Still Beating

Medialogy - P401 - 26-05-2025

4th Semester Project: Interactive sound systems

Bjarke Vinberg Hansen
Christoffer Bromberg Thomsen
Markus Engel Møller
Mathias Sejr Frandsen
Oliver Hee Mortensen
Sofie Daniel Andersen
Stacia Suwan Sørensen

Supervisor:
Signe Toftgaard Henriksen

AALBORG
UNIVERSITY

AALBORG UNIVERSITY
DENMARK

Department of Architecture, Design & Media Technology
Aalborg University
http://www.aau.dk

Title:
Still Beating
A Tell-Tale heart adaptation

Theme:
Interactive sound systems

Project Period:
01/02/2025 - 26/05/2025

Project Group:
P401

Participant(s):
Bjarke Vinberg Hansen
Christoffer Bromberg Thomsen
Markus Engel Møller
Mathias Sejr Frandsen
Oliver Hee Mortensen
Sofie Daniel Andersen
Stacia Suwan Sørensen

Supervisor(s):
Signe Toftgaard Henriksen

Copies: 1

Page Numbers: 82

Date of Completion:
November 20, 2025

Abstract:

This project aimed to create a psychological horror game in order to research the effects that acousmatic sound design has on player anxiety. The game *Still Beating* was developed in Unity using a first-person perspective to immerse players in an ambiguous and unsettling setting. The narrative was intentionally fragmented, and visibility was purposely limited, leaning into the fear of the unknown. Acousmatic sounds were also utilized in an attempt to understand the effect it had on player anxiety. Testing of the project was conducted using A/B testing, comparing the control version, A, that did not use acousmatic sound design to the experimental version, B, that did. The test included a total of 32 participants, with 16 participants testing version A and 16 participants testing version B. The evaluation results revealed that, although participants frequently identified acousmatic sounds during interviews, the questionnaire and physiological measurements showed no statistically significant difference. In conclusion, while acousmatic sounds appear to influence players' anxiety, the data collected did not reveal a statistically significant difference and thus, this project cannot definitively conclude as to what degree acousmatic sounds effect player anxiety. Further research into the topic, as well as optimization of the game and test procedure is required in order to reach a more fulfilling conclusion.

Contents

1 Introduction

Horror games are uniquely positioned to stimulate powerful emotional response, immersing players in suspense, fear and anxiety [63][46]. Unlike other genres, they engage not only through visuals and gameplay, but also through the player's own imagination and anticipation of the unknown [6]. This emotional intensity makes horror games an exciting area for research, especially when it comes to exploring how interactive systems shape the player's experience. Furthermore, sound in horror plays a highly important role in creating an atmosphere and player experience that is immersive, unsettling, and emotionally charged. Sound can trigger emotional and physiological responses in players, such as tension, discomfort, and alertness. Some suggest that sound is the most important component in eliciting fear, as it can shape mood, suggest unseen threats, and intensify suspense even in the absence of visual stimuli, as well as having been proven to significantly reduce immersion when absent [25][31][14][15][58][23].

This project sets out to develop and conduct research within a horror game that incorporates acousmatic sound design as a core element of the gameplay. The motivation to work within the horror genre stems from a shared fascination among the group members. Horror is not just entertaining, it offers a compelling framework for experimenting with psychological reactions, particularly through sound. We are especially interested in the concept of anxiety within horror games. Rather than relying on traditional jump scares or sudden shocks, our project explores how acousmatic sound design can cultivate a lingering, anticipatory dread. By focusing on fear of the unknown and anxiety caused by ambiguous, uncertain threats, we aim to evaluate the influence of acousmatic sound design on player anxiety.

1.1 Initial Problem Statement

As the project intends to explore how interactive sound design within a horror game can affect a players anxiety, the project requires research regarding anxiety, horror as a genre and sound, specifically among its specific design elements and the effects that these elements can have within an interactive sound system. Thus, leading to the initial problem statement:

"How does sound affect player anxiety in a horror game?"

2 Analysis

This chapter initially explores the horror genre as a whole, before delving into the psychology behind the genre, as well as establishing a better understanding of fear of the unknown. This chapter also focuses on game design and development theory, primarily in regards to the MDA framework [27], while also thoroughly researching minimalist narratives, visuals and most importantly sound in a horror game setting. Larger game titles such as the Silent Hill series, as well as popular indie game titles, are analysed as examples for environment and character designs. This chapter also researches horror game sound theory, focusing on the different forms sound can take and the methods that can be used to achieve a desired sound, as well as how sound can influence player anxiety.

2.1 The Horror Genre

Both fear and anxiety are central to horror, yet they are distinct emotional states that play different roles in how horror media affects audiences. Understanding the difference between them is crucial for designing horror experiences, particularly in interactive media such as video games, where emotional pacing and anticipation are key to immersion [11].

As outlined in The Handbook of Emotions [37], fear and anxiety are differentiated primarily by the presence or absence of a clear, identifiable threat. Fear is a response to an immediate and specific danger, such as a visible monster. In contrast, anxiety arises from the anticipation of a threat that is uncertain, ambiguous, or yet to occur. In this sense, anxiety is often "pre-stimulus" (occurring before the threat), while fear is "post-stimulus" (occurring in reaction to a threat) [37]. Therefore, a definition of the terms can be defined as fear arises in response to a known threat, while anxiety stems from anticipation of an unknown danger.

The human body reacts through physiological symptoms due to the release of adrenaline, noradrenaline and cortisol when experiencing fear and anxiety. Some of the primary symptoms include an increased heart rate, faster breathing, and sweating [9][12][62][52]. However, an important note is that while these responses are commonly associated with fear, they are not exclusive to it. These physiological reactions can also be triggered by other emotional states, such as attention or general emotional arousal [52].

2.1.1 The Psychology of Horror

There are several theories as to why people find enjoyment in horror experiences, which contains these unpleasant emotions, often revolving around the build-up of a horror story. Two big pillars of setting up a story in the horror genre is suspense and resolution. A horror story most often contain some sort of threat or manifestation of it, and the build up to this threat is the suspense. Once the threat is neutralized or avoided, the feeling of resolution is obtained [44].

One theory by Dolf Zillman, Virginia Ordman and Minet De Wied suggest that an effective resolution of suspense is what causes the highest level of enjoyment, because the viewer throughout the story feels empathy for the most often "likeable" main character, and the resolution of the great threat therefore provides relief and euphoria is exchanged for dysphoria [10]. The theory was concluded from a study showing that the intensity of suspense during the story correlation with the amount of enjoyment experienced with the resolution.

Another theory by G. Neil Martin states that the suspense itself is what creates enjoyment as the thrill of horror is provided regardless of resolution, which is also seen in horror movies such as "The Exorcist" [19] and "Friday the 13th" [7] where no resolution is provided at the end of the story [44]. The feelings and emotions granted from an experience with a horror story, is a sensation often sought

for by the viewer or user, which leads to the positive relationship with enjoyment, but the level of enjoyment tends to be individual depending on motivation for the sensation seeking [44].

2.1.2 Fear of the Unknown

In an extensive paper, researching fear of the unknown (FOTU) and its place as a fundamental fear, Cartelon describe FOTU as "an individual's propensity to experience fear caused by the perceived absence of information at any level of consciousness or point of processing" [6]. Cartelon further links FOTU to anxiety, stating that FOTU may be the cause of many anxiety disorders such as Generalized Anxiety Disorder and Social Anxiety Disorder. Cartelon as well, reaches the conclusion that FOTU can be referred to as a fundamental fear based on requirements developed by Reiss [56] and Taylor [64]. These requirements entail that the fundamental fear "...appears (1) to be an emotion; (2) inherent; (3) logically evolutionarily supported; (4) continuously and normally distributed in the population; (5) a logical reduction of higher-order constructs; (6) logically non-derivative and irreducible; (7) able to account for variance in higher-order constructs; and (8) factorially distinct" [6].

2.1.3 Subgenres

Horror as a genre is made up by multitudes of subgenres such as monster horror, psychological horror, Found Footage horror, Slasher and more.
One of the most popular, and well liked sub genres of horror is psychological horror [61], known for movies such as *The Shining* (1980), *The Silence of The Lambs* (1991) and more recently *Get Out* (2017) and *Midsommar* (2019). Unlike traditional horror, which often relies on violence, gore or jump scares to scare the audience, psychological horror utilises atmosphere, tension and emotional vulnerability, such as guilt, paranoia and anxiety, to discomfort the audience [32]. The subgenre often blurs the line between reality and illusion, presenting characters whose perceptions are unreliable or distorted, due to trauma or mental instability [32]. Instead of monsters as threats, psychological horror focuses on the psyche and internal struggle of the characters, as replacement for the "monster". It thrives on ambiguity and leaving elements up for interpretation [39].

2.2 Game Design and Development Theory

When making a game, it is important to consider the foundations of game design and game development. A framework often used or referenced when analyzing game design at its core is the mechanics, dynamics, and aesthetics (MDA) framework developed by Hunicke et al. in 2004 [1][8][50]. In the paper, mechanics are described as the rules and components that make up the game, deciding what is and what is not possible within the game. Dynamics is the interaction between the player and mechanics. Lastly, aesthetics describe the emotional response these dynamics accomplish. The MDA framework strives to achieve a better understanding of the relationship between the cause and effect of different design choices, focusing on the experience and environment that a game creates [27]. Hunicke et al. establish a taxonomy for the different aesthetic effects which follows:

Taxonomy of Aesthetic Effects	
Sensation	Game as sense-pleasure
Fantasy	Game as make-believe
Narrative	Game as drama
Challenge	Game as obstacle course
Fellowship	Game as social network
Discovery	Game as uncharted territory
Expression	Game as self-discovery
Submission	Game as pastime

Figure 1: In the table, a taxonomy of different aesthetic effects can be seen. The fist column describes the effect, while the second column describes the effect applied to a game. The second column helps understand what is meant by each aesthetic effect, in a game-sense.

However, it is stated that aesthetics is not limited to this taxonomy. A game can have many or few aesthetic goals and different ways of achieving them. When using the MDA framework, an iterative design process is carried out, constantly going back and changing the mechanics to observe the change of the dynamics and aesthetic outcome [27].

2.3 Horror Narratives in Video Games

A common type of story telling utilized within horror games, is a minimalist narrative. This was stated by King, in a study, which aims to deconstruct the current body of work regarding the methods used within horror games [33]. In this study, King emphasizes that less explicit storytelling is more effective in creating horror atmosphere. To further explain, King quotes the video game designer and horror game developer Rouse III from the essay "Match Made in Hell". In this essay Rouse III states, "In horror, the way the audience fills in the blanks will be far more disturbing than anything the writer could possibly come up with. Thus, minimalist game storytelling fits perfectly in the horror genre." [57]. Minimalist storytelling and the anxiety created by the players imagination, also fits into the definition of fear of the unknown, mentioned in Section 2.1.2.

2.4 Visuals in Horror Games

The visuals in a horror game contain a large amount of impact on perceptions and feelings. It can control the way a player immerse themselves in a game, as well as their knowledge and expectations of the world within the game. It is therefore important to be aware of the features within the visuals. However, as Müller et al. state in their paper, which investigates visual patterns in horror games, these features should not limit creativity but rather serve as a guide or inspiration [45]. In this paper, and many others like it, they describe a multitude of features to aid in understanding visuals in horror games. The following section will be a fusion of general features that appear in research papers.

2.4.1 Style

Müller et al. mention in their paper the "style", which they describe as a feature that affects all other aspects of a game. It dictates a level of abstraction that is chosen due to a specific intention [45]. Many popular horror games aim for a more realistic style, such as Alan Wake, Outlast, Alien: Isolation, Until Dawn etc. This creates a level of relatability, which is often an important part of creating horror that the player can internalize. This does not just apply to the visual aspect but also the narrative [21]. However, the completely photorealistic style has been and is more often than not unattainable. This is especially true for older games, as the capabilities of the game making technology only become more limited as we go further back in time. This becomes especially prevalent when looking at games with

older and newer iterations such as Silent Hill 2 or Resident Evil 2, 3 and 4. In the newer iterations, an observation can be made on how the games are changed to mimic reality to the best of the abilities of modern technology (Figure 2) [16][21].

Figure 2: Silent Hill 2 Remake vs Original - Physics and Details Comparison [20].

Although the style of games like the original Silent Hill 2 were created due to a limitation of technology, it resulted in a unique product which was enhanced by the limited graphics. Working around the technological restraints developers focused on primal fears such as the unknown (Section 2.1.2), taking away the focus from the details of the graphics, shifting it towards the information that was missing and the uncanniness of the environment [16]. For example in the first installation of Silent Hill, fog was implemented for this purpose (Figure 3). The fog is an important aspect of the tone and mood, as it limits the player's agency making the player feel vulnerable. As well as serving as a narrative tool. Since the first game, the fog has therefore become a staple of the franchise [41][67].

Figure 3: Silent Hill, 1999, Konami.

In a thesis concerning horror caused by glitches in games, the author Maldon explores the cultural context of this fear. Here, they discuss how the uncanniness of glitches plays a significant role in producing fear in the player. Maldon then mentions that older games as well contain this element of uncanny. They explain that this connection is made due to the artificial nature of older games and that this perception is especially prevalent in modern times [41].
The look and style of many older horror games was created because of limitations. However, today where those limitations don't exist anymore, game developers still choose to take inspiration from and to replicate the look and feel of older games. Using the retro style as a tool modern games like Mouthwashing, Slide in the Woods, The Salvation Project, Iron Lung (Figure 4) etc. create a unique horror experience which differs from other modern horror games.

Figure 4: Iron Lung, 2022, David Szymanski.

2.4.2 Environment

Another feature closely related to the overall themes and atmosphere of horror games is the environment [33][38][45][67]. In a thesis, the author Vorobeva delve into the meaning and impact of environment design in horror games [67].
In a segment, Vorobeva performs a case study on the environment in the previously mentioned game Silent Hill 2. They discuss the genre and themes of the game, which explore the human psychology. In Silent Hill 2, the environment not only serves as a tool for making the player feel certain things, but also as a way of exploring the main character's psyche. As in the game, the town Silent Hill appears different to each person in it. Reflecting the person's deepest desires and regrets. This paves way for a complex narrative with lots of symbolism and subtle storytelling [67].
Starting the game, the player is introduced to the playable character James Sunderland. He has received a letter from his wife Marry, who presumably died of a disease 3 years prior. In the letter, she says that she is in the town of Silent Hill and that she is waiting for him. As stated the environment reflects how James feels while walking through the town looking for his wife. The moody large empty town and muted colour palette, reflects his sadness and loneliness. The environment also reflect as a sense of regret and struggle, with the oppressive nature of the environment. The fog outside and long halls and small rooms inside the buildings as well, cause the feeling of claustrophobia (Figure 5) [67].

Figure 5: Silent Hill 2, 2001, Konami.

The monsters and the objects in the environment also contain meaning, as many of the monsters are themed around sickness and the town is filled with gurneys and beds, symbolizing the sickness of Marry and her death. However, the mood and things within the environment is not the only thing that is affected, the composition and layout of the environment is affected as well. The environment warps and buildings become nonsensical (Figure 6). James has to jump down into many dark holes, which represents him diving deeper into his consciousness [67].

Figure 6: Silent Hill 2, 2001, Konami.

This effect is also discussed by Müller et al. along with other mentioned effects which they name and define. They call the changing of environment "Contrast during Encounter". In their paper, they focus on the change in environment that happens as the player encounters an enemy. However, they define it in a broader aspect as well, as a display of release and tension through the environment. The act of conveying themes and story through environment and visuals is mentioned by Müller et al. as well. They define this as visual semantics, where a theme or an important aspect of the story is given visual form. Such as the theme of illness in Silent Hill 2 or many of the other themes given form through the

environment [45][67]. Thus, the environment in a horror game can have a large impact on the mood and feelings of the player as well as the narrative. This can be achieved by being aware of what you put in your environment, how you structure it and what feelings you want to convey.

2.4.3 Characters

Characters and their actions mostly serve as narrative tools, but a large portion of how a character is perceived is based on their appearance. Many types of characters may appear in horror games, but the most mentioned and defined are the main character and the enemies. Just like with the style, a more realistic and relatable main character is often chosen, as this makes the player able to relate to the main character and experience the horror through them. They are often portrayed as weak and therefore empathetic [21][45]. Another type of character often appearing in horror games are enemies. They serve as a threat and are often portrayed as vile and horrifying creatures that the main character must overcome. They can symbolize things, such as a manifestation of guilt and desire for punishment, like in Silent Hill 2 (Figure 7) [67], but at their core they evoke fear and this is often portrayed through their appearance [21][45].

Figure 7: Silent Hill 2, 2001, Konami.

2.4.4 Colour and light

When analysing and discussing visual features of a horror game, the colour and lighting is almost always mentioned. They are the most primal forms of visual input and therefore extremely important, as they set the entire mood throughout the game [33][38][45][67]. Colour especially plays a large role in setting the tone in a horror game. For example by using a desaturated and gray colour palette you can create a depressing atmosphere like in Silent Hill 2. Or by using saturated and bright colours, you can create an uncomfortable and hostile tone which is often used in Mouthwashing (Figure 8) [38][45][67].

Figure 8: Mouthwashing, 2024, Wrong Organ.

Like colour, lighting is often used to convey tone but is also often used to build tension. In the horror genre the most used type of lighting is low-key lighting, which consists of very high contrast. This creates very intense imagery and can give a sense of visual obscurity and disorientation. The intense lighting in horror games is often achieved by providing the player with poor and limited lighting, such as a sparsely lit room or a single flash light as in Slide in the Woods (Figure 9) [33][38][45][67]. This visual obscurity and lack of information created by such lighting, is a prominent factor in utilizing fear of the unknown (see Section 2.1.2).

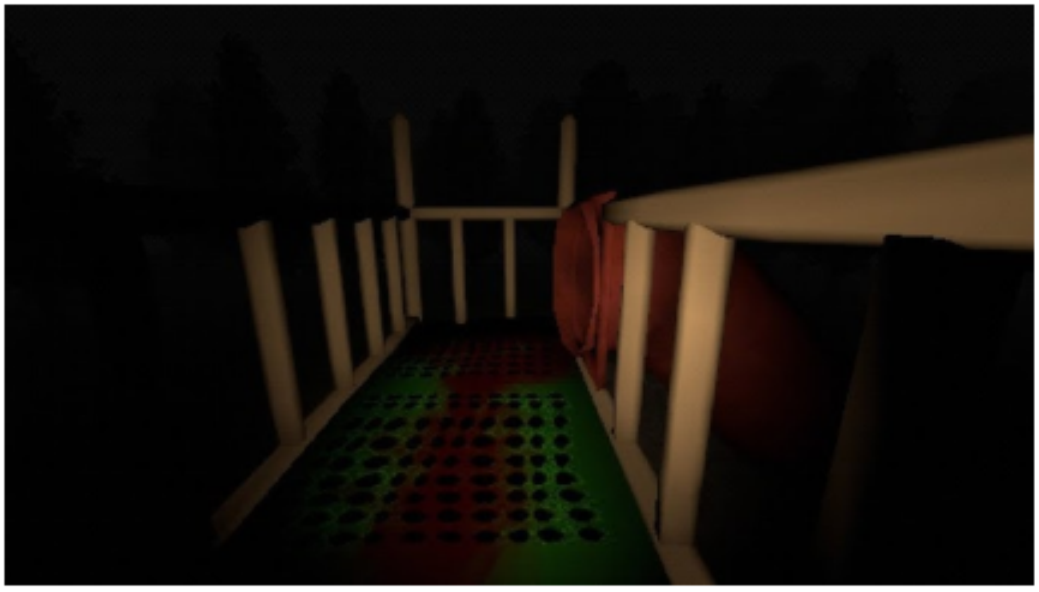

Figure 9: Slide in the woods, 2021, Jonny's Games.

2.5 Sound in Horror Games

Sound is well recognized for its importance in audiovisual media, such as film and video games. Sound is described as a crucial element in horror games for eliciting emotions and immersion [14][15][58]. Some scholars say sound is even the most important element for creating emotions and immersion [65], or that "sound carries more emotional content than any other part of a computer game" [23].

Studies have found that the absence of sound in gameplay led to significant decreases in immersion [25]. One study, in particular, noted that the absence of sound decreased immersion in such a way that "'the fictional world seems to disappear and that the game is reduced to rules and game mechanics" [31].

Many studies have examined the role of sound in horror games, particularly in how it induces emotions such as fear and anxiety. These studies can generally be divided into two main categories: quantitative -and qualitative properties, though some studies include both quantitative and qualitative properties in their study [23].

2.5.1 Quantitative Properties of Sound

Research focusing on the quantitative properties of sound is concerned with how the measurable aspects of audio, which can be manipulated through sound processing techniques, impact emotions such as fear and anxiety. These properties include acoustic qualities such as reverberation, frequency, volume [23][24][58][65]. Many effects of the quantitative properties of sounds have been described. Roux-Girard paraphrases how Cho, Yi, and Cho's (2001) research on textile sounds which shows that loud and high pitched sounds were unpleasant to listen to, while Halpern, Blake, and Hillenbrand (1986) meant that loud, low-mid frequencies were unpleasant [58]. Garner et al. describes how reverberation can change the perception of space in a game, making environments feel larger or more confined, and can make the player feel smaller and more lonely [22]. Toprac and Abdel-Meguid describes how louder sound effects are more likely to be perceived by the player, and can evoke more sudden and shocking emotions in the player than soft sounds can [65].

This project is concerned with anxiety and therefore focuses on sound techniques that support the creation of spatial uncertainty, unease, and anxiety. Some of these include reverb, spatial audio, and pitch manipulation. These techniques affect the quantitative properties of sound, but also play a key role in shaping how players perceive them psychologically. The following sections will explore these audio strategies in more depth.

2.5.2 Reverb

Reverb is a very common sound effect often used when an audio occurs from someone or something off screen, or in scenes that takes place in a tunnel, or narrow canyon [60] as it adds this echo effect and has a spatial influence of where the sound is coming from [60]. In horror reverb is utilised in many ways, where one could make a room feel smaller and cramped or larger and more lonely than it actually is by applying more or less reverb [43]. Reverb can be controlled by many parameters but the most used and common key parameters are [30]:

Room size/Decay time - This parameter controls how long the reverb lasts mimicking how big or small a room is.

Pre-Delay - This is the time between the original sound and the onset of the reverb. The length of this delay affects the perceived distance of the sound. A longer pre-delay makes it seem as though the sound source is farther away, while a shorter pre-delay suggests it is closer.

Damping - The damping effect reduces high-frequencies in the reverb-tail which is the end of the reverb and simulates how soft or hard the surface the sound bounces off.

Wet/dry mix - Balances the original version of the sound which is the dry version, and the reverberated version which is the wet version.

2.5.3 Spatial Sound

Spatial sound is a way to mimic realistic sound environments, where audio is represented in a 3D space and audio can be located based on which channels its played from in a stereo system. A study at Aalborg University concluded that spatial sound granted higher levels of immersion and emotional engagement, compared to non-spatial sound in a horror game [29].

2.5.4 Panning Sound

A panning sound occurs when the position of an audio signal is shifted between the left and right stereo channels during playback. This spatial effect adds a sense of movement and depth to the sound. When used deliberately, panning can simulate a sound source moving across a space, for example, footsteps passing from one side to the other. In horror sound design, sudden or unpredictable panning can be especially effective, as it creates disorientation and tension, making the listener feel as though something is moving just out of sight [4].

2.5.5 Distortion

In horror sound design, distortion is used to intentionally deform audio signals, crafting abrasive and unsettling textures. By driving sounds beyond their natural limits, distortion introduces harsh harmonic content that evokes tension, chaos, and fear. This gritty, aggressive quality is frequently applied to elements like screams, mechanical noises, or ambient drones to heighten unease and disorient the listener. Once dismissed as an undesirable artifact, distortion has become a vital tool for shaping the disturbing and otherworldly sonic landscapes that define horror media [68].

Distortion has many properties, but the most effective and noticeable are the following:

Gain - The Gain controls the input level going into the distortion circuit. Higher levels of gain causes more clipping and intense distortion effect.

Clipping type - The clipping type defines how the waveshape is altered when it exceeds its limit. This can be done with a hard clipping that cutoff waveform peaks more harsh and aggressive, or with a soft clipping that gentlys rounds of peaks.

Tone/EQ Shaping - The Tone/EQ decides how the frequencies of a sound are cutoff or boosted before and after the distortion is applied. The Tone/EQ can be focused on low, mid or high frequencies and grant them respective effects.

2.5.6 Pitch

The pitch of a sound is at what frequency a sound is. A high pitch can be perceived as a very sharp and shrill sound, which is unpleasant to the hum ear if the pitch is too high. On the contrary a low pitch is perceived as a deep and heavy sound which can be used in horror to evoke feelings of dread and unease [2].

The pitch effect of a sound can be manipulated in various ways such as turning it up or down to get a different feeling from the original sound, or creating sudden changes in the pitch which can enhance suspense in the audience, or it can be used to scratch a sound, making it more eerie and enhance dramatic moments [2].

2.5.7 Defying Expectations

When building suspense in a horror game, many sound effects can be used to signal tension, such as those mentioned earlier. For instance, a reverb that gradually shrinks can suggest that a threat is approaching, or a specific sound cue might indicate that something is about to happen. Over time, these cues form a kind of audio "recipe" for suspense, which will be a pattern the player begins to recognize and rely on [43].

However, to keep the player engaged and unsettled, this pattern must occasionally be broken. Just as the player starts to understand when they are safe or in danger, the rules can shift — a threat might appear without any warning cues, defying their expectations. This kind of subversion keeps the experience unpredictable and maintains tension throughout the game [43].

2.5.8 Proximity

The proximity of a sound is how far away it is perceived by the player, which can be altered by using spatial sound, adjusting volume levels, using the reverb effect and changing the frequency detail. all these effects can create the wanted proximity and alterations wanted. Alterations in proximity can evoke strong emotional responses such as shivers or chills, especially if a sound moves closer to or right past the player [26].

2.5.9 Qualitative Properties of Sound

Qualitative properties of sound is concerned with how players interpret and perceive sounds within the context of the game. These studies explore the contextual meaning of sounds and how the player's past experiences, culture, expectations and context influence the perception of sounds. Acousmatic sounds refers to sounds that do not have a visible originating source or cause and play a crucial role in increasing the player's anxiety in horror games [23].
When a player is unable to locate the cause or source of a sound, it can increase the sensation of anxiety. This ties into the broader fear of the unknown, where the absence of visual confirmation allows the imagination to fill in the blanks — often with worst-case scenarios. When players hear a sound but cannot identify its source, they instinctively interpret it as a potential threat. This reaction is linked to evolutionary survival mechanisms, as Parker and Heerema explain: "A prey animal that can only hear the predator is in an unknown amount of trouble, and it pays to believe the worst" [22][53].
Kromand expands on this by explaining how horror soundscapes are intentionally designed to keep players suspended between knowledge and ignorance. His concept of a "framework of uncertainty" describes how game audio can blur the boundary between diegetic (existing in the game's world and hearable by the character) and non-diegetic (post produced and non hearable by the character) sound. The missing barrier between diegetic and non-diegetic sound ensures that players cannot easily distinguish whether a sound belongs inside the game world or not, which strategically build the horror atmosphere [34].

Toprac and Abdel-Meguid found in their research that acousmatic sounds are likely to induce anxiety and fear, and that medium-volume sound effects are most effective for creating anxiety as it forces the listener to pay extra attention [65]. Breinbjerg reinforces this by highlighting that intentional ambiguity regarding a sound's location or source is essential to creating anxiety. He explains that the knowledge that "something is happening around the corner" heightens anxiety because it is both unseen yet heard, amplifying uncertainty [5][22]. This perspective is further supported by Ekman, who similarly argues that the uncertainty of an unseen sound intensifies its fear-inducing potential, as the player cannot predict its source or intentions. They researched sounds using localization cues to manipulate the scariness of four different sound samples. Sounds coming from behind the listener were generally perceived as scarier than those from the front [15]. This view also aligns with the

work of Reber, Schwarz, and Winkielman, who suggest that positive aesthetic judgments are strongly linked to how easy it is to process stimuli. Inverting this concept, sounds that are difficult to identify, localize, or assign meaning tend to evoke negative judgments.

While acousmatic sounds are often mentioned in studies on game audio and sound design, much of the existing research focuses on sound in general and does not examine acousmatic sounds as a distinct subject. Although some research has been conducted on acousmatic sounds, the topic remains understudied, and several studies emphasize the need for further investigation into the specific qualities and effects of acousmatic sounds [15][35]. Though qualities of acousmatic sounds, such as volume, timing, and location [65] and familiarity [35] have been researched, there is limited research on the practical implementation of acousmatic sound within games themselves. As a result, there is very little existing work to guide game developers in using these sounds effectively within interactive environments.

2.5.10 Relevance to this Project

This project does not aim to explore these specific properties. Instead, it aims to incorporate acousmatic sound into a game to explore to what degree it can increase anxiety. These insights are highly relevant to this project. By combining acousmatic sound design with technical audio techniques, such as reverb, spatial audio, pitch shifting, and proximity filtering, we aim to use sound as a central mechanic for evoking anxiety. The quantitative aspects of sound design help us fine-tune how these acousmatic sounds are experienced by the player. For example, manipulating reverb can suggest distance or vast, empty spaces, while spatial audio and panning can imply unseen movement around the player. Together, these technical tools enhance the psychological impact of the acousmatic audio and allow us to shape more effective, anxiety-inducing experiences. This combined understanding provides both theoretical and practical tools for optimizing our game's sound design to achieve a more immersive and anxiety increasing horror game.

3 Final problem statement

As stated throughout the analysis, horror is universally defined by its connection to fear, the immediate release of tension. However, the tension and anxiety leading up to fear is equally as important, as often utilized by popular genres such as psychological horror. This effect of "*prestimulus*" is the basis for the concept: fear of the unknown.
This entails techniques such as minimalist storytelling, where the absence of explicit detail in the story, requires the player to fill in the gaps using their imagination. Within the visuals, many other technics contribute to this sense of unease and missing information. Such as visual obscurity, which withhold clarity in order to keep the player in a constant state of anticipation. This is achieved by designing the layout and lighting around this idea, of making the player expect something to happen. Alongside these visual and narrative choices, narrative-driven sound design is used to reinforce the anxiety-driven tension of an anticipated fear. This research will utilise such techniques with the goal of manipulating player perception and emotional response. In particular, the study will focus on the role of acousmatic sound design, which involves sounds that originate from an unseen source, and its influence on anxiety.

Having reiterated the findings, the initial problem statement has been refined and has led to the final problem statement:

"To what degree does acousmatic sound design increase horror-game-player's anxiety, compared to the lack thereof, in a psychological horror game based on fear of the unknown?"

4 Methods

The aim of this project was research to what degree acousmatic sound design can increase anxiety in a psychological horror game compared to the lack of acousmatic sounds. To answer this, 2 versions of a horror game were developed: A version without acousmatic sound design, and a version with acousmatic sound design, with the acousmatic sounds being the only thing distinguishing the two versions. The game was developed with Unity Engine 6 [66]. To evaluate whether the version with acousmatic sound design was successful in increasing anxiety in players compared to the version without, A/B testing was done to compare the two versions. Based on research into the physiological responses associated with anxiety, the evaluation included the measurement of HR and GSR, inspired by methods used in horror research and related studies [3][47][51]. Data collection in the test also included quantitative data from a questionnaire across four categories: Focused Attention, Reward, Anxiety and Sound, inspired by O'Brien's User Engagement Scale [49], as well as qualitative data from interviews. It was analysed whether there were any differences in the anxiety levels reported by the questionnaires, HR and GSR data and the interviews.

5 Design Requirements

Design requirements were established based on discussions about the creative vision for the game, as well as how to incorporate the theory that was covered in the analysis.
For the creative discussions, a group brainstorm (Figure 10) was held, where the members of the group outlied the most important aspects of the project based on the MDA framework (see Section 2.2). Initial core mechanics were decided, followed by the dynamics of these mechanics which then formed a clearer vision for the game. From this, the focus shifted to the taxonomy of aesthetic effects (Figure 1). Four effects were chosen as the main focus points moving forward into the design process, those being Sensation, Narrative, Challenge and Discovery. From this, discussions about each effect branched out into a multitude of design choices being made, such as art style, narrative setting, sound design and game mechanics, while incorporating theory previously discussed in the analysis (see Section 2.2, 2.3, 2.4, 2.5).

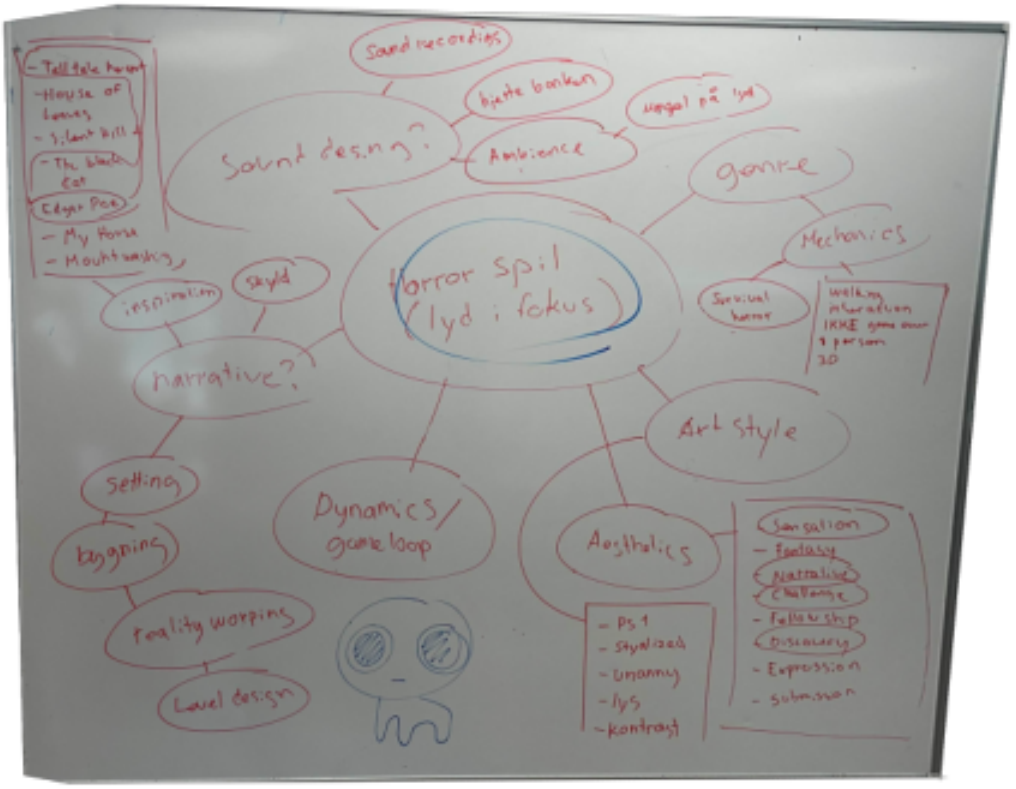

Figure 10: Aesthetic Effects Brainstorm

After narrowing down the scope and vision for the project, the design requirements were established and set up as a combination between Functional and Non-Functional and GameFlow elements modified to suit the project, these can be seen on Figure 11.

Design Requirements		
Principle	**Functional**	**Non-Functional**
Aesthetic Effects	The game should revolve around the aesthetic effects sensation, narrative, discovery and challenge.	Every design choice will be rooted in achieving one of the chosen aesthetic effects
Control	The player should feel a sense of control over their actions in the game.	The game will give the player free movement and interaction within confined areas and with specific objects. Achieving a sense of control while still following the planned gameplay route.
Concentration	The game should require concentration, and the player should be able to concentrate on the game.	The game will provide a limited field of view and lighting, requiring player focus in order to properly navigate the world.
Clear Goals	The game should provide the player with clear goals at appropriate times.	The player will be guided towards obtainable objects in the game with the use of spatial sound design.
Feedback	The player must receive appropriate feedback at appropriate times.	The player will receive interaction clues upon opportunities to interact with objects in the world, along with appropriate sound clues to go along with said interactions.
Immersion	The player should experience deep but effortless involvement in the game.	The game will provide spatial audio along with limited visuals and lighting which will push the player to engage heavily with the world, potentially increasing immersion.
Acousmatic Sound Design	The player should encounter acousmatic sounds throughout the game.	Acousmatic sounds must be placed in accordance with the path required to complete the game, ensuring that the player encounters them.
Fear of the Unknown	The player should experience a sense of anxiety or unease.	The game will put the player into situations where the previously discussed elements along with a lack of knowledge should provide an uncomfortable unknown situation that leads the player to become anxious.

Figure 11: Design Requirements

6 Design

This chapter will present the major decisions made throughout the design process of the project. The focus of this segment will be on narrative, visual and auditory design choices which shape the mechanics, dynamics and aesthetics of the game (see Section 2.2). Each decision was guided by the goal of enhancing the player's experience and reinforcing feelings of suspense and anxiety while playing the game. As previously explored during the analysis, there is no definitive blueprint to follow when designing a horror game. However, for the course of this project, the principles of "less is more" were followed and led to the following choices in order to best invoke anxiety.

6.1 Story

When designing a narrative for a video game, there are several factors to consider. These factors could be how the story should develop, where to take inspiration and where to be original and overall thematics and the objects in play thereof. This section will convey the thought process and decisions on how the story of the project's horror game was shaped.

6.1.1 Development and Adaptation

Early in development, it was decided that the narrative would be based on an existing story, rather than creating a new story. This was done to scope the project to be done within the allocated time frame and to work off of the themes and predefined storylines that have seen success within the horror genre. Ultimately Edgar Allan Poe's famous short story "Tell-Tale Heart" was chosen [54].

Tell-Tale Heart is a story about a man going insane by the sound of the beating heart of his own long deceased victim [13]. The story is short and to the point, delving into themes of guilt and lunacy, while depicting a classic grotesque staple: Murder. Furthermore, the idea of an ever-changing house was inspired by the novel 'House of Leaves' by Mark Z. Danielewski [42] in order to further explore the narrative mind of an insane individual. 'House of Leaves' is a story about a family who moves into a new home, where the house is not as it seems. Appearing small on the outside, but having an infinite amount of rooms that never stay the same on the inside.

This concept establishes the foundational settings for the game's environment, which evolves as the narrative progresses. The game begins in a modern home, referred to as the 'Victim Home', featuring contemporary furniture and décor. Once the storyline in the Victim Home unfolds, a staircase transports the player to the next phase.

The second setting mirrors the first in architectural layout but shifts in time: it's styled with 1970s furniture and wall treatments, giving it a distinctly retro aesthetic as is referenced as 'Childhood Home'. This temporal transition hints at a deeper narrative layer while maintaining spatial familiarity.

The final environment is the protagonist's former workplace, referenced as 'The Office' and shares the same structural design as the previous homes. However, this setting introduces a surreal twist, echoing the infinite, shifting architecture of *'House of Leaves'* [42], with seemingly endless rooms and corridors, enhancing the game's psychological atmosphere.

It was decided that the story should be told through cassette tapes found in the environment. Instead of finding tapes from a lunatic, objects relating to the incident that had taken place would be found. This structure of telling the story by finding fractured bits instead of being directly told a cohesive story, was chosen to support the notion of not forcing horror on the player, but instead letting them create their own horrors from the absence of information in the narrative, utilizing the concept of FOTU (see Section 2.1.2).

Several iterations of how the story would progress were discussed and drafted. Ultimately the final story was decided upon being a simple one. This was decided on to follow the notion that whatever narrative is created, it can never match up to what the players themselves conjure up, when letting their minds speculate (see Section 2.3). Thus, the story on the surface is being caught in the footsteps of following a murderer, but concealing more in its underlying nature. This allows the possibility for a deeper narrative in multiple directions, while still adhering to the 'less-is-more' principle of Fear of the Unknown (see Section 5).

6.1.2 Character and Storyline

A screenplay was written to plot out the narrative and pace out the storytelling and dialogue in the tape recordings (see appendix 11).

The player is spawned into a closed room with a single door. When going through the door, they arrive in a modern suburban house and are met with a victim outline on the living room floor, accompanied by a shadow. As they step closer to it, the shadow spirals inwards and disappears, leaving behind the text written in blood "Follow the beat" and rewarding the player with their first cassette tape.

From here on the story unfolds, as told through the tapes left behind by what is referred to as 'The Narrator'. Going through the three different iterations of the same house, finding different 'objects' that have some form of relation to whatever 'The Narrator' decides to talk about, while retaining an off-putting feeling by being either grotesque or paranormal. These objects would then be accompanied by shadowy figures looming and a constant beating heart guiding the player forward until the sound crescendos at the last setting in the office, where the shadows and a physical heart erupt and consume the player.

This is the surface-level experience from the players point of view. Underneath this, lies a story that is meant to be excavated by perceptive players. Themes like sins of the father, told through the second level, where the players are placed in the décor of a childhood home and told ramblings about a dysfunctional childhood from 'the narrator'. Or schizophrenia, with certain notes from the player avatar, like when finding the time sheet (see figure 12) =: "... I used to work here as a janitor...". This was meant as a subtle hint towards 'The Narrator' and the player themselves perhaps not being so different people after all.

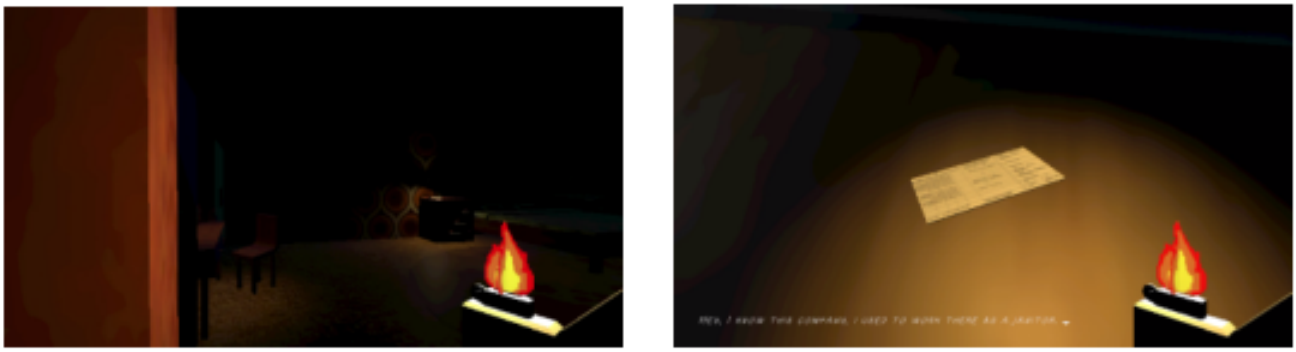

Figure 12: Screenshots of childhood home and the timesheet object respectively.

All the story threads were purposely left ambiguous, none necessarily being the right answer, with the goal of supporting the notion, that the players themselves will concoct their own interpretation of the narrative, yielding greater uneasiness and fear.

6.1.3 Tapes and Objects

In the pursuit of foregoing a heavy-handed approach to the story, while still feeding players minimal narrative bits to keep them anxious and engaged in the environment created, the idea of the aforementioned tapes arose. This supports the principle of concentration and immersion (see Section 5), as the the short bits of dialogue lets the player get invested into seeking more tapes and uncovering more of the story. At their core, the tapes are adhering to the whole notion of Fear of the Unknown (see Section 5), letting the players become anxious from an overall lack of knowledge. The tapes were designed to mimic a lunatic, breathing, and talking manically into a recorder as he is recounting his past. With them, vague storytelling of what might have occurred, or will occur, is placed throughout the game, serving as eerie breadcrumbs to the overall narrative. The previously mentioned narrator will recount different anecdotes based on the object that is found and tied to the given tape.
The objects come as means to guide the narrative thread forward, which ultimately pushes the whole game experience forward.
As the objects are found throughout the game by following the sound of an increasingly louder beating heart, they adhere to the principle of Clear Goals (see section 5). Adding to this, the given objects are vague, letting the player at first hand generate thoughts and ideas as to how they add up to the overall narrative, which follows the principle of Fear of the Unknown (see Section 5). They are designed to relate to either the victim or the perpetrator. The first part of the game takes place in what is referred to as the victim home, where every object found is something connected to the victim; an eyeball, an arm, or the time sheet from a workplace. These objects let the narrator ramble about his own wants and needs regarding the given victim. Then, as the transition up the stairs occurs, the player is transported to the referred childhood home, which contains objects that all relate to the narrator himself but also functions as 'what ifs' for the tools used for the murder that occurred.
Having the objects and tapes in unison like this allows the story to go into raw, grotesque, and unnatural turns, which generates this uneasy feeling throughout the investigational adventure the player embarks on.

6.2 Visuals

The visual design is primarily centred around the chosen aesthetic effects; Sensation, Narrative, Challenge and Discovery (see Section 5). The visual features; style, environment, characters, colour and lighting, serve as the categories of all design choices made in regards to the visuals (see Section 2.4).

The desired sensation the player should feel is a sense of unease and discomfort. To achieve this, the style of the game utilizes the uncanny nature of older games, by mimicking the limitations of older software (see Section 2.4.1). This choice of style greatly impacts the design of the environment. As the environment must adhere to the look of older games such as the first Silent Hill (see Figure 3). To further lean into the uncanny, the layout as well is designed to convey a sense of familiarity that is unnatural. Such as the use of a normal setting with unnatural scaling or warping, creating either strange emptiness or confinement. This effect of anxiety, created by not knowing where you are headed, is the same reason why most doors in the game are closed. However, in some cases doors are left slightly or completely open. This is used sparsely and is done to communicate that something is different, which causes the player to expect something to happen. Whether or not a payoff is given, such as a sudden noise or a light flicker, the player becomes anxious of something happening. This same effect is created by large empty rooms. Such as in the kids-room in the first environment (Figure 13), which contain a limited amount of furniture and a single light source.

Figure 13: First environment:Kids room.

In Figure 14 the layout of an area within the game can be seen. This figure includes an early version and the final version. The changes in sizing of the rooms can seen as well, with some rooms becoming larger while others shrink. In this area a hidden room can also bee seen which later reveals a large staircase, which adds to the strange and uncanny construction of the layout. The environment also plays a significant role in conveying narrative and encouraging discovery. Each area symbolizing different time periods and relations between the characters, indirectly contributing to the storytelling (see Section 2).

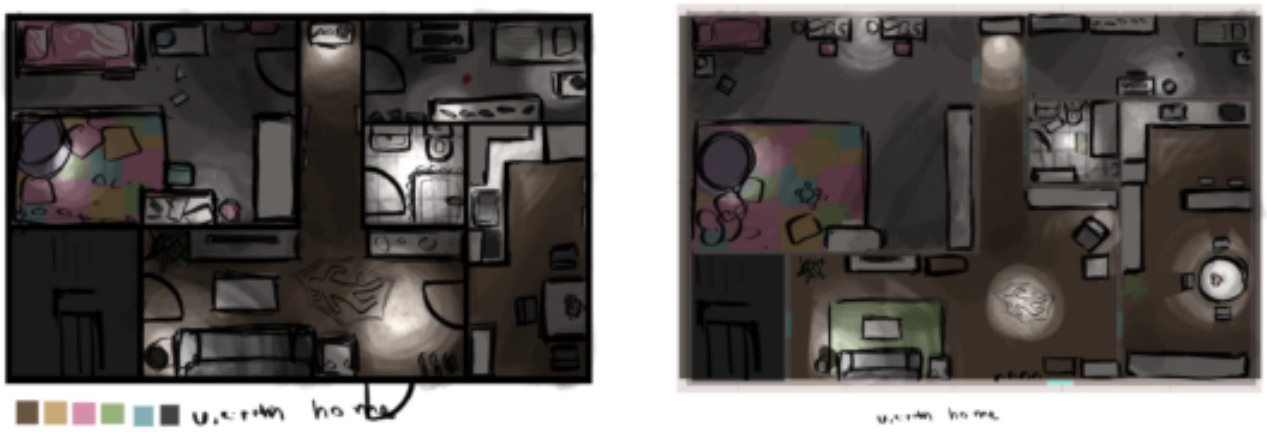

Figure 14: Layout of an area in early stages of development and the final design.

Characters as a visual tool, is another form of narrative and sensation in the design (see Section 2.4.3). The main Character of the game is not shown. As to achieve empathy and immersion, the game is played in first person through the protagonist. Another type of character which appears in the game are passive entities (shadows), which emerge as short visual and auditory events. In contrast to enemies, they do not serve as a means to evoke fear. Instead they contribute to the sensation and narrative.

Figure 15: A shadowfigure at the start of the game, guiding the player to the tape and revealing the text "follow the beat".

To strengthen the feelings and time periods the environment is trying to convey, appropriate colour-pallets have been chosen as well. Such as the use of dull and desaturated colours which are used to convey loss and sadness (see Section 2.4.4). Or colours that appeared in many homes in the 70's-80's, to convey that time period. Application of this in the game can be seen in Figure 14, where were the absence of colour convey its modern time period and the few colours convey children living here. However, the dull and gray colour pallet also conveys a sense of sadness and quietness, which is meant to symbolise that something bad happened taking away the life and joy of the environment.

The lighting of the game is important in relation to both atmosphere and the players means of getting around. To satisfy both criteria, the light in the game is low-key, with few light sources and a short range light which follows the player. Making the light have an impact on sensation, discovery and challenge. Based on the desired effect such as tension or setting, the light throughout the game is tinted a specific colour as well. Such as all lights becoming red, at the highest point of tension within the game (see Section 2.4.4). In Figure 16 the different types of lighting can be seen, as the game reaches its climax. A light following the player can be seen, in the form of a lighter. Meanwhile, the rest of the scene appears dark, with only a single light source above the water-dispenser. Further in, appears to be a room filled with blood and a single red light.

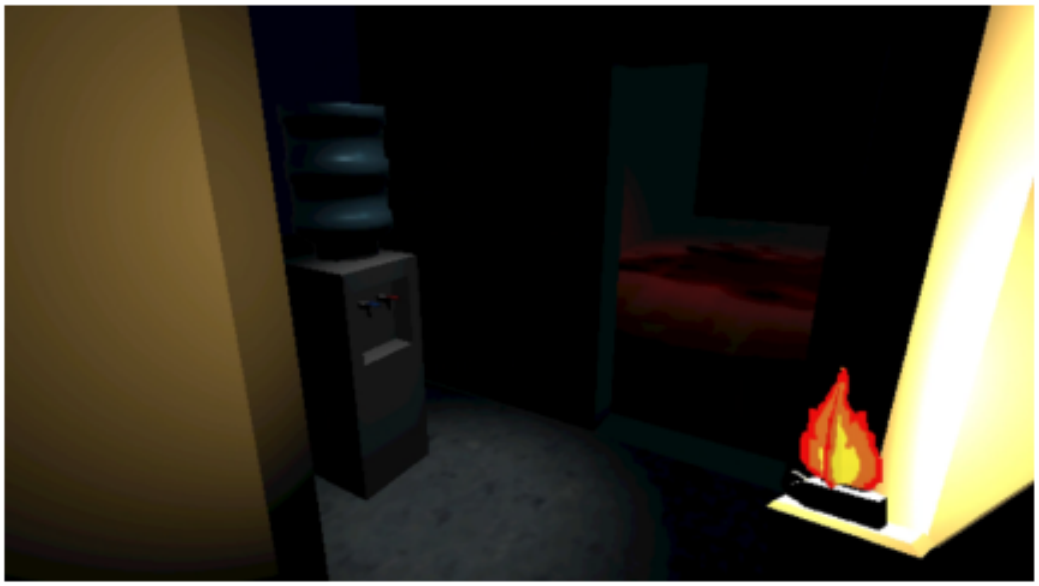

Figure 16: Lighting right before the climax of the game.

Thus the visuals are designed to fulfil the chosen aesthetic effects; Sensation, Narrative, Challenge and Discovery in many different ways. With the visuals having more impact on some than others. In the process of achieving the aesthetic affects other requirements (see Section 5) are accomplished as well. Immersion being obtained by achieving the aesthetic effects, as well as "Fear of the Unknown" being the tool utilized to create sensation within the game. As well is control and discovery closely tied in regards to the visuals, as by creating an interesting and intractable environment both criteria are fulfilled. As mentioned in the non-functional requirement for concentration (see Section 5), the design of the light will contribute to the games need for concentration from the player.

6.3 Sound

Sound design plays a crucial role in shaping the overall experience of a horror game, deeply influencing the mood and how players interpret the unfolding narrative. In this game, the sound design is crafted to create an unsettling environment, filled with off-putting and ambiguous audio cues that immerse players in psychological tension. Most importantly the soundscape should impose a great deal of suspense on the play by utilising different sound effects (see Section 2.5).

The sound design is structured around three distinct parts of the game: the victim's home, the childhood home, and the office. In the first two parts, which take place in the victim's home and later the childhood home, the game features realistic but subtly obscured sounds such as a dripping faucet, a stove hood, lamp static, and a television. These familiar yet obscured sounds help ground the player in a recognisable reality while still fostering unease. They support immersion by creating the setting of the game as the narrative begins to reveal its more disturbing layers.

In addition to the natural sounds each scene includes a unique background horror ambience. The ambience is different in each scene to indicate the progress and new chapter of the story, yet they are similar in mood and feelings, as they both are not too aggressive and gushing, but more unsettling and creating a subtle horror setting of anxiety.

A significant shift occurs in the final part of the game, which is set in an office. Here, all environmental sounds are transformed to feel 'void-like' or submerged, as though heard underwater obtained with suffocating reverb filters on all surrounding sounds. This audio manipulation marks a turning point, and for the first time any doubt about the environment being realistic or not vanishes. The

surreal soundscape reinforces the sense that the situation has become more serious, psychological, and supernatural.

6.4 Acousmatic Sounds

The game features three key acousmatic sounds that are each designed to provoke anxiety and grant glimpse of another perspective on the narrative. These acousmatic sounds were only a part of the sound design in the B version of the game, while the A version contains the exact same sound design except for the three acousmatic sounds.

The first acousmatic sound is an obscured cheerful child laughter, with a kid that actually sounds happy, which by being contrapuntal, makes it more unsettling. This is the introduction of acousmatic sounds and throws the player off as it does not have any visual source of the sound, which should spark the doubt of whether the game is in a realistic setting. The sound contains a deep inhalation symbolising the sounds takes the character back with a quick breath to a distant memory.

The second acousmatic event occurs on the staircase connecting the victim's home and the childhood home. It features another reversed breath to signal its otherworldly nature, accompanied by faint, unintelligible whispers. These whispers represent the protagonist's subconscious attempting to pierce through their delusional perception. Their low volume encourages focused listening, getting the player to be even more on edge.

The final acousmatic sound triggers when the player enters a room containing one of the hidden murder weapons. Suddenly, rapid footsteps pass closely by the player, as if someone - perhaps the one who hid the weapon - is rushing past. This use of proximity and directionality reaches the peak of the game's tension so far. This sound also defies the players expectations as the two previous acousmatic sounds were soft and reverberated when they easily sneaked up on the player, while this sound suddenly appears and storms towards the player unlike any earlier sounds, which should further enhance the suspense and anxiety by breaking the former audio "recipe".

6.5 Iterations

During the implementation of the product, different iterations were made to test some mechanics and design choices, and determine changes to them. Specifically two iterations were made, one for testing the movement and environment, and the second to test for anxiety.

6.5.1 Movement and Environment Test

The movement in the game was implemented using a simple first person controller which makes the player able to walk using the WASD keys on the keyboard and the mouse to look around. At the beginning of the project, a "Movement and Environment" test was conducted with five participants from Aalborg University in Copenhagen. The purpose of the test was to ensure that the basic mechanics and the environment of the first scene in the game were intuitive and did not hinder immersion. The participants were diverse in age and gender and included both gamers and non-gamers. During the test, they received instructions and follow-up questions regarding their experience with each mechanic and the surrounding environment.

Movement and Environment Test		
Question	**Example of feedback**	**Changes made based on feedback**
"How does it feel to couch?"	"It is intuitive to push "Control" to crouch, but maybe it could be a bit slower" (TestID - 3)	Kept the crouch at control, but changed the speed and depth of the crouch.
"How does it feel to interact with objects in the game?"	"Pushing E makes sense for interacting. Outline is okay, but an icon would work better than text" (TestID - 3)	Removed interaction text and outline and added interaction icons instead of.
"Is it intuitive to use the inventory?"	"I feel that is it intuitive to use I, but now that the concept has been explained, I think J would be better for Journal" (TestID - 5)	Changed opening the journal from pressing I to J
"How does it feel to move around and explore the game?"	"Looking around seems a bit slow, while walking around seems a bit fast" (TestID - 2)	Change the mouse sensitivity to a higher sensitivity and slowed the movement speed down a bit.
"How does the size and proportions of the surroundings seem?"	"It seems natural with a bit large room. It's nice with some size difference from room to room"	No changes made to the environment.

Figure 17: Changes based on Movement test

Based on feedback from multiple participants, adjustments were made to ensure that the core mechanics were solid, allowing key design decisions to be confidently developed and implemented.

6.5.2 Anxiety Test

After developing the first of three scenes in the game—focusing on core design choices—a second user test was conducted with five new students from Aalborg University in Copenhagen.
The purpose of this test was to gather user feedback on how players experienced the first part of the game, in order to determine whether the current design choices should be implemented in the rest of the game. The test consisted of two parts:

- Part 1 – Gameplay Session: Participants played the game alone in a dark, isolated room to simulate an immersive horror experience. A livestream of the gameplay, along with a video feed of the participant, was sent to two group members in a separate room. Participants were informed of the following:
  - No footage or recordings would be saved.
  - They could end the test at any time by waving to the camera. These measures were put in place to ensure the participants' comfort and consent throughout the process.
- Part 2 – Structured Interview: After gameplay, participants took part in a structured interview focused on various aspects of the experience, including the environment, lighting, narrative, and their sense of fear during the playthrough.

The interview questions and answers can be seen in Appendix 1.

Anxiety Test			
Theme	**Question**	**Example of Feedback**	**Considerations**
Environment	"Did you feel lost or disoriented while exploring?	"Only in the beginning where I had to find all the doors, but I thought it was great. I would even like to spend more time exploring to get an overview" (TestID 5 – Male 22 years old)	The level design works and intrigues exploration.
	"Did any particular locations make you feel uneasy? Why?"	"The tent in the kids' room was quite creepy. It was also a big room I had to go far into. It was a big commitment." (TestID 2 – Male 22 years old)	Darkness and distance seem to amplify a feeling of creepiness.
	"Did you find the experience engaging? Why?"	"Yeah, I'd say so. I think it was sometimes hard to hear what the tapes were saying. The tapes are fine, it was just hard to follow, because you are also focused on looking around. I think it's hard to balance it" (TestID 2 – Male 22 years old)	A few bugs in the tape-interaction both in the gameplay and journal were fixed after the test.
Lightning	"How did your lighting affect your ability to control the player's character?"	" I feel the lighting was pretty decent, I feel it was a little too orange which was a little odd and a little sharp. You could see so that was fine, but the colour choice was odd." (TestID 1 – 27 years old)	A lighter will be added later, which most likely will clarify the choice of colour and light.
	"How did the lighting make you feel while you were exploring and why?"	"I felt like it made me look more around, because I could create an overview right away. The darkness kind of forced me into every room to look around." (TestID 4 – 24 years old)	Lighting is very important in a horror game, and it seemed to work in this scene.
Narrative	"Did you feel like you were presented with enough of the narrative? Too much narrative?"	"It was cool to not have that much of the narrative and slowly piecing the story together." (TestID 3 – 22 years old)	The narrative seems to work so far and intrigues the participants.
	"Were there any story moments that made you feel particularly anxious or intrigued?"	"The eye, and just the general voice-over. It was scary to have some lunatic talking to you" (TestID 3 – 22 years old)	Unsettling audio and visual elements are effective for creating tension and should be further utilized in the story.
Experience of Anxiety	"Did you feel like you were being watched or followed?"	"As soon as the heartbeat started, many games have sound queues to alert you to danger, so when I heard that I figured something be happen." (TestID 2 - 22 years old)	Now that this effect works it can be implemented in the rest of the game.
	"Did you feel anxious while playing?"	"A little bit, but mostly because I was anticipating a scare when interacting with the world." (TestID 1 – 27 years old)	This shows that anxiety is created in the first scene.
	"Did you feel afraid, without knowing why at any point?"	"After finding the first tape, it was a bit creepy to be in a new place where something evidently happened." (TestID 5 – 22 years old)	Environment and tapes grant a feeling of fear as wanted.
	Any last comment?	"I wanted to continue playing" (TestID 5 – 22 years old)	Overall, the first scene seems to intrigue and scare the participants

Figure 18: Feedback from Anxiety Test

7 Implementation

This chapter will present implementation of visuals, mechanics and sound, and the decisions made for each, based on the analysis.

7.1 Visuals

The visuals of the game, play a large part in the overall experience while playing the game. It as well, impacts and contributes to the story, mechanics and feelings of the player while they experience the game. Therefore every visual input matters. As described in Section 6.2, a multitude of choices were made and the following segment will delve deeper into the implementation of various visuals within the game.

7.1.1 3D Modelling

As previously mentioned (see Section 6.2) the game takes inspiration from older 3D games and the limitations they faced. Each model in the game, made within the modelling program Blender [17], was therefore made with a lower polygon count. The technic of applying a rendering mode called "shade smooth" was also used. This was done to mimic tricks older games would use to mask the low polygon count. Another notable design choice of the 3D models, is the lower resolution textures. Like the polygons, this was done because older games were also limited in pixels. An example of a finished 3D model with these techniques applied can be seen in Figure 19. Besides the 3D models themselves the rendering resolution was also changed to mimic older games. This was done by creating and applying a render texture in Unity, with a lower resolution (can be seen in Figure 21).

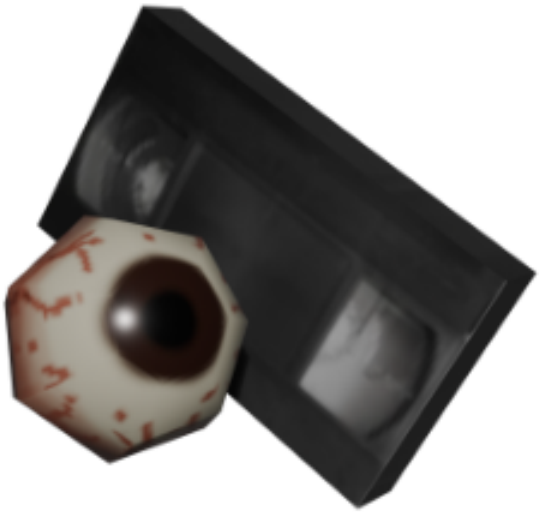

Figure 19: Eye and tape render.

7.1.2 Environment

The environment design is very deliberate, as the layout is integral to the storytelling and so is the placement and inclusion of different objects throughout the environment. As seen in Figure 20, 3 distinct locations appear in the game yet they all share the same room layout. This is important to the story, but it also contributes to the desired uncanny design of the environment. The size and purpose of each room is also considered, as this also holds meaning in the story and the uncanny environment.

Figure 20: Layout of all 3 environments: victim's home, childhood home, and office.

Objects and lights are placed as a means of communicating the purpose of the room, such as a child's bedroom, a bathroom or a kitchen. However most placements of objects and lights are also strategically placed to induce anxiety. Such as the two shelves placed before the sofa in the second environment encountered in the game (Figure 21). As they block the view and walking-path of the player they must manoeuvrer themselves around without immediately knowing where they are headed. As well, is their only light source their lighter-light and the light coming from the TV by the sofa.

Figure 21: Second environment: Living room behind a shelf.

7.1.3 Animation

A range of animations is used throughout the game, activated either by player interaction or scripted events. Some of the animations, such as doors and drawers opening and closing were implemented directly in Unity through coding. These were handled through the use of coroutines with IEnumerator, which allows for timed animation sequences.

The RotateDoor method (Figure 22) is implemented as a coroutine and is responsible for smoothly animating the opening and closing of doors by rotating them to a specified target angle. This is achieved using linear interpolation (Mathf.Lerp) (Figure 22, Line 11) to transition from the door's current angle to the desired angle over time. The animation speed can be adjusted via a speed variable. The method is triggered whenever an interactable door is interacted with, and the targetAngle is determined by a boolean isOpen, which defines whether the door should open or close. Each door has its target angles defined in the Inspector. To prevent overlapping animations, a _isAnimating flag ensures only one animation can happen at a time.

```
1   private IEnumerator RotateDoor(float targetAngle)
2   {
3       _isAnimating = true;
4       float currentAngle = transform.localRotation.eulerAngles.y;
5
6       float time = 0f;
7
8       while (Mathf.Abs(currentAngle - targetAngle) > 0.1f)
9       {
10          time += Time.deltaTime * speed;
11          currentAngle = Mathf.Lerp(currentAngle, targetAngle, time);
12          transform.localRotation = Quaternion.Euler(xAngle, currentAngle, 0f);
13          yield return null;
14      }
15
16      transform.localRotation = Quaternion.Euler(xAngle, targetAngle, 0f);
17      _isAnimating = false;
18  }
```

Figure 22: RotateDoor IEnumerator

The ShakeDoor coroutine (Figure 23) simulates a locked door shaking when the player tries to interact with it. It begins by playing a locked door sound (Line 5) and starting a dialogue sequence using the lockedDialogueLines (Figure 23, Line 6). During the animation, the door's position is moved back and forth along a specified axis, x, y, or z (Figure 23, Line 11-19), for a set duration (shakeDuration) (Figure 23, Line 8), using a random offset within the defined range (shakeAmount) (Figure 23, Line 9). This creates a visual feedback to indicate the door is locked. Once the duration ends, the door's position is reset to its original state to stop the shaking (Figure 23, Line 24).

```
    private IEnumerator ShakeDoor()
    {
        float elapsedTime = 0f;

        SoundManager.Instance.PlaySound(source, lockedClipName);
        Dialogue.Instance.StartDialogue(new List<string>(lockedDialogueLines));

        while (elapsedTime < shakeDuration) {
            float shake = Random.Range(-shakeAmount, shakeAmount);

            if (shakeAxis == "x") {
                transform.position = originalPosition + new Vector3(shake, 0f, 0f);
            }
            else if (shakeAxis == "y") {
                transform.position = originalPosition + new Vector3(0f, shake, 0f);
            }
            else if (shakeAxis == "z") {
                transform.position = originalPosition + new Vector3(0f, 0f, shake);
            }

            elapsedTime += Time.deltaTime;
            yield return null;
        }
        transform.position = originalPosition;
    }
```

Figure 23: ShakeDoor IEnumerator

More complex animations were created using keyframe animation in Blender. These include sequences such as an eye rolling out of a wall and an arm jumping from a drawer. In some cases, both Unity scripting and Blender animations were combined. The animation of a floating, beating heart utilized Blender for the pulsating movement, while the floating motion was done in Unity. Additionally, the project incorporates animated textures, which were created using frame-by-frame 2D animation. At runtime, a script cycles through each frame by assigning them sequentially to a material, resulting in an animated effect (Figure 24). This technique is similar to the visual style found in older games, such as Silent Hill.

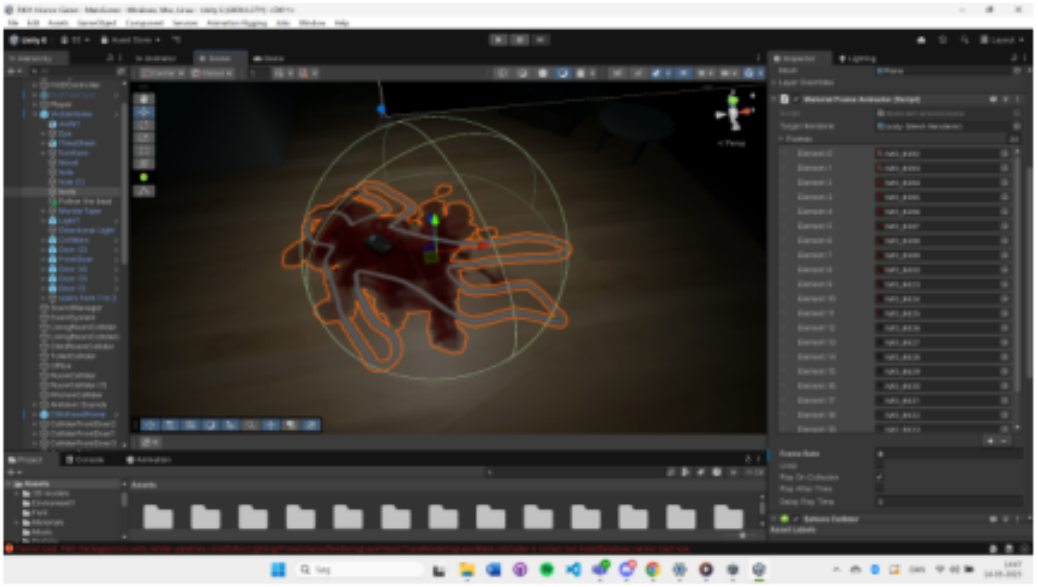

Figure 24: Unity scene and inspector view of custom texture animation.

7.2 Mechanics

This section aims to explain some of the implemented mechanics within the game. These include interaction between the player and objects, progression within the game and audio integration.

7.2.1 Interaction

Interaction works trough 3 scripts mainly. PlayerInteraction (Figure 25), Object (Figure 27) and Interactable (Figure 26). Each interactable object in the game has 2 different interaction types, Interact or Inspect. Interact is used for objects, such as doors and drawers that can be opened, Inspect is used for objects that the player picks up to look at.

The PlayerInteraction (Figure 25) handles checking for interactable objects. This is done by constantly casting a spherecast in the direction of the camera, which returns the first eligible game object hit (Figure 25, Lines 10-27). All 'Interactable' components are then stored in an array and iterated through a loop statement that skips any disabled components and subsequently stores the first enabled component in the 'newInteractable' variable (Figure 25, Lines 31-38) . When 'E' is pressed, the 'Interact()' method in the 'Interactable' script associated with the latest given game object is called (Figure 25, Lines 6-7).

```
1  public class PlayerInteraction : MonoBehaviour
2  {
3      void Update()
4      {
5          CheckForInteractable();
6          if (Input.GetKeyDown(KeyCode.E) && _currentInteractable != null)
7              _currentInteractable.Interact();
8      }
9
10     public void CheckForInteractable()
11     {
12         RaycastHit hit;
13         Ray ray = new Ray(Camera.main.transform.position, Camera.main.transform.
               forward);
14         float sphereRadius = 0.3f;
15
16         if (!Physics.SphereCast(ray, sphereRadius, out hit, playerReach, _layerMask))
               {
17             DisableCurrentInteractable();
18             return;
19         }
20
21         Interactable newInteractable = null;
22         Interactable[] interactables = hit.collider.GetComponents<Interactable>();
23
24         foreach (Interactable interactable in interactables) {
25             if (!interactable.enabled) continue;
26
27             newInteractable = interactable;
28             break;
29         }
30
31         if (newInteractable == null) {
32             DisableCurrentInteractable();
33             return;
34         }
35
36         DisableCurrentInteractable();
37         SetCurrentInteractable(newInteractable);
38     }
39 }
```

Figure 25: PlayerInteraction.cs

When 'Interact()' is called, a serialized manually modified 'Unity Event' is invoked (Figure 26, Line 11). This event can call any public methods in scripts attached to game objects, but was primarily used to call methods on objects the event (or rather, the 'Interactable' script) is attached to.

```
1  public class Interactable : MonoBehaviour
2  {
3      public UnityEvent interactEvent;
4      {
5          Inspect,
6          Interact,
7      }
8
9      public InteractionType interactionType;
10
11     public void Interact() => interactEvent.Invoke();
12 }
```

Figure 26: Interactable.cs

Inspect

Inspecting objects in the game is handled by a 'Object' script on the gameobject (Figure 27). This script has the functionality for picking up the object and being able to inspect it using the mouse to rotate it.

When an object is interacted with the object is moved to a predetermined position in front of the player camera (Lines 20 - 46). The player is able to inspect the object using the mouse to rotate it. This is done in the Update() method, wherein a directional Vector3 is calculated using the difference between a previously stored _lastMousePosition and the current mousePosition (Line 8). This Vector3 is then used to rotate the transform of the object on the x-axis and the y-axis (Lines 10 - 11).

```
public class Object : MonoBehaviour
{
    void Update()
    {
        if (!_isInspecting) return;

        // rotation of the object
        Vector3 deltaMouse = Input.mousePosition - _lastMousePosition;
        float rotationSpeed = 0.1f;
        transform.Rotate(_playerCameraTransform.up, -deltaMouse.x * rotationSpeed,
            Space.World);
        transform.Rotate(_playerCameraTransform.right, deltaMouse.y * rotationSpeed,
            Space.World);

        _lastMousePosition = Input.mousePosition;

        if (_isClue) return;

        if (Input.GetMouseButtonDown(0)) StopInspecting();
    }

    private IEnumerator SmoothMoveToPosition(Vector3 targetPosition, Quaternion
        targetRotation, Vector3 targetScale)
    {
        if (_isInspecting) Debug.Log("moving to new position");
        else if (!_isInspecting) Debug.Log("moving back to original position");

        float duration = 0.5f;
        float elapsedTime = 0f;

        Vector3 initialPosition = transform.position;
        Quaternion initialRotation = transform.rotation;
        Vector3 initialScale = transform.localScale;

        while (elapsedTime < duration)
        {
            transform.position = Vector3.Lerp(initialPosition, targetPosition,
                elapsedTime / duration);
            transform.rotation = Quaternion.Lerp(initialRotation, targetRotation,
                elapsedTime / duration);
            transform.localScale = Vector3.Lerp(initialScale, targetScale,
                elapsedTime / duration);
            elapsedTime += Time.deltaTime;
            yield return null;
        }

        transform.rotation = targetRotation;
        transform.localScale = targetScale;
        _isPositioned = true;
    }
}
```

Figure 27: Object.cs

Journal

The TapeInventory script manages the collection of tapes and the journal UI i. It allows players to view unlocked audio tapes, read their transcripts, and see images of the tapes and objects associated with them. The inventory can be toggled on/off pressing J. The script also tracks tape collection progress across two game areas and triggers specific events once all tapes in an area have been found to progress in the game, like unlocking the bathroom door.

The UnlockTape method (Figure 28) is called when a new tape is found and is responsible for registering it and updating the journal UI. The method replaces the "???" in the journal with the actual name of the tape, using the tapeName string passed as an argument. The method also changes the text color to indicate the tape is unlocked, makes the corresponding button interactable for player selection, and increases the total tape counter. Additionally, it determines which area the tape belongs to based on the tapeNumber argument and updates the corresponding area counter. If all tapes in a specific area are collected, this can trigger special in-game events such as unlocking a door or removing a bookshelf.

```
public void UnlockTape(int tapeNumber, string tapeName)
{
    if (tapeNumber >= 0 && tapeNumber < tapes.Length) {
        tapes[tapeNumber].text = tapeName;
        tapes[tapeNumber].color = unlockedColor;
        tapes[tapeNumber].gameObject.tag = _tag;

        if (tapeNumber < tapeButtons.Length) {
            tapeButtons[tapeNumber].interactable = true;
        }

        CountTapes(tapeNumber);
    }
    else Debug.LogWarning("Invalid tape number");
}
```

Figure 28: UnlockTape Method

The SelectTape method (Figure 29) manages the selection of a tape in the UI when the player clicks on it. It first checks if the tape clicked is already selected to avoid unnecessary updates. If a different tape was previously selected, the method removes its hover effect by accessing the HoverText component and resets its font style to normal. Then, it updates the currentlySelectedTape variable to the new tape number, which is passed as an argument into the method as int tapeNumber. It also disables the hover effect on the newly selected tape, and sets its font style to bold to highlight the selection. Finally, the method looks up the transcript for the selected tape in the _tapeTranscripts dictionary and displays it in the journal UI.

```
public void SelectTape(int tapeNumber)
{
    if (currentlySelectedTape == tapeNumber) return;

    if (currentlySelectedTape != -1 && currentlySelectedTape < tapes.Length) {
        HoverText previousHoverText = tapes[currentlySelectedTape].GetComponent<
            HoverText>();
        if (previousHoverText != null) previousHoverText.enabled = true;
        tapes[currentlySelectedTape].fontStyle = FontStyles.Normal;
    }

    currentlySelectedTape = tapeNumber;
    HoverText currentHoverText = tapes[currentlySelectedTape].GetComponent<HoverText
        >();

    if (currentHoverText != null) currentHoverText.enabled = false;

    if (_tapeTranscripts.ContainsKey(currentlySelectedTape)) {
        tapeText.text = _tapeTranscripts[currentlySelectedTape];
        tapes[currentlySelectedTape].fontStyle = FontStyles.Bold;
    }
    else Debug.LogWarning("Note number not found in content dictionary.");
}
```

Figure 29: SelectTape Method.cs

7.3 Sound

Sound plays a significant role in this project and can be encountered both voluntarily and involuntarily throughout the gameplay experience. All audio assets were either recorded or sourced from the online sound library Freesound [18] and subsequently edited using either the digital audio workstation Reaper [55] or DaVinci Resolve - Studio [28], before being implemented into the game. Some sounds, such as the static hum emitted by the in-game lamps, required minimal processing, primarily looping adjustments and volume balancing. In contrast, more complex elements, such as the acousmatic clips and the immersive soundscape featured in the final part of the game, which is set in an office environment, involved layering multiple audio samples and applying various effects to achieve the desired atmosphere. Tapes and event sounds were sorted into an AudioDatabase, from where the sound clips could be accessed through the SoundManager.cs.

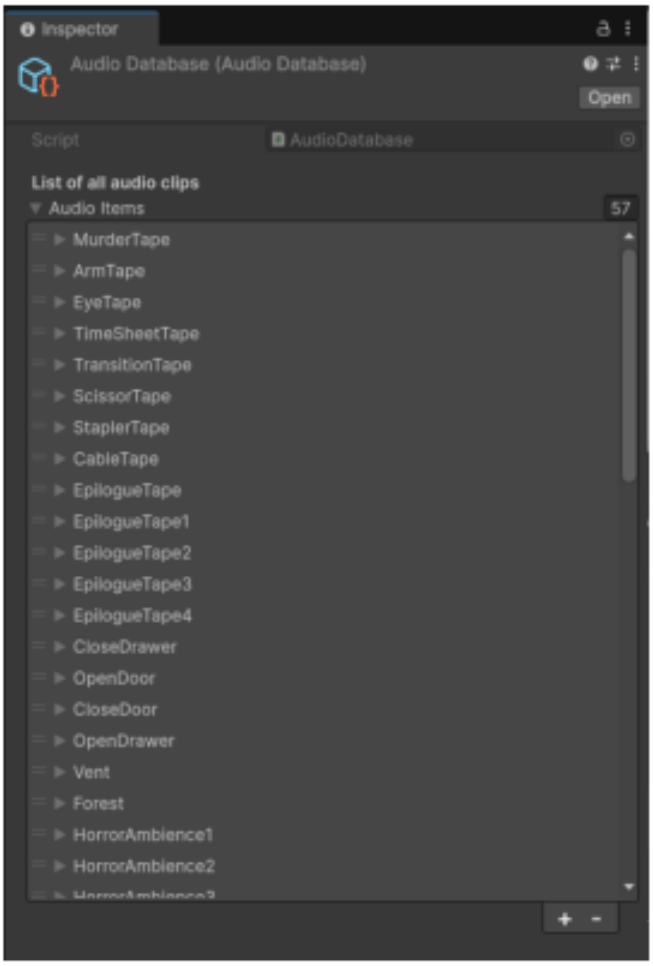

Figure 30: Audio Database

The SoundManager.cs manager controls how and when the audio clips are played via four overloaded methods, that reference an audio clip by either name, specific audio source, source key or from database index. Below one of the overloaded methods can be seen in Figure 31, where an audio clip is found in the audio database by its name. Once the clip has been found its assigned and played through the audio source attached to where the sound is coming. An example of this can be seen in the Bookcase script (see Figure 23).

```
        // Plays a sound using the default audio source
public void PlaySound(string clipName)
{
    PlaySound(defaultAudioSource, clipName);
}

public void PlaySound(AudioSource source, string clipName)
{
    if (audioDatabase == null)
    {
        Debug.LogWarning("AudioDatabase is not assigned!");
        return;
    }

    AudioClip clip = audioDatabase.GetClipByName(clipName);

    if (clip == null)
    {
        Debug.LogWarning($"Clip with name '{clipName}' not found!");
        return;
    }

    source.clip = clip;

    source.Play();
}
```

Figure 31: SoundManager.cs

7.3.1 Ambience and Effects

The ambient music that plays throughout the gameplay is controlled by Ambience.cs seen in Figure 32. Each level is surrounded by their own collider which I set to trigger the audio clip that is attached to the audio source of the collider. The script contains only two methods for when the player enters or exits the collider, making the ambient audio clip fitting to each scene play on loop, while the player is within the specific collider. Objects within each scene that contains a sound playing on loop throughout the entire game has an audio source attached with the fitting audio clip, that can be heard within a set 3D range as seen below on the television in the childhood home in Figure 33.

```
        public class Ambience : MonoBehaviour
{
    private AudioSource audioSource;

    private void Awake()
    {
        Collider collider = GetComponent<Collider>();
        collider.isTrigger = true;

        audioSource = GetComponent<AudioSource>();

    }

    private void OnTriggerEnter(Collider other)
    {
        if (other.CompareTag("Player"))
        {
            audioSource.Play();
            audioSource.loop = true;
        }
    }

    private void OnTriggerExit(Collider other)
    {
        if (other.CompareTag("Player"))
        {
            if (audioSource.isPlaying)
            {
                audioSource.loop = false;
                audioSource.Stop();
            }
        }
    }
}
```

Figure 32: Ambience.cs

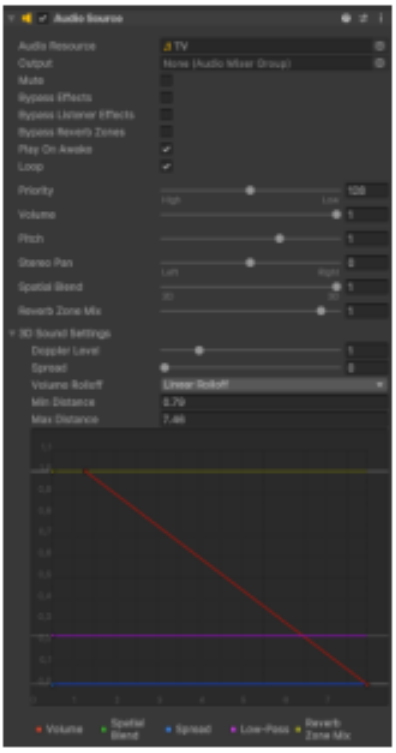

Figure 33: Audio Source

Some of the audio sources in the game have a 3D sound range that extends beyond physical boundaries, such as walls. This can lead to hearing unwanted sounds, for example the sink sound from the bathroom while standing in the bedroom. To prevent this, the OnOff_Sound.cs seen in Figure 34 includes a check that compares the player's current room with the room assigned to the audio source. Each room is identified by a unique roomID and has a trigger collider that tracks when the player enters or exits. If the player is not in the same room as the audio source, the script mutes the sound by setting its volume to 0f. When the player enters the correct room, the sound is unmuted and allowed to play normally.

```
    void Update()
    {
        if (roomTracker.currentRoomID == roomID)
        {
            if (!audioSource.isPlaying)
                audioSource.Play();

            audioSource.volume = 1f;
        }
        else
        {
            audioSource.volume = muted;
        }
    }
}
```

Figure 34: OnOff_Sound.cs

This system ensures a more realistic and immersive sound environment, where audio respects the layout of the game world and doesn't leak through walls.

7.3.2 Acousmatic sounds

The three acousmatic sounds were only implemented in the B version of the Game. For the A version all the acousmatics sounds were removed. In the B version the three acousmatic sounds are triggered when the player collides with their individual box collider. RoomAmbience.cs Checks for collision, and plays the audio clip once when triggered, and hereafter destroys the box collider, so it can't be triggered again.

Acousmatic Child Laughter
In this sound design, an audio clip has been edited in Davinci Resolve [28], using both equalization and spatial effects to create a sense of enclosed, distant realism: A parametric equalizer has been used to carve out unwanted frequencies and focus the listener's attention. Specifically, a narrow cut at 1.8 kHz (-17.1 dB) was applied to reduce harshness or competing midrange content, which helps create space for other elements in the mix. The sound was further shaped using a reverb effect emulating a small 12m² room (bathroom). A reverb time of nearly 2 seconds adds noticeable tail and decay, creating the impression that the sound occurs in a confined, reflective environment. High-frequency content was reduced in both the early reflections and reverb tail, which smooths the reflections and contributes to a more dampened, muffled character. The wet signal is fully maxed (100%), as the sound is meant to feel completely distant, without any direct signal presence.

Figure 35: Acousmatic Child Laughter

Acousmatic Whispers
In this acousmatic sound composition, three different audio clips have been edited to create an immersive spatial experience:

- A reverse breath clip is used without any additional effects, serving as a subtle buildup or transitional element.
- A sound clip of distant whispers has been divided into three separate clips. These are panned across the stereo field, moving from one channel to the other, creating an "ear-to-ear" effect that enhances the listener's sense of space and movement.
- A final breath clip has been processed with reverb to increase spatial depth, giving the impression that the sound gradually fades away or dissolves into the environment. The settings of the reverb sound effect can be seen in Figure 37.

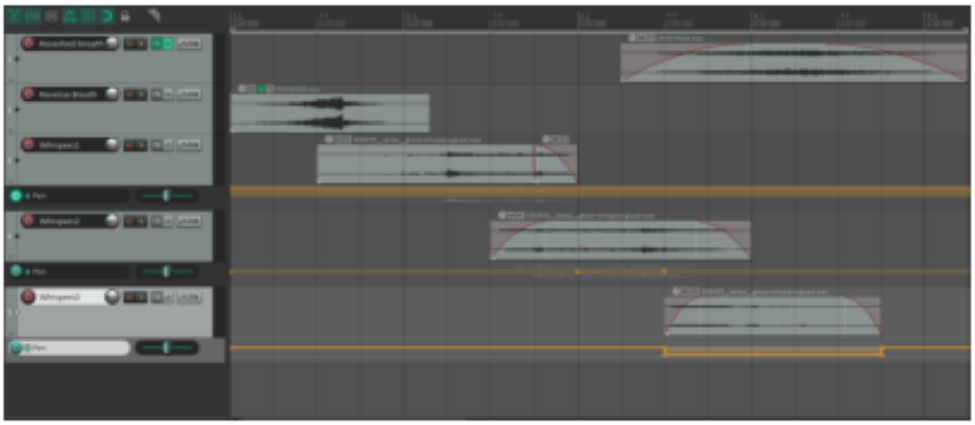

Figure 36: Acousmatic Whispers

Figure 37: Reverbed Breath

Acousmatic Run

In this acousmatic sound clip, a single audio clip of running footsteps has been edited and layered across three separate tracks to create a dynamic, spatial listening experience.
The original footstep clip is used on all three tracks, but with slight timing offsets and stereo panning automation, creating a sense of motion as if someone is running past the listener.

- On Track 1, a pitch shifter effect (ReaPitch) (Figure 39) has been applied to lower the pitch by approximately 2.83 semitones, adding variation and weight to the steps to make them feel more grounded and distinct from the others.
- Each track begins and ends with volume fades, contributing to a sense of depth and realism as the sound appears to approach and then recede.
- Combined, these edits generate a three-dimensional illusion of movement and direction, mimicking footsteps that pass by the listener from one side to the other.

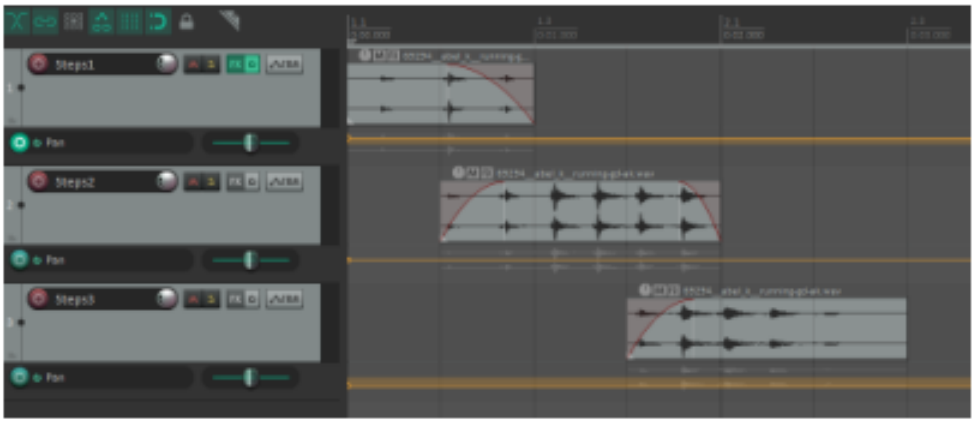

Figure 38: Acousmatic Run

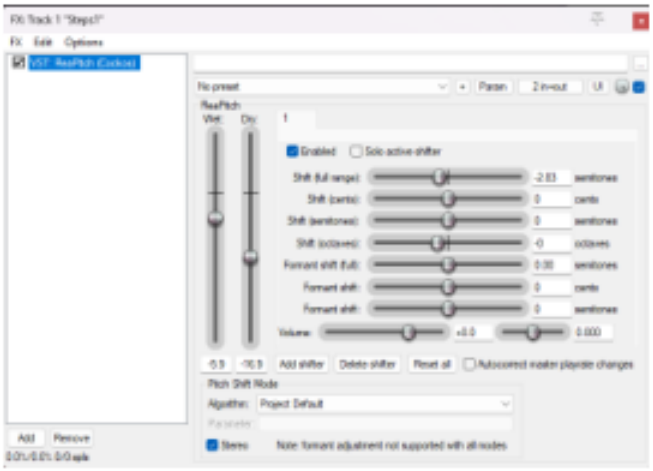

Figure 39: Run Pitch

7.3.3 Tapes

All tapes in the game were recorded in a home studio and edited in Davinci Resolve [28], where the same reverb filter used on the Child Laughter seen in Figure 35 were applied along with a distortion filter seen below in Figure 40. The filter contains a high level of distortion (82.4%) which applies some harsh overtones, along with a narrow frequency range (954 Hz-1.65k Hz) which reduces the sound quality and makes the tape sound old and worn.

Figure 40: Distortion filter

8 Evaluation

This chapter will present evaluation of the final test, including sampling methods, data collecting measures, data analysis and findings.

8.1 Participants and Sampling

This evaluation included control group (Group A) of 16 participants and an experimental group (Group B) of 16 participants. The experimental group engaged with the game with acousmatic sounds added, while the control group engaged with the game without acousmatic sounds. Group A included male = 15, female = 1. This sample encompassed individuals from Aalborg University. The participants feel within the age range of 20 to 27 years old. Group B included male = 11, female = 5. This sample encompassed individuals from Aalborg University. The participants feel within the age range of 21 to 28 years old. Due to the nature of horror games, participants were provided with a consent form as part of the questionnaire. The consent form included detailed information about the game's sensitive content, the collection of physiological data (GSR and HR), audio recordings, and assurances of anonymity. Participants were assigned anonymized ID numbers to ensure anonymity, and all data were labeled accordingly. All preliminary information regarding the participants from group A can be viewed in Appendix 1, while preliminary information regarding the participants from group B can be viewed in Appendix 3. The raw data from the questionnaires, including questions and answers for both groups, can be viewed in Appendix 4. The raw data from the GSR and HR, can be viewed in Appendix 5.

The sampling method utilized for testing was convenience sampling and snowball sampling, which can introduce biases. Convenience sampling involves selecting participants who are easily accessible, while snowball sampling often includes individuals from the same social network. This can result in the sample lacking diversity in terms of backgrounds, experiences, and perspectives, making it less representative of the broader population. Additionally, testing with friends and acquaintances can introduce social desirability bias, where participants may offer more favorable feedback than what they might would have done. Due to time limitations, all participants who were willing to test the game, were accepted into testing, which has resulted in skewed gender-distribution and the inclusion of participants, who do not like horror games.

8.2 Procedure

Before final testing, a pilot test was made. The pilot test included 2 male university students from Aalborg University. The testing was conducted in May 2025 and aimed at uncovering any inherent usability issues within the game and validating the procedure on a smaller scale, ensuring the questionnaire and interview questions were not misinterpreted by participants before implementing the procedure in our final evaluation.
Both quantitative and qualitative methods were utilized to gather comprehensive insights for our final evaluation. Below is a step-by-step outline of the procedure:

1. The participants are given a verbal introduction from the conductor of the test.
2. The participants are given the questionnaire to fill out the consent form (see Appendix 12).
3. The participants' baseline GSR and HR measurements are recorded for 2-3 minutes.
4. The participants are given the next part of the questionnaire to fill out preliminary information.
5. The participants are given a verbal explanation of the next part of the test from the conductor.
6. The participants' GSR and HR measurements are started.

7. The game is started and the conductors leave the room, while a livestream of the game is going on.
8. The participants play the game.
9. The participants' GSR and HR measurements are stopped when they finish the game.
10. The participants are given a verbal introduction to the questionnaire.
11. The participants answer the questionnaire.

For participants who were interviewed, the following steps were included:

12. The participants were given a verbal introduction to the interview.
13. The conductor interviews the participants.

Out of the 32 participants, 15 semi-structured interviews were held with participants from Group B regarding the acousmatic sounds which only appead in version B, following the questionnaire. Interview questions can be found in Appendix 6. The transcripts can be found in Appendix 7.

8.3 Data Measures

The data measures for the final test included a questionnaire, galvanic skin response, heart rate monitoring, and interviews. This approach provided both quantitative and qualitative methods to evaluate the player's anxiety.

8.3.1 Questionnaire

The questionnaire took inspiration from O'Brien et al.'s User Engagement Scale (EUS). O'Brien and Toms (2010) developed The UES to measure user engagement, consisting of thirty-one items and measuring six dimensions of user engagement. In a newer study O'Brien et al [49] revised and shortened the UES into the UES-SF (short-form), only measuring four dimensions of engagement and twelve items in the questionnaire. The UES-SF and UES-LF (long-form) offer guidance on measuring and scoring user engagement using the provided questionnaire, also in the context of games [49][48].

The questionnaire for the testing consists of 14 items distributed across 4 different categories: Focused Attention, Reward, Anxiety and Sound. While Focused Attention and Reward are directly from O'Brien's work, Anxiety and Sound were added to address specific aspects of our game that we considered important to measure. These categories were added as O'Brien argues that a questionnaire "will be useful only if it fits the researcher's conceptualization of the variable of interest" [49]. The Engagement items are Likert-scale format, all items being positively formulated, ranging from 1 (strongly disagree) to 5 (strongly agree). The questionnaire items can be found in Appendix 8.

8.3.2 Heart Rate

The test will include heart rate monitoring, as it is commonly used to asses physiological arousal such as stress, fear, excitement, or similar emotional responses. In this testing procedure, the response will primarily be used as a supplementary to previously discussed testing methods, as heart rate acceleration, as well as deceleration, can infer to states such as fear [40]. Measurement will be performed using a Samsung Galaxy Watch 4 Classic, using a custom app that logs the heart rate data in a CSV file. The app has the option of logging a baseline heart rate, and an option for logging during gameplay. The app utilizes the biometric sensors on the watch to acquire data. The CSV file includes the heart rate logged, along with the corresponding system time. Consistent placement of the monitoring device is prioritised in order to reduce the risk of signal interference throughout the test.

8.3.3 Galvanic Skin Response

The test will also include the monitoring of GSR through a sensor. GSR is measured through electrodermal activity, henceforth EDA, through two electrodes which are placed on the fingers of a participant. EDA represents changes in skin conductivity with the activation of the sweat glands, which correlates with activation of the sympathetic nervous system. This system is part of the activation pattern of physiological responses originating from fear or similar emotions [59]. GSR measurement will be performed using a Grove GSR sensor, which is connected to an Arduino Uno. This system then continuously reads the values output by the GSR sensor, which is then logged on command in an excel sheet with the use of Microsoft Data Streamer. It should be noted that GSR can be influenced by a number of factors, such as the skin moisture of the participant and the ambient temperature of the testing environment. For this reason, rather than specific thresholds, an approach of focusing on relative change for individual participants was chosen. Consistent placement of the monitoring device is prioritised in order to reduce the risk of signal interference throughout the test.

8.3.4 Interview

The interviews were conducted with the participants from test group B - 15 individuals in total, as one participant's interview recording was lost. The interviews consisted of three short questions, focusing specifically on the participants' experiences of anxiety and how these may have been influenced by the sound design or specific sounds. The aim of the interviews were to explore whether the participants would mention acousmatic sounds without being directly asked about them.
The interviews were intentionally kept very short for several reasons. We already had a large amount of data to analyze, and we had limited time to carry out the testing. Keeping the overall test duration short also made it possible to test over 30 participants within our timeframe and increased the likelihood that people would agree to participate.

8.4 Data Analysis

The following section will highlight and contextualise the analytical methods utilised within the evaluation of the collected data.

8.4.1 Questionnaire Analysis

The questionnaire was analysed on three different levels. First, The total score of the questionnaire for each group encompassed each participant's score (mean of all items). This data was used to calculate the overall total of each group, which encompassed the mean (the overall score for the group), the mean difference, the standard deviation (SD), SD difference and p-value. Second, the scores for each category were analyzed similarly, including means, mean differences, SDs, SD differences, and p-values. Third, for the Anxiety and Sound categories, each individual item was also analyzed with the same statistical measures.
To assess the assumptions for statistical testing, frequency distribution, Shapiro-Wilk test, and QQ-plot were used to assess the normality of the datasets and Levene's was used to assess homogeneity of variance. Mann-Whitney U was used to assess statistical significance in the datasets of each item and category, as these were not normally distributed, while independent T-test was used for the overall total of each group, as these datasets were normally distributed. For the categories Reward and Focused Attention, it was deemed these items should not be looked at individually, as they are taken directly from O'Briens UES-SF. As with many standardized questionnaires, the items are not meant to be looked at individually, such as with SUS-scores [36].

8.4.2 HR & GSR Data Analysis

The HR and GSR data were analysed using the same procedures due to similarity in data. The datasets were not based on raw values but rather consisted of each participant's average change from baseline, the delta heart rate and delta GSR values relative to their individual baseline measurements. The analysis began with removing abnormalities and outliers. Normality was assessed using the Shapiro-Wilk test, which assesed normality for all data sets. This was followed by Levene's test to evaluate the homogeneity of variance. The HR data showed equal variance, while the GSR data did not. Therefore to assess statistical differences, the independent t-test was used for HR, while Welch's t-test was used for GSR. The overall mean for each dataset was also calculated.

8.4.3 Interview Analysis

The interviews were analyzed using content analysis, a method that allows for quantifying qualitative data. Two researchers independently coded the interview transcripts to ensure reliability and consistency in the analysis. After the initial coding, the coders discussed any discrepancies to reach consensus. This process helped improve the accuracy of the coding and ensured inter-coder reliability. The content analysis focused on identifying how many participants directly mentioned, indirectly referenced, or did not mention acousmatic sounds at all. The frequency of references to specific acousmatic sounds, as well as cases where participants referred to an unspecified acousmatic sound without identifying exactly which one was also identified.

8.5 Findings

This chapter presents the findings from the study's the data measures used in the final testing: the questionnaire, heart rate (HR), galvanic skin response (GSR) and participant interviews. The findings are presented in the following sections.

8.5.1 Questionnaire

The questionnaire was conducted for both Group A ($n = 16$) and Group B ($n = 16$). The questionnaire assessed scores in four categories, totaling 14 items in total. Each item was presented in Likert-scale format, featuring positively framed statements, where participants indicated their level of agreement with each statement on a scale of 1 (strongly disagree) to 5 (strongly agree). The first dataset consisted of the mean of the participants' scores across all items in all categories. Firstly, the datasets for each group were tested for normality using visual inspection of their frequency distributions (see Appendix 9). The frequency distributions suggested a tendency toward normality, though this was challenging to assess, particularly for Group A, which had more data points clustered at the higher end. To support this assessment, Q-Q plots (see Appendix 10) were also used for visual inspection. These plots indicated that both groups approximated a normal distribution, but Group B's data aligned more closely with the line, whereas several data points in Group A deviated more from the line. Therefore, a Shapiro-Wilk test was used to confirm the normality. The results confirmed that the null hypothesis, which states that data comes from a normally distributed population, could be accepted for both Group A ($p = 0.14$) and Group A ($p = 0.93$)

A boxplot over the questionnaire scores was created for both groups (Figure 41). For group A, the box plot showed a median around 3.8, meaning that around 50% of the data falls below this value and the remaining 50% above. The whiskers range from a minimum of approx 3.4 to a maximum of approx. 4.75, encapsulating all data points except for one outlier, represented as a dot. Although outliers can be removed, all data points were kept, as every response is considered valuable including less positive ones. For group B, the box plot showed a median around 4.1. The whiskers range from a minimum of approx 3.1 to a maximum of approx. 4.8, encapsulating all data points.

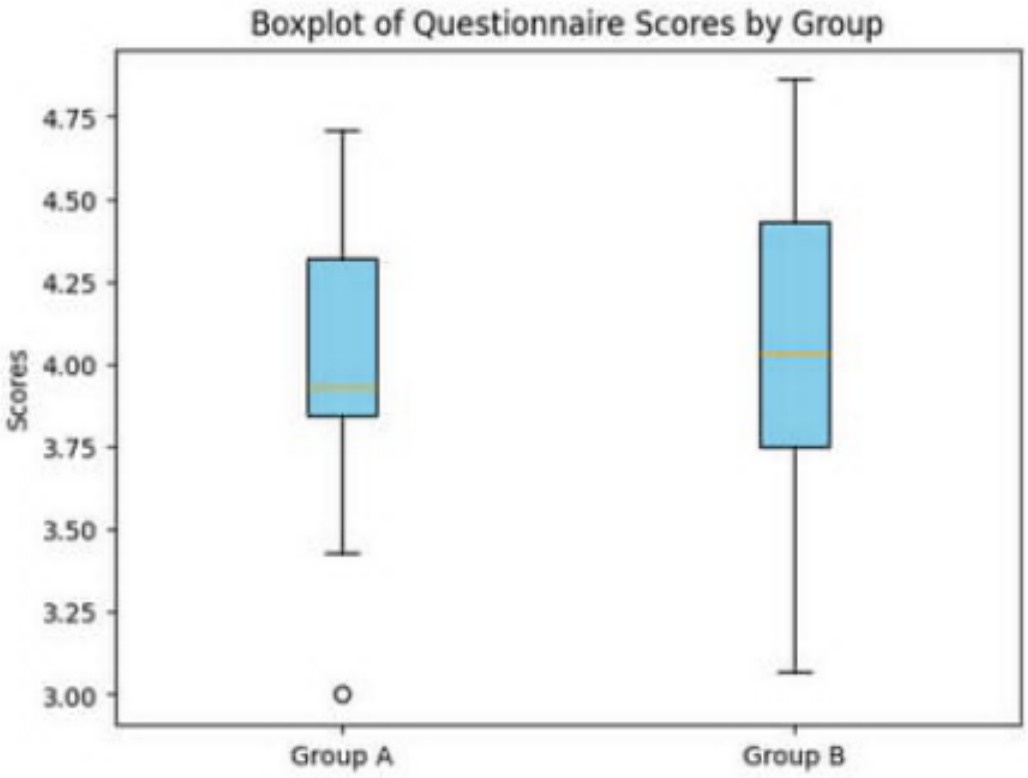

Figure 41: Boxplot of questionnaire scores for Group A and Group B. The x-axis indicates the two participant groups, while the y-axis shows the questionnaire scores on a Likert scale. Each box represents the interquartile range (IQR), the horizontal line inside the box shows the median score, and the whiskers indicate the range excluding outliers. An outlier is marked as a circle.

The means, standard deviations (SD), and difference in SD and means between the two datasets were calculated. To assess whether there was a statistically significant difference between the groups, homogeneity of variance was assessed using Levene's test. The test indicated that the variances were equal, allowing us to proceed with an independent t-test. The results can be viewed in Figure 42. The independent t-test yielded p-value above 0.05 ($p = 0.92$) significant level, which means The difference between the two groups is not statistically significant.

For all categories total, the same approach was used to assess normality and variance: frequency distributions, Q-Q plots, and the Shapiro-Wilk test were used to evaluate normality, while Levene's test assessed homogeneity of variance. None of the datasets in each group for all categories were normally distributed, but homogeneity of variance was confirmed for all the categories. Therefore, to assess statistical differences between groups, the non-parametric Mann-Whitney U test was used. Across all category totals, none of the p-values fell below the significance threshold of 0.05, meaning none of the differences between the two groups in any of the categories are statistically significant.
For the categories Anxiety and Sound, each individual item was also analysed using the same procedure: tests for normality and variance were conducted, followed by Mann-Whitney U tests to assess group differences. As with the category totals, no statistically significant differences were found. All of the results can be viewed in Figure 42 below. Though, it was noticeable that Anxiety received consistently lower ratings than Sound in both groups. To examine whether this difference was statistically significant, a Mann-Whitney U test was conducted for each group, as the data were not normally distributed but showed equal variance. The results showed a p-value of 0.00 for both Group A and Group B, indicating a statistically significant difference between the Sound and Anxiety scores within each group.

Additionally, we assessed whether there were significant differences in gender, how often participants play video games, or whether they enjoy horror games. However, either the distributions were too skewed, for example in group A, where 15 participants were male and only 1 was female, making statistical testing unreliable or no statistically significant differences were found. Therefore none of the findings will be reported.

Questionnaire Results

	Gr.	Mean	Mean diff	SD	SD diff	p-value
Focused Attention						
Total	A	4.17	-0.11	0.93	-0.20	0.33
	B	4.06		0.73		
Reward						
Total	A	4.23	-0.21	0.86	-0.07	0.12
	B	4.02		0.79		
Anxiety						
AX1	A	3.31	+0.44	0.87	-0.09	0.15
	B	3.75		0.78		
AX2	A	4.00	-0.06	1.10	-0.04	0.84
	B	3.94		1.06		
AX3	A	3.69	+0.06	0.70	+0.16	0.58
	B	3.75		0.86		
AX4	A	2.81	+0.19	0.91	+0.25	0.63
	B	3.00		1.16		
Total	A	3.45	+0.16	0.99	+0.03	0.30
	B	3.61		1.02		
Sound						
SD1	A	4.31	-0.12	0.70	+0.29	0.92
	B	4.19		0.99		
SD2	A	4.19	+0.44	0.91	-0.29	0.14
	B	4.63		0.62		
SD3	A	4.38	-0.13	0.72	-0.03	0.58
	B	4.25		0.69		
SD4	A	4.25	+0.38	0.93	-0.31	0.24
	B	4.63		0.62		
Total	A	4.28	+0.14	0.81	-0.06	0.30
	B	4.42		0.75		
TOTAL						
Total	A	4.01	+0.02	0.5	0.00	0.92
	B	4.03		0.5		

Figure 42: Questionnaire results comparing Group A and Group B across four categories: Focused Attention, Reward, Anxiety, and Sound. The individual items in the category Anxiety are labeled AX1 through AX4, and the individual items in the category Sound are SD1 through SD4. For each item and category, the table shows the mean score, standard deviation (SD), differences in means and SDs between groups, and associated p-values. "Total" rows summarize scores across all items within each category, while the final "TOTAL" row combines results from all questionnaire items in their respective groups.

8.5.2 Heart Rate Analysis

HR was measured for all participants across both Group A ($n = 16$) and Group B ($n = 15$), though one reading was lost during testing. Because of unreliable readings, outliers were removed from each group using Z-scores with a threshold of ± 2.5, which resulted in the removal of one substantial outlier. Normality was thereafter assessed using the Shapiro-Wilk test. The results from the Shapiro-Wilk confirmed that the null hypothesis, which states that data comes from a normally distributed population, could be accepted for both Group A ($p = 0.21$) and Group A ($p = 0.20$). Homogeneity of variance was then evaluated using Levene's test. The results indicated that the variances between the

two groups were unequal ($p = 0.01$). As a result, Welch's t-test was utilized to assess any statistical difference, as it does not assume equal variance. The results yielded no statistical difference between Group A and Group B ($p = 0.16$) . The Mann-Whitney U test was also conducted as a non-parametric comparison, similarly reporting no significant difference ($p = 0.47$). Group A had a mean of $M = 6.22$, while Group B had a mean of $M = -0.02$.

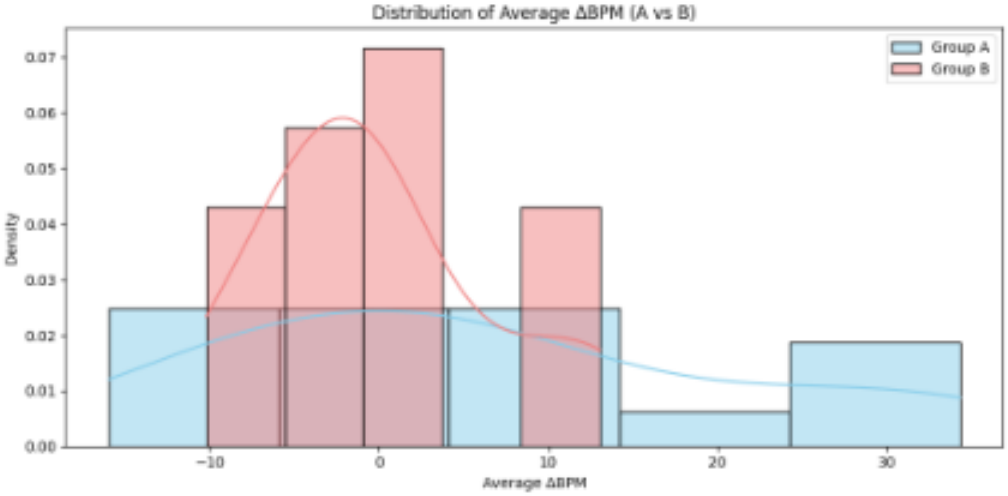

Figure 43: Distribution of average ΔBPM values for Group A and Group B participants. This figure presents histograms and kernel density estimation (KDE) plots of ΔBPM for each participant, calculated by subtracting their baseline BPM (mean of the baseline phase) from their smoothed game-phase BPM. The x-axis shows the average ΔBPM per participant, while the y-axis represents the estimated probability density.

8.5.3 GSR Analysis

GSR was measured for all participants across both Group A ($n = 12$) and Group B ($n = 12$), though 4 readings from each group was lost during testing. Because of unreliable readings, outliers were removed from each individual dataset using Z-scores with a threshold of ± 3.5. Subsequently, group-level outlier removal using a threshold of ± 2.0, which identified no additional outliers across samples.Normality was thereafter assessed using the Shapiro-Wilk test. The results from the Shapiro-Wilk confirmed that the null hypothesis, which states that data comes from an approximately normally distributed population, could be accepted for both Group A ($p = 0.50$) and Group A ($p = 0.70$). Homogeneity of variance was then evaluated using Levene's test. The results indicated that the variances between the two groups were unequal ($p = 0.80$). As a result, the independent t-test was utilized to assess any statistical difference. The results yielded no statistical difference between Group A and Group B ($p = 0.09$). The Mann-Whitney U test was also conducted as a non-parametric comparison and similarly showed no significant difference ($p = 0.10$). Group A had a mean of $M = -166.60$, while Group B had a mean of $M = -44.06$.

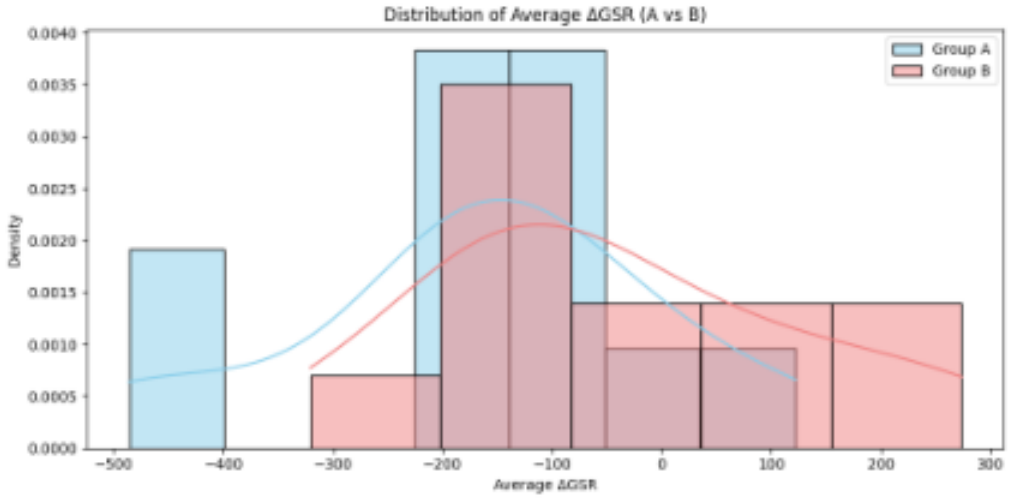

Figure 44: Distribution of average ΔGSR values for Group A and Group B participants. This figure displays KDE plots and overlaid histograms of average ΔGSR values, computed by subtracting each participant's baseline GSR (approximated from the first 100 samples) from their GSR readings. The ***x-axis*** *represents the average ΔGSR per participant, while the* ***y-axis*** *indicates the estimated probability density*

8.5.4 Interviews

A total of 15 interviews from Group B were included in this analysis. The bar chart below (Figure 45) shows how many participants referenced acousmatic sounds. Out of the 15 participants, 6 (40%) directly mentioned acousmatic sounds, 6 (40%) did not mention them, and 3 (20%) indirectly referenced them. Examples of indirect mentions include statements like, "*So there was a sound that came, and then it was like 'uhh, where did that come from?'*" (B11) or "*Noises that came like out of the blue*" (B09).

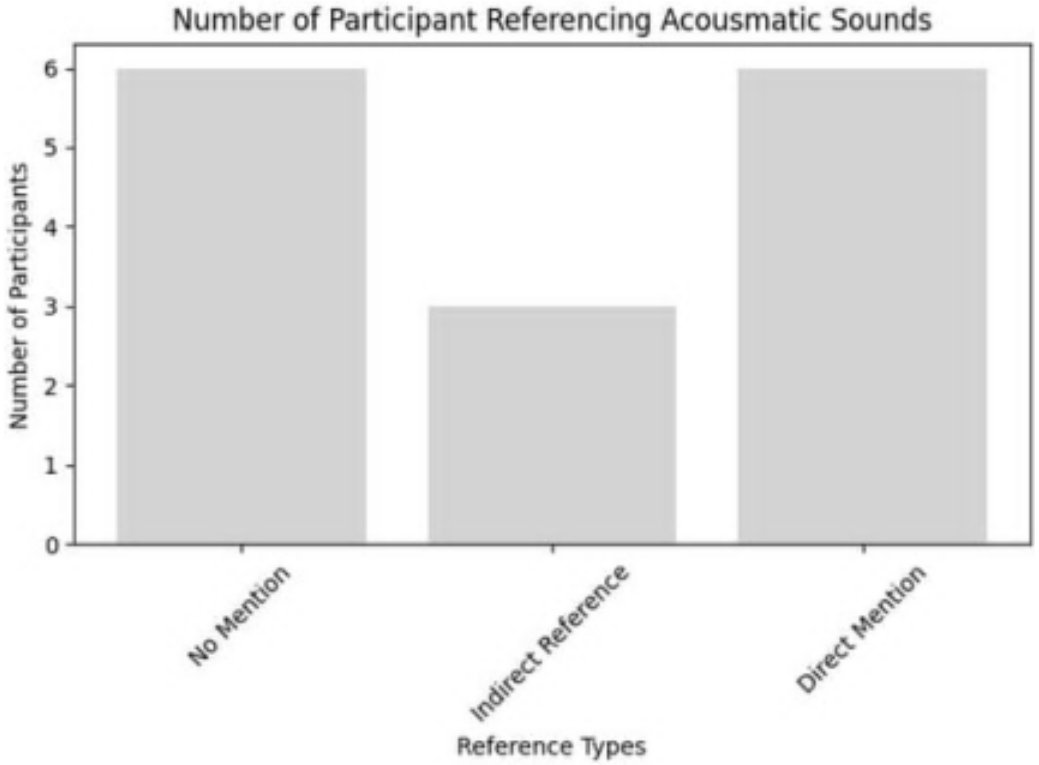

Figure 45: Barchart showing the number of participants by type of reference to acousmatic sounds. The x-axis represents the three reference types: Direct (participants who explicitly mentioned acousmatic sounds), No Mention (participants who did not mention acousmatic sounds), and Indirect (participants who implicitly referred to acousmatic sounds) The y-axis shows the number of participants in each category.

When looking at the number of different acousmatic sounds mentioned (counting only unique mentions per participant), footsteps were mentioned by 5 participants, children's laughter by 2, whispers by 1, and general indirect references to acousmatic sounds were made by 3 participants (Figure 46).

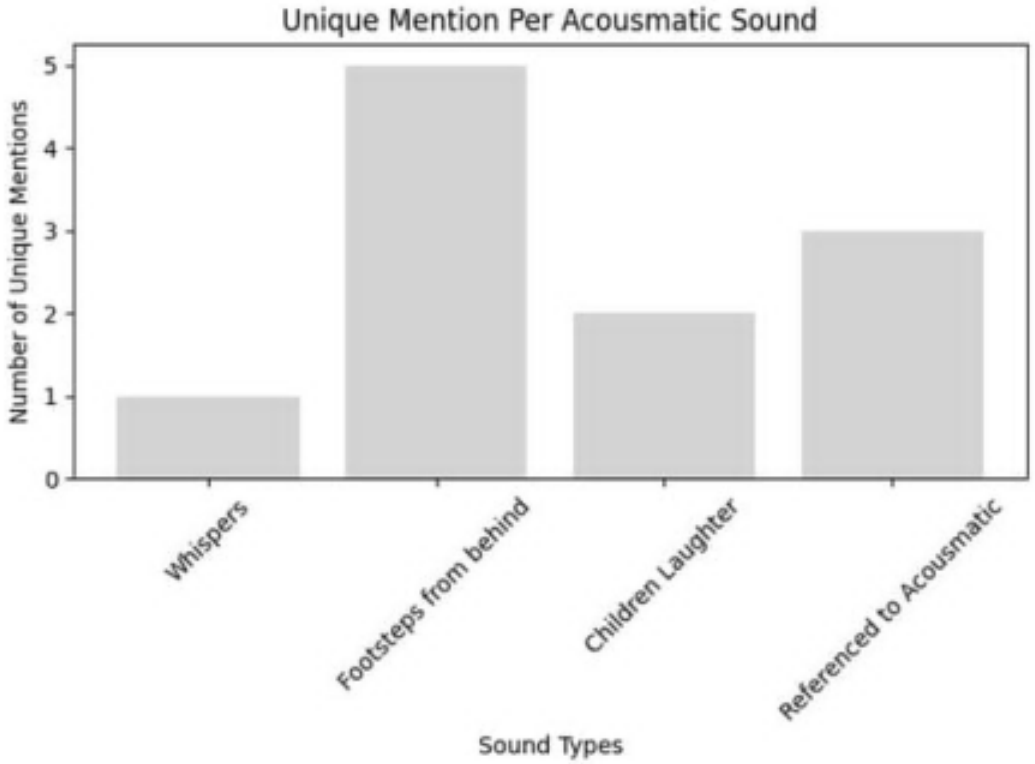

Figure 46: Barchart showing the number of unique mentions of different acousmatic sounds. The x-axis lists the categories: Whisper, Footsteps from behind, Children's laughter, and Reference to acousmatic sounds (which indicates indirect mentions). The y-axis represents the number of unique mentions, counting each participant's repeated mentions of the same sound only once.

9 Discussion

This chapter will discuss the results of the final test, aswell as design, implementation and test procedure.

9.1 Questionnaire

The results from the questionnaire showed that the overall mean engagement score for Group A (no acousmatic sounds) was 4.01, while Group B (with acousmatic sounds) had a mean of 4.03. This results in a mean difference of 0.02, and an independent samples t-test indicated no statistically significant difference between the groups ($p \approx 0.92$). Although both groups had relatively high overall scores, the project aimed to explore the extent to which acousmatic sounds could intensify anxiety. Both groups had a standard deviation (SD) of 0.5, suggesting similar overall variability in responses. However, the boxplot for Group B showed a slightly wider spread, which is visible in the longer whiskers and the larger box, showing that all the data in general had a wider range compared to Group A (see Figure 41). While the SDs are identical, this could be because of the single lower outlier (3.00) in Group A, which could artificially increase the SD. If this outlier were removed, Group A's SD might be slightly lower, reflecting less variability. However, given the small difference and lack of statistical significance, these minor variations are likely due to random variation rather than a meaningful effect.

When examining the four categories, Focused Attention, Reward, Anxiety and Sound, none of them showed any statistically significant difference between groups, as all p-values were above the 0.05 threshold. In terms of mean differences, Group A scored higher in Focused Attention (mean difference ≈ 0.11) and Reward (mean difference ≈ 0.21), while Group B scored higher in Sound (mean difference ≈ 0.16) and Anxiety (mean difference ≈ 0.14). Although it could be interpreted that Group B's higher scores in Sound and Anxiety as suggesting that acousmatic sounds had some effect, these differences are small, and given the lack of statistical significance, it is most likely due to random variation rather than meaningful effects.
When looking at the standard deviation in general, they could be interpreted as relatively high. This can be due to different reasons, such as whether participants enjoy horror games, whether they play video games at all, and what genres they prefer, especially within horror. A game is not meant to appeal to everyone equally, and people also react differently to sounds. Some may be desensitized and less affected because they are used to horror games, while others who rarely play or watch horror may respond more strongly. To explore whether these differences could explain the variability, it was attempted to assess statistical significant differences in gender, how often participants play video games, and whether they enjoy horror games. However, as discussed in Findings (see Section 8.5.1) for the questionnaire, either the group distributions were too skewed or no statistically significant differences were found. This does not necessarily mean that no real differences exist, but that we might not have had a large or balanced enough sample size to detect them. Therefore, a larger and a more balanced sample size would be needed to detect these potential differences.

While there were no significant differences between the groups in the four categories when comparing Group A and Group B's categories, there was a noticeable difference between the category Anxiety and Sound within both groups. Group A (p 0.00) and Group B (p 0.00) both had significant differences when comparing their Anxiety and Sound categories to each other within their respective groups, with the category Sound having a much higher overall mean than the category Anxiety both for group A and Group B. The significantly higher scores in the Sound category compared to Anxiety indicate that while the sound design was well received, it did not translate into heightened anxiety, even for Group B, which experienced acousmatic sounds. This suggests that although the sound elements were anxiety-increasing, they were not sufficient on their own to elevate overall anxiety throughout the experience. Additionally, the acousmatic sounds may have had too subtle an impact, or were not used in ways that maximized their unsettling potential. Maybe more acousmatic sounds should have been

added throughout the game to make a stronger impact.

9.2 HR & GSR

The HR and GSR data both showed no statistically significant difference between Group A and Group B, as determined by both the independent t-test and Mann Whitney U. This suggests that, within the limitations of our setup, there was no clear indication of increased physiological reaction in either group during gameplay. The reported means for ΔHR for group A was 6.22. while for Group B it was -0.02, and for ΔGSR the reported means for Group A were -166.69 and -44.06 for Group B. While for HR, group A on average had higher change in HR, both groups had negative changes in their GSR. The reliability of these results is limited by several methodological constraints. The HR measurements were collected using a self-built system due to a lack of facilitation of validated commercial devices. Both the GSR and HR apparatus measured irregular and abnormal data points during the test.
Furthermore, participants were not given sufficient time to return to a true resting state when reading their baseline recordings and before the gameplay phase began, leading to elevated baseline readings for both GSR and HR. This is evident in Group B's negative mean ΔHR, and the overall negative changes in GSR may also indicate that baseline measurements were higher than they should have been. It would not make sense for the average heart rate to drop below resting levels during a horror game, especially when compared to the questionnaire results. While the anxiety measure did not show the strongest response, indications were still made that participants felt somewhat anxious.
Potential spikes in each participant's HR was examined. However, no consistent spikes aligning with the acousmatic sounds were found. Additionally, the large number of inaccurate and unreliable data points meant that even if some spikes had been observed, it would still be difficult to draw any meaningful conclusions.

Several actions could be made, to improve the data collection based on observed faults in the procedure. This includes the procedure itself and the data measurements. Some of the biggest issues encountered during the test was loss of data. Many actions had to be taken in regards to collecting and storing of data. This led to user errors, and thus loss of data or failure of collection. Such actions which complicated the data collection include actively starting each recording of data, manually moving and renaming of data after collection, changing between testing group A and group B and so fourth. Given more time or better circumstances, improvements could be made to the collection of data by automating more processes. However, some amount of manual actions must remain to keep control of the process.

Before using the HR and GSR apparatus for the final testing, it was tested multiple times within the group to ensure it collected reliable data. While some issues were identified during this initial testing, they seemed to be resolved before the final test. However, that turned out not to be the case, as further issues arose during the final testing phase, and there was not enough time to address them properly. Although we attempted to account for potential problems by testing the devices within the group beforehand, this was clearly not sufficient enough to ensure reliable readings. It would have been beneficial to include the equipment in the pilot testing and, more generally, to begin working with the HR and GSR sensors earlier to minimize errors during the final test. The issues encountered included missing data points, where measurements were not recorded at all, and unrealistic spikes in the data, both extremely high and low readings that were not plausible. However, this simply is based on observation and it cannot definitively be said how reliable or unreliable the physiological data is.

The handling of the HR and GSR during testing could also have been improved, mostly in terms of the baseline readings which were logged before actual gameplay readings. Taking more time to ensure that a proper baseline reading was done would make the datasets more reliable, as the current setup did not allow for a cooldown period for when participants arrived. The loss of participant data further reduced the sample size, highlighting the need for better data management.

Regarding validity, it is important to acknowledge that changes in HR and GSR could be influenced by factors other than anxiety. For example, participants may experience nervousness simply due to being monitored or due to the testing environment itself. Although efforts were made to reduce this, such as providing rest time before the game and leaving the room during gameplay, it cannot be stated with complete certainty that any observed physiological changes when it comes to HR and GSR are caused by anxiety alone. Overall, alot needs to be improved when it comes to HR and GSR measurements before any meaningful conclusion can be made. Therefore, given the small sample size and known measurement errors, these results should be interpreted with caution.

9.3 Interview

The results indicate that acousmatic sounds were a significant part of the participants' experience, with 60 percent of particiapnts mentioning them either directly or indirectly (see Figure 45) . This suggests that these sounds contributed noticeably to the experience. Among the specific sounds, footsteps made the strongest impression on participants, while whispers were mentioned least frequently (see Figure 46.) This difference could be due to several factors, such as their timing in the experience or that whispers being more subtle could have been less noticeable or impactful or deemed a less scary sound.

Although acousmatic sounds influenced participants' experience, it is possible that the number or intensity of these sounds was not sufficient to significantly raise overall anxiety levels throughout the almost 20-minute-long game. The length of the experience might have diluted their impact over time. A longer or more in-depth interview could potentially have uncovered richer insights into how participants experienced these sounds and their effects on anxiety. However, due to time constraints and the need to conduct multiple tests, the interviews were kept brief, limiting the depth of qualitative data collected.

Despite the fact that the interviews were surface level and did not go in-depth about participants' experiences in depth, the fact that over half of the participants independently identified acousmatic sounds as being big contributors to them feeling anxious suggests there is meaningful potential in this area. These findings support the idea that acousmatic sounds can influence anxiety response. As mentioned earlier, the number and intensity of such sounds might need to be increased to produce a more consistent or measurable effect.

Importantly, the interview questions were intentionally broad and open-ended. While the interview questions could have asked participants directly about the three specific acousmatic sounds used in the game, it was chosen not to in order to avoid influencing their responses. This allowed us to see whether participants would bring up these sounds by themselves, which can be a stronger indicator of impact. That said, it is possible that some participants who did not mention acousmatic sounds were still affected by them but simply did not recall them during the brief interviews. The short interview length could have prevented participants from fully reflecting on all aspects of their experience regarding the sounds, meaning some reactions to specific sounds could have gone unreported in the interviews. A more effective approach could have been to first allowing participants to speak freely about any sounds they remembered, such as done in the interviews and then, if they did not mention the acousmatic sounds, ask the participant a more direct follow-up question regarding the acousmatic sounds specifically. This would have maintained the integrity of the open-ended approach while also ensuring relevant data was not missed and still have kept the interviews fairly short.

One area that could have been improved was the design and execution of the interviews. The interviews conducted were short and lacked depth. While they did gather some useful data, the focus was primarily on counting how many participants mentioned specific elements like acousmatic sounds,

thereby quantifying rather than understanding how and why these elements affected them. Conducting longer, more structured interviews could have provided richer qualitative insights and allowed for a more nuanced understanding of the player experience. This would have helped in evaluating the emotional impact of acousmatic sounds. In the future, giving more time for in-depth interviews could significantly strengthen the quality of the qualitative data collected.

9.4 Design, Implementation & Test

One aspect of the design and implementation that could have been handled differently was the overall project scope. The project may have been overly ambitious, which ultimately led to delays. Too much time was spent on narrative development and 3D modelling, which limited the focus on implementing acousmatic sounds effectively and having fully finished games without bugs. During the final testing phase, a number of bugs were still present, and several participants encountered these issues while playing. Therefore, it could be discussed whether these bugs could have impacted player's immersion, thus reducing anxiety experiences. While this does not explain the lack of difference in anxiety responses between the two game versions, it may have contributed to the overall low anxiety scores observed in the questionnaires in both groups.

Another important aspect that was not put enough attention to was the level of interactivity in the game environments. The current version of the game features three different environments, but due to limited time, the environments feel underdeveloped. The lack of interactivity might have affected the player experience in relation to the core design focuses of Discovery, Narrative, and Challenge, which were central to the design of the game. The game has limited opportunities for exploration and meaningful interaction, which makes the game end up feeling quite linear, with not much to discover despite having large environments. This could potentionally be weakening the game's potential for players to feel immersed and emotionally impacted by the game. More interactive elements, such as puzzles, dynamic event and sound triggers, or narrative clues in the environment could have strengthened the sense of discovery, challenge and narrative.
Based on the discussion about immersion, it could have been beneficial to include evaluation of immersion as a part of the final evaluation. This could have been done using standardized immersion questionnaires, such as the Immersive Experience Questionnaire (IEQ), to assess how immersed the players were during the gameplay. Including this could have helped identify whether immersion was a contributing factor to the perceived anxiety or lack thereof. For example, it might could have revealed whether the acousmatic sounds were effective but their impact was reduced by low immersion, or conversely, that the game was immersive but the sounds were not unsettling or frequent enough to induce anxiety.

The design and implementation would also have benefitted from a more iterative design process, as also called for by the MDA framework (see Section 2.2). The effectiveness of various design elements, the overall game experience and the acousmatic sounds could have been evaluated earlier and more frequently throughout development of the game. For example, different acousmatic sounds could have been tested on participants before deciding which ones to use in the final version, in order to identify which were perceived as the most unsettling or anxiety-inducing.
Short sound clips could have been presented to individuals in a quiet testing environment, where they would rate each sound on dimensions such as unsettling and anxiety-inducing. This could have been done using Likert scales, for example from 1 = not unsettling at all to 5 = extremely unsettling, along with by open-ended questions like "What emotions did this sound evoke for you?".
In addition to isolated sound testing, the acousmatic sounds could have been integrated into the earlier prototype test, such as Anxiety test. Participants could then give feedback on how the sounds affected their emotional state within the scene within the given context, not just as isolated sounds. This kind of iterative testing: gathering feedback, refining sounds, and re-testing would have made it possible to select and fine-tune the acousmatic sounds. Not only would this have made the audio

design more intentional, but it would also have ensured that the chosen sounds resonated with players in the intended way, potentionally increasing the overall emotional impact of the experience.

While a movement/controls test and a fear test were conducted, the results from the Anxiety category suggest that these evaluations were not sufficient enough to determine whether the game was effective in provoking anxiety. Many changes were also made after these early tests, and the game was still far from complete at that stage. This meant that many newly implemented elements were not tested at all within those early assessments. Additional testing throughout the implementation phase could have provided valuable feedback that would have given more meaningful iterations to the design and implementation.

Regarding the implementation of acousmatic sounds, it has been discussed whether more of these sounds should have been included in the final design. Additionally, it could be considered whether the game should have incorporated some form of resolution or payoff in relation to the acousmatic sounds or just in general added a threat of some sort. The game was designed to evoke anxiety, which - as defined in the Analysis - relates to the anticipation of a threat that is uncertain, ambiguous, or yet to occur, in contrast to fear, which is triggered by an immediate and identifiable danger (see Section 2.1). With anxiety being anticipatory, it relies on the potential for something to happen, a threat to occur. If acousmatic sounds repeatedly occur without leading to any type of threat or negative outcome, players may begin to recognize that there is no real threat present within the game. This lack of payoff or in general lack of threat in the game could potentially cause player's to become desensitized to acousmatic sounds, which thereby could lead to the sounds eventually losing their emotional impact. This could also have been tested in the early prototypes of the game together, similar to testing the actual acousmatic sounds. Specifically, two versions of the prototype could have been created: one where acousmatic sounds occurred frequently without any threat or consequence linked to them, and another where the acousmatic sounds were directly linked to an in-game threat. By comparing player reactions between these versions, it could have been assessed whether the lack of payoff led to desensitization and diminished the emotional impact. This approach would have provided valuable insight early in development on how to maintain the anticipatory anxiety we aimed for and informing the sound design decisions in the final game to better sustain anxiety. If this showed to be true, the game could have benefitted from including some sort of threat, enemy or likewise to make sure players knew there was a threat present and preserved the sense of anticipation by confirming that the sounds signalled actual danger, rather than empty warnings.

Regarding the approach for this FPS, the testing methods are more closely aligned with the question “Can acousmatic sounds increase anxiety?” rather than “To what degree do they increase it?”. Even if the game had successfully increased anxiety, it would not have been possible to fully answer the FPS in terms of measuring the extent of that effect. At best, the results could indicate that anxiety can be increased and maybe to what degree the three acousmatic sounds included in the project could increase anxiety. However, determining to what degree acousmatic sound design in general could increase anxiety would require a significantly broader scope and other testing methods. Testing multiple different versions of the game with varying amounts and types of acousmatic sounds could have helped identify a potential “sweet spot” in sound design, meaning the optimal point at which acousmatic sounds most effectively increase anxiety before players begin to become desensitized or where additional acousmatic elements no longer contribute meaningfully to increased anxiety. Rather than a simple A/B testing approach, A/B/n testing would be necessary to explore the relationship between acousmatic sound implementation and anxiety levels.

10 Conclusion

The project sought to answer the final problem statement: *"To what degree does acousmatic sound design increase horror-game-player's anxiety, compared to the lack thereof, in a psychological horror game based on fear of the unknown?"* Based on the findings and our discussion, we conclude that while acousmatic sounds were noticed by players and mentioned in interviews as impactful elements, they did not significantly increase measured anxiety compared to non-acousmatic sound design. The questionnaire results revealed no statistically significant difference in scores between the two groups, and physiological measures (HR and GSR) showed no significant difference either, though these results were limited by reliability and validity. Despite the lack of quantitative evidence, the qualitative data suggests that acousmatic sounds contributed to the feeling of anxiety. Over half of the participants identified them independently during interviews, particularly noting the effectiveness of inducing anxiety of certain sounds such as footsteps. However, the intensity, the frequency and the usage of these sounds may not have been sufficient to produce a consistent or measurable rise in anxiety across the players. This indicates that while acousmatic sound design holds potential for increasing anxiety in horror games, we cannot conclude to what degree acousmatic sound increases anxiety.

In conclusion, acousmatic sounds appear to influence players' anxiety to some extent, but in this study, they were not sufficient on their own to significantly elevate anxiety to a measurable or statistically significant level. Therefore, we are not able to conclude as to what degree acousmatic sounds affect player anxiety.

References

1. Abdul Rabu, S. N. & Ismail, N. H. in *Reimagining Transformative Educational Spaces: Technological Synergy for Future Education* (eds Edwards, B. I., Tanko, B. L., Klufallah, M., Abuhassna, H. & Chinedu, C. C.) 155–174 (Springer Nature, Singapore, 2024). ISBN: 978-981-9787-52-4. https://doi.org/10.1007/978-981-97-8752-4_9 (2025).
2. Andersen, A. *9 brutally-effective horror sound design techniques - by horror master Alessandro Romeo* A Sound Effect. https://www.asoundeffect.com/horror-sound-design-techniques/ (2025).
3. Andersen, M. M. *et al.* Playing With Fear: A Field Study in Recreational Horror. *Psychological Science* **31.** Publisher: SAGE Publications Inc, 1497–1510. ISSN: 0956-7976. https://doi.org/10.1177/0956797620972116 (2025) (Dec. 1, 2020).
4. BoomBo, x. *Lunch and Learn: Surround Panning For the Sound Effects Editor* Boom Box Post. https://www.boomboxpost.com/blog/2017/8/22/surround-panning-for-the-sound-effects-editor (2025).
5. Breinbjerg, M. The Aesthetic Experience of Sound: Aesthetics of Play. *Aesthetics of Play* (2005).
6. Carleton, R. N. Fear of the unknown: One fear to rule them all? *Journal of Anxiety Disorders. Fearing the Unknown* **41,** 5–21. ISSN: 0887-6185. https://www.sciencedirect.com/science/article/pii/S0887618516300469 (2025) (June 1, 2016).
7. Cunningham, S. S. *Friday the 13th* in collab. with Miller, V., Kurz, R., Palmer, B., King, A. & Taylor, J. IMDb ID: tt0080761 event-location: United States. May 9, 1980.
8. Da Silva Junior, J. N., Teotônio, M. d. S. C., Melo Leite Junior, A. J., Vasconcelos Pinheiro, J. G. B. & da Silva, L. L. Gamification 2.0: Gamifying an Entire Introductory Organic Chemistry Course Again. *Journal of Chemical Education* **102.** Publisher: American Chemical Society, 679–687. ISSN: 0021-9584. https://doi.org/10.1021/acs.jchemed.4c01183 (2025) (Feb. 11, 2025).
9. Davis, M. The Role of the Amygdala in Fear and Anxiety. *Annual Review of Neuroscience* **15.** Publisher: Annual Reviews, 353–375. ISSN: 0147-006X, 1545-4126. https://www.annualreviews.org/content/journals/10.1146/annurev.ne.15.030192.002033 (2025) (Volume 15, 1992 Mar. 1, 1992).
10. De Wied, M., Zillmann, D. & Ordman, V. The role of empathic distress in the enjoyment of cinematic tragedy. *Poetics. Emotions and Cultural Products* **23,** 91–106. ISSN: 0304-422X. https://www.sciencedirect.com/science/article/pii/0304422X94000104 (2025) (Jan. 1, 1995).
11. Dudek, B. A Sense of Fear and Anxiety in Digital Games: An Analysis of Cognitive Stimuli in Slender – The Eight Pages. *Game Studies* **21.** ISSN: 1604-7982. https://gamestudies.org/2102/articles/dudek?utm_source=chatgpt.com (2025) (July 2021).
12. E. LeWine, H. *Understanding the stress response* Harvard Health. Section: Staying Healthy. https://www.health.harvard.edu/staying-healthy/understanding-the-stress-response (2025).
13. Edgar Allan Poe. *The Tell-Tale Heart – The Poe Museum* https://poemuseum.org/the-tell-tale-heart/ (2025).
14. Ekman, I. *Psychologically motivated techniques for emotional sound in computer games* 20–26 (Jan. 1, 2008).
15. Ekman, I. & Kajastila, R. *Localisation Cues Affect Emotional Judgements–Results from a User Study on Scary Sound* (Jan. 1, 2012).
16. Folorunso, C., Weinel, J. & Otero, N. *Horror in Modern and Retro 3D Games* in. Proceedings of EVA London 2024 (BCS Learning & Development, July 1, 2024), 350–352. https://www.scienceopen.com/hosted-document?doi=10.14236/ewic/EVA2024.68 (2025).

17. Foundation, B. *blender.org - Home of the Blender project - Free and Open 3D Creation Software* blender.org. https://www.blender.org/ (2025).
18. Freesound. *Freesound* https://freesound.org/ (2025).
19. Friedkin, W. *The Exorcist* in collab. with Blatty, W. P., Burstyn, E., Sydow, M. v. & Blair, L. IMDb ID: tt0070047 event-location: United States. Dec. 26, 1973.
20. GameBest. *Silent Hill 2 Remake vs Original - Physics and Details Comparison* May 31, 2024. https://www.youtube.com/watch?v=O6LsBexX30g (2025).
21. Gantz, M. Analysis of the Horror Genre and its Implementation in Video Games. *Analysis of Horror Genre and its Implementation in Video Games*. https://www.researchgate.net/profile/Matan-Gantz/publication/340398284_Analysis_of_the_Horror_Genre_and_its_Implementation_in_Video_Games/links/5e87081192851c2f5277de78/Analysis-of-the-Horror-Genre-and-its-Implementation-in-Video-Games.pdf (2025) (2019).
22. Garner, T., Grimshaw, M. & Nabi, D. A. *A preliminary experiment to assess the fear value of preselected sound parameters in a survival horror game* in *Proceedings of the 5th Audio Mostly Conference: A Conference on Interaction with Sound* AM '10: The 5th Audio Mostly Conference (ACM, Piteå Sweden, Sept. 15, 2010), 1–9. ISBN: 978-1-4503-0046-9. https://dl.acm.org/doi/10.1145/1859799.1859809 (2025).
23. Garner, T. A. Game Sound from Behind the Sofa: An Exploration into the Fear Potential of Sound & Psychophysiological Approaches to Audio-centric, Adaptive Gameplay (2013).
24. Grimshaw, M. The audio Uncanny Valley: Sound, fear and the horror game. *Games Computing and Creative Technologies: Conference Papers (Peer-Reviewed)*. https://www.researchgate.net/publication/30502890_The_audio_Uncanny_Valley_Sound_fear_and_the_horror_game (Jan. 1, 2009).
25. Grimshaw, M., Lindley, C. A., Nacke, L. & Nacke, L. Sound and Immersion in the First-Person Shooter: Mixed Measurement of the Player's Sonic Experience. https://core.ac.uk/download/pdf/301020284.pdf (2007).
26. Honda, S. *Proximal Binaural sound can induce subjective frisson* https://arxiv.org/pdf/1904.06851.
27. Hunicke, R., LeBlanc, M. & Zubek, R. MDA: A Formal Approach to Game Design and Game Research. https://cdn.aaai.org/Workshops/2004/WS-04-04/WS04-04-001.pdf (2004).
28. inci. *DaVinci Resolve – Studio | Blackmagic Design* https://www.blackmagicdesign.com/products/davinciresolve/studio (2025).
29. Jacob Junker Larsen & Marc Pilgaard. *The Effect of Spatial Audio on Immersion, Presence, and Physiological Response in Games* 2015. https://vbn.aau.dk/ws/files/213012770/151031_Rapport.pdf?utm_source=chatgpt.com.
30. JoeCrow. *Reverb Parameters Explained!* Joe Crow - The Audio Pro. https://www.joecrowtheaudiopro.com/2020/03/17/reverb-parameters-explained/ (2025).
31. Jørgensen, K. On the Functional Aspects of Computer Game Audio. https://bora.uib.no/bora-xmlui/bitstream/handle/1956/6734/paper-KJorgensen.pdf (2006).
32. Judytl. *Psychological Horror – Writing Across Contexts* https://blogs.charleston.edu/writing-across-contexts/2022/04/30/psychological-horror/ (2025).
33. King, J. K. An Analysis of the Methods and Techniques Used to Create an Unsettling Atmosphere in Horror Games. https://static1.squarespace.com/static/54340376e4b0935ee578d933/t/55abd6cfe4b0ba36033940db/1437325007514/JamieKingDissertationPrint.pdf (2015).
34. Kromand, D. Sound and the diegesis in survival horror-games. *Audio Mostly*. https://es.scribd.com/document/521510586/Control-of-Sound-Environment-Using-Genet (2025) (2008).

35. Lantz, F. *Exploring the impact of familiarity on the emotional response to acousmatic sound effects in horror film* https://urn.kb.se/resolve?urn=urn:nbn:se:ltu:diva-84249 (2025) (2021).

36. Lewis, J. R. & Sauro, J. *Item Benchmarks for the System Usability Scale - JUX* JUX - The Journal of User Experience. https://uxpajournal.org/item-benchmarks-system-usability-scale-sus/ (2025).

37. *Handbook of emotions* (ed Lewis, M.) 3. ed (Guilford Press, New York, 2008). 848 pp. ISBN: 978-1-59385-650-2.

38. Lewitzki, A. *Taking control of the horror : Working with visuals in the psychological horror game genre* https://urn.kb.se/resolve?urn=urn:nbn:se:ltu:diva-63981 (2025) (2017).

39. Limantoro, G. H. & Atma, Y. D. The Psychological Horror & Psychoanalysis. *Journal of Social Sciences and Cultural Study* **1.** Number: 2, 109–115. ISSN: 3032-0631. https://swastikajournal.com/index.php/jsscs/article/view/91 (2025) (Mar. 31, 2024).

40. Lonsdorf, T. B. *et al.* Don't fear 'fear conditioning': Methodological considerations for the design and analysis of studies on human fear acquisition, extinction, and return of fear. *Neuroscience & Biobehavioral Reviews* **77,** 266. ISSN: 0149-7634. https://www.sciencedirect.com/science/article/pii/S0149763416308466 (2025) (June 1, 2017).

41. Maldon, A. Wrongness Done Right: Conceptualization of Horror Experience Caused by Glitches in Video Games and Its Application in Game Design. https://www.researchgate.net/profile/Aleksandr-Maldon/publication/388175160_Wrongness_Done_Right_Conceptualization_of_Horror_Experience_Caused_by_Glitches_in_Video_Games_and_Its_Application_in_Game_Design/links/678d2005ec3ae3435a6e04c5/Wrongness-Done-Right-Conceptualization-of-Horror-Experience-Caused-by-Glitches-in-Video-Games-and-Its-Application-in-Game-Design.pdf (2025) (2025).

42. Mark Z. Danielewski. *HOL* http://archive.org/details/HouseOfLeaves_201804 (2025) (2000).

43. Marshall McGee. *How To Design Sounds For Horror Games* Apr. 9, 2020. https://www.youtube.com/watch?v=TFLWaTG0NTM (2025).

44. Martin, G. N. (Why) Do You Like Scary Movies? A Review of the Empirical Research on Psychological Responses to Horror Films. *Frontiers in Psychology* **10.** Publisher: Frontiers. ISSN: 1664-1078. https://www.frontiersin.org/journals/psychology/articles/10.3389/fpsyg.2019.02298/full (2025) (Oct. 18, 2019).

45. Müller, I., Sundström, P., Murer, M. & Tscheligi, M. *Gaming after Dark* in *Entertainment Computing - ICEC 2012* (eds Herrlich, M., Malaka, R. & Masuch, M.) (Springer, Berlin, Heidelberg, 2012), 16–29. ISBN: 978-3-642-33542-6. https://link.springer.com/chapter/10.1007/978-3-642-33542-6_2.

46. Németh, K. & Szűcs, J. *Gaming Under Stress: Sensor-Monitored Physiological Responses to a Horror Gameplay* in *2024 IEEE 28th International Conference on Intelligent Engineering Systems (INES)* (2024), 000059–000064.

47. Nielsen, D. L., Hansen, K. Y. H., Hansen, T. P. & Traskinaite, G. Psychoacoustic effects of infrasound on game experience. *Psychoacoustic effects of infra-sound on game experience.* https://vbn-aau-dk.zorac.aub.aau.dk/ws/files/58307463/Group708_paper.pdf (2011).

48. O'Brien, H. L. & Toms, E. G. The development and evaluation of a survey to measure user engagement. *Journal of the American Society for Information Science and Technology* **61.** _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1002/asi.21229, 50–69. ISSN: 1532-2890. https://onlinelibrary.wiley.com/doi/abs/10.1002/asi.21229 (2025) (2010).

49. O'Brien, H. L., Cairns, P. & Hall, M. A practical approach to measuring user engagement with the refined user engagement scale (UES) and new UES short form. *International Journal of Human-Computer Studies* **112,** 28–39. ISSN: 1071-5819. https://www.sciencedirect.com/science/article/pii/S1071581918300041 (2025) (Apr. 1, 2018).

50. Oguta, S., Ojo, S. & Maake, B. Prototype Implementation of a Robotic Gamification Model for Climate Change Literacy for Green Innovation and Entrepreneurship with Social Robot Nao. *Journal of Computing Sciences Research* **9,** 3491–3523. https://www.researchgate.net/profile/Stephen-Oguta/publication/388627794_Prototype_Implementation_of_a_Robotic_Gamification_Model_for_Climate_Change_Literacy_for_Green_Innovation_and_Entrepreneurship_with_Social_Robot_Nao/links/679f7430645ef274a45f87be/Prototype-Implementation-of-a-Robotic-Gamification-Model-for-Climate-Change-Literacy-for-Green-Innovation-and-Entrepreneurship-with-Social-Robot-Nao.pdf (2025) (2025).

51. Öhman, A. Of snakes and faces: An evolutionary perspective on the psychology of fear. *Scandinavian Journal of Psychology* **50.** _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1111/j.1467-9450.2009.00784.x, 543–552. ISSN: 1467-9450. https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1467-9450.2009.00784.x (2025) (2009).

52. Öhman, A. & Mineka, S. Fears, phobias, and preparedness: Toward an evolved module of fear and fear learning. *Psychological Review* **108,** 483–522. ISSN: 1939-1471, 0033-295X. https://doi.apa.org/doi/10.1037/0033-295X.108.3.483 (2025) (2001).

53. Parker, J. R. & Heerema, J. Audio Interaction in Computer Mediated Games. *International Journal of Computer Games Technology* **2008.** _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1155/2008/178923, 178923. ISSN: 1687-7055. https://onlinelibrary.wiley.com/doi/abs/10.1155/2008/178923 (2025) (2008).

54. POE Museum. *Edgar Allan Poe – The Poe Museum* https://poemuseum.org/edgar-allan-poe/ (2025).

55. Reaper. *REAPER | Audio Production Without Limits* https://www.reaper.fm/ (2025).

56. Reiss, S. Expectancy model of fear, anxiety, and panic. *Clinical Psychology Review* **11,** 141–153. ISSN: 0272-7358. https://www.sciencedirect.com/science/article/pii/0272735891900929 (2025) (Jan. 1, 1991).

57. Rouse III, R. in *Horror Video Games: Essays on the Fusion of Fear and Play* (McFarland & Company, 2009).

58. Roux-Girard, G. *Listening to Fear: A Study of Sound in Horror Computer Games* https://services-igi-global-com.zorac.aub.aau.dk/resolvedoi/resolve.aspx?doi=10.4018/978-1-61692-828-5.ch010. ISBN: 9781616928285 Publisher: IGI Global. https://www-igi-global-com.zorac.aub.aau.dk/chapter/listening-fear-study-sound-horror/46793 (2025).

59. Sharma, M., Kacker, S. & Sharma, M. A Brief Introduction and Review on Galvanic Skin Response. *International Journal of Medical Research Professionals* **2.** ISSN: 24546356, 24546364. http://ijmrp.com/Article.aspx?id=307&volume=2&issue=6&type=1 (2025) (Dec. 23, 2016).

60. SoundGirls. *Audio Post Production Archives* SoundGirls.org. https://soundgirls.org/tag/audio-post-production/ (2025).

61. Statista. *U.S.: top horror film subgenres 2022* Statista. https://www.statista.com/statistics/1346910/horror-movie-subgenres-united-states/ (2025).

62. Steimer, T. The biology of fear- and anxiety-related behaviors. *Dialogues in Clinical Neuroscience* **4,** 231–249. ISSN: 1294-8322. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3181681/ (2025) (Sept. 2002).

63. Sun, C.-T., Lin, H. & Lu, H.-Y. *Using physiological response data to examine horror video game enjoyment* in *Abstract Proceedings of DiGRA 2019 Conference: Game, Play and the Emerging Ludo-Mix* (2019).

64. Taylor, S. The structure of fundamental fears. *Journal of Behavior Therapy and Experimental Psychiatry* **24**, 289–299. ISSN: 0005-7916. https://www.sciencedirect.com/science/article/pii/000579169390053Y (2025) (Dec. 1, 1993).

65. Toprac, P. & Abdel-Meguid, A. *Causing Fear, Suspense, and Anxiety Using Sound Design in Computer Games* https://services-igi-global-com.zorac.aub.aau.dk/resolvedoi/resolve.aspx?doi=10.4018/978-1-61692-828-5.ch009. ISBN: 9781616928285 Publisher: IGI Global. https://www-igi-global-com.zorac.aub.aau.dk/chapter/causing-fear-suspense-anxiety-using/46792 (2025).

66. Unity. *Unity 6: Download the Latest Release of Unity 6* Unity. https://unity.com/releases/unity-6 (2025).

67. Vorobeva, E. *Building atmosphere in a horror game through environment design* Accepted: 2024-06-05T06:14:34Z. http://www.theseus.fi/handle/10024/862614 (2025).

68. *Why is Distortion In Music So Important? Let's Break it Down!* Unison. Section: Distortion. https://unison.audio/distortion-in-music/ (2025).

11 Appendix

1 Interview questions and answers from anxiety test

The interview questions and answers from the anxiety test can be found in the ZIP file under the filename: "*Anxiety Test Questions and Answers*".

2 Preliminary information Group A

2.1 Age Distribution

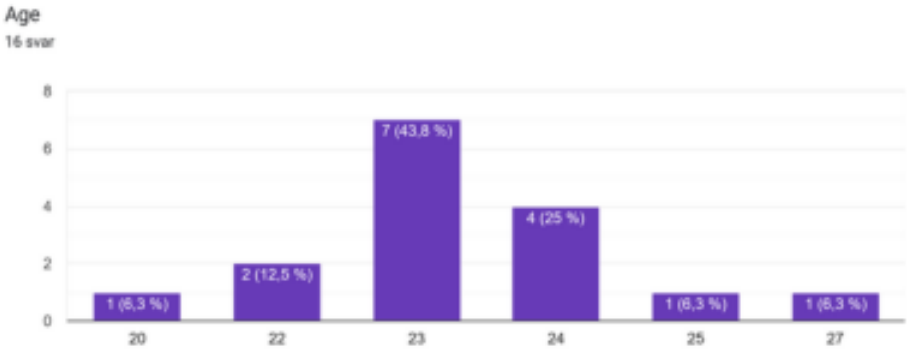

Figure 47: Age Distribution Group A

2.2 Gender Distribution

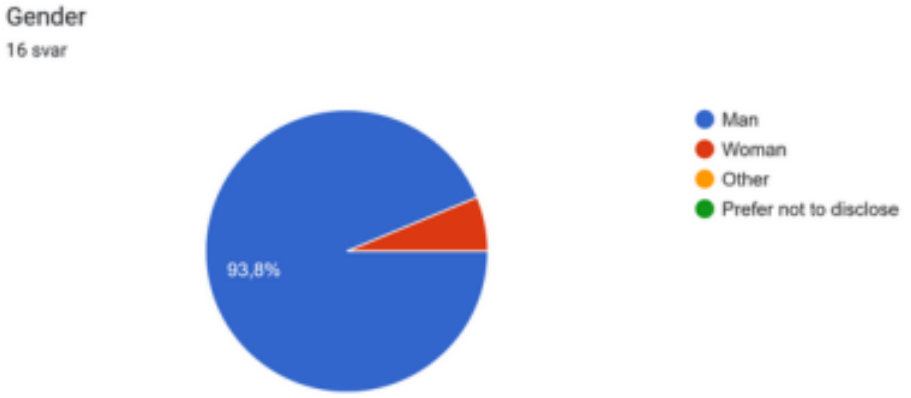

Figure 48: Gender Distribution Group A

2.3 How often do you play video games?

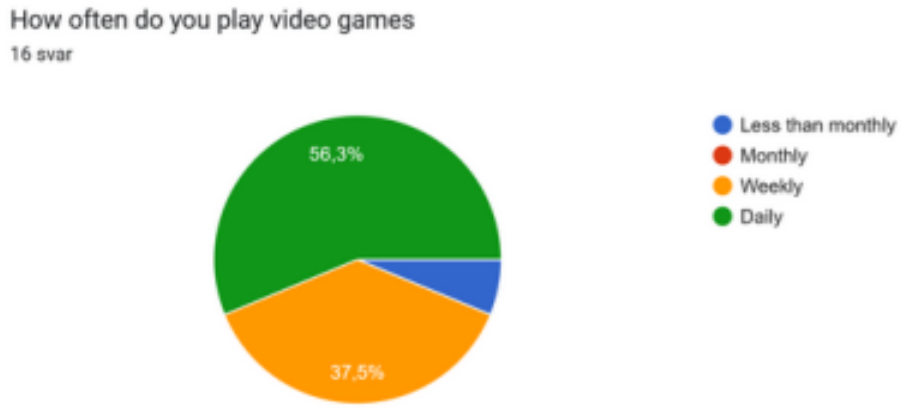

Figure 49: How Often The participants play video games for Group A

2.4 How often do you play horror games?

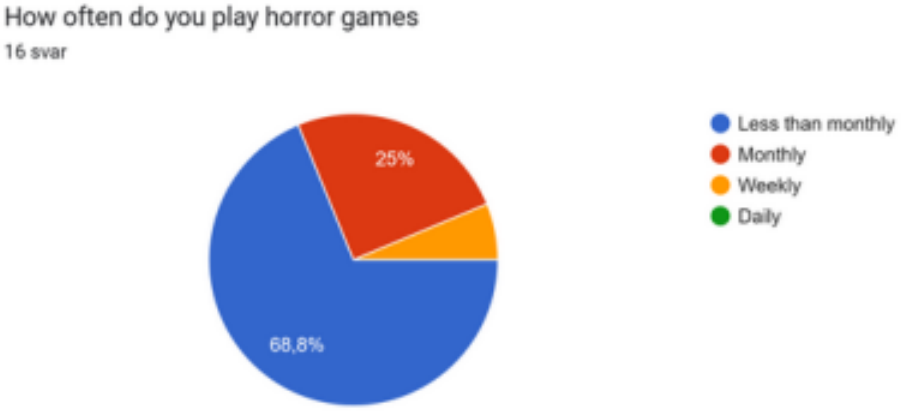

Figure 50: How Often The participants play Horror Games for Group A

2.5 Do you like horror games?

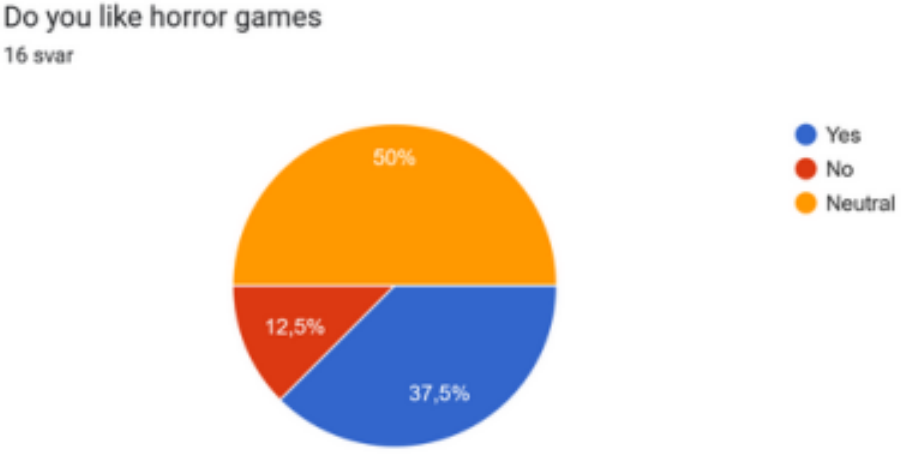

Figure 51: How users like horror games group A

3 Preliminary information Group B

3.1 Age Distribution

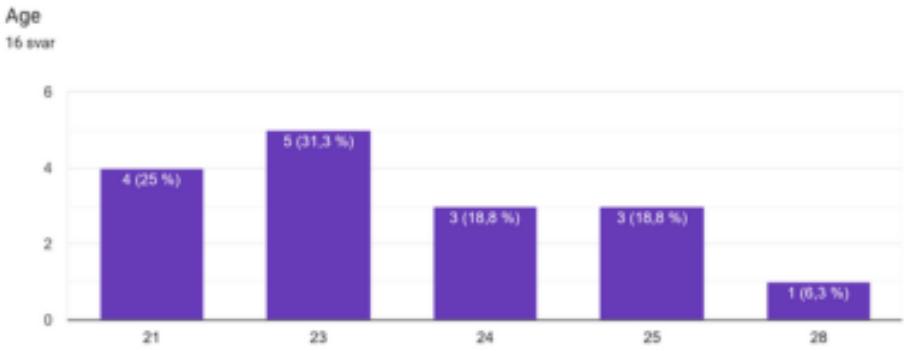

Figure 52: Age Distribution Group B

3.2 Gender Distribution

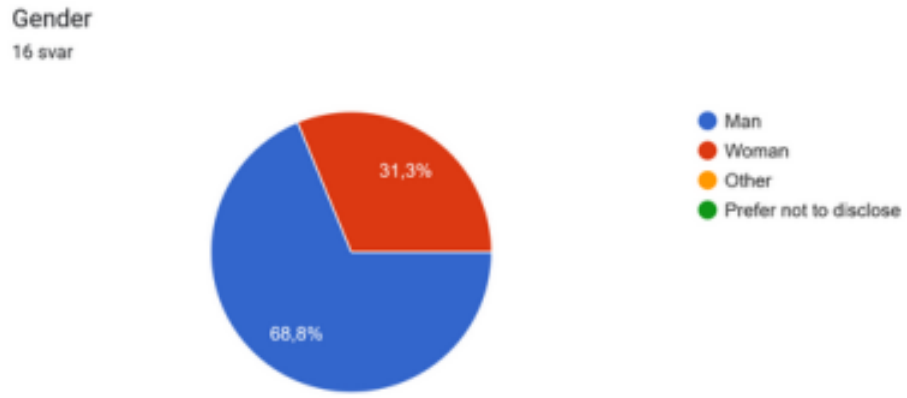

Figure 53: Gender Distribution Group B

3.3 How often do you play video games?

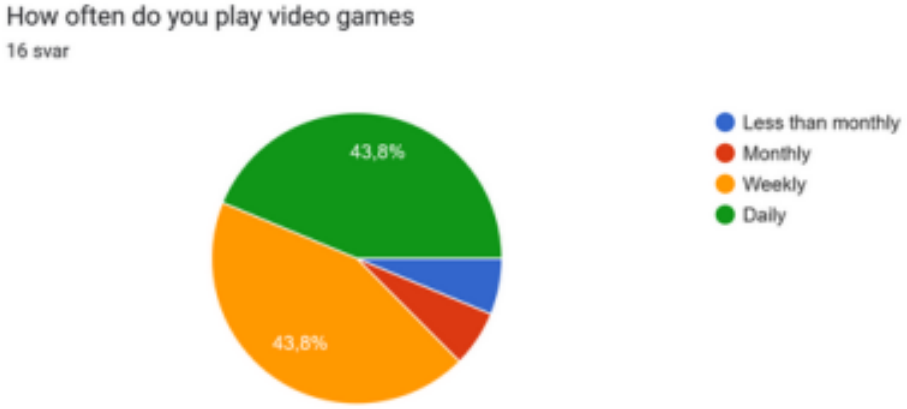

Figure 54: How Often The participants play Video Games Group B

3.4 How often do you play horror games?

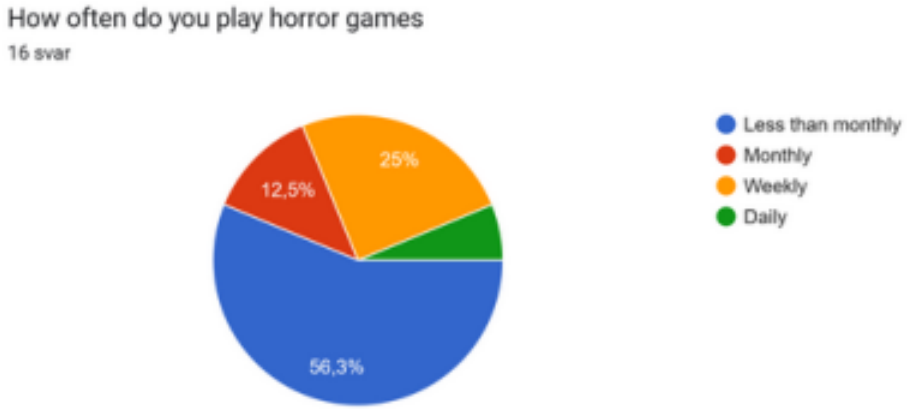

Figure 55: How Often The participants play Horror Games for Group B

3.5 Do you like horror games?

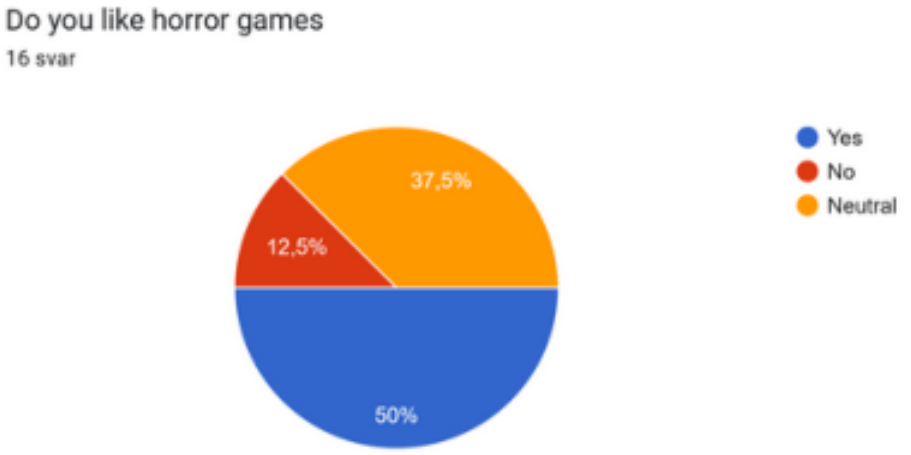

Figure 56: How users like horror games group B

4 Raw data from questionnaire final test

The raw data, including questions and answers can be found in the ZIP files under the filenames: "Final test Group A Raw data" and "Final test Group B Raw data".

5 Raw data from GSR and HR final test

The raw data, including questions and answers can be found in the ZIP files under the filenames: "HR raw data" and "GSR raw data".

6 Interview questions from final test

1: At any moment, did you feel anxious or uneasy? If yes, can you recall any specific moments that made you feel that way?

2: At any moment, did the sound design make you feel anxious or uneasy? If yes, can you recall any specific moments where that happened?

3: At any moment, did you notice yourself reacting to a sound, such as jumping, pausing, or becoming more cautious? If yes, can you recall any specific moments where that happened?

7 Interview transcripts from final test

7.1 Participant B01

Interviewer: At any moment, did you feel anxious or uneasy? If yes, can you recall any specific moments that made you feel that way?

Participant B01: Ja, ja det gjorde jeg. Erhm, right when I entered, I think it was the boys bedroom where there was the scissors under the bed, there was a running noise right at the beginning, that was probably when I got the most scared

Interviewer: At any moment, did the sound design make you feel anxious or uneasy? If yes, can you recall any specific moments where that happened?

Participant B01: Yeah, the pulsing, yeah, but also right at the end when there was no journal, but this journal guy was just screaming in my ear, I can't remember what he said but he was screaming something, that was also part of it.

Interviewer: At any moment, did you notice yourself reacting to a sound, such as jumping, pausing, or becoming more cautious? If yes, can you recall any specific moments where that happened?

Participant B01: Yeah, I paused a lot, and I was very cautious the whole time. And for example the little girls, I don't know, playtent? I made sure to go check that out last, because I thought something bad was gonna happen right in that tent. Yeah so, I made sure to plan so I checked everything around the thing I thought was scary first.

7.2 Participant B02

Interviewer: At any moment, did you feel anxious or uneasy? If yes, can you recall any specific moments that made you feel that way?

Participant B02: Det vil jeg sige ja, især her til sidst hvor man lige pludselig skulle løbe og ikke rigtig vidste hvad der skete og ja, hvad der var rundt om en, når rummene lige pludselig skiftede.

Interviewer: At any moment, did the sound design make you feel anxious or uneasy? If yes, can you recall any specific moments where that happened?

Participant B02: Ehh, det vil jeg også sige ja, også bare at hele tiden have det her hjerteslag, der bliver ved med at man sådan, at det er det man skal følge for at finde ting og sådan noget. Men altså bare det at have lyden gør en lidt mere bange fordi at, ja, ens hjerte slår hurtigere når man er bange.

Interviewer: Så altså det her ambience lyden og lignende?

Participant B02: Præcis ja

Interviewer: At any moment, did you notice yourself reacting to a sound, such as jumping, pausing, or becoming more cautious? If yes, can you recall any specific moments where that happened?

Participant B02: Altså der da bogreolen, som der lige pludselig noget der røg ud af den, så var

det lige sådan hurtigt, ja en lille smule vil jeg sige.

Interviewer:: Var der andre tidspunkter eller noget?

Participant B02: Også en lille smule der til sidst når man skulle til at løbe lige pludselig, når man bliver fanget og alt det sorte kommer, så nåede jeg også at få et lille chok, hop lignende.

7.3 Participant B03

Interviewer: At any moment, did you feel anxious or uneasy? If yes, can you recall any specific moments that made you feel that way?

Participant B03: Yeah, the second bathroom I think, when the door was locked.

Interviewer: At any moment, did the sound design make you feel anxious or uneasy? If yes, can you recall any specific moments where that happened?

Participant B03: Yeah, a lot of the time there was a heartbeat at some point, which I found quite interesting and made me a bit anxious.

Interviewer: At any moment, did you notice yourself reacting to a sound, such as jumping, pausing, or becoming more cautious? If yes, can you recall any specific moments where that happened?

Participant B03: Ehhh, not really, there was a small section where sound cut out, before repeating so it didn't loop, like, perfectly, that was the only part where I think, I became more aware of the sound really, so it had quite the opposite effect somehow, but that was, like, the only thing.

7.4 Participant B04

Interviewer: At any moment, did you feel anxious or uneasy? If yes, can you recall any specific moments that made you feel that way?

Participant B04: Yes, I would say I was anxious, yeah.

Interviewer: Were there any specific moments?

Participant B04: A lot of the times when the heart was beating when you got like closer to where some of the clues would be, yeah I felt that was like a point of tension.

Interviewer: At any moment, did the sound design make you feel anxious or uneasy? If yes, can you recall any specific moments where that happened?

Participant B04: Yes, I would say so as well, I think mostly at the end, where it sounded like someone was running behind me, that was, uh yeah, very scary [nervous laughter].

Interviewer: At any moment, did you notice yourself reacting to a sound, such as jumping, pausing, or becoming more cautious? If yes, can you recall any specific moments where that happened?

Participant B04: Yeah, that was the, when he yelled run at the end, I expected the heart to fly at me, but not like a big sound, so I jumped a bit in the chair [laughter]

7.5 Participant B05

Interviewer: At any moment, did you feel anxious or uneasy? If yes, can you recall any specific moments that made you feel that way?

Participant B05: Yeah, there were two moments when I got straight up goosebumps, very specifically there was the biggest effect was when I heard footsteps behind me, ooooo, that creeped all the way up, that was nice. And then at the very end when it said "run", and I just heard a lot of noise behind me

Interviewer: At any moment, did the sound design make you feel anxious or uneasy? If yes, can you recall any specific moments where that happened?

Participant B05: Uhmm like, the sound design, helped with the different effects, some of them were better than others, but overall sound experience wise, I think that's more specifically on the recordings, for me they didn't really that feel that scary I got more, just, annoyed at the part where the microphone peaked, more than anything. That's for that specifically. I don't feel like the sound design as a whole made me anxious it was more specific places.

Interviewer: Like the footsteps behind you?

Participant B05: The footsteps behind me yeah.

Interviewer: At any moment, did you notice yourself reacting to a sound, such as jumping, pausing, or becoming more cautious? If yes, can you recall any specific moments where that happened?

Participant B05: Footsteps worked really well, got me really anxious that someone was there, also because before that I had seen the figure walk up the stairs. The heartbeat, very intense, liked that a lot, that really also elevated the experience a lot I feel like.

7.6 Participant B06

Interviewer: At any moment, did you feel anxious or uneasy? If yes, can you recall any specific moments that made you feel that way?

Participant B06: Yes, throughout most of the game I think I felt pretty on edge. Yeah, multiple, like the child's laughter in the children's room in the first part of the game, and the footsteps at one part, I don't remember when there were running footsteps, that was in the second part I think, those two stood out to me and then the ending of course, the run part was also pretty intense.

Interviewer: At any moment, did the sound design make you feel anxious or uneasy? If yes, can you recall any specific moments where that happened?

Participant B06: Yeah, I think the examples I had were very much sound related right? I feel like the sudden sounds like worked well

Interviewer: At any moment, did you notice yourself reacting to a sound, such as jumping, pausing, or becoming more cautious? If yes, can you recall any specific moments where that happened?

Participant B06: Yep, I think the running footsteps made me turn around and close the door immediately, yeah I was not gonna laugh at this one, yeah but it was like, oh! Oh nope! No thank you to that. Yeah.

7.7 Participant B07

Interviewer: At any moment, did you feel anxious or uneasy? If yes, can you recall any specific moments that made you feel that way?

Participant B07: Uhm, I think after like the beginning when I got a little more immersed it was a little, like, anxious, scary, but I think its maybe because I have played games like this before, uhh, it was not as, like, it wasn't a new thing to me, but it was immersive I would say.

Interviewer: So I guess I can take that as, there were no moments that you could pinpoint that made you feel anxious or uneasy?

Participant B07: I guess I could, probably the most, like, a bit anxious was probably when the stairs appeared the second time I went through the house right, cause that was something that happened without me knowing, when I thought I knew the environment.

Interviewer: At any moment, did the sound design make you feel anxious or uneasy? If yes, can you recall any specific moments where that happened?

Participant B07: I think, just generally the heartbeat when it was really loud you knew that something was going to happen so that made you kind of anticipate something, uhh, so I guess that made me a little uneasy.

Interviewer: At any moment, did you notice yourself reacting to a sound, such as jumping, pausing, or becoming more cautious? If yes, can you recall any specific moments where that happened?

Participant B07: Hmm, I, yeah that was some point, but not really that much, it was like in the bathroom for example when they made a loud noise and then everything outside of the bathroom changed, I was a little, "woah what's happening here" but other than that there wasn't really any moment that made me, like, physically react to it.

7.8 Participant B08

Interviewer: At any moment, did you feel anxious or uneasy? If yes, can you recall any specific moments that made you feel that way?

Participant B08: I, ja, ja det gjorde jeg,i hvert fald lige der til slut der når man mærker hjertet sådan helt, det bare, fordi at lyden bare cutter ud randomly, så var det nogen gange bare mere humoristisk, end det var direkte skræmmende, dog at den nogle gange også bare cutter tilbage, så er det sådan, for eksempel lige der i slutningen med hjertet, så fanger jeg den der run, hvilket jeg kan mærke, sådan, skræmmer mig og så cutter lyden lige bagefter. Og så er det bare sådan, "nå". Lidt antiklimatisk. Jeg løb bare og så kunne jeg se at jeg var ved at dø, well, okay, forstået.

Interviewer: At any moment, did the sound design make you feel anxious or uneasy? If yes, can you recall any specific moments where that happened?

Participant B08: Ja, klart, I hvert fald surround sound med hjerte lydene når man gik hen til ting så havde det en eller anden form for immersion lyd, om det var tv'et, nogle gange følte jeg at lydene ikke rigtig passede, man gik op til vinduet og så var der fugle, der gav mig sådan lidt en, hvad skal man kalde det, en god følelse. I hvert fald også tapesene, igen nogen af dem hørte jeg slet ikke, da jeg opdagede at jeg kunne play dem tilbage så prøvede jeg jo det for ligesom at regne ud om "har jeg misset et eller andet", jeg missede så også et tape så, det ved jeg ikke hvor er, ja det tror jeg er det.

Interviewer: At any moment, did you notice yourself reacting to a sound, such as jumping, pausing, or becoming more cautious? If yes, can you recall any specific moments where that happened?

Participant B08: Ja, det er klart, det med run lyden, der var også nogle gange med Markus voice-over hvor det var sådan, meget uforventet højlydt, eller den laver en eller anden cut off lyd, så kunne jeg godt mærke at "Oh!" Der var et eller andet, man lige skulle reagere på der. Men det var mest de høje lyde, hvor det var sådan, de kørte de samme niveauer, og så lige pludselig sådan et lyd jumpscare, hvis man skal kalde det det.

7.9 Participant B09

Interviewer: At any moment, did you feel anxious or uneasy? If yes, can you recall any specific moments that made you feel that way?

Participant B09: Not a lot, but a little bit.

Interviewer: Can you recall any specific moments that made you feel that way?

Participant B09: Ehh, sometimes when there would be noises that came like out of the blue.

Interviewer: At any moment, did the sound design make you feel anxious or uneasy? If yes, can you recall any specific moments where that happened?

Participant B09: I don't know, I feel that it did the purpose of the game, like the sound.

Interviewer: At any moment, did you notice yourself reacting to a sound, such as jumping, pausing, or becoming more cautious? If yes, can you recall any specific moments where that happened?

Participant B09: Eh, a little bit yeah, and also with like the heartbeat when it was stronger somewhere I knew it was in the right place and yeah [nervous laughter].

7.10 Participant B10

Interviewer: At any moment, did you feel anxious or uneasy? If yes, can you recall any specific moments that made you feel that way?

Participant B10: Ja, det synes jeg, er det noget specifikt eller bare sådan generelt?

Interviewer: Ja, noget specifikt?

Participant B10: Jeg synes især lydende var meget, altså hver gang der kom sådan en lyd bagfra eller sådan, det er fordi jeg tror, har i det sådan at det kommer i forskellige øre? Fordi det kan man godt høre, fordi nogle gange bliver man lidt sådan, "woah", der er et eller andet, så klart de moments.

Interviewer: At any moment, did the sound design make you feel anxious or uneasy? If yes, can you recall any specific moments where that happened?

Participant B10: Klart, sound designet var det, der gjorde at man følte sig anxious. Og også når man blev lidt "Uhh" så var det fordi der var et eller andet, enten var det Markus der råbte ind i hovedet på mig eller også er der et eller andet der kom bagfra og var sådan, ja.

Interviewer: At any moment, did you notice yourself reacting to a sound, such as jumping, pausing, or becoming more cautious? If yes, can you recall any specific moments where that happened?

Participant B10: Ja, jeg synes jeg kunne mærke at jeg fik et lille sæt på et tidspunkt, ikke sådan noget vildt, men ja.

Interviewer: Nu har du allerede sagt, når der f.eks. kommer lyd bagfra, men har du et specifikt moment?

Participant B10: Ja, et specifikt moment, altså især i de der recordings der var der et eller andet der faldt ned eller et eller andet der sådan sagde, jeg tror det var der med scissor moment eller sådan noget der var der ligesom et eller andet, jeg kan ikke huske præcis hvad det var, men der var et eller andet der, der fik mig.

7.11 Participant B11

Interviewer: At any moment, did you feel anxious or uneasy? If yes, can you recall any specific moments that made you feel that way?

Participant B11: Hmm, jo, det vil jeg sige. Mest fordi man ikke rigtig vidste hvad der og hvad man skulle og sådan noget, så det var meget sådan et murder mystery til at starte med, noget med død og noget med blod. Så det var meget sådan, lidt anxious omkring hvad skal der ske.

Interviewer: At any moment, did the sound design make you feel anxious or uneasy? If yes, can you recall any specific moments where that happened?

Participant B11: Ja jeg føler faktisk det var det der, sådan, var mest med til at skabe sådan en uhyggelig stemning

Interviewer: Var der nogen specifikke tidspunkter?

Participant B11: Altså helt til sidst var det jo meget mere sound og meget mere sådan, ja, on top of each other, men også bare sådan nogle, jeg føler generelt, også bare sådan nogle småting som, uhh, jeg lavede ikke lige noget og men så var der en lyd der kom og så var det sådan "uhh hvor kom den fra?".

Interviewer: At any moment, did you notice yourself reacting to a sound, such as jumping, pausing, or becoming more cautious? If yes, can you recall any specific moments where that happened?

Participant B11: Jeg kan godt huske der på et tidspunkt var en lyd, som kom sådan lidt bagfra mig, og så kiggede jeg sådan tilbage, tror jeg, for at se om der var noget eller et eller andet. Ja, jeg tror at jeg reagerede ret meget på lydende fordi de var med til at guide hvad der foregik, ellers var der jo ikke andet der bevægede sig ud over mig derinde, så på den måde reagerede jeg.

7.12 Participant B12

Interviewer: At any moment, did you feel anxious or uneasy? If yes, can you recall any specific moments that made you feel that way?

Participant B12: Uhm, I mean a little bit in the end, where you were running from the monster, is probably what I would memorize the most. I probably felt a little bit anxious during the, when the different tapes were played, and also, I mean it differed, because also at some moments it also

reduced my feeling of being anxious, when I recognized the same sound being played and I just kind of got used to it.

Interviewer: At any moment, did the sound design make you feel anxious or uneasy? If yes, can you recall any specific moments where that happened?

Participant B12: I mean, I actually think the acting, it was actually pretty good, it was pretty good, I liked it, it was pretty fun. It at least absorbed me in the experience, it immersed me, and also kind of, because it immersed me, It also kind of made me feel more anxious, so the tapes are probably a strong key component in making me feel anxious.

Interviewer: At any moment, did you notice yourself reacting to a sound, such as jumping, pausing, or becoming more cautious? If yes, can you recall any specific moments where that happened?

Participant B12: I feel that, maybe, there wasn't a like big, big reaction, but there might have been a slight reaction, but that would be at the, probably at the end, because I accidently ran into the monster because I expected it to come behind me but it was actually in front me so I had to turn around, that kind of was like "oh shit I need to change direction". And uhm, certain moments during the tapes as well, there were like moments where the audio got a little bit louder and I didn't expect it but it all just added to the experience.

7.13 Participant B14

Interviewer: At any moment, did you feel anxious or uneasy? If yes, can you recall any specific moments that made you feel that way?

Participant B14: Generally every single part where there is not a shadow creature moving around. The shadow creature is just like, "oh great, I have like, a fixed point where I can focus my fear" and now it's just like "oh now I know it's just a game enemy". Everything where it was just the general atmosphere trying to make you anxious, quite succeeded

Interviewer: At any moment, did the sound design make you feel anxious or uneasy? If yes, can you recall any specific moments where that happened?

Participant B14: I mean yeah, the sound design, if it has just been the visuals I would have been a lot more at ease and just be able to walk around as "oh that's a cool uhh, lighting effect" but then there is just the [unintelligible] and the heartbeat keeping you on edge and changing volume depending on where you are.

Interviewer: At any moment, did you notice yourself reacting to a sound, such as jumping, pausing, or becoming more cautious? If yes, can you recall any specific moments where that happened?

Participant B14: Yes, I did, sadly I had already, like heard the last tape at the start by just opening the journal, pressing play tape, I heard the final tape, so that didn't take me off guard that he was suddenly like, no longer speaking from a tape recording, but the voice became clear, and it sounded like he was inside of your head, but at another point he just, like, screamed and that shocked me like, woah, yeah.

7.14 Participant B15

Interviewer: At any moment, did you feel anxious or uneasy? If yes, can you recall any specific moments that made you feel that way?

Participant B15: Jeg tror jeg var anxious i starten af spillet, og i midten af spillet, og i slutningen af spillet. Det var faktisk bare hele vejen igennem.

Interviewer: At any moment, did the sound design make you feel anxious or uneasy? If yes, can you recall any specific moments where that happened?

Participant B15: Ja, det synes jeg, det hele var sådan, gjorde mig høj puls, jeg er heller ikke så god til gyserspil så jeg bliver mere opslugt så jeg lever mig mere ind i spillet også, ja.

Interviewer: Var der nogen sådan specifikke lyde som du føler?

Participant B15: Jeg tror det er hjertebanken, fordi så føler du at dit hjerte begynder at banke til den rytme, og sådan hviskende og knirkende lyde så man tror at der er nogen men der er der ikke.

Interviewer: At any moment, did you notice yourself reacting to a sound, such as jumping, pausing, or becoming more cautious? If yes, can you recall any specific moments where that happened?

Participant B15: Ja, det gjorde jeg, ja. Det var en del af det med whisper, som jeg nævnte før.

7.15 Participant B16

Interviewer: At any moment, did you feel anxious or uneasy? If yes, can you recall any specific moments that made you feel that way?

Participant B16: Ja, især når der var, altså lydeffekterne var virkelig gode, der var nogle især, jeg kunne mærke mit eget hjerte hoppe, især der var på et tidspunkt en der løb i baggrunden, eller sådan selve musikken altså når der skete noget dramatisk, for eksempel da hånden kom op. Super godt.

Interviewer: At any moment, did the sound design make you feel anxious or uneasy? If yes, can you recall any specific moments where that happened?

Participant B16: Hele tiden, ej det var virkelig godt, det var super nice, også når man fandt tapesene og han snakkede, jeg kunne godt lide at det ikke bare sådan var monotont kedeligt snak der var virkelig gjort noget ud af det, det gjorde det super nøieren.

Interviewer: At any moment, did you notice yourself reacting to a sound, such as jumping, pausing, or becoming more cautious? If yes, can you recall any specific moments where that happened?

Participant B16: Ja, det var det jeg sagde før, det var ikke sådan så at jeg hoppede, men jeg kunne mærke at jeg fik det der "uh!", gys, altså sådanne gisp gennem kroppen ik.

8 Questionnaire items final test

Questionnaire Items
Focused attention
FA1: "I lost myself in the game."
FA2: "The time I spent playing the game just slipped away."
FA3: "I was absorbed in the game."
Reward
RW1: "Playing this game was worthwhile."
RW2: "My experience was rewarding."
RW3: "I felt interested in the game."
Anxiety
AX1: "I felt anxious / uneasy while playing the game."
AX2: "I was anxious of what might would happen more than what was actually happening."
AX3: "I felt on edge while playing the game"
AX4: "I was afraid while playing the game."
Sound
SD1: "The overall sound design was immersive."
SD2: "Certain sounds made me feel like something was present around me."
SD3: "Certain sounds made me anticipate something scary was about to happen."
SD4: "The sound design intensified the feeling of anxiety throughout the game."

Figure 57: Questionnaire Items

9 Frequency distribution over questionnaire scores for Group A and Group B

9.1 Group A Frequency Distribution

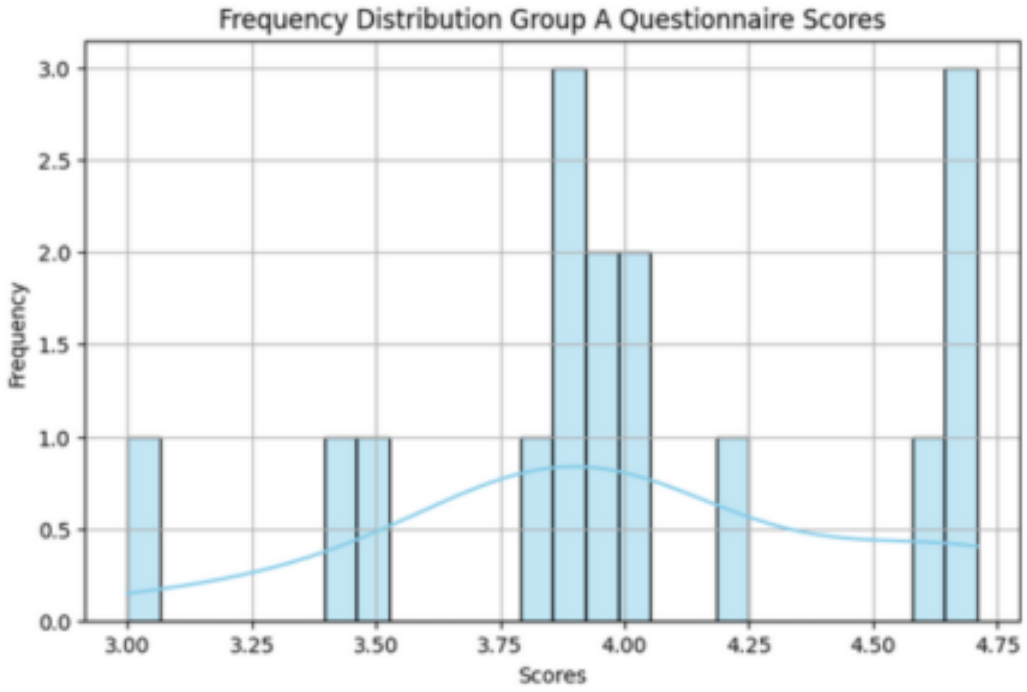

Figure 58: Frequency Distribution Group A Questionnaire Scores

9.2 Group B Frequency Distribution

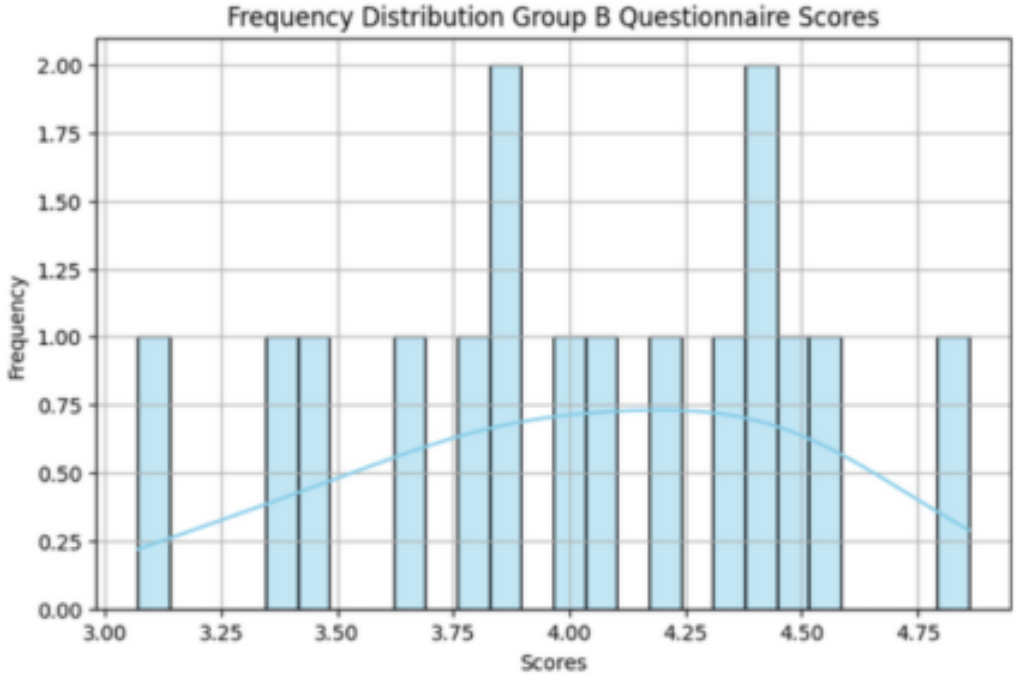

Figure 59: Frequency Distribution Group A Questionnaire Scores

10 Q-Q plots over questionnaire scores for Group A and Group B

10.1 Group A Q-Q plot

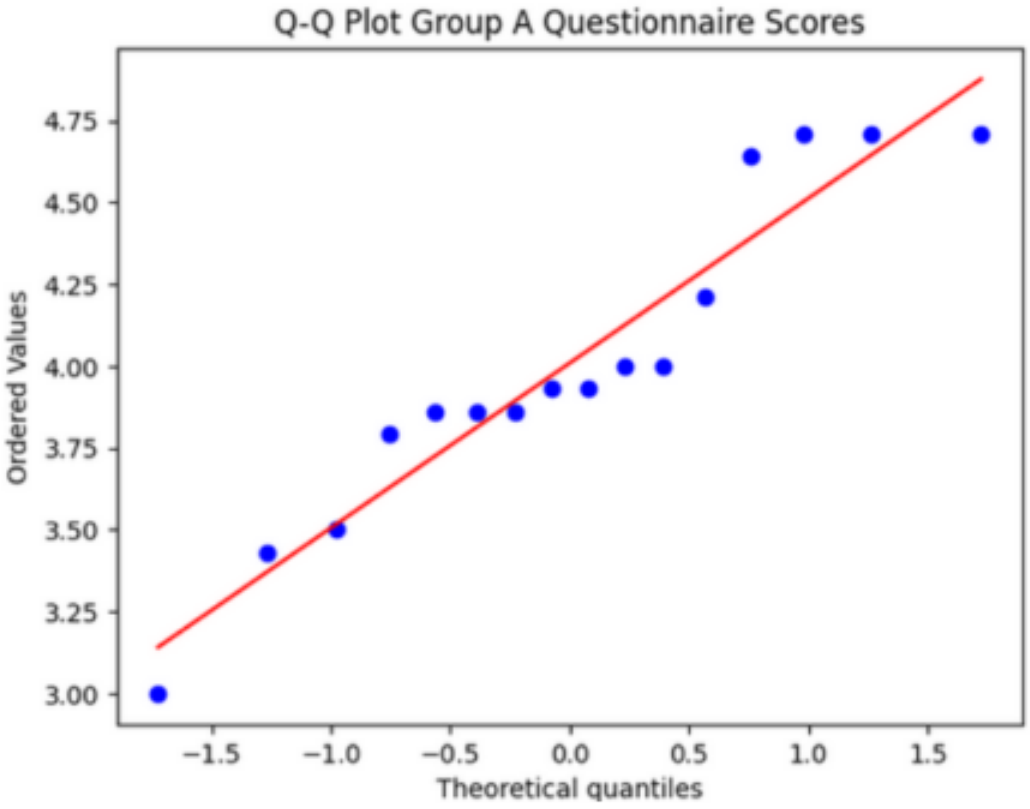

Figure 60: Group A Q-Q Plot

10.2 Group B Q-Q plot

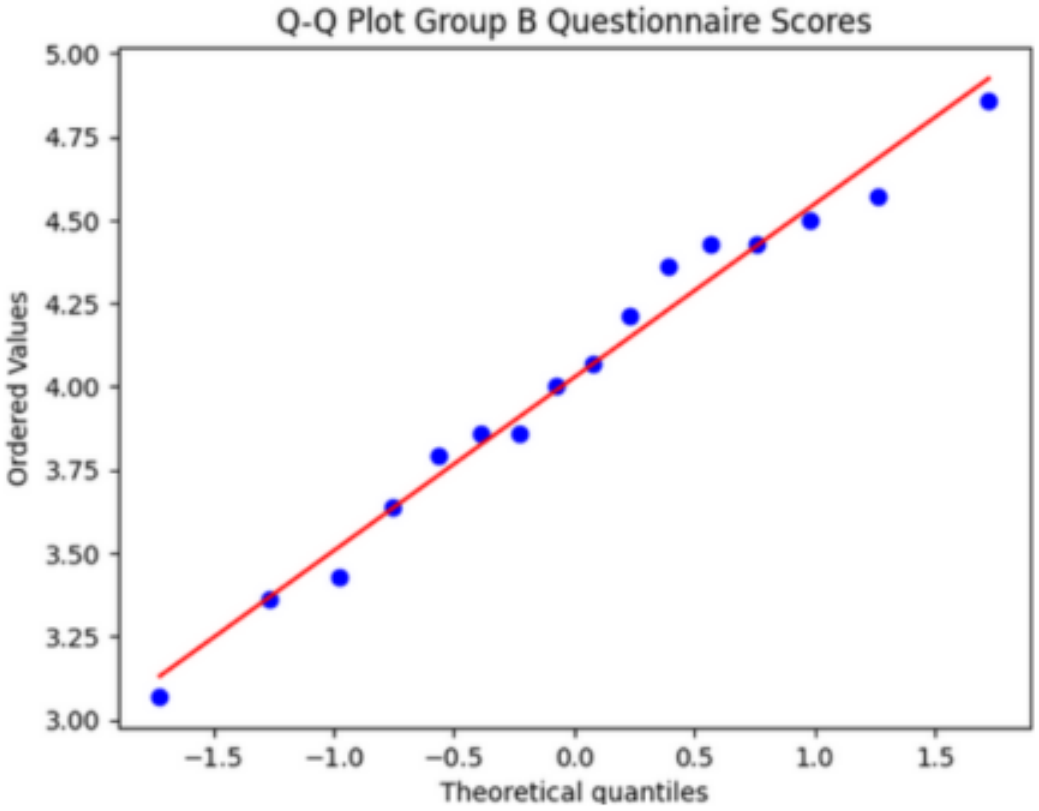

Figure 61: Group B Q-Q Plot

11 Shadows Of The Heart Screenplay

The screenplay can be found in the ZIP file under the filename: "Shadows of the Heart Final DRAFT.pdf"

12 Consent Form

the consent form can be found in the ZIP file under the filename: "Consent Form.png"