Accessibility Design for People with Hearing Impairment in Virtual Reality Horror Escape Game

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Abstract: When we talk about early horror video games, they often had no accessibility features for disabled players. It was not easy to obtain the adaptive controllers even if they had because they were not in wide use and were expensive. Many disabled players found ways to make horror games playable through their efforts. Although the rules and the guidelines are still in their infancy, such accessibility features have rapidly grown more common, particularly over the past three to five years, notably for deaf and hard-of-hearing people. Besides visual prompt to make the player with no disability feels frightened, audio cues also play a crucial role in most horror games. They are mainly used as a hint to inform the player from which direction the harmful event is coming, and they also give a slight suggestion on which way the player should choose at a fork in the road. However, players with hearing impairment cannot be aware of these audio cues. The game's overall difficulty gets higher, while the game's scariness gets lower compared to players with no disability. Dedicated games built for people with hearing impairment are somewhat unacceptable because such games make the disabled players unable to experience the fear and anxiety of the horror games. In this paper, we introduced a method to help deaf and hard-of-hearing players to be able to play horror games under the same rules as hearing players. The proposed method "Glitch Effect," generates a visual noise that distorts the screen when harmful events are near at hand. We introduced this effect as a metaphor of anxiety, for we often see it on a broken television. For example, when a zombie gets near the player character in game, the camera at the viewpoint of the character begins to repeat small glitch animation at regular intervals. The closer the zombie gets, the stronger and shorter the glitch and its intervals become. This paper describes the system design of the horror game and the result of the user experiments.

1. Introduction

Accessibility in video games has come a long way, and however, it is still not as progressive as it needs to be. Incorporating video games with impairments can be difficult for game developers since impairment types depend on the individuals. It seems like an impossible task to provide a proper method for gamers with impairments.

Video games are meaningful for disabled gamers because they are at a higher risk of social isolation. The game may provide a universal community for both disabled and non-disabled gamers. Disabilities make it harder for gamers to share such an experience; however, we can break the boundary with technologies. A gamer with muscle dystrophy can play various video games using eye movement tracker or an adapted joystick.

Nowadays, subtitles, colorblind modes, and enhanced closed captioning are more common in many games. Game developers like Naughty Dog [15] in their game "The Last of Us Part II" have made significant improvements in accessibility features, including more optional settings to improve the gameplay experience of gamers with a disability without ever changing the rules inside the game. Game Accessibility Guidelines [7] also clearly lay out the hows and whys of including those with motor, cognitive, visual, auditory, and speech-related disabilities. VR gaming is also a real champion when we mention accessible games, as many VR games are very suitable for many people with disabilities. However, this may not apply to horror games.

Horror media can produce a range of physiological responses such as shaking, jumping, covering our eyes, and making us feel anxious or disgusted [5, 9]. A study in 2016 proved the claim by evaluating those who played versus watched the horror game Silent Hill P.T, and those who played had a greater heart rate and were more frightened [11]. Horror games do not always show grotesque scenes, they often like to leave the players in suspense. This suspense is always aided by the accompanying music inside the game, as pulsing or eerie music gives us a slight hint to the players that they should be fearful of what danger is coming [2, 12]. The sound design in horror games can be as influential in invoking fear as visual stimulation. Even fundamental sounds such as footsteps can induce fear inside the player's brain. Because sound design plays a crucial role in horror games, this creates a problem where gamers with hearing impairment cannot truly experience the fear and cannot realize the danger that comes toward them. There is a sense of unfairness among gamers with hearing impairment when it comes to horror games because when they cannot listen to the danger that is coming, the game becomes significantly harder to beat. As the game difficulty increases, their horror experience decreases to none. They would get confused and absurd rather than terrified.

In this paper, we introduced one method to induce fear and anxiety in VR horror games to gamers with hearing impairment using an effect that we called a Glitch Effect. This visual effect generates a pulsing visual static noise that distorts the screen to help gamers with hearing impairment visually by giving them a hint of what danger is coming in the absence of sound. We focused on the Glitch Effect performance and how it can affect gamers in a particular horror scenario in VR environments during the absence of sound.

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2. Related Work

2.1 Sound-Awareness Approaches

Mirzaei et al. [13] proposed a method to help gamers with hearing impairment play VR games using a haptic device built with an Arduino Nano, two vibration motors, a stereo audio cable, and a Universal Serial Bus (USB) cable. The Arduino is used to process the sound inside the VR environment, while two vibration motors send a vibration to the user's ear. Gamers with hearing impairment can feel where the sound is coming from inside the VR environment through the vibration given by the two motors.

Jain et al. [10] proposed several designs to support sound awareness for people with hearing impairment. They implemented a real-time sound visualization that will focus on the active speaker and use a heads-up display to tell the user which direction the sound was coming with an arrow or pulse as a visual indicator. The proposed design was then tested on the user using a Google Glass.

Both studies provide a robust method to help people with hearing impairment of sound awareness both in a VR environment and in an actual environment. We decided to adopt the latter approach, which uses a visual indicator to give awareness. Because the former approach requires a dedicated device, we believe that the gamers should enjoy horror games under the same rules and environment with or without impairment. We also made the design with a negative ambiance as it will induce the user with a more horror experience, making them feel anxious and fearful.

2.2 Fear and Immersion

To induce fear with the absence of sounds in horror games is a daunting task because we took out the crucial part of what makes horror games scary. Ntokos [16] divided the psychological aspects into ten categories of a spectrum that could represent different states in horror games, as shown below.

- Level 1 – Calmness
- Levels 2 to 4 – Anxiety
- Levels 5 to 6 – Stress
- Levels 7 to 8 – Fear
- Level 9 – Terror
- Level 10 – Panic

We considered those levels of fear as a basis for player movement and navigation inside the game, especially throughout the process of designing. This way, we can induce fear in the players by simply adding a scary character or enemy to the game and moving the enemy towards the player when the players are not looking.

2.3 Level Design

Milam et al. [6] proposed five patterns to guide a player through levels. We chose the following four patterns to help us orient the player inside our level and understand player behavior and movement in different situation in the game.

- Collection Pattern
  These patterns can be defined by the items or objects that the players found by navigating through the level. It involves picking up items such as ammunition or keys placed within a level.
- The Player is Vulnerable Pattern
  Players are said to adapt their movement when they are in a vulnerable state and exposed to hazards or additional attacks that increase the specific scenario at hand. It includes when players run or take cover to hide from enemies.
- Pursue AI Pattern
  The pattern is the fundamental movement in response to a friendly or hostile character within the game.
- Path Target Pattern
  This pattern is used to orient the player's movement to a goal at that specific level. It can be a visual landmark or roadway that attracts the player's attention in limited directions.

These patterns are used as a framework for the level design in our game. We use these patterns to help us orient the player inside our level and understand player behavior and movement in different situations in the game.

3. Glitch Effect

We propose a design method to help gamers with hearing impairment survive longer in a horror game, giving them the same immersive horror experience as gamers without hearing impairment. When malicious events are near at hand, the game system generates a kind of visual noise that distorts the player's screen. We chose this effect as a metaphor to give the player a sense of anxiety, for we often see a glitch on a broken TV (Figure 3-1).
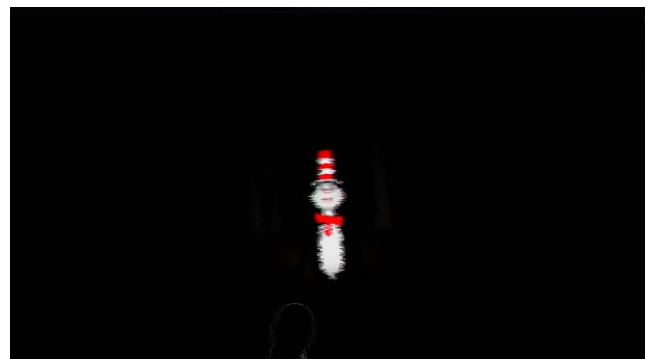

Figure 3-1 Glitch Effect generated when CAT is getting close to the player

In our game scenario, when an unfriendly character gets close to the player character in the game, the camera will start the glitch animation at regular intervals. The closer that character is, the stronger and shorter the glitch gets.

3.1 Game Design

We divide the game design into two core parts: Game Design

and Level Design. The core game design will contain all game rules and all player interactions, and the level design is according to the limits and restrictions of the core game design.

The game runs on Oculus Quest 2 HMD. The player can look around using the HMD and interact with objects inside the game using the controller. We also made two different game modes, Standing Mode and Seating Mode. In standing mode, player can play the game standing in a room scale area, and in seating mode, the player can play the game while seated in comfortable position. The player can do basic things like looking around, moving, grabbing objects, and turning on/off the flashlight. Second, the location map was given to the player only for narrative purposes. The player can also hide from the enemy "CAT" by turning off the flashlight and standing still in the darkness. That way, the "CAT" cannot see where the player position is and turn around away from the player position.

The prototype game developed with Unity is a survival horror game where the player needs to find six items scattered throughout the level to banish the "CAT" into a box. After the player collects the first item, the "CAT" will then chase the player, and the "CAT" speed will increase much faster for every item found. The glitch effect will start when the "CAT" gets closer to the player's position. When the "CAT" gets close enough to the player, he will eat the player, and the game is over. The concept was inspired from "Slender: The Eight Pages". [8]

Figure 3-2 Game Poster

3.2 Level Design

This game has one straightforward linear level that circles the forest area. Landmarks and roadways are also added to the game to orient the player inside the level. We also made the environment and the scene inside the level somewhat misleading; for example, we created many forked roads to make the player lose their sense of direction. The purpose is to study the impact of the level design on player experience and see if horror elements had different effects on player behavior when playing the game without using auditory stimuli. Figure 3-3 shows the map and the location of the items in the game.
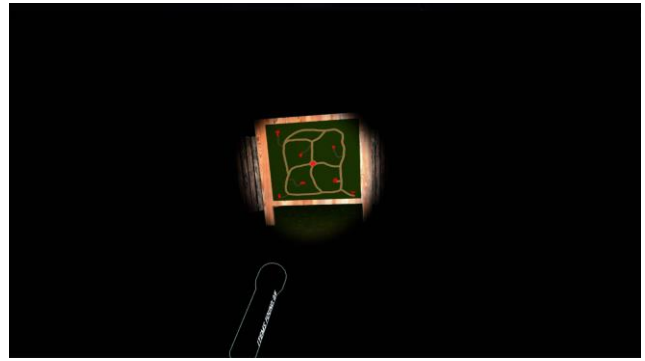

Figure 3-3 The map of the forest and all the item's location

Red circles in the map are all the six items that the player need to collect to banish the cat. The middle of the map is the last place to go after collecting all the items.

Giving the player a feeling of anticipation and anxiety about what danger will come is crucial in the horror game genre. We made the environment inside the level pitch black with only lights coming from a flashlight that only illuminate a small portion of the area (Figure 3-4). This restricted view will trick the player's brain into thinking that someone or something will come out of the dark to give them what we call a jump scare. The addition of trees and ambiguous-shaped objects can also play tricks with the player's brain.

Figure 3-4 In-game environment and atmosphere

4. Method and Experiments

For our experiments, we asked hearing gamers to play our game with two different level, (1) one with an accessibility feature in the system (CAT) and (2) one without an accessibility feature (Haunted Warehouse). To test the performance of the Glitch Effect, we also asked them to play the game without using any auditory stimuli. The experiment was conducted in a safe and controlled environment to avoid any unwanted accidents that happened to the gamers. Then all gamers that participated before the experiments were given a questionnaire to make sure they were in the fit condition to play VR games and had no sensitivity to flashing lights, or frightening graphics. We chose to conduct the experiments on hearing gamers because we could not invite deaf and hard-of-hearing gamers to our lab due to COVID-19 limitations. The participants (N=11, male,

from 18 to 24 years old) self-identified their interest in VR horror games and as having no history of seizures, hallucinations, or other health factor that VR horror games could provoke.

In the first part of the experiments, we asked the hearing gamers to play the "Haunted Warehouse" (Figure 4-1) game as the first game since it has no accessibility feature designed in the system. Therefore, to avoid sudden death by the monster inside the game, we gave the hearing gamers three attempts to play this game without any auditory stimuli. The first two attempts were counted as tutorial sessions so the hearing gamers could get used to the VR environment as well as the controller and headset. In the last attempt, hearing gamers will try their best to collect all items inside the game to escape the warehouse. After they played the game, we asked them to answer the questionnaire based on their experience during the Haunted Warehouse gameplay.

Figure 4-1 Participant playing Haunted Warehouse

In the second part, we asked hearing gamers to play the "CAT" game with accessibility features designed inside the game (Figure 4-2). They are also required to play the game without any auditory stimuli as in the "Haunted Warehouse" before. Given that the objective between the two games is relatively similar, we decided to give the hearing gamers one attempt and twenty minutes to finish the game. The game will be over when the players can banish the "CAT" or get eaten by the "CAT". Hearing gamers were also required to answer the questionnaire after playing the game.

Figure 4-2 Participant playing CAT

We also gave a questionnaire regarding the game immersion and the performance of Glitch Effect. This is because deaf and hard-of-hearing gamers rely heavily on the game's visual aspect of the game, especially in VR gaming, and not the audio aspect of the game.

5. Results

The results of this study were collected from three questionnaires filled out by the participants. One questionnaire before playing the game and two questionnaires after playing each game. The sections that follow detail results from 11 participants engaged in these activities.

5.1 Pre-Play Questionnaire

With the questionnaire given before the participants played the game, we asked the participants how many hours they played the video game in a week. Most participants showed that they played video games for less than 3 hours a week. Some participants played video games for 3-15 hours, while others showed that they play video games for more than 15 hours in a week, as shown in Figure 5-1. We also asked what genre of video games they preferred to play. Figure 5-2 shows almost all the participants chose First Person Shooter (FPS), some participants chose RPG and Action genre. Only one participant was interested in the horror genre.
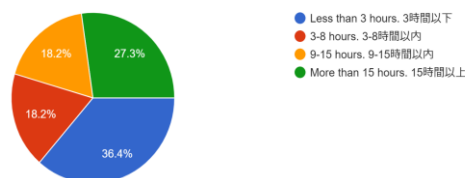
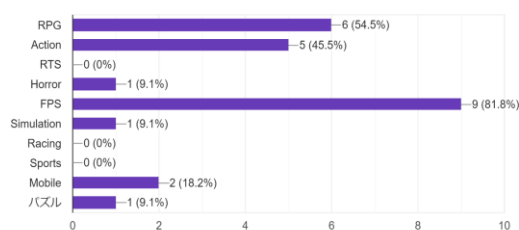
Figure 5-1 Hours taken to play video games in a week

Figure 5-2 Preferred video game genre

Results also showed that even though most participants chose FPS, RPG, and Action as their preferred genres, they also played horror video games before the experiment. Biohazard Series and Phasmophobia were the highest chosen horror games the participants played. The results are just as we predicted before, that mainstream horror genres are more likely to be played rather than the more nonmainstream or indie horror games. Such as Amnesia Series, Alien: Isolation, or The Layers of Fear. Half of them says they have not played VR horror games before.

Next, we asked participants to tell us what aspects make horror games scary. And the results that we got also matched our prediction during the game development stage. The number one aspect that makes horror games scary is sound effects as it shown in Figure 5-3. Followed by tension inside the game and the game atmosphere that resembles darkness, also the feeling of someone or something lurking in the dark.
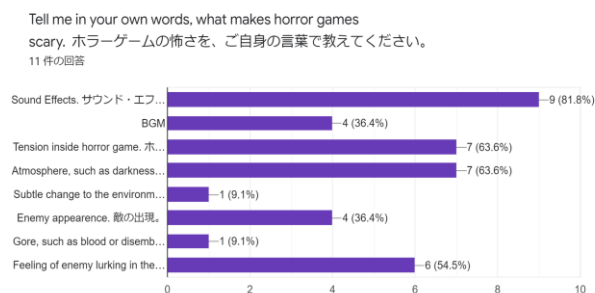

Figure 5-3 Aspects that makes horror game scary

5.2 Haunted Warehouse Results

After playing Haunted Warehouse game, participants were asked to complete a questionnaire which asked them a series of questions regarding their horror experience playing the game. In this game, participants were given a task to collect all 4 barrels to escape from the haunted warehouse without using any auditory stimuli and utterly rely on their visual stimuli. To our surprise, all participants could not complete the game, and even after we gave them three attempts to try to complete it. Most of the participants could collect collect two barrels before they were eaten. Two of the participants managed to collect three barrels but did not have the chance to escape from the haunted warehouse. Playing a horror escape game without any auditory stimuli increased the overall difficulty unexpectedly. It is almost impossible to clear the game as it shown in Figure 5-4 and Figure 5-5.
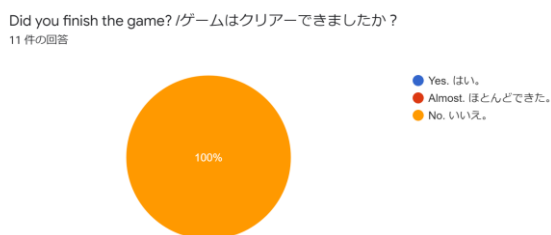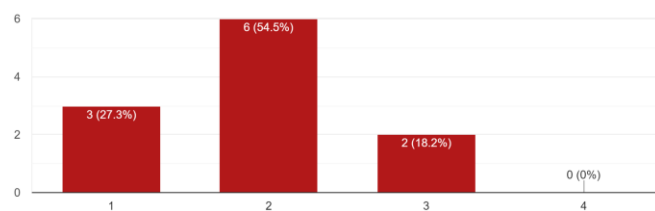

Figure 5-4 Game clear rate

Figure 5-5 Barrels taken without accessibility features

When asked about the impression of the game during gameplay, we received several answers that further proved the impossibility of playing a horror escape game without any auditory stimuli. One participant stated that he was suddenly attacked by the monster and died without even knowing what was happening. Other participant felt that the game was frightening with the lack of sound because they found it difficult to figure out where the monster was, and they found it hard to clear the game.

In the game replayability aspect, without the accessibility features we achieved an average score from the participants as shown in Figure 5-6. Most participants will gladly play the game again when they have a chance. Figure 5-7 shows most participants enjoyed the overall horror experience when they were playing the game. We achieved this result from the details of the level inside the game, such as environments and atmosphere that can affect the horror experience even without using any auditory stimuli. By designing the game environment and atmosphere into a scarier looking, the horror experience can be increased. The reasons were also because the participants feel alerted when they cannot hear the monster that will come toward them.
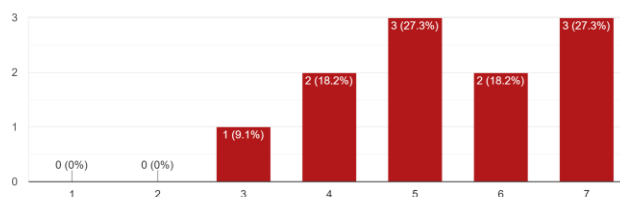
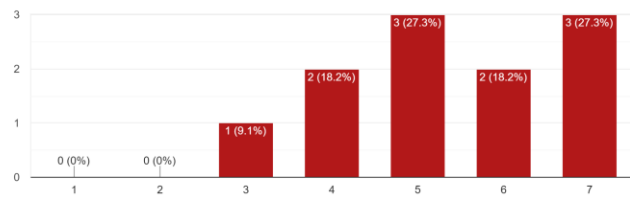Figure 5-6 Haunted Warehouse game replayability

Figure 5-7 Haunted Warehouse game horror experience

The results for the scariest aspect of the game are also matched with the results we achieved before playing the Haunted Warehouse. Most of the participants' answers were a lack of sound. The lack of sound in this situation where the players need to escape from a monster creates more tension and a different atmosphere in the game.

The least scary aspect of the game was also the lack of sound. We were surprised that the lack of sound in horror video games could make the game much more frightening than expected. However, at the same time, it could make the game more confusing than it already is. One participant said in his answer that because of the lack of sound, he suddenly died in the game and didn't even know why he died.

5.3 CAT Results

After all the participants have played the game CAT, we ask them to answer the same questionnaire. Questions regarding the performance of the accessibility features and game designs are also included in this questionnaire. In this game, we gave all participants one attempt with 20 minutes time limit to collect six items scattered across the map and banish the cat into the box instead of giving them three attempts to clear the game. The purpose of that is that we want to keep the difficulty high while having accessibility features present. Participants also played this game without any auditory stimuli.

As shown in Figures 5-8 and 5-9, we achieved a different result from the previous game. With accessibility features present inside the game, we could see that the participants' actions inside the game were changed drastically. More than half of the participants were almost able to collect all six items and banish the CAT. They survived more than 10 minutes during gameplay.
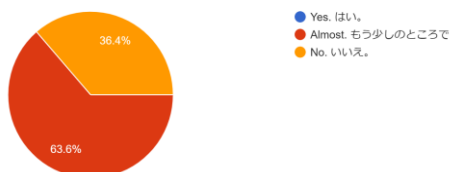
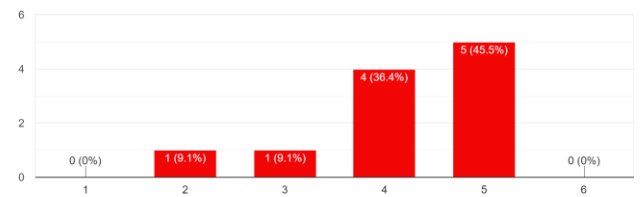Figure 5-8 Player's performance using accessibility feature, Glitch Effect

Figure 5-9 Items taken with accessibility feature present in the game

The participants' impressions of the game CAT were more positive than the previous Haunted Warehouse. With answers such as, "I felt like I was being chased more than in the first game", or "the enemy was right behind me, and I could not shake him". Until this point, we can give players more tension and fear during the gameplay with the accessibility features alone, even without auditory stimuli.

The replayability aspect had a higher score than the previous game, and most participants were almost willing to play the game again for the second or third time. Also, the horror experience was more solid.
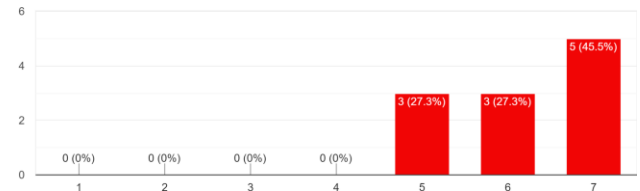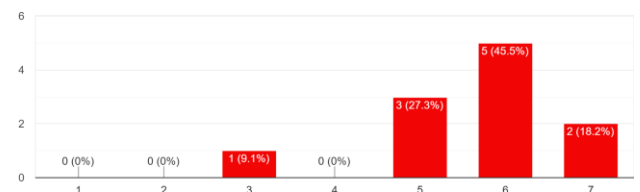

Figure 5-10 CAT game replayability

Figure 5-11 CAT game horror experience

There seems to be no difference in the level of fear between the two games. However, some participants still felt scared after playing the CAT game. When they were asked if anything in the game contributed to their feelings, they said that the Glitch Effect made the game much scarier.

As shown in Figure 5-12, we found that the Glitch Effect

made most participants feel anxious when they saw it. We are satisfied with these results because we have managed to create tension in a horror game without heavily relying on sound effects.
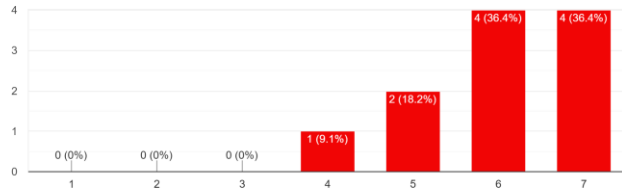

Figure 5-12 Anxiety created by the Glitch Effect

The Glitch Effect also helped participants survive even longer from the CAT that chased them across the map. More than 70% of the participants agreed that the glitch effect incredibly assisted them when they could not hear the enemy's footsteps.
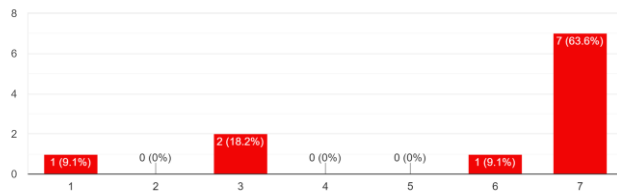

Figure 5-13 Glitch Effect performance when running from the enemy

However, one participant did not feel that the glitch effect could assist him when running from the enemy (Figure 5-13). It could have happened that he started running from the enemy when he saw the enemy from a remote distance — making the glitch effect inactive.

From the participants' point of view, the glitch effect slightly obstructed their vision when they tried to run away (Figure 5-14). We consider that the glitch effect intervals and distortion were too strong when the enemy was near enough to the player. Luckily, as shown in Figure 5-15, the intensity of the noise generated by the glitch effect was not too strong to make the participants feel dizzy when using the VR headset.
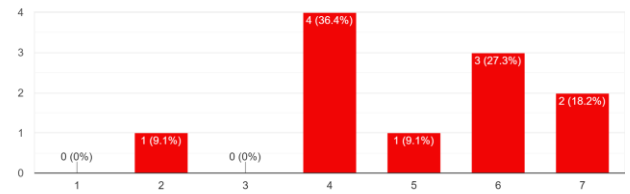
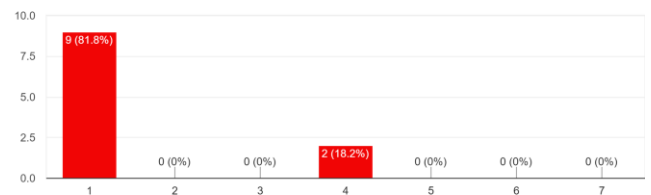Figure 5-14 Levels of Glitch Effect that obstructing player's view

Figure 5-15 Glitch Effect intensity level

The glitch effect serves as a hint for a coming enemy and increases the game's tension and level of fear significantly. Most participants said that the scariest aspect of the game CAT was the noise generated by the glitch effect while the CAT was chasing them.

6. Conclusion

This paper proposed and tested an accessibility feature called the "Glitch Effect" for gamers with hearing impairment in VR horror games. We conducted a comparative experiment to evaluate the accessibility feature of the Glitch Effect.

The results indicated that most participants preferred to have accessibility features present in VR environments when auditory stimuli were absent. Though the participants were not impaired, we believe that the effect would benefit deaf and hard-of-hearing gamers to survive longer in such a scenario where the player needs to run from the enemy without hearing the enemy's footsteps. In addition, its visual indicator that resembles something negative, like a distorted noise, could create tension and anxiety.

In the next step, we will conduct the same experiments on deaf and hard-of-hearing gamers in the future as the number of COVID-19 cases decreases.

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