parts that you are not satisfied with?