Enhancing Immersion: Exploring Environmental Feedback in VR Horror Gaming

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Contents

1 Abstract

This research aims to enhance immersion in virtual reality horror gaming through the development of environmental feedback systems that respond dynamically to player actions. It addresses a key limitation in the genre: the reliance on scripted scares, which often lose impact with repeat exposure. This project explores how emotional unpredictability can be achieved within a linear game structure by focusing on adaptive soundscapes, real-time visual feedback, and psychological engagement triggers.
This research demonstrates that narrative control and player reactivity can coexist in a new model for horror game design which maintains emotional engagement without losing structure. The study contributes to an under-explored area in VR: blending reactive environmental systems with guided storytelling to maintain tension and replayability.
My research attempts to boost player presence and emotional engagement through its focus on these neglected areas which will advance the VR industry by creating authentic immersive experiences. The research establishes connections between virtual and real-world experiences through innovative sound design and interactive visual elements and psychological cues to improve human-computer interaction and human factors in VR settings.

2 Acknowledgements

I want to thank the creators and contributors of resources critical to this project. The sound effects in this game are sourced from Freesound.org, a repository and portal for free, high quality sound files without royalties attached. I am also grateful to the one-person sound designers who make it possible to create immersive audio experiences.
All visual assets used in the game are also from the Unity asset store, where there are pre-made quality assets. This makes game development even more efficient and allows more concentration on the gameplay mechanics, environmental interactivity and narrative design.
These resources were a big part of forming this project, and I value the communities and platforms that provide them.

3 Background and Motivation

Virtual reality creates immersive experiences yet its ability to provide responsive feedback diminishes user presence. The technology for fully interactive worlds remains limited in VR horror where sensory feedback is crucial. Ineffective environmental feedback is a significant problem in achieving the full potential of VR immersion, which is how virtual worlds respond to the player's actions and deliver real-time sensory information. Without responsive interactions, users will feel disconnected from the immersive experience, which reduces their sense of presence. In VR horror games, sensory feedback and environmental interactivity are critical for building tension, fear, and emotional engagement. [1] However, the technology of creating this kind of immersion is underdeveloped. This dissertation explores enhancing immersion in VR horror gaming through improved environmental feedback. In the words of Yiing Y'ng Ng and Chee Weng Khong from the Multimedia University in Malaysia, "Our grasp on human emotions, behaviours and strategies in VR settings is still in need of deepening." [1] This Research highlights the lack of connection between players' experiences when virtual worlds lack realistic responses to their actions. The research will help fill this knowledge gap by studying under explored aspects of VR horror games which involve how dynamic soundscapes and real-time visual feedback affect player immersion and emotional engagement. [2] The project seeks to enhance player presence and emotional response through three core feedback mechanisms which include dynamic soundscapes that change based on player proximity and narrative elements and real-time visual cues that modify lighting and environmental features through user interactions and psychological engagement triggers that adjust sensory inputs to increase emotional tension. I believe the virtual reality industry will grow exponentially as we get closer to simulating perfect immersion. By focusing on these enhancements, this research aims to bridge the gap between virtual and real-world experiences by improving our knowledge of HCI and human factors with VR.

4 Aims and Objectives

This dissertation aims at exploring and improving ways of achieving user immersion and emotional engagement in Virtual Reality horror experiences. This would be further enhanced by establishing responsive environmental feedback mechanisms that respond to the actions of the player and create more suspense, fear and uneasiness. I have three core objectives: dynamic soundscapes, visual feedback, and psychological engagement. I have also explained in detail what I planned to add to my game to achieve each of the objectives.

4.1 Develop Adaptive Dynamic Soundscapes

- Implement dynamic, layered soundscapes that react to player movement and location.
- Implement 3D spatial audio for proximity-based effects, for example, whispers, footsteps, and environmental creaks that respond to the player's position and movement.
- Use sound to heighten anxiety and allude to invisible dangers.
- Gradually adjust the ambient sound environment in response to player progress or actions.

4.2 Create Real-time Visual Feedback and Environmental Interactivity

- Introduce interactive elements, such as flickering lights, slamming doors, and moving objects that respond to player actions.
- Include scares triggered by where the flashlight points and responses that react to player hesitation or movement.

4.3 Integrate Psychological Engagement Triggers

- Explore post-processing effects (e.g., vignette, chromatic aberration) to distort perception and unease.
- Introduce subtle shifts (e.g., flickering lights, distorted audio, object movements) to manipulate player perception.

4.4 Optimise Player Immersion

- Balance high-quality visuals with smooth performance by investigating ways to increase performance.
- Leverage these optimisations to maintain a stable frame rate without sacrificing the immersive experience.

4.5 Conduct Playtesting to Evaluate Immersion and Emotional Impact

- Collect qualitative feedback through surveys and interviews to assess player engagement, emotional responses, and perceptions of immersion.
- Measure physiological data, such as GSR and PPG, to gain objective insights into emotional stimulation and the effectiveness of environmental triggers.

5 Related Work

Research concerning the entry into immersion via playing horror video games and their interaction with sensory cues, player interactivity, and psychological triggers has gained increasing attention. Previous studies have primarily achieved their goal of creating the immersion of environments; however, they heavily depend on scripted, static events that lose impact in most situations after repeated play-throughs. This project plans to fill gaps by integrating aspects such as adaptive soundscapes, dynamic visual feedback, environmental interactivity, etc., into familiar networks, thus providing a new way to look for uniformly sustaining immersion and further increasing replayability. The project's approach aligns with this existing research, aiming to build on it and contribute to the field of VR horror gaming.

5.1 Existing Research in Immersive Horror Mechanics

Audio and visual cues have been key to the player's experience in horror games. Yicong Qiu (2023) [3] acknowledges the importance of 3D spatial audio to build tension, while horror games such as *Silent Hill* and *Phasmophobia* use spatial sound and environmental storytelling to invoke fear. The research from SkyFunVR (2023) also demonstrates that dynamic lighting and interactive objects play a crucial role in enveloping players in the immersive experience of VR games; [4] however, pre-programmed triggers have become predictable and do not work psychically with time. Like *Silent Breath*, this project takes such ideas further by adding randomness and interactivity to its audio and visual elements. Instead of static implementations, this project relies on dynamic audio cues, such as ghostly sounds and flickering flashlights triggering in random places, and shutters and moving fridges as examples of environmental interaction, among many others. These elements react to the player's presence and actions, creating a constantly unpredictable and unsettling atmosphere that maintains immersion.

Figure 1: Examples of level design in *Silent Breath* (left) and shadow effects in *Phasmophobia* (right).

5.2 Advancements in Soundscapes and Visual Feedback

This project builds on these advancements by implementing dynamic soundscapes that adapt to player movement and location and real-time visual feedback that alters lighting and environmental features based on user interactions. These innovations aim to create a more immersive and emotionally engaging VR horror experience.

While games like *Layers of Fear* use changes in environmental sound coupled with visual distortion to disorient players, such cues are often reserved for scripted events; the novelty of this project lies in employing random ghost sounds with a trigger from any player's actions or vicinity to specific areas of the house. While static, predictable soundscapes provide a foundation, incorporating player-driven dynamism and interaction transforms them into unpredictable auditory experiences. I believe this unpredictability is crucial for creating an effective horror atmosphere, especially when combined with flickering lights and moving objects.

Thus, by adapting these sounds and visuals interactively, the project raises its immersion to a level not seen in many VR horrors today. Not only is the environment alive, constantly changing and reacting to player movement, but it also makes immersion at a level few games of this genre fully exploit regarding environmental reactivity available to the game.

5.3 Psychological Triggers in VR Horror

Psychological immersion in horror has been extensively examined in games. Research suggests that VR significantly increases emotional experiences compared to a traditional monitor. (Sophia C. Steinhaeusser) [6]. The VR's ability to engage the player's senses greatly enhances psychological immersion Adaptive algorithms have been used to increase unpredictability in the gameplay. However, many current VR horror games fail to fully integrate these psychological triggers with player actions, leading to a less immersive experience. These triggers are ambient shifts, sounds, and unexpected interactions that create emotional reactions. Features like ghostly whispers or quick changes in lighting can react to the player's decisions during the experience. Traditional game systems rely more on fixed, predetermined triggers that do not respond to the player's behaviour, reducing the overall immersion.

5.4 Under-Researched Areas in VR Horror

Extensive research has contributed to various dimensions of audio-visual-psychological immersion techniques; however, some areas remain not thoroughly investigated, especially in VR horror games. This project aims to fill these gaps by addressing the following:

- **Dynamic and Reactive Environments:** Most horror games work pre-scripted events, and those tend to feel repetitive and predictable. One can expect a more unpredictable engagement by creating a randomised and reactive environment to the player's actions and interactions. The flickering light in the game, randomly triggered ghost sounds, and moving objects create a dynamic environment that changes as the player progresses, so every time the scene is played, it is a fresh and unnerving experience.

- **Replayability through Randomization:** The primary restraint about VR horror games concerns predictable events. This project innovates by introducing randomised triggers for events such as flickering lights, ghost noises, and environmental changes. The result is a heightened appearance of replayability for the game but keeps the sense of unpredictability that is so much a part of the horror experience. Unlike programmed events, which can get quite limited after several applications, randomisation ensures players find new experiences and scares every time they play.

- **Psychological Engagement:** Instead of generic psychological triggers, this project tailors them to the player's actions and location in the game world. For example, entering a specific room might cause subtle changes in ambience or trigger faint whispers, making the horror feel more personal. This contextual approach enhances immersion and creates a more profound emotional impact than traditional, static systems.

While my experience is railroaded to ensure the study is consistent with each participant, I have allowed for randomisation through aspects of the game that can contribute to this under-explored area in vr horror.

6 Design

More than the standard jump scares typical of many VR horror games, this project focuses on the environmental design necessary for establishing an engaging yet terrifying virtual reality experience. Innovative techniques and research are employed to develop dynamic supernatural events, unreliable gameplay mechanics, flashlight management challenges, and atmospheric effects such as fog and spatial audio. These elements aim to create tension and disconcerting atmospheres for players, pushing the boundaries of VR as a horror medium. The goal is to offer a consistent experience with a predetermined outcome while allowing for player interaction and suspense. This project explores how VR can intensify horror and immersion through technical proficiency in Unity and innovative design, providing a profoundly engaging and unnerving experience.

6.1 3D Spatial Audio

3D Spatial Audio: The game employs 3D spatial audio for every sound-emitting object, from ticking clocks and creaking windows to the player's flashlight. Random eerie sounds such as ghostly whispers, players' footsteps, and other unsettling noises are also spatially positioned within the environment. This gives the illusion that they belong to specific areas in the house or forest, making it feel like a lively world one lives in but threatened by its surroundings. For instance, a disembodied voice can emanate from directly behind the player, or a door creak from far away becomes louder as one walks toward it; these evoke that unsettling feeling of being watched or pursued. This audio system increases tension and keeps the players in complete unease so that they remain engaged in the haunting ambience of the game.

6.2 Dynamic Ambience

When a player passes through different zones in the game world, the environments change in ambience, becoming gradually more unsettling as the player approaches the climax of the game. This ambience evolution is a slowly building experience designed to foster unease in preparation for a big jump scare. Because the experience is tailored to adapt and develop, the invariable tension will stay with the player, successfully amplifying the overall effect of the final scare. This is achieved with lighting, and sound design.

Figure 2: highlights the shifting ambience in the VR horror game. The left image shows the first floor, a claustrophobic, dark space where visibility is limited to a flashlight, creating isolation and tension. The right image depicts the third floor, where red lighting and intense music heighten the sense of danger. This progression builds suspense, preparing the player for the climax.

6.3 Mechanics and Gameplay

The core gameplay is designed to immerse players in an unsettling, dark environment where every action builds tension and contributes to the overall atmosphere of fear. Throughout the game, dynamic supernatural events such as flickering lights, eerie noises, and objects moving heighten the player's anxiety and contribute to an unpredictable, unnerving atmosphere. These events build up to a final death scene on the third floor, ensuring every player experiences the same chilling climax. The flashlight, the player's only light source, is unreliable and frequently flickers or turns off, leaving the player in complete darkness. The player must shake the flashlight to restore the light, adding interactivity and tension. This mechanic ensures that the player is often left in pitch-black moments, enhancing the horror atmosphere and intensifying the fear of the unknown. Combined, these mechanics create a consistent, immersive experience where every player's journey is dictated by the same set of supernatural events and unyielding tension, culminating in the same conclusion.

6.4 Psychological Post-Processing Effects

Chromatic Aberration, Depth of Field, Motion Blur, Vignette, and Grain and Noise are powerful post-processing effects that replicate the experience of hallucination and supernatural manipulation. Each effect contributes uniquely to the player's psychological unease. These effects will be applied when the player doesn't move, or something supernatural happens to encourage them to continue progressing and keep the tension high. Chromatic Aberration introduces subtle colour distortions along the edges of objects, mimicking the imperfections of lenses and creating a sense of visual instability. This effect is particularly effective in evoking feelings of disorientation or altered perception. Depth of Field blurs objects outside the focal plane, making the environment feel surreal or dreamlike. This directs the player's attention and reinforces a sense of disconnection from reality, as though the world is shifting or unreliable. Motion Blur heightens tension by exaggerating the effects of rapid movement, creating an unnatural smearing effect that simulates the dizzying impact of panic, exhaustion, or mental strain. The vignette darkens the edges of the screen, subtly restricting the player's field of vision. This effect contributes to a sense of confinement or tunnel vision, replicating the physical sensations of fear or anxiety. Finally, Grain and Noise add a layer of visual texture, evoking the gritty analogy feel of film or an old, malfunctioning screen. This can suggest a historical connection to past events and a breakdown of perception, as though supernatural forces interfere with the player's vision.

6.5 The Games Narrative

Research suggests including a narrative can add immersion to a VR Experience, [5] so I decided to come up with this: The story starts when the player undertakes a drive to investigate an abandoned house, which is said to have intense supernatural activity. The trip immediately turns when the player's car crashes into a tree. Stranded and with no other option, the player enters the dense, eerie woods, searching for a way forward. While the player navigates the forest, they start encountering increasingly ominous signs, making them second guess if they are being watched: Voices and partial glances of moving objects behind dark trees. The player would come out into a field to reveal that the house stood opposite: worn-out and forbidding, signalling a threatening event to occur in that building. Curiosity drives the player indoors to search for clues about what happened in the house. While it is a fascinating investigation at first, with scattered remnants hinting at a dark past, the situation escalates as the player suddenly finds himself trapped inside, with all the doors slamming shut behind him. The once-abandoned house comes alive with unexplainable phenomena- flickering lights, shifting shadows, and ghostly sounds from afar. As the supernatural events accelerate, the player must work through the increasingly hostile environment to uncover the house's secrets and survive a series of terrifying encounters. The story continuously ratchets up the tension to a jump scare by a demon on the third floor.

7 Game Development Methodology

The following section describes the main development techniques that were used to create an immersive VR horror experience. It includes the game engine (Unity with URP), sounds and assets, post-processing effects for hallucinations, lighting design, fog effects, and optimization strategies like LOD grouping and IL2CPP. These elements enhance atmosphere, performance, and player immersion.

7.1 Game Engine

The game is built with Unity and the Universal Render Pipeline (URP) as it offers a good balance between performance and visual fidelity and is well suited for VR horror. Unity supports VR integration and has good support for major platforms such as Meta Quest, HTC Vive and PlayStation VR. The real time rendering capabilities of URP allow for dynamic lighting, shadows and post processing effects that enhance the horror atmosphere. The physics system and VR interaction toolkits in Unity allow for realistic object manipulation which increases immersion.

7.2 Sounds and Assets

The game uses a monster model together with a flashlight and a house environment which were specifically chosen to fit the frightening atmosphere of the game. The game's visual components derive from these assets which strengthen the horror experience.
The audio content combines both original and sourced sounds to create tension while improving immersion. The Freesound platform provided high-quality royalty-free ambient sound effects which included creaking floors and distant whispers and sudden noises to enhance the game's unsettling atmosphere. Native Instruments served as the tool for composing the ambient music. The game achieves its deeply immersive and psychologically disturbing horror experience through the combination of carefully chosen assets and custom sound design.

7.3 Postprocessing

The psychological horror experience in VR receives significant enhancement through post-processing effects which specifically serve to intensify hallucinations and distortions of reality. The combination of Bloom effects with color adjustments produces supernatural glows which create an eerie atmosphere and chromatic aberration and lens distortion create visual instability that makes the world appear dreamlike or warped. The combination of depth of field with motion blur creates a sense of dizziness that enhances disorientation to match a character's mental deterioration. The combination of film grain with vignette creates a dark and confined environment that increases tension levels. Panini projection techniques together with split toning methods create small distortions in perspective while modifying color tones to change how objects appear. The combination of tonemapping with white balance control enables developers to adjust exposure levels and temperature settings which makes environments appear more unnatural. A VR horror game can create intense paranoia and disorientation in players while making their hallucinations feel disturbingly real through strategic implementation of these effects.

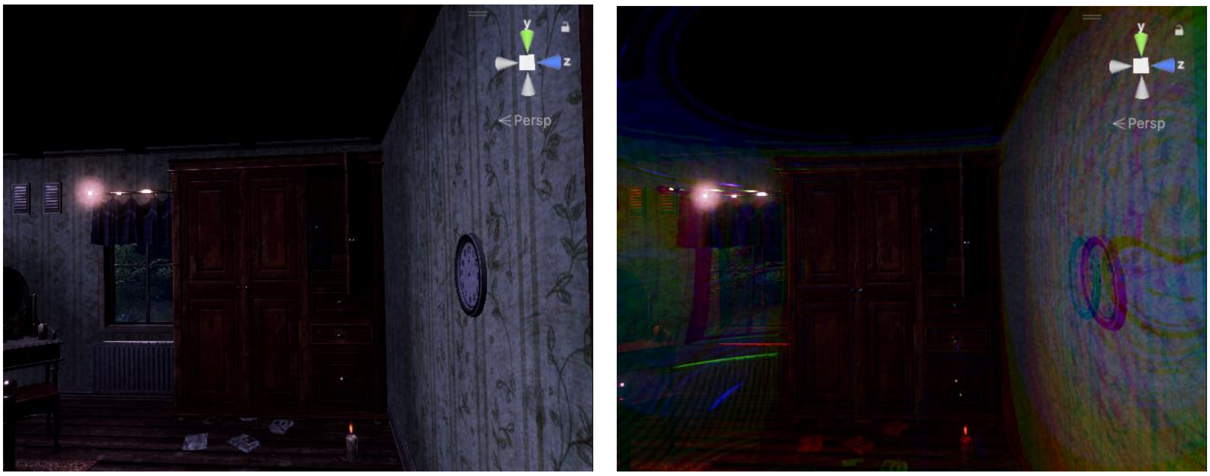

Figure 3: The images show the game environment without hallucination effects on the left and with hallucination effects on the right. The right image shows the application of post-processing effects including chromatic aberration and lens distortion and color shifting to create a disorienting hallucination effect. The visual distortions create psychological horror by distorting perception which makes the environment unstable and unsettling for the player.

7.4 Lighting Design

The lighting functions as a core element which determines the game atmosphere while simultaneously improving visual appearance and emotional depth. I designed the lighting system to maintain a balance between realistic effects and performance capabilities and immersive gameplay while generating visually striking environments.

The game uses a directional light source together with a 2D dark texture overlay to establish its lighting foundation which controls ambient light conditions. The texture creates uniform darkness throughout the scene to maintain an ominous and moody atmosphere. The framework enables flexible lighting control to create realistic interactions between light and shadow.

The flashlight functions as a core lighting design element which adjusts its behaviour to create more immersive gameplay. The flashlight produces unpredictable flickers when the player enters the house which generates an unstable atmosphere of unease. The effect works well in supernatural areas because the light will malfunction and produce unpredictable behaviour. The outdoor beam from the flashlight provides a strong consistent light which enhances the open atmosphere of the environment while keeping players suspended in anticipation. The dimmed and focused beam of light occurs indoors to create intense claustrophobic tension in tight spaces while forcing players to use minimal visibility for navigation.

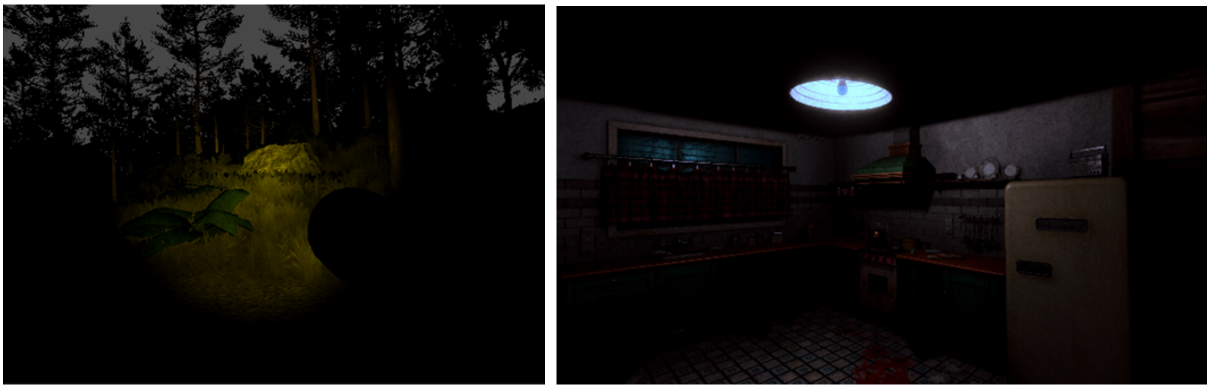

Figure 4: Examples of lighting design in my VR horror game, on the left is the flashlight which has a stronger brightness when the player is outside. The Right image dipicts the lighting inside the house

7.5 Fog and Volumetric Fog

Fog plays a key role in creating an eerie atmosphere. An exponential squared fog effect fades distant objects into complete blackness. This technique obscures the environment, heightening the sense of mystery and isolation while keeping players on edge. Additionally, volumetric fog enhances the dynamic atmosphere, with light beams cutting through the mist and shifting in real-time. This interaction creates dramatic lighting effects, allowing fog to envelop or reveal the environment.

Figure 5: Demonstrating the influence fog has on the atmosphere

7.6 Optimisation

Due to my game being quite resource intensive, the game has several optimisation techniques implemented to reduce computational load without sacrificing visual quality:

7.6.1 LOD Grouping

The Asset pack that I used with unity included LOD grouping for the objects in the scene. I focused on adapting these values to best fit performance while maintaining

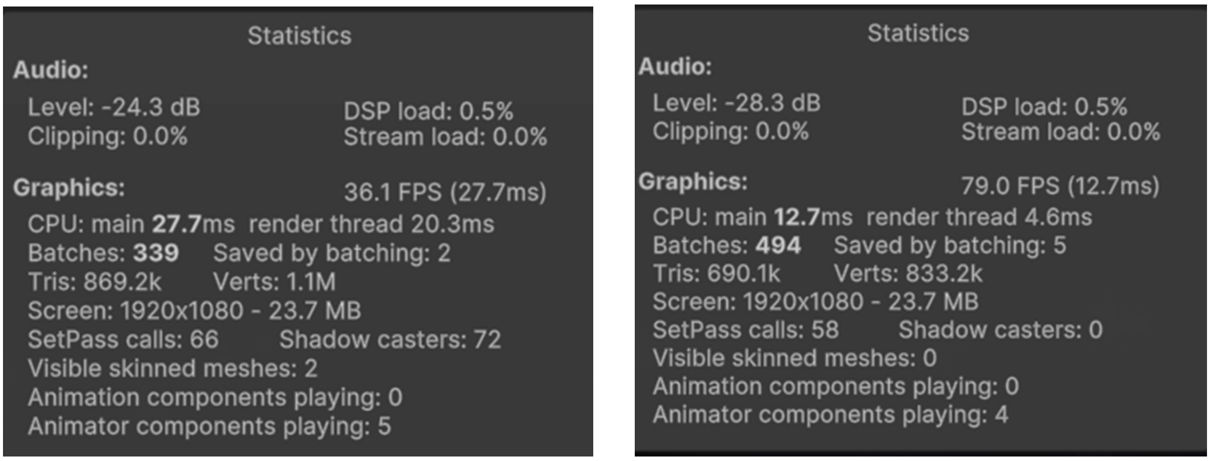

Figure 6: Before and after of the optimisation techniques being integrated

steady shifts - Different levels of mesh detail will be used based on the distance from the camera. When objects are far away or occupy a smaller portion of the screen, lower-resolution models with fewer triangles will be used, helping to maintain a stable frame rate. This is especially useful when the player is entering an area where there are a lot of objects.

7.6.2 Frustum Culling

The camera view will dynamically remove objects outside its view which makes sure that only objects which are visible will be rendered. This optimises performance by reducing the number of objects that need to be processed.

7.6.3 Occlusion Culling

The game uses occlusion culling as a crucial optimisation technique. Frustum culling differs from occlusion culling because it removes objects outside the camera view but occlusion culling removes objects within view that are hidden by other objects from the player.

7.6.4 Lowering Textures

The performance issues were addressed by changing from 2048x2048 to 1024x1024 textures. The approach reduces memory consumption and enhances frame rates without negatively affecting visual quality especially for less detailed or distant objects. The game achieves a smoother experience by adjusting texture resolution according to object importance and player distance especially in VR because high frame rates are essential for immersion. The technique strikes a balance between visual quality and performance optimisation to enable efficient gameplay with impressive visuals.

7.6.5 IL2CPP

IL2CPP stood out as an interesting solution for performance in my VR horror experience. This is because it compiles managed C# code into highly optimized native C++ which reduces runtime overhead and improves execution speed which is crucial for maintaining high frame rates in immersive VR environments. IL2CPP uses Ahead-of-Time

(AOT) compilation unlike Mono which relies on Just-in-Time (JIT) compilation, which eliminates performance spikes caused by runtime code generation. This ensures smoother gameplay, reduced latency, and better overall responsiveness, enhancing player immersion. Other interesting and useful reasons I used IL2CPP is because it also increases security by making the game harder to reverse-engineer and is required for platforms like Quest and PlayStation VR, ensuring broader compatibility. Just something to think about if the game is ever released. [7]

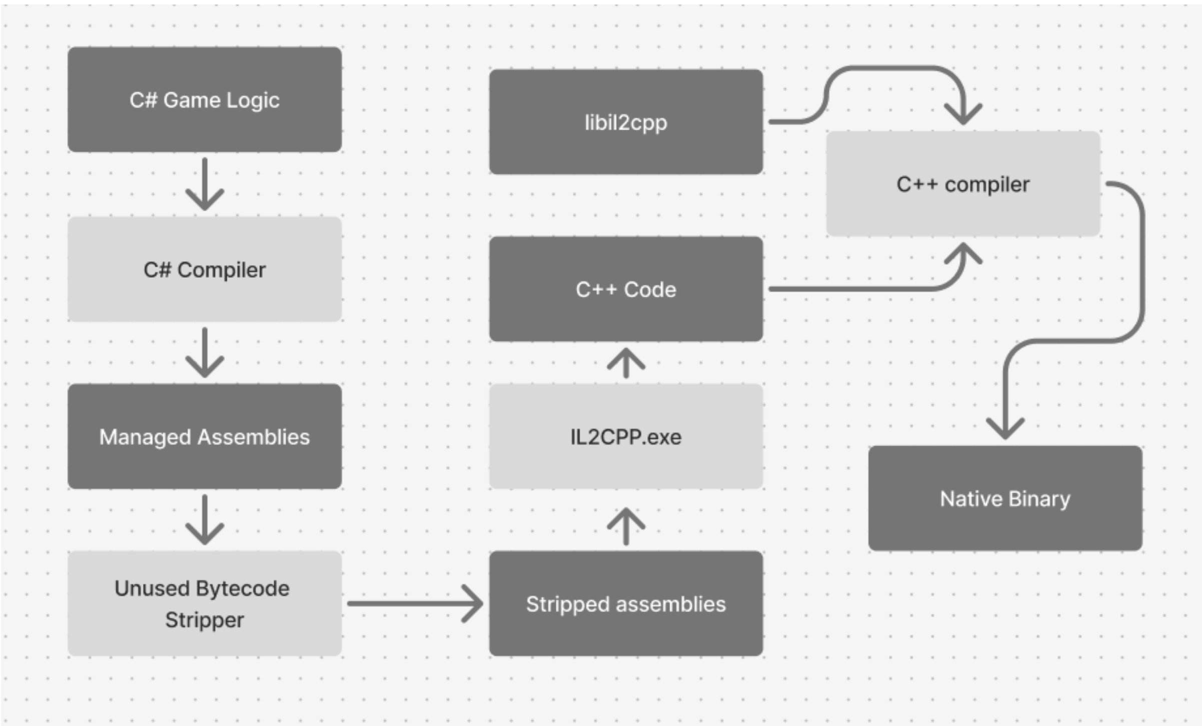

Figure 7: The diagram demonstrates how IL2CPP transforms C# code into optimized native code which enhances performance through elimination of JIT overhead and memory reduction and speedup for delivering smooth VR horror gameplay.

8 Implementation

This section outlines how different game mechanics, from event triggering to visual effects and dynamic gameplay systems, work together to create a cohesive and immersive horror experience for the player.

8.1 Event System

The Eventsystem script manages railroaded horror events by using event triggers and animations and sound effects and hallucinations.
The InitializeEventChecklist() function generates a list of required events which determine the conditions for specific actions to occur. The InitializeEventHandlers() function makes each EventSignaller subscribe to the HandleHorrorEvent() method which enables the detection of event triggers when the player enters particular areas. The InitializeOuijaBoard() function sets the Ouija board to a specific location which determines its starting

position.
The main part of this script is the HandleHorrorEvent() function. When an event is triggered, it passes an identifier corresponding to a specific horror effect. This function then calls the appropriate event function based on a switch statement.

```
private void HandleHorrorEvent(string eventName)
{
    switch (eventName)
    {
        case "MonsterWalk":
            TriggerMonsterWalk();
            break;
        case "FrontDoor":
            TriggerFrontDoor();
            break;
        case "BathroomJumpScare":
            TriggerJumpScare();
            break;
        ...
```

When the player activates the "TriggerFrontDoor" event the TriggerMonsterWalk() function becomes active. The script executes a function that probably makes the monster pursue the player while beginning a coroutine to eliminate the monster after five seconds and it updates the event checklist to prevent event repetition.

```
private void TriggerFrontDoor()
{
    if (!eventChecklist[2])
    {
        FrontDoorAnimator.Play("DoorOpen");
        FrontDoorAudio.Play();
        WindowEyes.SetActive(false);
        FridgeAnimator.enabled = true;
        eventChecklist[2] = true;
        flashlightS.minIntensity = 0.01f;
        flashlightS.inHouse = true;
        Debug.Log("Triggered Dooropen");
    }
}
```

The script enables me to modify the post-processing system which produces the hallucinating effect. The Update() method checks for hallucination by tracking the boolean isHallucinating. The script enables a post-processing effect which modifies the player's vision when the condition is true. A countdown timer controls the duration of hallucination until it automatically disables and the game plays a heartbeat sound effect whenever the player enters a hallucination state to increase tension.

The Front Door Closing event required more intricate sequence management than other events. The script executes an animation to close the door while producing spooky sound effects when triggered. A coroutine controls the sequence to create timed sound spacing which produces a more dramatic effect. The door produces a creaking sound before slamming shut and then generates an unsettling noise. The activation of an extra audio object occurs after several seconds which might add more environmental sound effects.

```
private IEnumerator FrontDoorCloseRoutine()
{
    FrontDoorAnimator.Play("FrontDoorClose");
    FrontDoorCloseCreak.Play();
    yield return new WaitForSeconds(0.4f);
    FrontDoorSlam.Play();
    FrontDoorScary.Play();
}
```

The EventSignaller script is a simple but crucial component that interacts with Eventsystem. Each object in the game world that can trigger an event is assigned an EventSignaller script.

```
private void OnTriggerEnter(Collider other)
{
    if (other.tag == "player")
    {
        HorrorEvent?.Invoke(EventName);
    }
}
```

The script sends a signal containing the event's name when the player enters the object's trigger collider. The Eventsystem script listens for this signal and executes the corresponding horror event, ensuring a dynamic and interactive horror experience. Its designed to ensure some triggers arent activated until the player progresses to that point. The design enables a highly modular and expandable event system. I can add new horror events easily by defining them in HandleHorrorEvent() and linking them with EventSignaller objects in the Unity editor. The game maintains a logical flow by structuring events in a centralized manner, which ensures that scares are delivered effectively and at the right moments.

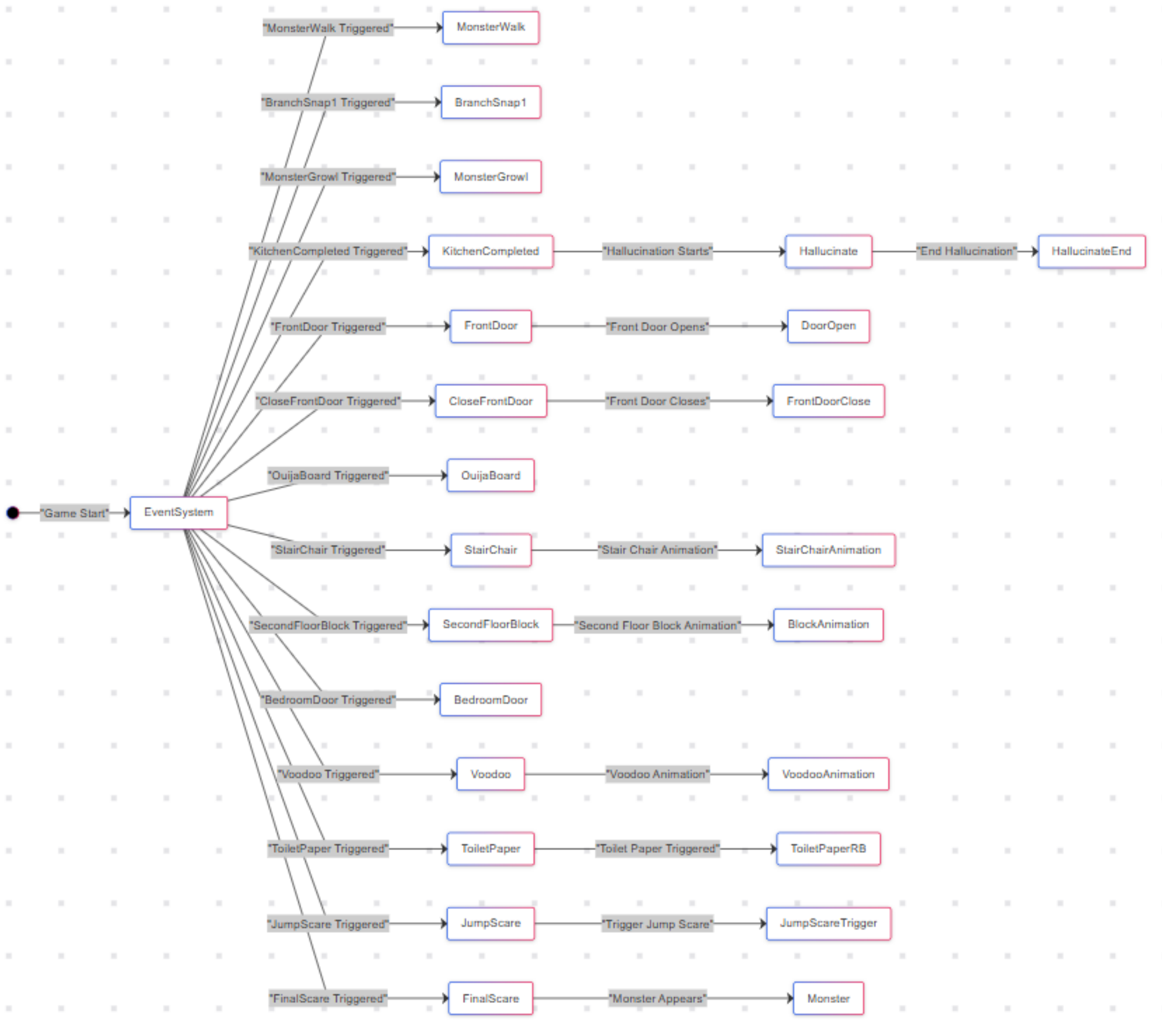

Figure 8: Basic Mermaid diagram providing a clear overview of the railroaded experience each participant undergoes, showcasing the sequential horror events and their triggers within the game.

8.2 post processing

I modified Unity's chromatic aberration effect to create full-screen colour distortion rather than just edge-based shifting. By default, Unity's aberration subtly separates RGB channels at the screen's periphery, mimicking real-world lens distortion. However, for intense hallucination sequences, I needed a more immersive, overwhelming effect. By adjusting the aberration spread multipliers, I expanded the color separation uniformly across the entire screen, making even the center visually unstable. This created a stronger sense of disorientation and unease, reinforcing the game's psychological horror elements and making hallucinations feel more intense and reality-breaking.

My research into post-processing techniques led to the creation of two separate VR horror modes which implement various effects to improve gameplay. The first mode maintains a constant application of bloom and colour adjustments and other effects to establish a chilling atmosphere. The effects remain active throughout the game while adjusting their values to preserve a steady level of immersion. Bloom makes light sources appear softer through a gentle illumination effect while channel mixing and colour grading reduce image brightness to create an oppressive dark atmosphere.
The second mode(halucination visuals) introduces a more extreme alteration with chromatic aberration and lens distortion activated. This mode warps the player's perception, shifting values of distortion over time to simulate a disorienting effect. Colour curves and LUTs are adjusted dynamically to fine-tune the emotional impact, so the experience feels unsettling without overwhelming the player.

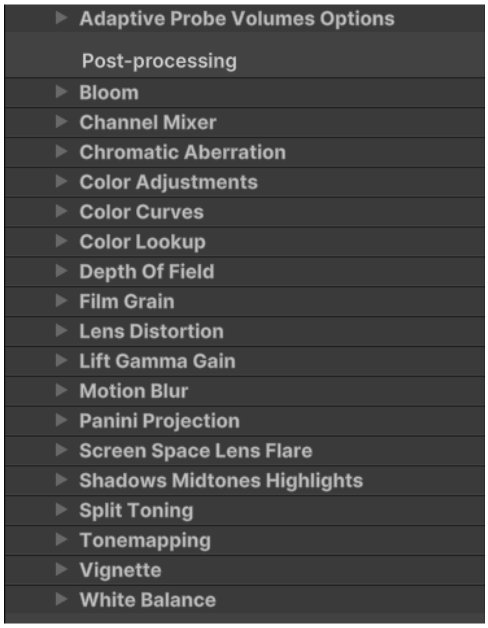

Figure 9: This shows all of the post processing effects I used in my game after researching different effects

The game's visual appearance was shaped by adjusting effect parameters including bloom intensity and lens distortion strength and colour desaturation level. The transition between modes becomes smooth because certain events use this system to move from the first mode with steady tension to the second mode with stronger visual distortions. The precise execution of these changes keeps players immersed while adapting the horror experience according to their actions.

8.3 Kitchen light

The flickering light in the kitchen works with a script that simulates a light flickering effect in Unity, which is influenced by the player's movements and location to the light source. It has two main components: a flickering light effect and a "breaking" mechanism when the player gets too close. The script controls both flickering intensity and audio feedback through the player's distance from the light source. The light flickers according to a sinusoidal function which uses the player's distance to determine its intensity. The light intensity lowers when the player moves closer until the player reaches breakDistance at which point the flickering stops and the "break" sound plays.

In terms of mathematics, the flicker effect is controlled by the following formula for amplitude:

$$\text{amplitude} = \left(\frac{\text{far} - \text{distance to player}}{\text{near}}\right)^3$$

8.4 Footstep Sound System

The SoundLayers script in Unity is designed to play different footstep sound effects depending on the surface the player is walking on. It uses LayerMask variables for three surface types: wood, stairs, and terrain, each associated with an AudioSource and respective sound clip arrays. The script tracks the player's movement and calculates the distance traveled in each frame. When the player moves a certain distance (stepDistance), a downward raycast is performed to detect the surface under the player. The sound clip from the corresponding array is played depending on which surface is hit (wood, stairs, or terrain). This creates dynamic footstep sounds that change according to the terrain, enhancing immersion. The accumulated distance ensures the sounds are played only at set intervals, preventing constant playback.

```
if (accumulatedDistance >= stepDistance)
{
    accumulatedDistance = 0f;

    if (Physics.Raycast(transform.position, Vector3.down, out
       RaycastHit hit, 10f, wood))
        woodSfx.PlayOneShot(WoodFloorClips[UnityEngine.Random.
           Range(0, WoodFloorClips.Length)]);
    else if (Physics.Raycast(transform.position, Vector3.down,
       out hit, 10f, stairs))
        stairsSfx.PlayOneShot(StairsClips[UnityEngine.Random.
           Range(0, StairsClips.Length)]);
    else if (Physics.Raycast(transform.position, Vector3.down,
       out hit, 10f, terrain))
        terrainSfx.PlayOneShot(TerrainClips[UnityEngine.Random.
           Range(0, TerrainClips.Length)]);
}
```

The Fridge script functions independently to manage fridge behavior through door animations and audio effects that respond to player proximity.
The AudioSource controls a "shake" sound volume which grows more intense according to the player's distance from the fridge. The door begins to open when the player reaches a specific near distance while the shake sound becomes inactive. The script controls the door animation speed through its adjustment mechanism. The animation speed decreases as the player approaches closer thus creating a delay before the door opens. When the animation speed reaches zero, the door opens by triggering an animation and the fridge's

interaction is marked as finished. The amplitude is calculated based on the player's distance to the fridge, which affects both the volume of the shake sound and the animator speed.

```
float amplitude = Mathf.Clamp((far - (player.transform.position
    - point).magnitude) / near, 0, 1);
amplitude *= amplitude * amplitude;

shake.volume = amplitude;
GetComponent<Animator>().speed = amplitude;

if ((player.transform.position - point).magnitude < near)
{
    door.enabled = true;
    shake.enabled = false;
}
```

8.5 Car Scene

The car scene utilises Unity's built-in spline system, based on Bézier curves, to control the car movement. I didn't write the movement code myself; instead, I set up the spline path in the Editor and adjusted speed, start position, and offsets to get the animation right. The script doesn't actually control the motion of the car itself, but it does synchronize things like audio, rotation locks, and fade transitions to the motion. That way, the whole sequence feels more cinematic than a physics-driven system.

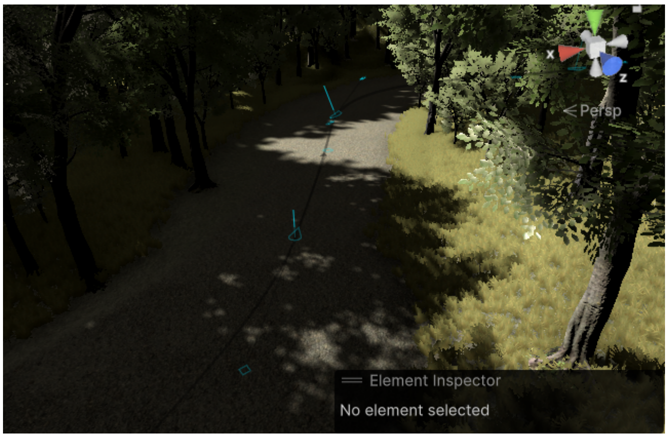

Figure 10: Showcase of the smooth curves generated after fine tuning

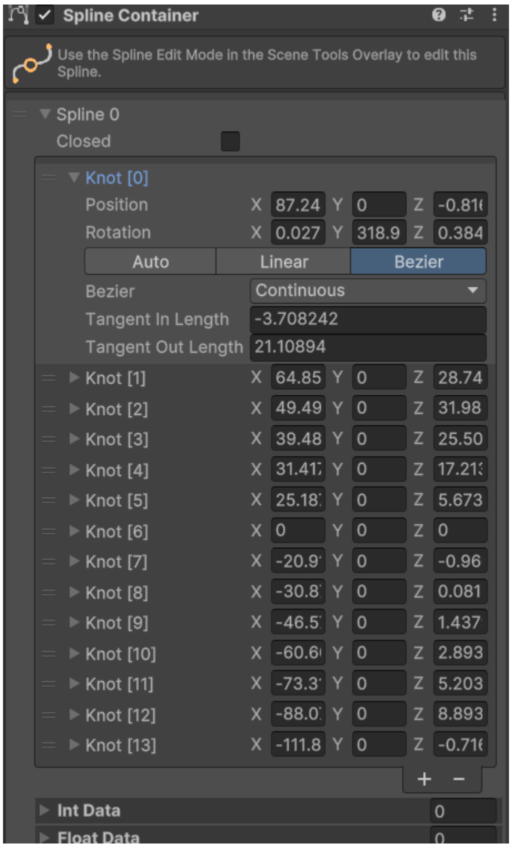

Figure 11: showcasing bézier curves and how their tangent values were changed in order to make a smooth car scene

8.6 flashlight

The FlashlightFlicker script creates a flickering flashlight effect which responds to battery charge, player movement and indoor position. The flashlight loses charge over time when inside the house but can be slightly recharged through movement. The flashlight remains steady when the charge reaches 55 or higher. The light begins to flicker between being on and off when the charge drops below 55 and it turns off completely when the charge reaches 20. The script generates realistic sound effects when the flashlight activates or deactivates. Randomized flickering effects occur through a delay timer which produces unpredictable behaviour.
The charge system makes the flashlight more than just a static light, it's a dynamic gameplay element. Battery drain is handled with a simple decrement, while movement-based recharging is based on vertical displacement.

```
if (inHouse) {
    charge -= (Time.deltaTime * 3f);
    charge = Mathf.Max(charge, 10);
}

float yDifference = Mathf.Abs(transform.position.y - prevPos.y);
charge += (yDifference * 5f);
prevPos = transform.position;
```

The flickering is based on charge level, with a random binary switch deciding whether the flashlight stays on or off when the charge is low.

```
if (charge > 55) {
    flashlight.intensity = chargeIntensity + 8;
} else if (charge < 55 && charge > 20) {
    OnOff = Random.Range(0, 2);
    flashlight.intensity = (OnOff == 0) ? 0 : chargeIntensity + 8;
    lightFlicker.PlayOneShot(OnOff == 0 ? onSound : offSound);
} else {
    flashlight.intensity = 0f;
}
```

The script keeps flickering unpredictably by using a delay timer that resets randomly within a specified range. The player is forced to shake there controller to "charge" the battery back up so they can see in front of them again.

```
if (delay <= 0) {
    delay = Random.Range(minFlickerDelay, maxFlickerDelay);
}
delay -= Time.deltaTime;
```

The script avoids performance issues by updating flickering logic within Update() instead of using coroutines because Unity operates with a single thread. The result is a responsive, immersive flashlight system that dynamically reacts to in-game conditions.

9 Study Methodology

The research on user responses to emotionally charged virtual reality (VR) environments used a multi-method approach that included observational studies, biometric data collection, and qualitative user feedback. This section describes the methods used to study fear and immersion in human-computer interaction within VR.

9.1 Playtesting Sessions

I performed observational research in a controlled setting at the mixed reality lab. I observed participants playing the VR game through OBS while I recorded their gameplay and physiological data. I documented all aspects of their virtual experience by writing down their physical reactions together with their virtual interactions.

9.2 Physiological Measurements

I collected evidence of emotional responses by using the Shimmer Base 6U to gather biometric indicators which included Galvanic Skin Response (GSR) and Photoplethysmography (PPG) data. The physiological markers were recorded throughout the experience to evaluate the relationship between design elements and emotional reactions such as fear and tension.

9.3 Interviews and Questionnaires

The participants underwent semi-structured interviews following their VR experience to gather detailed information about their emotional and cognitive reactions. Participants assessed their fear levels through a scale from 1 to 10 while also sharing their general experience feedback and identifying their most frightening moments and periods of tension. The survey asked participants about their first reactions when they entered the virtual space and how the sound effects affected them as well as which visual aspects they found most notable and whether they experienced immersion and why. The participants needed to analyse their physical responses when faced with intense situations by observing their breathing patterns and body posture and muscle tension. The research used structured questionnaires to obtain quantifiable data about emotional responses and fear intensity and perceived immersion in addition to qualitative interviews. The research design combined both qualitative interview data and quantitative survey data to achieve a more detailed user experience analysis.

9.4 Data Analysis

The collected data from playtesting sessions, physiological measurements, and interviews were systematically analysed to identify trends in user reactions. Observational notes and recorded gameplay were reviewed to correlate visual and auditory elements with fear responses. Physiological data were examined to detect spikes in arousal corresponding to specific in-game events. Finally, qualitative responses from interviews and questionnaires were coded to extract common themes related to fear, immersion, and user engagement. The research combines these methodologies to deliver a complete understanding of user responses to fear-inducing VR environments which will guide future improvements in immersive experiences.

10 Results and Discussions

The research findings section includes both physiological data (GSR and PPG) and qualitative data gathered during and after the VR horror gameplay experience. The study tracked participants' biometric responses in real time while post-experience interviews assessed their subjective emotional and cognitive reactions.

10.1 Claustrophobia

The experience of navigating narrow corridors and dark rooms through unfamiliar layouts proved to be among the most frightening aspects according to participants. The loss of control intensified their vulnerability while the confusing visual and auditory signals made their situation worse. The inability to foresee what lay ahead created increasing tension which intensified their feelings of claustrophobia and panic.

The unreliable flashlight functioned as a regular trigger throughout the game. The inconsistent light behaviour which flickered or suddenly stopped created stress because it eliminated the player's primary means of perceiving their environment. The unpredictable light caused multiple players to freeze in place while they hesitated moving forward and questioned their environment. However, a select few struggled to navigate because they were always looking at the floor in the attempt to hide from visual horror event and some mentioned that the lighting prevented them from fully noticing visual scares or design cues, reducing their engagement.

"The flashlight cutting out was annoying but I think it helped make the game more scary"

The narrow field of view and real-time shadows cast by the flashlight also contributed to this effect, constantly keeping players in suspense and on edge.

"It felt really claustrophobic. Like, even though I knew it was a game, I didn't feel safe turning corners."

Participants reported physical responses such as tensing up, crouching involuntarily, or holding their breath in anticipation.

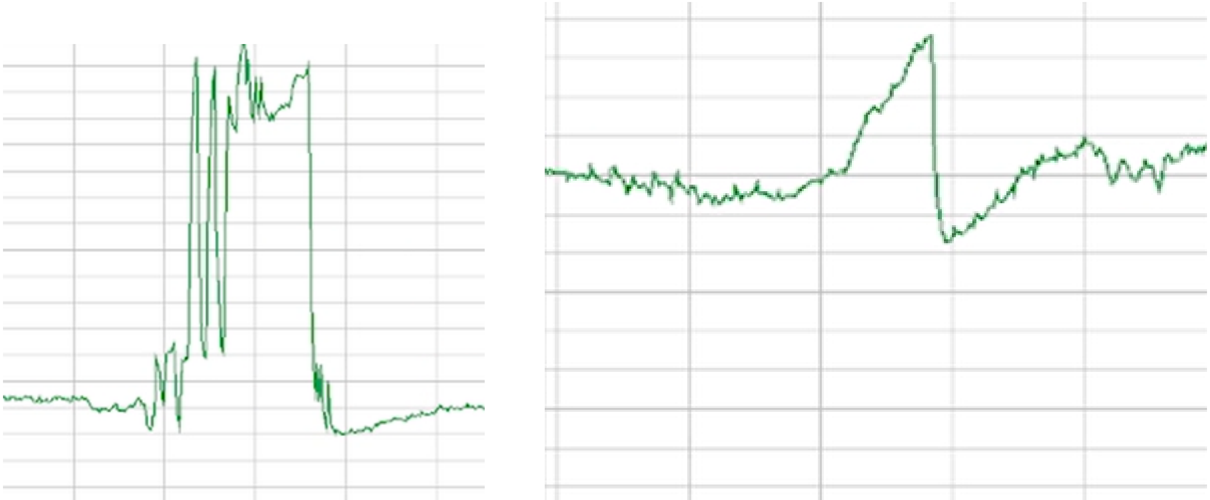

Figure 12: PPG spikes indicating a sharp increase in heart rate when the flashlight turned off, suggesting heightened stress and anxiety as the player's visibility was reduced, increasing uncertainty and fear. Second image dipicts later stage of the game, where participant is more used to it

10.2 Sound as a Fear Amplifier

The element of sound proved to be the most consistent factor which produced fear and immersion according to participant feedback. The soundscape received negative feedback from many players who described it as oppressive and unpredictable while the combination of whispers and pig snorts and directional audio lines (e.g., "it's behind you") maintained constant tension. Through its layered structure the game pushed players to maintain a state of high alertness as they anticipated threats although no threats appeared in their field of vision.
"The sound design constantly made me look over my shoulder. I was on edge the whole time."
The third floor emerged as the primary location where fear-related stress reached its peak. The third floor created feelings of claustrophobia and unease among players while the sound effects grew louder which matched the rising PPG (photoplethysmography) values that indicate increased heart rate and emotional response.

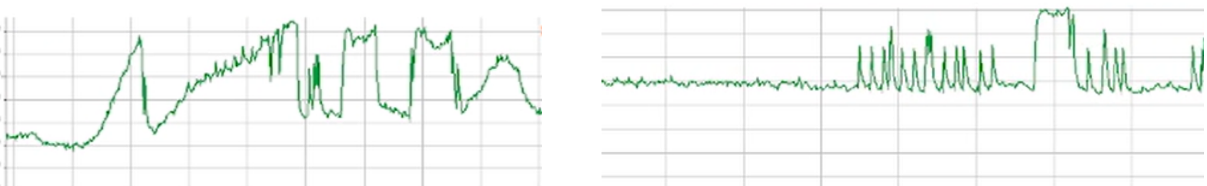

Figure 13: PPG activity spikes during the third-floor sequence. Elevated heart rate correlates with interview data describing the space as "claustrophobic" and "nerve-wracking," with no immediate scare but constant tension from ambient sound.

The study demonstrated that randomized sound cues including distant crashes and whispers and monster growls triggered powerful physiological reactions without showing any visual stimulation. The sudden audio events consistently triggered both PPG (heart rate) and GSR (galvanic skin response) spikes which indicated startle responses and

increased sympathetic nervous system activity.
The data showed strong effectiveness at the start of the experience when the player first enters the house yet stopped spiking after the player became accustomed to the environment.

Figure 14: Left: PPG spike triggered by an unexpected sound cue. Right: GSR spike showing increased emotional arousal during the same auditory event. These responses reinforce the role of unpredictable audio in sustaining tension.

Sound and Startle Response: The event-based sound design received strong responses from participants as the atmosphere intensified before the first jumpscare and the front door slamming shut. The participants experienced fear and surprise which they described as startling or panic-inducing during these specific moments.

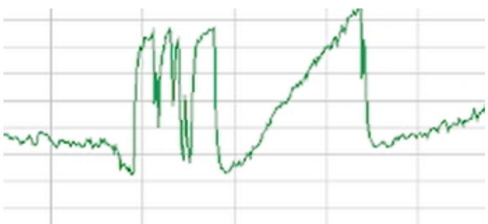

Figure 15: Left: PPG spike marking the primary response to the initial jumpscare. Right: A smaller anticipatory spike as the participant briefly glimpsed the monster beforehand, indicating rising fear prior to the main event.

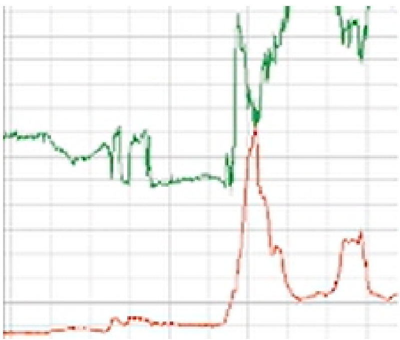

Figure 16: Left: PPG spike following the front door slam. Right: Concurrent PPG and GSR spikes signal a strong combined physiological response—surprise, stress, and emotional arousal—immediately after the auditory scare.

10.3 Findings from Physiological Measurements

The physiological data showed consistent patterns of arousal across participants, mainly captured through photoplethysmography (PPG). The PPG data showed spikes during key fear-inducing moments, such as jump scares (e.g., the fridge event, the bathroom mirror sequence) and during high-tension environments like the top floor. These spikes suggest moments of heightened sympathetic nervous system activation, which is consistent with participants' reported experiences of fear and tension.

The GSR data showed less consistency. Two participants showed spikes in GSR, one of whom was unable to complete the experience due to high fear levels and the other who frequently displayed avoidance behaviours such as looking away from stimuli or focusing on the floor. This suggests that while GSR can reflect emotional arousal, it may be more susceptible to individual coping strategies or levels of engagement.

The most intense and enduring physiological reactions emerged from situations of uncertainty rather than explicit scares including the flashlight blackout and the dark staircase climb and the unsettling background sounds. The research confirms that fear anticipation becomes more influential when players experience reduced control and visibility in horror environments.

10.4 Body Movements and Physical Reactions

The participants exhibited diverse instinctive physical reactions to fear which demonstrated that presence within VR operates through bodily responses. The experience caused many participants to feel physically tense as they tightened their posture and crouched or hesitated before entering unfamiliar or threatening areas. The most frequent reactions occurred when participants faced restricted visibility or auditory uncertainty while approaching corners or hearing unexplained noises in adjacent rooms.

The tension increased substantially because of claustrophobic design elements which included narrow hallways and dim lighting and an unreliable flashlight. The unpredictable flashlight behavior between flickering and failure made participants freeze or step back because their loss of visual control triggered both physiological and psychological stress. The uncertainty of what lay ahead together with audio direction cues motivated participants to explore with caution. The participants experienced a conflicting mix of curiosity and fear which drove them to approach threatening stimuli even though they strongly felt afraid. Physical posture showed a consistent pattern of fear alongside engagement in all participants.

10.5 Shared Quantitative and Qualitative Findings

The most intense physiological reactions occurred at the specific moments when participants admitted they felt the most terrorized by events such as the fridge scene and bathroom jumpscare and staircase ascent. Some participants who suggested less terrified fear in interviews displayed substantial biometric changes which indicated emotional masking or underreporting (Participant 2 rated their fear at 4/10 but exhibited continuous arousal spikes).

The participant who called the bathtub scare "predictable" still had a spike in both GSR and PPG during that moment, showing a dissonance between perceived and physiological fear.

The combination of data types enhances result credibility which supports using biometrics as an additional method for evaluating VR horror.

10.6 Limitations

The results from this study offer important knowledge about physiological and emotional responses of participants in a VR horror environment but several limitations need to be considered when interpreting the results.
The participant pool consisted of 10 individuals but one participant abandoned the game due to them finding it too scary, and the first participant encountered major connectivity problems because of AirLink system instability when connected to the university's Edurom Wi-Fi which resulted in an unfinished session. The study's findings have limited generalizability because of these factors so additional research with a bigger diverse participant group is required to understand VR horror environment effects on human physiology and emotions.
The accuracy of GSR and PPG measurements might have been affected by motion artifacts. The VR environment led participants to move their bodies often because they either reacted to the environment or needed to adjust their position for the headset. The recorded movements could have added noise to the physiological data which would have distorted the research findings. The accuracy of readings suffered from adjustments made to the headset through changes in strap tightness and position.
The initial participant encountered multiple technical problems during setup because of connectivity issues. The combination of AirLink system with the university's Edurom Wi-Fi network produced unstable connections which resulted in poor streaming quality and delayed choppy VR experience. The substandard immersive environment probably affected both participant responses and overall experience. I moved to my personal router (LAC) for the next participants because it provided a stable connection that enabled better gameplay. The change probably enhanced data quality in subsequent sessions yet the initial problem remains crucial for assessing the first participant's results.

despite limitations, The study delivers important findings about VR horror environment interactions between environmental design and emotional reactions and physiological responses despite its methodological constraints. Future research needs to include a bigger and more varied participant group along with improved sensor calibration methods and better methods to reduce technical and environmental interference.

11 Conclusions and Reflections

11.1 Project Management on the Game

In managing this project, I have adopted a hybrid approach that incorporates elements of both waterfall and iterative methodologies. Although my initial framework follows the structured phases typical of a waterfall, such as requirements gathering, design, implementation, and testing real-world applications, it has revealed the need for flexibility and adaptation. The early stages, particularly in developing adaptive soundscapes and real-time visual feedback, have involved prototyping and playtesting that inform subsequent design decisions. This iterative feedback loop allows ongoing refinement, prioritising player experiences and emotional engagement. By integrating regular assessments and adjustments into the project timeline, I can navigate the complexities of VR development while still adhering to overarching goals and milestones. Certain Gantt chart modifications have been found necessary with the course of the game. Some of these changes have been optimisation in the mechanics, refinement in post-processing, and writing a distinctive narrative to develop the story. Also, I continued to identify improvements in the above features to create a better experience for the player. Much development time has gone into defining and clarifying the main parameters of the game. Initially, the ideas were very general, not specific to how the targets would be achieved. As the project progressed, things have been developed into smaller, more informative, and actionable parts that could be scheduled and prioritised. For example, many early plans contained broad goals such as optimised lighting, which has since become, through more narrowing, "dynamic flashlight mechanics," "proximity-based flickering," and the addition of atmospheric effects such as volumetric fog. The Gantt chart modifications enabled me to deal with unexpected problems and incorporate newly researched methodologies. For example, in advanced post-processing effects research, where I learned things like chromatic aberration and dynamic ambient audio systems, I was aware that applying them practically takes much more time and effort than initially seemed. Early incorporation of scheme changes into the Gantt chart ensured that the timeline remained realistic and thus served the project's goals.

11.2 Project Management on Study

Looking back at this study, I believe it was a successful exploration into the physiological and emotional responses elicited by environmental design in VR horror experiences. The mixed-methods approach, combining biometric data (GSR and PPG) with qualitative feedback from participants, provided valuable insights that I'm confident contributed to the overall success of the study.

One of the things I'm particularly proud of is how well the physiological data correlated with the emotional responses participants expressed. The spikes in heart rate during key moments, such as jump scares and tense environmental changes, validated the immersive effects of my environmental design choices. I had confidence in the role of sound and lighting, and the data truly reflected how these elements heightened fear and suspense in participants. Seeing such clear physiological evidence of emotional engagement was incredibly rewarding and reassured me that the design choices were effective in creating the intended experience.

The study also gave me a deeper understanding of how individual differences can influence emotional responses in VR. While some participants reported being less afraid or even downplaying their fear, the biometric data often contradicted this, revealing significant spikes in their heart rate and GSR. This showed me that, despite how participants might perceive their emotional engagement, their bodies were still responding to the environment in significant ways. If I were do continue this study, a more diverse participant pool could provide even richer insights into how these variables affect engagement and fear.

Despite facing some technical challenges—especially with connectivity during the early stages of the study—I think I handled these obstacles well. I quickly adapted the setup to ensure more stable connections for the remaining participants, which helped improve the overall experience and the quality of the data collected.

Ultimately, this study has given me a lot of confidence in my ability to design experiments that explore complex emotional responses in immersive environments. While I'm aware

that there are areas I could refine, particularly with sensor calibration and the sample size, I believe the study achieved its objectives and provided valuable insights into the physiological impact of VR horror environments. The findings from this study will undoubtedly influence my future research and design decisions, and I'm proud of how it turned out.
I feel I am far more confident in my abilities with unity, and research into HCI and human factors. Skillsets necessary for my future career path

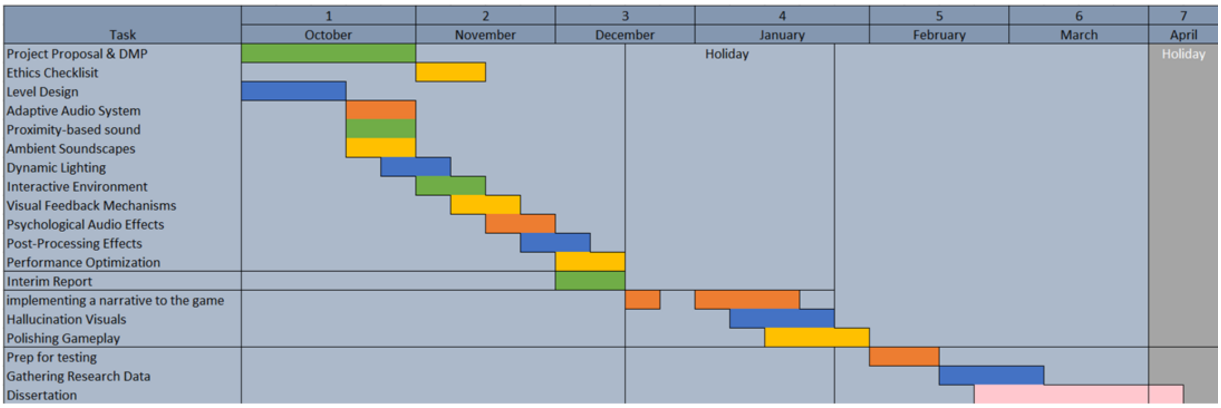

Figure 17: My updated Gantt Chart

11.3 Social, Ethical, and Professional Issues (LSEPI)

11.3.1 Intellectual Property Created

Identifying the ownership of what I created is essential. I designed the game's source code and some audio assets. I ensured that the audio and assets I did not make were part of the Creative Commons ownership agreement.

11.3.2 Data Protection

My research will include human participants testing the VR horror game and collecting their experience and feedback. The participants will be anonymous, and no personally identifiable information will be collected. Before starting the participation, I will have informed consent to ensure that the individuals understand how their data is used and how I will protect it. Once the research is complete, I will delete the data to fit the data protection laws such as the GDPR. I'll ensure the study complies with relevant legislation, including the Equality Act 2010 and the Data Protection Act 2018. The participants will also be able to withdraw from the study if they find the experience too much to ensure their psychological well-being is protected.

11.3.3 Ethical Challenge

An ethical challenge for this project is that the experience might impact the players. The experience was designed to evoke fear and anxiety, and I ensured the players were warned of the following content. The social responsibility of creating a horror experience that doesn't cause permanent harm to vulnerable people is something to consider; the psychological well-being of players should remain a top priority.

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