

東京工科大学大学院バイオ・情報メディア研究科

修士論文

論文題目

<p>Fear the Glitch: Studying the Effects of Visual Warning for Deaf Gamers in VR Horror Escape Games</p>
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Abstract

Title	Fear the Glitch: Studying the Effects of Visual Warning for Deaf Gamers in VR Horror Escape Games
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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.

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. Because sometimes they get confused rather than terrified.

Dedicated games built for people with hearing impairment are somewhat unacceptable because they want to experience gaming enjoyment just as much as people without disabilities. 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 comparative result of the user experiments. The results indicated that the "Glitch Effect" can serve as a visual warning for a coming enemy even without using audio and increases the game's tension and level of fear significantly.

修士論文要旨

論文題目	Fear the Glitch: Studying the Effects of Visual Warning for Deaf Gamers in VR Horror Escape Games
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<p>初期のホラーゲームといえば、障害者向けのアクセシビリティ機能がないことが多かった。また、障害者用のコントローラがあっても、普及率が低く高価なため、入手するのは容易ではなかった。しかし、多くの障害者プレイヤーの努力により、ホラーゲームをプレイしやすくする工夫がなされた。ルールやガイドラインはまだまだ整理されていないが、特にこの 3～5 年の間に、聴覚障害者を中心に、こうしたアクセシビリティ機能が急速に普及した。多くのホラーゲームでは、障害のないプレイヤーに恐怖を感じさせる視覚的なプロンプトのほかに、音声による合図も重要な役割を担っている。音声による合図は、主に、有害な出来事がどの方向からやってくるかをプレイヤーに知らせるヒントとして使われる。</p> <p>しかし、聴覚に障害のあるプレイヤーは、これらの音声合図を認識することはできない。そのため、障害のないプレイヤーと比べて、ゲーム全体の難易度は高くなり、恐怖よりも混乱することがあるからゲームの怖さは低くなってしまう。聴覚障害者は、健常者と同じようにゲームの楽しさを体験したいため、聴覚障害者向けに作られた専用ゲームは、受け入れがたいものがある。そこで、本研究では、聴覚障害者が健常者と同じルールでホラーゲームをプレイできるようにするための視覚効果を提案する。</p> <p>提案した手法「Glitch Effect」は、有害な事象が間近に迫ったときに、画面を歪ませる視覚的なノイズを発生させるものである。この効果は、壊れたテレビでよく目にすることから、ホラーゲームの雰囲気には適合する不安のメタファーとして導入した。例えば、ゲーム内でゾンビがプレイヤーキャラクターに近づくと、キャラクター視点のカメラが一定間隔で小さなグリッチアニメーションを繰り返し始める。ゾンビが近づくほど、グリッチとその間隔が強く、短くなる。</p> <p>本論文では、ホラーゲームのシステム設計とユーザー実験の比較結果について述べる。比較実験の結果、「Glitch Effect」は音声を使わなくても敵の出現を知らせる視覚効果となり、ゲームの緊張感や恐怖感を大幅に高めることが分かった。</p>	

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FIGURES

Figure 2-1 Linear Level Structure	5
Figure 3-1 Analog Glitch Effect.....	8
Figure 3-2 Digital Glitch Effect.....	9
Figure 3-3 CAT Game Poster.....	10
Figure 3-4 Forest Level development in Unity Game Engine	11
Figure 3-5 Map of the forest and items	11
Figure 3-6 The player being chased by CAT.....	12
Figure 3-7 The Hospital Level structure in Unity Game Engine.....	13
Figure 3-8 Hospital scene using red tint.....	14
Figure 3-9 The ghost inside the hospital.....	15
Figure 3-10 Old Hospital Level atmosphere	16
Figure 3-11 Hospital corridor filled with objects.....	16
Figure 4-1 Participant playing without the effect.....	18
Figure 4-2 Participant playing with the effect	18
Figure 5-1 Hours taken to play video games in a week	21
Figure 5-2 Preferred video game genre	21
Figure 5-3 Aspects that makes horror game scary	22
Figure 5-4 Game clear rate.....	22
Figure 5-5 Barrels taken without accessibility features	23
Figure 5-6 Replayability rate	24
Figure 5-7 Horror experience without the glitch effect	24
Figure 5-8 Player's performance using the Analog Glitch Effect	25
Figure 5-9 Items taken with the Glitch Effect.....	25
Figure 5-10 Replayability with Glitch Effect	26
Figure 5-11 Horror Experience with the Glitch Effect	26
Figure 5-12 Anxiety created by the Glitch Effect.....	27
Figure 5-13 Glitch Effect performance	27
Figure 5-14 Levels of Glitch Effect that obstructing player's view	28
Figure 5-15 Glitch Effect intensity level.....	28
Figure 5-16 Items collected without the Glitch Effect.....	29
Figure 5-17 Items collected with the Analog Glitch.....	30
Figure 5-18 Items collected with the Digital Glitch.....	30
Figure 5-19 Level of difficulty on Analog Glitch Level	31
Figure 5-20 Claustrophobic effect in Digital Glitch Level.....	32
Figure 5-21 Claustrophobic effect in Analog Glitch Level.....	32
Figure 5-22 Fear level in the second Hospital.....	33

Figure 5-23 Analog Glitch Level horror experience.....	34
Figure 5-24 Digital Glitch Level horror experience.....	34
Figure 5-25 Feeling of anxiety created by the Analog Glitch Effect	35
Figure 5-26 Feeling of anxiety created by the Digital Glitch Effect	35
Figure 5-27 Analog Glitch usability.....	37
Figure 5-28 Digital Glitch usability	37

TABLE OF CONTENTS

1	INTRODUCTION.....	1
1.1	Horror Media.....	1
1.2	Recent Development.....	2
1.3	The Glitch Effect.....	3
2	RELATED WORK.....	4
2.1	Sound-Awareness Approaches.....	4
2.2	Fear and Immersion.....	5
2.3	Level Design.....	5
2.4	Horror Atmosphere and Soundless Horror Experience.....	6
2.5	Visual Warning.....	7
3	GAMES AND EFFECTS DESIGN.....	8
3.1	Visual Warning Design.....	8
3.2	CAT Game Design.....	9
3.3	CAT Level Design.....	10
3.4	The Old Hospital Game Design.....	12
3.5	The Old Hospital Level Design.....	13
4	METHOD AND EXPERIMENTS.....	17
4.1	CAT and Analog Glitch Effect.....	17
4.2	The Old Hospital and The Glitch Effects.....	19
5	RESULTS.....	20
5.1	No Glitch and Analog Glitch Comparative Results.....	20
5.1.1	Pre-Play Questionnaire.....	20
5.1.2	No Glitch Level.....	22
5.1.3	Analog Glitch Level.....	24
5.2	Analog Glitch and Digital Glitch Comparative Results.....	29
5.2.1	Item Collection and Difficulty.....	29
5.2.2	Fear and Horror Experience.....	31
5.2.3	Psychological Effect Created by the Glitch Effects.....	34
6	CONCLUSION AND FUTURE WORK.....	38
	ACKNOWLEDGEMENT.....	39
	REFERENCES.....	40

ACHIEVEMENT	42
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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 [16] 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 [8] 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.

1.1 Horror Media

More than 100 years since the first horror media hit the screens, the genre is still going strong [17]. While horror is scary for some people, those who enjoy it, treat horror media as an attraction. Because horror media are fun and they tap into our shared fears about death and the unknown. In 1992, a British heavy metal band called Iron Maiden released their ninth studio album titled "Fear of the Dark." The song with the

same title tells a story about a paranoid man who constantly fears that there's someone or something about to spring out at him from the dark as a result of watching horror films and studying the occult [20]. Following the footsteps of horror media, horror games seem to be the only genre that never changed. For horror games, the essence is always fear, whether it is fear of the dark, the unknown, bloodshed, psychological torment, or childhood trauma. There is only one objective in horror video games which is to scare the player. Either with sinister visuals or loud and scary noises.

Horror media can produce a range of physiological responses such as shaking, jumping, covering our eyes, and making us feel anxious or disgusted [5, 10]. 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 [12]. 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, 13]. 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.

Even though horror video games have a powerful formula for building tension and instilling fear, VR horror games still have a weakness compared to other VR game genres. Many VR horror games created by game developers still rely heavily on the audio aspect of the game. Most of the time, VR horror games use audio to subtly tell the player that there is danger waiting for them to come. This formula created a problem among gamers with hearing impairment. Since they cannot hear any audio from the game, they cannot sense the danger that is coming. Thus, making the game much more difficult.

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.

1.2 Recent Development

Recent improvements in Virtual Reality (VR) development have resulted in affordable and easy-to-access VR Head-Mounted-Displays enabling many gamers, both with a disability and without disabilities, to experience more VR content. However, to this day, almost all VR applications available in the market are still targeted toward gamers without disabilities. And many gamers with hearing impairment find it too

hard to enjoy VR content or lose interest before even trying. This is simply because they cannot perceive any audio information within the VR environment.

Previous study shows that using LED to indicate where the sound is coming from can improve gamers with hearing impairment experience when running sound-related VR applications [15]. Other study using a visual indicator as an approach also shows positive feedback from user with hearing impairment towards sound visualization [11]. Our main hypothesis is, gamers with hearing impairment may have a strong awareness to visual indicator given by the VR device. The study done in 2017 by Codina et al. [6] strengthens our hypothesis stating that a person with hearing impairment has faster peripheral vision reaction time.

In our earlier work, we designed a VR horror game for gamers with hearing impairment and without hearing impairment. In the game, the player's objective was to collect six items and escape from the enemy that chased them through the game. We also use a visual warning called the "Glitch Effect" to help gamers with hearing impairment sense a danger that is coming. The "Glitch Effect" will work when the enemy gets closer to the player. The closer the enemy gets, the faster and stronger the intensity of the glitch. Because of the Glitch Effect visuals that look like a broken old television screen, it also acted as a way to instill fear and anxiety.

1.3 The Glitch Effect

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.

A comparative user study was conducted to investigate our hypothesis and to evaluate the newly designed Digital Glitch Effect. We use three conditions without audio to compare the task performance: with Analog Glitch Effect, with Digital Glitch Effect, and without any effects. We use post-play questionnaires to investigate the player's desire between the Analog and Digital Glitch Effects. And the level of horror experience given by each effect.

2 RELATED WORK

2.1 Sound-Awareness Approaches

Mirzaei et al. [14] 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. [11] 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 [18] 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

Flow is one of the reasons why new horror scolds for the fact that the game has more become an action game than a horror. In this game, we wanted the player to follow a specific route we created to give the maximum amount of horror experience. Therefore, we decided to design a closed linear level rather than an open level. In the book "Beginning Game Level Design," Feil and Scattergood mentioned that linear level design can create frustration since the player must follow the path the developers intended [21].

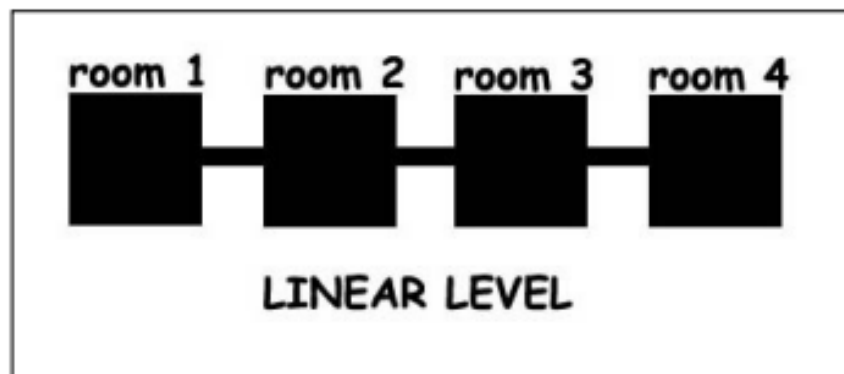


Figure 2-1 Linear Level Structure

The player needs to search the items from one room to the next while being chased by the enemy. We considered this linear-level design the most optimal to give the player more horror experience since we intended to set out a challenge when they encounter an enemy.

Milam et al. [7] 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.

2.4 Horror Atmosphere and Soundless Horror Experience

Inducing fear and giving enough horror experience inside the game without using audio is quite a spiky task since audio is also needed to complete the game design. This paper [22] showed that based on the player's willingness to be scared, they distinguish a level design that appears to be a "complete fantasy adventure" from "a total horror" game. Greg Kasavin from Supergiant Games and developer for the game Hades notes that the game atmosphere should have a "unique identity" and "unique feel." He also stated that the game atmosphere "help to create immersion" [23].

To our knowledge, no prior work on giving the player or inducing fear into the player's head without using any audio in VR horror games. Since horror video games,

especially in VR, still rely heavily on using sound effects and scary visuals to give a good scare to the player.

We decided to give the player a horror experience without using audio will be heavily based on the design of the level and the player's encounter in the game. To meet those requirements, we used the linear design level mentioned before. And to give immersion to the player, we chose a situation where the player needs to investigate an abandoned hospital.

2.5 Visual Warning

Using the help of visual warnings as a sign of a threat to the player is always the dominant key aspect of any game, especially in horror video games [26]. Our previous work uses a "Glitch Effect" as a sign of a threat to gamers with hearing impairment. The Glitch Effect works when the enemy gets closer to the player. The closer the enemy is, the stronger and faster the intensity of the Glitch Effect. We adopted the "Glitch Effect" and designed a new, more modern design for the Glitch Effect visual warning. Instead of a jittering line like what we would see on an old television, we use a digital glitch. This "Digital Glitch" serves as a metaphor for a dead pixel. Something that a new generation of gamers would see on their PC monitor when broken.

3 GAMES AND EFFECTS DESIGN

3.1 Visual Warning Design

In the first half of our research, we propose two new visual warning method for gamers with hearing impairment to feel fear and immerse in the VR horror game experience. The visual warning will act as a sign of a threat and a hint for gamers with hearing impairment surviving inside VR horror games. 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). We called this the "Analog Glitch Effect."

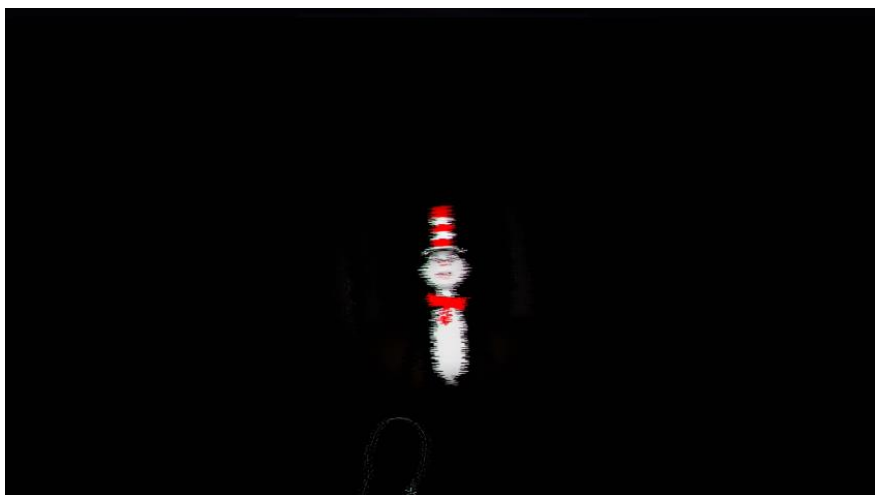


Figure 3-1 Analog Glitch Effect

The "Digital Glicth Effect" design is similar to the dead pixel in most monitors nowadays. We chose this design to give a sense of anxiety to the player, the same way as when they see a dead pixel on their monitors. When the horror events get closer to the player, the camera will begin shaking and generating dead pixels on the screen. In our game scenario, the digital glitch will spawn dead pixels into the screen whenever the enemy gets close to the player. The closer the enemy is, the more dead pixels the glitch spawns, blocking all of the player's vision (Figure 3-2). The reason we chose to use the Analog and Digital Glitch Effect is to investigate whether younger gamers will prefer traditional or modern visual warnings.



Figure 3-2 Digital Glitch Effect

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.

3.2 CAT Game Design

The game "CAT" 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". [9]



Figure 3-3 CAT Game Poster

3.3 CAT Level Design

CAT 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 as shown in Figure 3-4 to make the player

lose their sense of direction. The addition of trees and ambiguous-shaped objects can also play tricks with the player's brain.



Figure 3-4 Forest Level development in Unity Game Engine

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 3-5 shows the map and the location of the items in the game.



Figure 3-5 Map of the forest and items

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 3-6). 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.



Figure 3-6 The player being chased by CAT

3.4 The Old Hospital Game Design

Similar to the game CAT, we used the Unity game engine for The Old Hospital development and designed the game based on Game Accessibility Guidelines to fit gamers with and without hearing impairment. The game has all of the basic movements in VR and runs on the standalone device Meta Quest 2. In this game, the player can move the camera around using the HMD and interact with different items inside the game. We decided to use standing mode for the game as it will be easier for the player when moving around. Based on the player's preference, we give them two choices for the camera movements, Smooth Turning and Snap Turning. Smooth Turning allows the player to turn continuously without breaking in the middle of the rotation, while Snap Turning let the player turn in a 45 to 60-degree rotation. The player can also run from the enemy by entering the rooms and waiting for the enemy

to back away. With that strategy, the player can safely pass the enemy without getting caught.

There are six items scattered randomly inside an old hospital building. The player's goal is to search and collect those six items before the enemy catches them. The game is cleared when the player managed to collect all six items. When the player gathers the first item, the enemy will start to appear and patrol around. The enemy will begin to chase the player when they are near the enemy view radius. In our scenario, the enemy will start chasing at a fixed speed. The reason is that the closed level makes it much more punishing for the player to travel around while the enemy is chasing. We keep the game at a moderate difficulty for the player to beat.

We wanted to diminish unfairness in the game when the player happened to have an unreasonable enemy encounter and death. Thus, the game has a tutorial level before the player enters the real game scenario. Our tutorial level consists of a basic movement tutorial, an item-grabbing tutorial, and an enemy encounter tutorial. The digital glitch effect and game-over-like encounter also exist inside the tutorial. Players can freely move and try many things inside the tutorial level without any time limit. Once the player was ready to tackle the real game scenario, we explained the game mission.

3.5 The Old Hospital Level Design

To give a more scary atmosphere to gamers with hearing impairment, we use an abandoned hospital theme for our game. We decided this theme would fit the closed level structure that we designed. Also, an abandoned hospital atmosphere might induce Nosocomephobia or fear of hospitals inside the players giving more horror



Figure 3-7 The Hospital Level structure in Unity Game Engine

experiences. There is no map inside the level, and items spawn randomly when the game starts. The purpose is to investigate the effect of claustrophobia induced by the level design on a player's behavior and strategy when collecting the items. To give the player a more challenging horror encounter, we fill the level with objects that can obstruct their movement.

We created two similar levels using the same abandoned hospital theme. The level has the same closed structure (Figure 3-7) that lets the player roam inside the hospital. The difference between those two levels is the atmosphere, details of the level, item placements, and the glitch effect visual. The purpose is to investigate whether the characteristics of the virtual environment affect the player's horror experience.

The first level we introduced to the players also serves as the tutorial level and the Analog Glitch Level. At this level, we decided to give a red tint to the level atmosphere. The red color means to symbolize anger, danger, and aggression. The usage of the color red in many first-person shooter games usually serves as a warning to the player.



Figure 3-8 Hospital scene using red tint

We also make the lighting much darker and give a smoke effect to instill fear inside the player's head (Figure 3-8). The enemy also lurks inside the level and is hidden by the smoke effect (Figure 3-9) making the player have difficulty spotting the enemy. The level structure is pretty straightforward. There are two floors inside the building connected by a single staircase. Each floor is a corridor with rooms on the left and right sides.



Figure 3-9 The ghost inside the hospital

The second level serves as the No Glitch and Digital Glitch Level. The second level has a different atmosphere compared to the first one. The atmosphere on this level has a grey color tone. In color psychology, grey represents neutrality and balance. However, grey does carry some negative connotations, particularly when it comes to depression and loss. Its absence of color makes the level dull (Figure 3-10).

Structure-wise, this level also has the same structure as the other. However, the corridors on this level are narrower and filled with objects that could obstruct the player's movement (Figure 3-11).



Figure 3-10 Old Hospital Level atmosphere



Figure 3-11 Hospital corridor filled with objects

4 METHOD AND EXPERIMENTS

4.1 CAT and Analog Glitch Effect

For the first part of the research experiment, we asked hearing gamers to play our game with two different level, (1) one with an accessibility feature (Analog Glitch Effect) in the system and (2) one without an accessibility feature.

To test the performance of the Analog 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 (Figure 4-1) game without 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 gameplay.



Figure 4-1 Participant playing without the effect

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 with the effect

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.

4.2 The Old Hospital and The Glitch Effects

Our comparative experiment consists of three sessions of a game that the participants need to challenge. The first session was without the Glitch Effect, and the two with the Analog and Digital Glitch Effects. We mixed the order of the session to avoid any bias among the participants (N=12, male, from 18 to 24 years old). To improve the Glitch Effect usability, we asked the participants to play the game without using any audio. All participants were given a questionnaire before playing the game. The questionnaire's purpose was to confirm they were in a fit condition to play VR horror games. And to avoid unwanted accidents caused by flashing lights and claustrophobic effects. We experimented on hearing participants because of COVID-19 restrictions. It was still hard to invite deaf gamers into our lab. All participants had no history of seizures, hallucinations, or other health factors that VR horror games could provoke.

We split the experiment into three separate sessions, No Glitch, Analog Glitch, and Digital Glitch Session.

In the No Glitch Session, after the participants were satisfied with the tutorial level, the participants needed to challenge the game without using the Glitch Effect. To avoid sudden and unreasonable death by the enemy, the participants should steer clear of the enemy using their strategy. Upon clearing the game, we asked the participants to fill in a questionnaire regarding the design and horror experience of the game.

In Analog Glitch Session, the participants should clear the game with the Analog Glitch Effect serves as a visual warning. The glitch will start whenever the enemy gets close to the participants. The session commenced whenever the participants were ready. After clearing the game or game over, the participants needed to answer the questionnaire.

In Digital Glitch Session, the participants needed to clear the game with the Digital Glitch Effect as a visual warning. Similar to Analog Glitch Session, the glitch will start whenever the enemy gets close to the participants. The session commenced after the participants were ready to transition from the tutorial level. After clearing the game or game over, the participants needed to answer the questionnaire.

5 RESULTS

5.1 No Glitch and Analog Glitch Comparative 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.

5.1.1 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.

How often do you play games in a week? 1週間のうち、ゲームをする頻度を教えてください。
11 件の回答

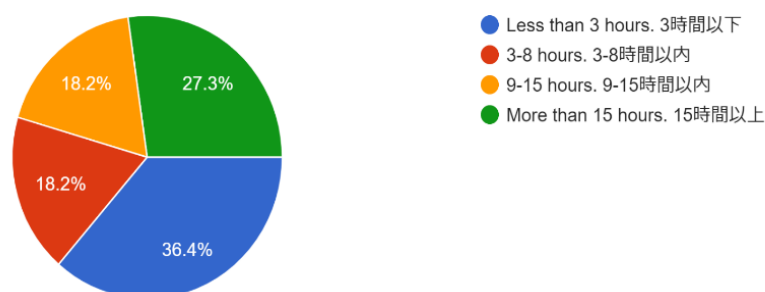


Figure 5-1 Hours taken to play video games in a week

What is your preferred game genre? You might choose more than one answers. あなたが好きなゲームのジャンルは何ですか? 複数回答可
11 件の回答

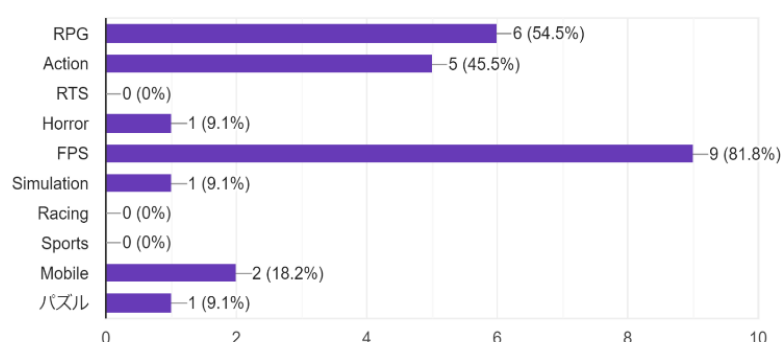


Figure 5-2 Preferred video game genre

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.

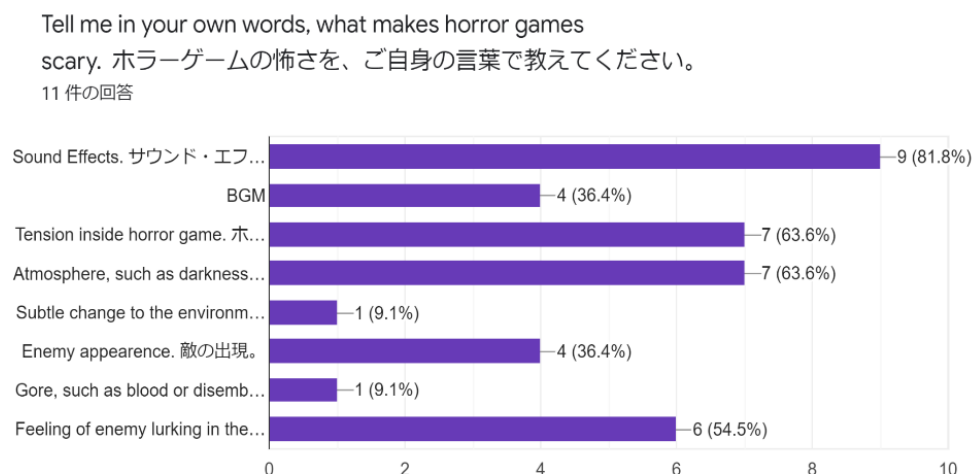


Figure 5-3 Aspects that makes horror game scary

5.1.2 No Glitch Level

After playing the 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 monster. 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.

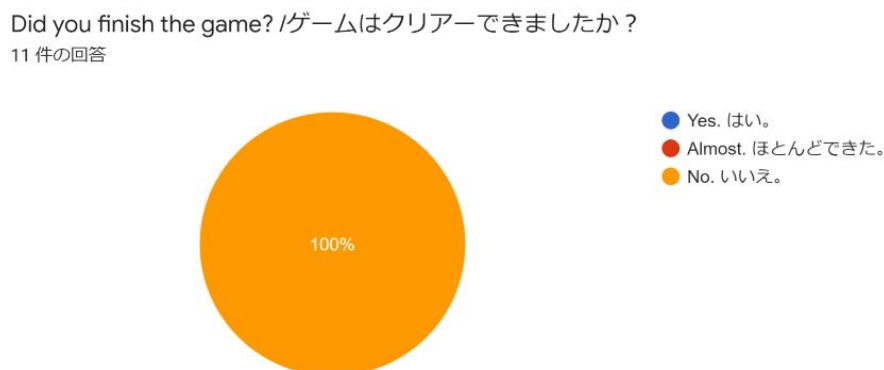


Figure 5-4 Game clear rate

How many barrels did you get in the game? / 樽は何個集められましたか？
11 件の回答

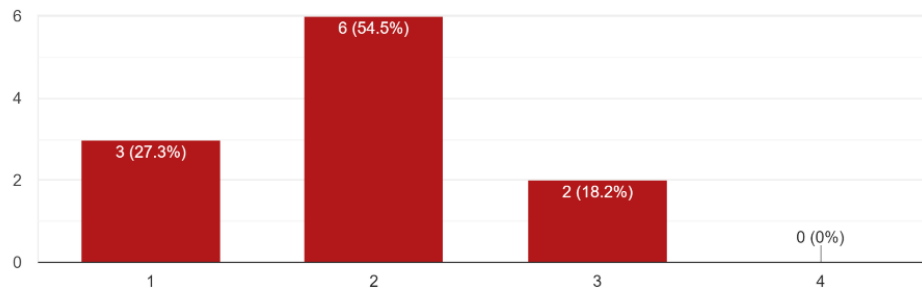


Figure 5-5 Barrels taken without accessibility features

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.

Do you wish to play the game again? Select the value from 1 to 7.

/もう一度ゲームをしたいですか？1～7から選んでください。

11 件の回答

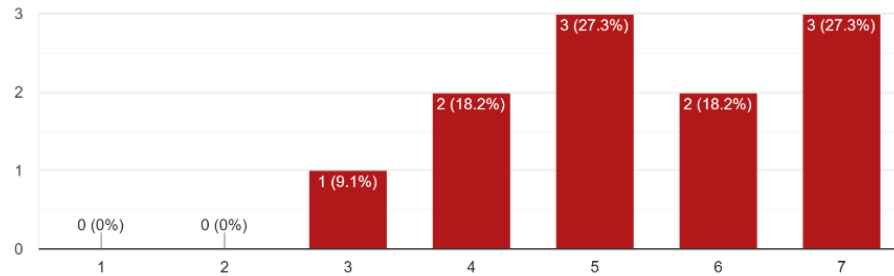


Figure 5-6 Replayability rate

Do you wish to play the game again? Select the value from 1 to 7.

/もう一度ゲームをしたいですか？1～7から選んでください。

11 件の回答

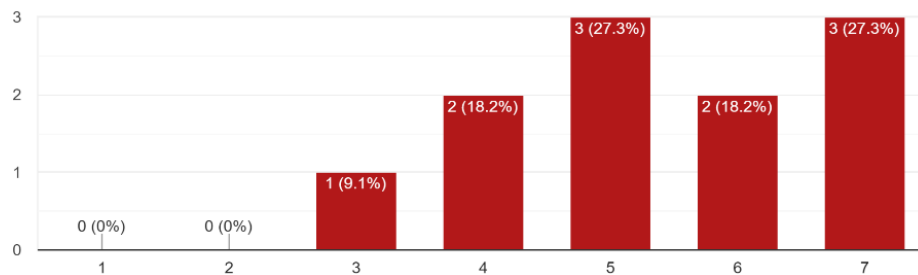


Figure 5-7 Horror experience without the glitch effect

The results for the scariest aspect of the game are also matched with the results we achieved before playing the game. 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.

5.1.3 Analog Glitch Level

After all the participants have played the game with the Analog Glitch Effect, 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.

Did you able to banish the CAT? CATを追い出すことはできたのでしょうか？
11 件の回答

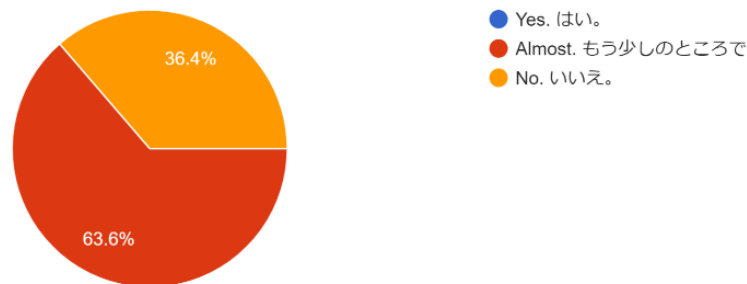


Figure 5-8 Player's performance using the Analog Glitch Effect

How many items did you get in the game? アイテムはいくつ手に入れましたか？
11 件の回答

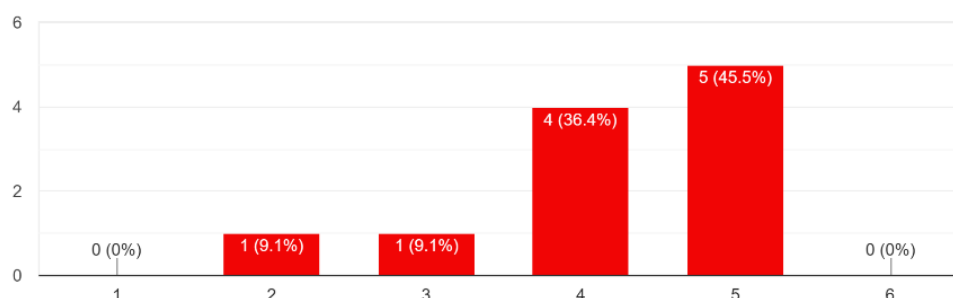


Figure 5-9 Items taken with the Glitch Effect

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.

Do you wish to play the game again? Select the value from 1 to 7.
もう一度プレイをしたいと思いますか？1～7から選んでください。
11件の回答

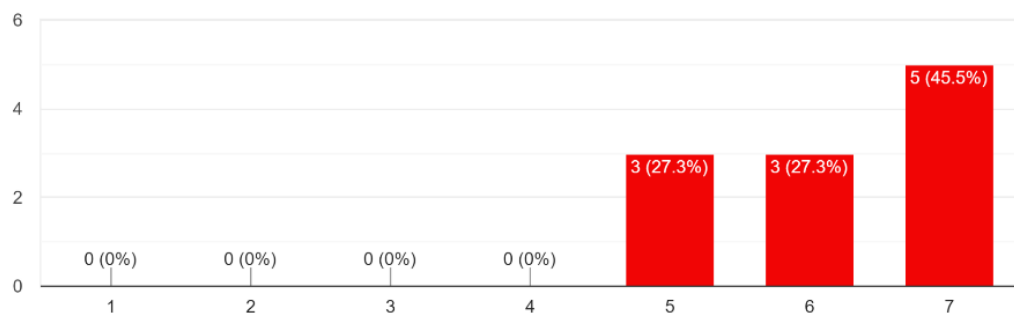


Figure 5-10 Replayability with Glitch Effect

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.

How much did you enjoy the horror experience? Select the value from 1 to 7.
ホラー体験はどの程度楽しめましたか？1～7でお選びください。
11件の回答

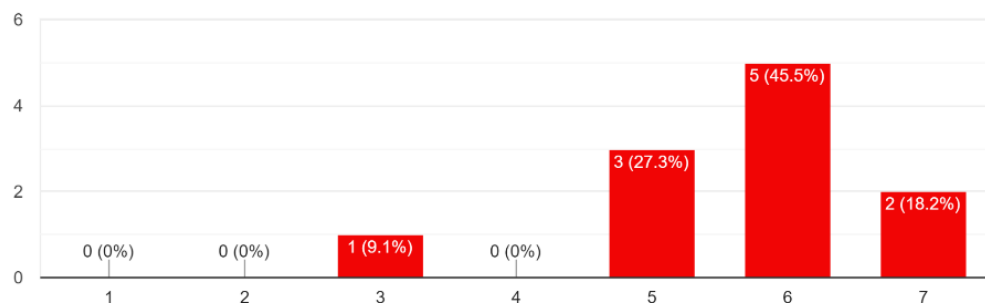


Figure 5-11 Horror Experience with the Glitch Effect

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.

How much does the glitch effect makes you anxious during your gameplay? Select the value from 1 to 7. ゲームプレイ中、glitch effectによる不安感はどの程度ありますか?1~7でお選びください。
11件の回答

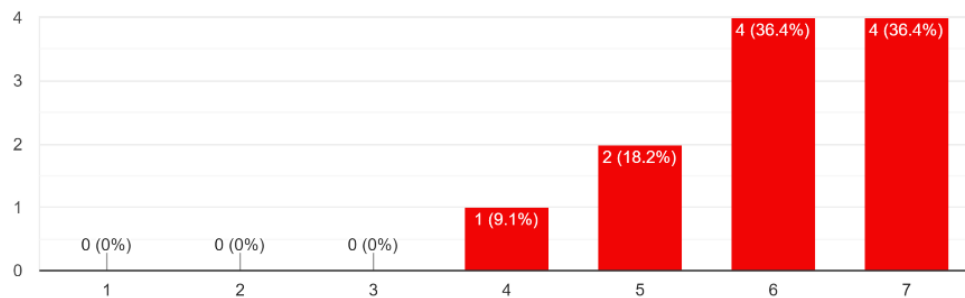


Figure 5-12 Anxiety created by the Glitch Effect

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.

How much does the glitch effect helped you when running from the enemy? Select the value from 1 to 7. 敵から逃げるとき、glitch effectはどの程度役に立ちましたか? 1~7でお選びください。
11件の回答

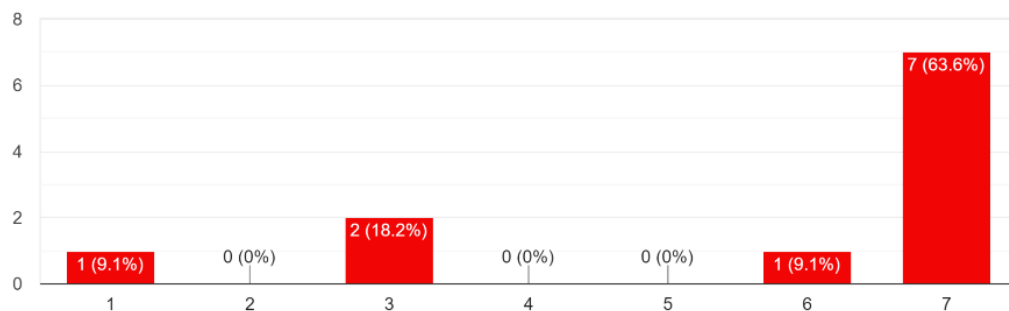


Figure 5-13 Glitch Effect performance

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.

How much does the glitch effect obstructing your vision during your gameplay? Select the value from 1 to 7. ゲームプレイ中、glitch effectはどの程度視界が遮られますか？1～7で選択してください。

11件の回答

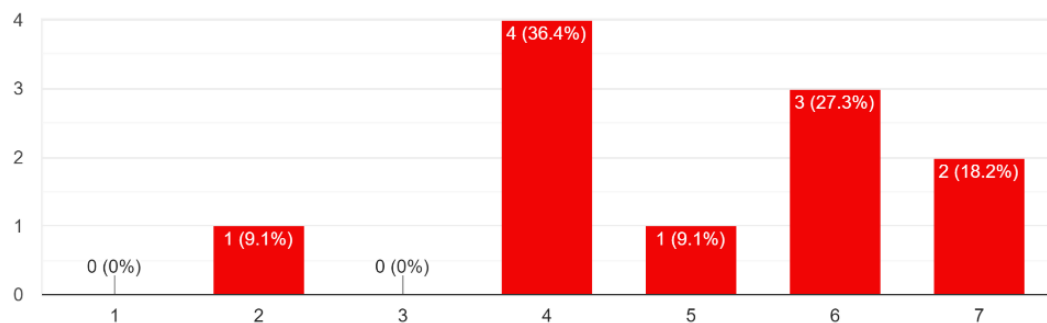


Figure 5-14 Levels of Glitch Effect that obstructing player's view

How much does the glitch effect makes you dizzy during your gameplay? Select the value from 1 to 7. glitch effectで、ゲームプレイ中にどの程度めまいがしますか。1～7でお選びください。

11件の回答

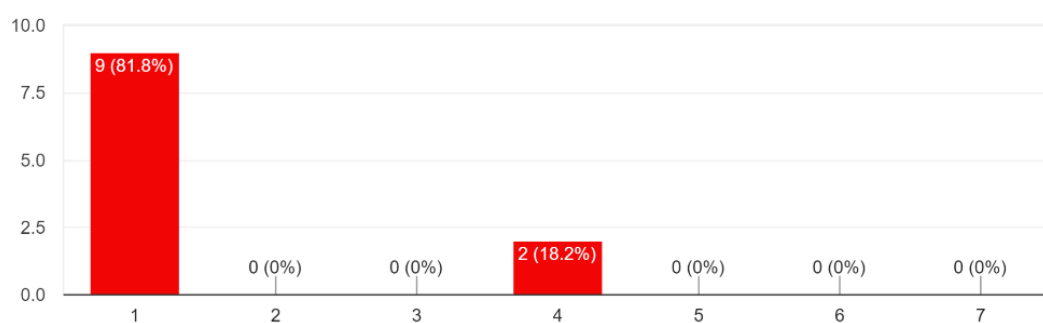


Figure 5-15 Glitch Effect intensity level

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.

5.2 Analog Glitch and Digital Glitch Comparative Results

The results of this study were collected from four questionnaires filled out by the participants. One questionnaire before playing the game and three questionnaires after playing each session. The sections that follow detail results from 12 participants engaged in these activities.

5.2.1 Item Collection and Difficulty

After finishing all three sessions, we asked the participants to complete a questionnaire regarding the item collection and the horror experience of playing the game. In all gameplay sessions, the participant's mission was to collect six items inside an old hospital building without being caught by the enemy.

How many items did you get in this level?

ブロックは何個取りましたか？

12 件の回答

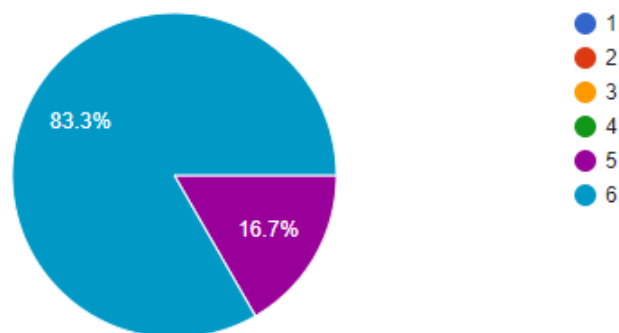


Figure 5-16 Items collected without the Glitch Effect

To our very surprise, most participants as can be seen in Figure 5-16, managed clear the game and collect six items even without the Glitch Effect present. Two participants only managed to get five items, yet still considered a high achievement. This result is beyond our expectations. We expected that playing a horror game without audio may increase the game's difficulty. Thus, making the game much harder.

There was a decrement in the item collection number when the participants were playing the game with the Analog and Digital Glitch Effects (Figure 5-17). With the Analog Glitch present, most participants managed to get five items and cleared the

game by collecting all six items. However, two participants struggled to finish the game and only managed with three items on their hands.

How many items did you get in this level?

ブロックは何個取りましたか？

12 件の回答

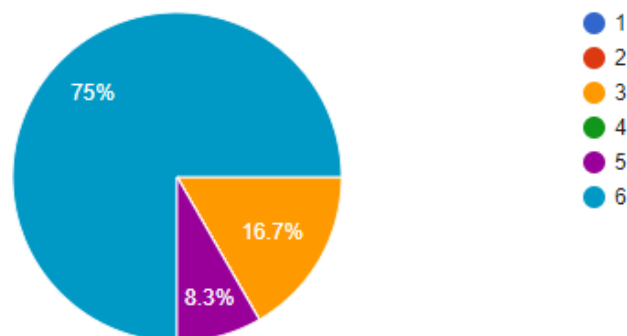


Figure 5-17 Items collected with the Analog Glitch

There was also a struggle when the participants played the game with the Digital Glitch Effect. At this level, 2 participants managed to get only two and three items (Figure 5-18). We see a slight progression toward a better item collection result in contrast to the item collection number at the Analog Glitch level. We still considered that the highest item collection number is when any of the Glitch Effects were unused.

How many items did you get in this level?

ブロックは何個取りましたか？

12 件の回答

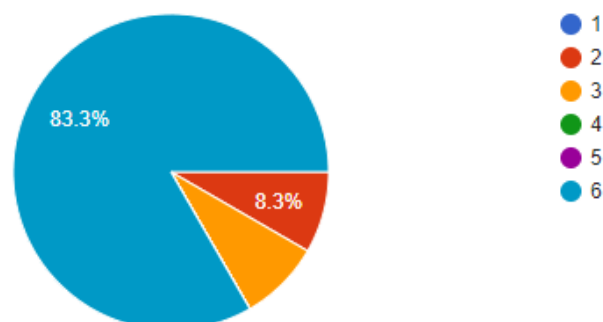


Figure 5-18 Items collected with the Digital Glitch

The participants then asked about the difficulty of each level. Most participants seem to have little to no struggle when playing the Analog Glitch Level (Figure 5-19).

How easy or difficult is this level?



このマップは簡単ですか、難しいですか？

12 件の回答

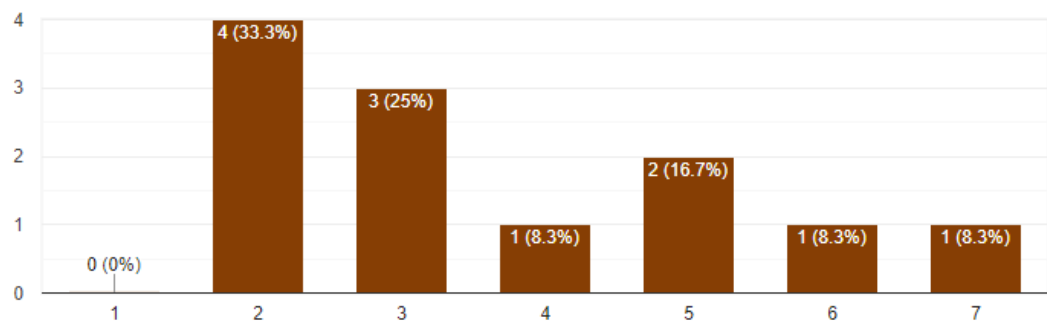


Figure 5-19 Level of difficulty on Analog Glitch Level

A cleaner level structure may also have some effects on the level of difficulty. The ones without the Glitch Effect and with the Digital Glitch Effect are significantly harsher than the Analog Glitch Level. This result could be affected by the obstructing objects that prevent the participants from freely moving.

5.2.2 Fear and Horror Experience

We also asked about the horror experience given by each one of the hospital-themed levels. First, we asked whether they felt a claustrophobic effect at every level. Based on the participant's responses, we found out that the Digital Glitch Level give claustrophobia effect to most of them as can be seen in Figure 5-20.

How much does this level makes you feel claustrophobic?

 コピー

このマップでは、どの程度、閉所恐怖症になるのでしょうか？

12 件の回答

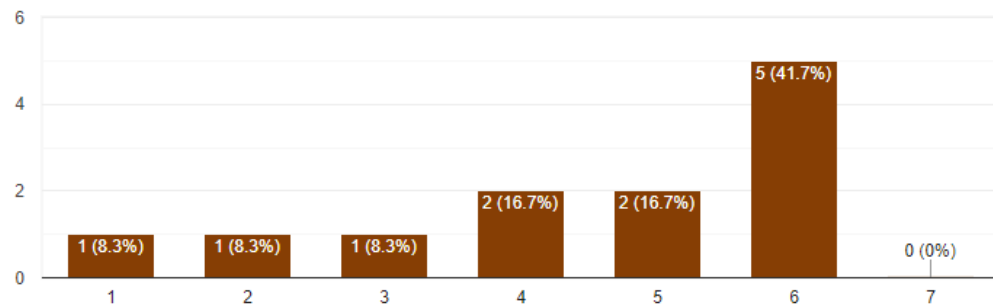


Figure 5-20 Claustrophobic effect in Digital Glitch Level

On the contrary, the Analog Glitch Level didn't have any claustrophobic impact on the participants (Figure 5-21). When we observed the video footage, it seemed that the obstructing objects and the Digital Glitch Effect, which resembles dead pixels, gave the claustrophobic impact.

How much does this level makes you feel claustrophobic?

 コピー

このマップでは、どの程度、閉所恐怖症になるのでしょうか？

12 件の回答

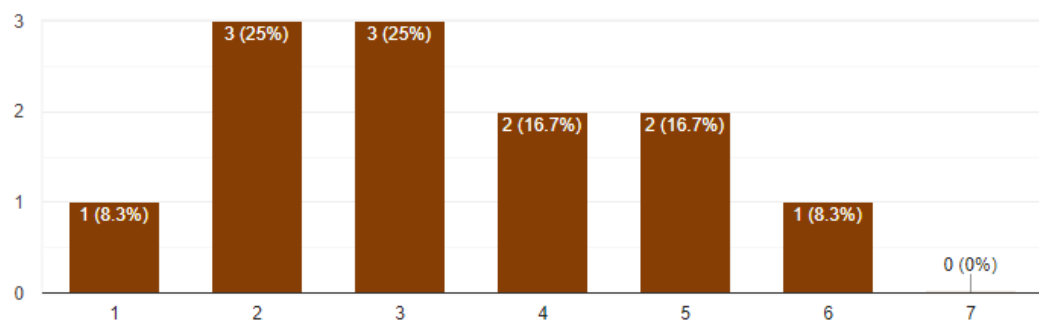


Figure 5-21 Claustrophobic effect in Analog Glitch Level

We also asked the participants if they were scared during the gameplay at each level. To our surprise, most participants felt scared playing the No Glitch and Digital Glitch Hospital Levels (Figure 5-22) with the grey tone. And they were not frightened at all playing the Analog Glitch Hospital Level with the red tint atmosphere. We

investigated further why this would happen, and we found out that the details of the level and atmosphere could be what affected their fear level. The claustrophobic effect may also play a part in the result.

How scared were you during the gameplay?

 コピー

プレイ中、どの程度怖かったですか？

12 件の回答

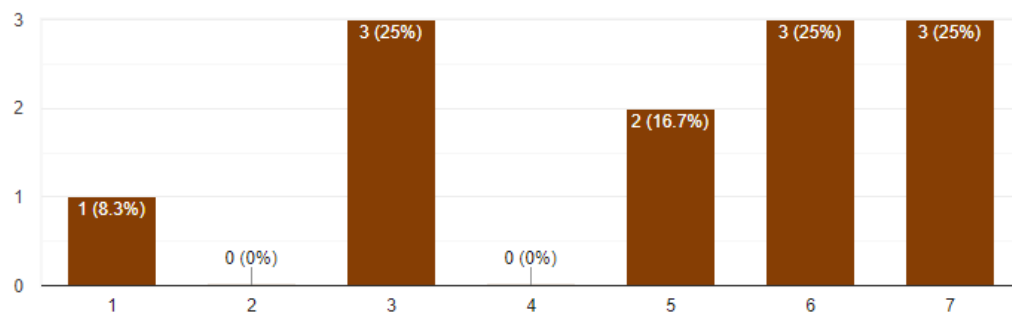


Figure 5-22 Fear level in the second Hospital

Although the fear level in the No Glitch and Digital Glitch Levels were exceptionally high, most participants' horror experience leaned towards the Analog Glitch Effect as in Figure 5-23. We found these results once again as a surprise. Usually, the fear level and horror experience on each level would be the same. However, we found that the Digital Glitch Effect has a lower enjoyment of horror experience (Figure 5-24).

How much did you enjoy the horror experience given in this level?

 コピー

このマップでホラー体験をどの程度楽しめたのでしょうか？

12 件の回答

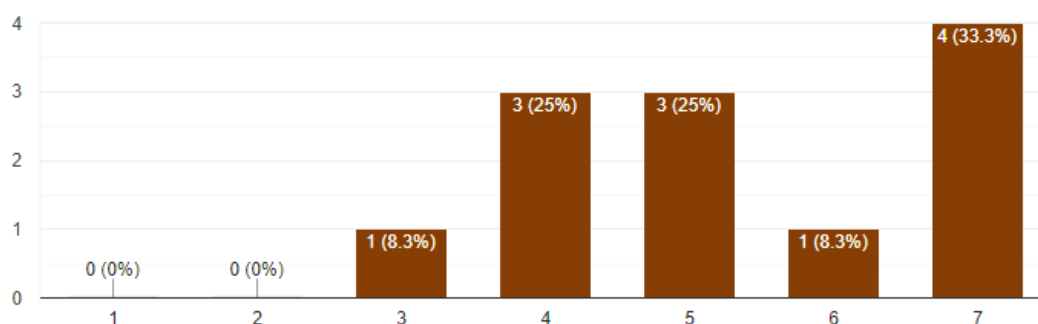


Figure 5-23 Analog Glitch Level horror experience

How much did you enjoy the horror experience given in this level?

 コピー

このマップでホラー体験をどの程度楽しめたのでしょうか？

12 件の回答

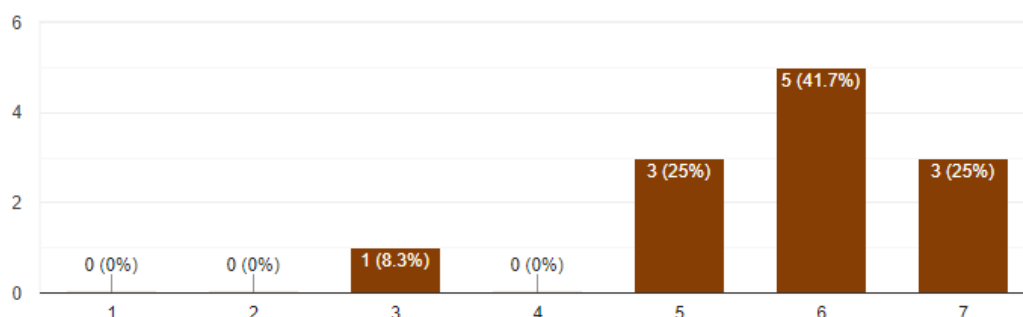


Figure 5-24 Digital Glitch Level horror experience

For each level replayability aspect, most participants preferred to play the Analog and Digital Glitch again if they had the opportunity. We expected this result, as the Glitch Effects have worked as a visual warning.

5.2.3 Psychological Effect Created by the Glitch Effects

Other results we obtained after comparing the Analog and Digital Glitch Effects were also astonishing. We were surprised by how much it affects the player psychologically just by changing the glitch design. In the previous session,

participant's fear levels were high when they played with the Digital Glitch Effect. However, the play session with the Analog Glitch Effect has higher horror experience enjoyment.

We investigate further the anxiety effect created by the two Glitch Effects. The results were similar to our previous work with the game CAT. The feeling of anxiety created by the Analog Glitch Effect (Figure 5-25) is more solid than the Digital Glitch Effect (Figure 5-26). This psychological effect could be why horror experience enjoyment scores using the Analog Glitch were much higher.

How much does the Analog Glitch Effect makes you anxious during your gameplay?

[コピー](#)

ゲームプレイ中、Analog Glitch Effectによる不安感はどの程度ありますか?

12 件の回答

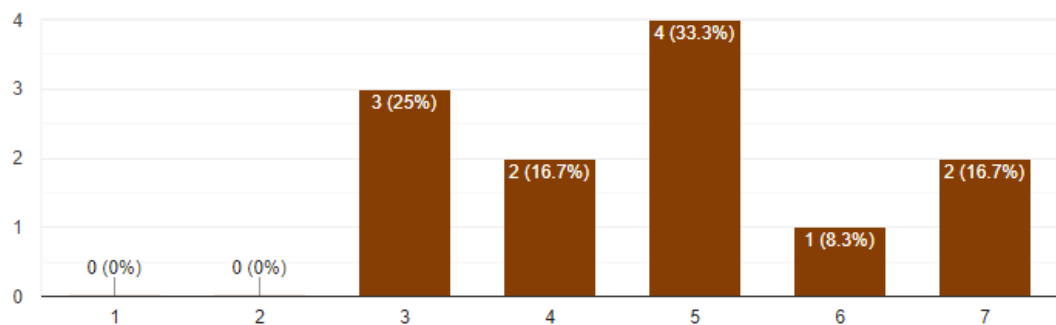


Figure 5-25 Feeling of anxiety created by the Analog Glitch Effect

How much does the Digital Glitch Effect makes you anxious during your gameplay?

[コピー](#)

ゲームプレイ中、Digital Glitch Effectによる不安感はどの程度ありますか?

12 件の回答

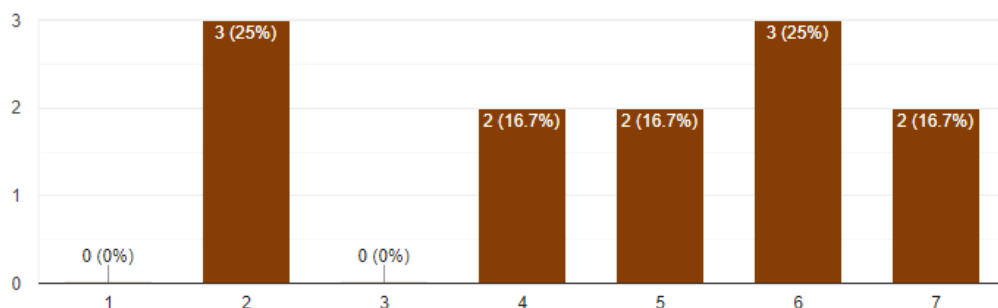


Figure 5-26 Feeling of anxiety created by the Digital Glitch Effect

We then compared the usability of each Glitch Effect by investigating which effect gave more help in the game scenario. As shown in the Figure 5-28, Digital Glitch Effect has a more solid score when helping the players notice the enemy. The Analog Glitch (Figure 5-27) also has a high score when it comes to usability. However, two participants did not feel the effect could help them in the game.

How much does the Analog Glitch Effect helped you to notice that there are enemy nearby?



Analog Glitch Effectによる、敵が近くにいることにどの程度気づけるようになりましたか？

12 件の回答

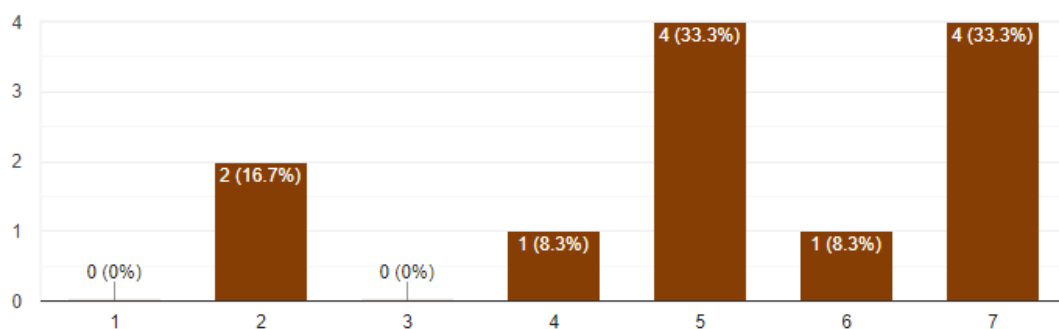


Figure 5-27 Analog Glitch usability

How much does the Digital Glitch Effect helped you to notice that there are enemy nearby?



Digital Glitch Effectによる、敵が近くにいることにどの程度気づけるようになりましたか？

12 件の回答

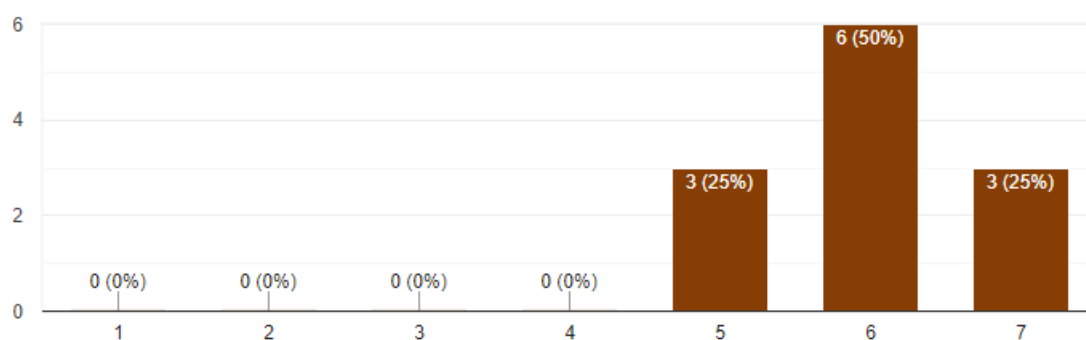


Figure 5-28 Digital Glitch usability

These comparative results between the Analog and Digital Glitches have given us a solid foundation for a better visual warning design in horror video games for deaf and hard-of-hearing gamers in the future.

6 CONCLUSION AND FUTURE WORK

Our research proposed and tested an accessibility feature called the "Glitch Effect" for gamers with hearing impairment in VR horror games. In the first part of the research, 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 warning that resembles something negative, like a distorted noise, could create tension and anxiety.

In the second part of our research, we conducted the same comparative experiments using the Analog and Digital Glitch Effects. This time we chose to use a linear closed-level design for the game scenario.

The results indicated that although Digital Glitch Effect has a more modern design than the Analog Glitch Effect, it did not affect the players psychologically. The Analog Glitch Effect still instill anxiety in the player's brain when they notice the enemy nearby. Also, for a scenario where the players need to collect items and escape from the enemy, a linear and closed-level design was not fit.

In the future, we will try to create a similar scenario using both Glitch Effects. However, there will be a new level design to avoid the game being too difficult or too easy to clear. The new level design would be a balance between open and closed levels. We also hope that in the future, as the number of COVID-19 cases decreases, we will be able to conduct the same experiment involving deaf and hard-of-hearing gamers.

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ACHIEVEMENT

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