Exploring Vision-Based Interactions in VR Horror Games

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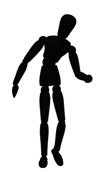


ABSTRACT

Gaze interaction in video games, using eye tracking, is in growth. No longer only used for novelty interaction but also as an integral part of the game's mechanics. However, while gaze interaction is becoming more and more prevalent, gaze aversion appears to continue in novelty. Within this paper, we explore the dichotomy of "see" and "not see"(look, don't look") interactions with what we define as "vision-based interactions" as an alternative to traditional eye-tracking gaze interaction for VR horror game elements. Related work applies an exploratory approach to gaze interaction but with a focus skewed towards one end of this dichotomy, and as such, this project is positioned as a comparative perspective on both. We contribute the results of a study investigating how effective these interactions are at eliciting different responses to these VR horror game elements. Our results suggest that we might be capable of expecting different interactions with differing intricacies to elicit stronger responses from users to VR horror game elements.

Contents

1 Introduction

Eye tracking, as a means of video game interaction, has become more prevalent. While this has been the case as a research topic in recent years, the gaming industry has gained an interest in the paradigm as well. With the recent release of the PSVR2 [26] as the first "budget" alternative for eye-tracking capable headsets, as well as the ability to publish on the largest console platform in the world, eye-tracking games have begun to emerge. Such games implement eye tracking capability, not just as a novel limited interaction[11], but as a key mechanic[10]. While this is true, scarcity still exists. Scarcity, not only within integrative implementations of gaze interaction but also hardware. Since the advent of eye-tracking capabilities in VR headsets, it has not been an affordable affair. While PSVR2 aims to bridge this gap, it is still significantly more expensive than the Quest 2 [18], as is used in this project. Not just this, development with the PSVR2 is limited to certified developers, subject to approval by Sony themselves. Open platform solutions are available, such as the Quest Pro [19], but they come with a very significant price tag. With this in mind, how could we develop something for the paradigm of gaze interactions but without the necessary hardware to do so?

Our aim is to provide the possibility for development within the paradigm of gaze interactions with less expensive and more widely available VR headsets. To this end, we approach what we call "Vision-based interactions.". While not utilizing eye-tracking capable headsets, we attempt to simulate the effects of which using the head-tracking capabilities of the headset as well as casting a ray from the center of the user's point of view. While this is not gaze interaction, as no eye tracking is involved, we believe it could be an appropriate concession. Sidenmark and Gellersen[25, p.4] show that while the user is capable of more, the user's gaze rarely extends beyond 30°, although they are capable of rotation up to 50°.

We seek to study the effectiveness of these interactions, specifically within the genre of VR horror games, and how the implementation of different vision-based interactions could increase the fright experienced by players. I.e.:

1. What are the effects of distinct vision-based interactions in VR-Horror games?
2. Can we expect some interactions to be scarier than others?

We approach this in the explorative manner, seen in other gaze interaction studies by Gomez and Gellersen[22, 21, 23] and Vidal et al.[29]. However, while these papers employ an explorative approach, they do not compare the effectivity of "gaze" and "gaze aversion"(look, don't look) as interaction methods. It is our goal to explore and compare this dichotomy through vision-based interactions, particularly in a horror video game context. To this end, we constructed a VR study environment to evaluate these interactions and provided the context for the relevance of our approach.

2 Related Work

Vision-based interactions are becoming more prevalent in the VR space and emerging slowly within the VR-gaming space. The area is rapidly gaining interest for research; however, the commercial solutions and products available to the consumer are scarce. Even when these solutions are available commercially, the technology is state-of-the-art. Out of this scarcity, it has become apparent that a more methodical and exploratory approach to these interactions is necessary.

We aim to provide the commercial context for this scarcity and how we aim to differ from the existing research on these interactions.

2.1 Gaze interactions and VR

When defining the landscape wherein our solution will exist, we must consider the commercial context. How do we define what the commercial context is when we wish to consider vision-based interactions in VR horror games? Eye-tracking is becoming more and more prevalent in video games. With the release of the PSVR2, an eye-tracking capable VR headset, games utilizing eye-tracking technology became more prevalent. Eye tracking allows for the translation of the user's gaze to input. However, even though this project does not utilize eye-tracking technology, eye-tracking solutions are still relevant as related work. Although the user can use a wider range of vision with eye tracking, it has been shown that the user rarely does[25]. Sidenmark and Gellersen[25] show that while the user is capable of more, the user's gaze rarely extends beyond 30°, although they are capable of rotation up to 50°. Keeping this in mind, a solution that does not use eye tracking but a collider or ray emitted from the head of the user could achieve equally accurate input. This is only guaranteed, however, should the ray or collider's diameter be wide enough to encompass a similar section of the user's FOV. Several launch titles for the PSVR2 headset use eye-tracking technology.

"Before your eyes"[10] is an upcoming PSVR2 game for the PlayStation platform. The game follows the player's life in flashing moments, allowing the player to control the progression of these moments by blinking.
"Switchback"[11] is yet another upcoming PSVR2 horror game, making use of eye tracking for another "blink" mechanic. The player enters an area of the level and is met by stationary figures. These figures' intimidation is increased the more the user blinks.

Existing research does exist within the paradigm of exploratory eye-tracking research. Gomez and Gellersen[21] explore the "not looking" aspect of gaze interactions. This approach allows them to explore the more intricate and atypical interaction of "not looking"[21] in gaze interactive video games. While gaze interaction as a paradigm is mostly studied in a more direct sense, meaning the use of a more typical "looking" interaction, the inverse is rarely so. Gomez and Gellersen[21] created a framework to analyze and categorize these "not looking" interactions in gaze-interactive video games. For each game present in the framework, the players are made to look away from said game, *... up to the extent they close their eyes*[21, p.1].

While this approach is explorative, as ours, the exploration of these interactions is not for intentional gaze interaction[21, p.1], the focus is instead; on what are the outcomes of unexpected using unexpected gaze interactions and how we approach interaction design for gaze with this in mind. This does not, however, mean that the dichotomy of looking or not looking is not present in their research. Still, the perspective is skewed to the unintentional use within this dichotomy and to the betterment of how to further gaze interaction design with this perspective in mind. As such, ours is an intentional approach. Studying how both looking and not looking could be two different interactions and the performance of each of these within a horror VR approach. The conclusion of the article is also that the exploration of

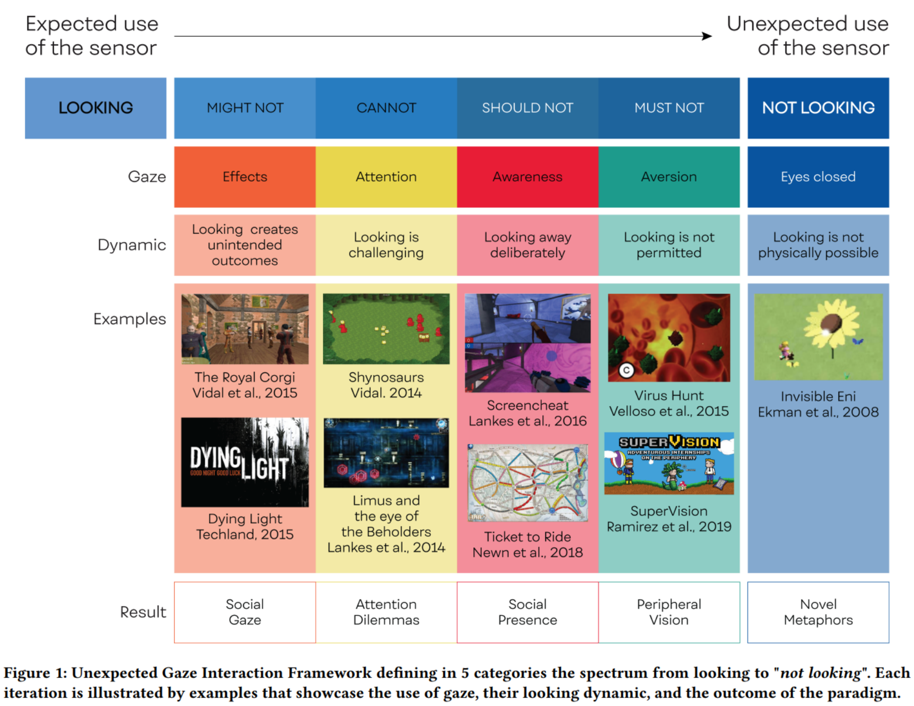


Figure 1: Unexpected Gaze Interaction Framework[21, p.3]

this "ambiguous"[21, p.6] not looking interaction could become a tool for designers to explore the limitations of the technology. As such, we follow up on this conclusion, approaching the unexpected interaction as an independent approach.

Looking Outside the Box: Reflecting on Gaze Interaction in Gameplay[22] is another exploratory study for gaze interaction in video games. The goal is to challenge the understanding of gaze interaction use cases for video games. This is done through the "common"[22, p.1] use of gaze as a pointer, used for navigation, selection, and aiming within their game "Twileyed." While this approach is exploratory, the goal is similar to that of Gomez and Gellerson[21], which is to further the conversation and discussion on the topic of gaze interaction within video games while thinking outside the box of the technical limitations of eye tracking. While we do not attempt to explore the intricacies of the "common" use of gaze or vision-based interactions in video games, our scope is that of the dichotomous "look" and "don't look." This project extends in the direction of different interaction types(static and dynamic) and how the intricacies of these interactions affect the user's experience. For example, would there be a discernible difference in how the user reacts to this behavior of a dynamic horror element while looking vs. not looking?

What about "not looking," also called "gaze aversion"? SuperVision[23] concerns gaze aversion, what we have previously called "don't look," and peripheral vision. Two parts of what we have explored here in this thesis. They constructed a framework in which this paradigm of gaze aversion is introduced and subsequently introduced a concept called "SuperVision." SuperVision is a collection of three games that play with gaze aversion and peripheral vision. The goal of these games, and the paper, is to challenge players through interactions that force them to play using their peripheral vision. Their findings showed that despite players only utilizing their peripheral vision, they found not only did they successfully complete the video games, but their peripheral awareness would also appear to have improved[23, p.9]. SuperVision's research shows us that it is possible to implement aversion as a successful means of interaction in video games. However, where our approaches differ is not only in the genre in which we present these interactions but also in how they function. While SuperVision concerns specifically the ability of the user to complete tasks only within the periphery of their vision, this project concerns the ability of the user to understand that they can and how they can interact with the environment using their vision. Subsequently, what impression these interactions leave the users with is also a key difference since SuperVision mainly concerns the performance of the users interacting with the game[23, p.9]. Gomez and Lankes[24] proposed a diegetic perspective to gaze interactions. In doing so, they suggested a diegetic approach to gaze mechanics in video games, introducing "gaze roles"[24, p.4] and "gaze metaphors"[24, p.6] as concepts. Gaze roles are described as follows:

- *Social Gaze: The use of gaze related to trigger social constructs, behaviors, and those events related to human relationships of attention. This role illustrates the gaze mechanics used to interact with characters, e.g., greeting or show attention socially.*
- *Gaze Power: When gaze is used to trigger actions that would be considered fictional or not possible in real-life. This role represents the gaze mechanics that allow the player to use special features that belong to the game avatar just by looking.*
- *Gaze Hurdles: The function of gaze assumes a curse or difficulty and a problem to the player posing a game challenge. This role*

> *illustrates the gaze mechanics that penalise the player for looking.* [24, p.5]

Ultimately categorizing and listing surveyed gaze interactions[24, p.8] in order to support designers in integrating gaze into existing implementations and using gaze as an integral part of other project's mechanics. Our aim is to integrate vision-based interactions as an integral part, and as such, our solution, if it were eye-tracking, could be categorized using this diegetic approach.

Extensive work is already present[23, 22, 29, 21, 24]; however, the concerns of these papers are not to cover gaze interactions' dichotomous "look," "don't look," but rather explore the intricacies of these two in relative isolation. Some, like Vidal et al.[29], cover the potential for gaze aversion in the context of social interaction. Some, like Gomez et al.[22], cover the potential for discovery outside the realm of the "common" use for gaze interaction.

2.2 VR and horror

Considering how vision-based interactions have been implemented in horror games and VR-horror games, particularly, is of interest. "Don't Look Back"[8] is a VR application that simulates the experience of an office worker being menaced by a supernatural entity. The user takes the place of the office worker and experiences this supernatural entity. The user looks for anomalous environmental effects in order to know when the entity is present.

> *The player's virtual sanity depends on maintaining a balance between their mundane work responsibilities and their anxious curiosity about the advancing horror.*[8, p.2]

Built with the same engine, as well as utilizing the same libraries for VR development, Don't Look Back has the same developmental prerequisites as this project. The user must keep a monster at bay behind them and look at them in order to do this. Looking at the monster makes it disappear, allowing for a "grace period"[8]. The user's real-life movement is translated into the game via. the headset, allowing the user to turn their head in-game physically [8]. As with this project, "Don't Look Back" aims for the key game mechanic to be the user's vision. The game uses the "sanity bar"[8] mechanic, which is present in many horror video games. The bar is a representation of the player's sanity, and a decrease too great will cause the player to fail.
Replacing the traditional antagonistic mechanics that games regularly use, such as literally attacking the player, sanity mechanics allows for a more visceral response to an enemy. It also opens the door to different interactions with enemies in the game. As with games such as "Amnesia: The Dark Descent"[9], the sanity meter is drained, not only when interacting with an enemy but also when lingering in the dark or experiencing something sinister. After this, the player's vision would begin

to become impaired, simulating an increasingly strong headache. The "painting" (5) elements present in this project were considered as an implementation of a sanity mechanic; however, this aspect was relegated to future work.
To elicit a more visceral interaction with the game elements, the horror elements were of necessity made to be frightening. As is with frightening elements, not just in video games, suspense proves effective. To that extent, a methodology was applied meant to heighten the suspense of the player's gameplay within the test environment, as warning systems in horror games have proven effective at eliciting the sought-after response[20]. Forewarning has been shown to increase the emotional response to horror elements in video games[20] as well as suspense.

Player fright has also been shown to be greater in moments where PSI[16] elements are present in VR horror games. Such elements are defined as:

> *"the illusion that what is happening is real even though you know that it is not real." (Slater, 2009, p. 3561). For example, in a survival horror VR game, we know that the zombies are not real, but when they walk up to us, our bodies and brains respond as if they were...*[16]

By employing a dynamic antagonistic element to the environment, we are trying to elicit the PSI illusory response from the user, producing player fright. If successful in our attempt to trigger this illusion, we hope for greatly improved user fright and, thus, a greater immersion due to the player's gut reaction.

We will examine the design and implementation of these interactions and, subsequently, how a study environment where in which to evaluate them was constructed.

3 Development process

3.1 Preliminary prototyping and test environments in Unity

The initial idea we had for an interaction using vision in virtual reality consisted of a dynamic horror element (a monster in this case) you had to pass without looking at it. If you look at it, it will start to chase you until you look away again. The level involved a narrow corridor where the monster would stand between you and the exit. We started out creating a small and simple level to see whether or not the idea had any merit at all. The level consisted of a small, fully textured corridor with an enemy or a monster in your path (2). We got the monster model from a website hosting free 3D models [15]. We even implemented animations (using the Adobe Mixamo website [1]), so the monster actually has an idle animation and a chase animation that can be switched between. Textures and meshes are from the Unity Asset Store [7]. The interaction was made using a simple raycast that is being sent forward from the middle of the VR view in the direction of the camera. The ray is able to detect a collision with a 3D collider and change the state of the object it is in collision with. Later we discovered a much more versatile method for doing this using Unity's OpenXR VR package instead of our own custom script. This idea of something chasing you based on where you look in VR turned out to be rather effective in terms of immersion and scare factor, we thought. This laid the foundation for further exploration of similar kinds of interactions.

Figure 2: First test level

3.1.1 The atmosphere in horror games

The atmosphere is a vital part of any horror game [13]. It helps set the tone/mood and immerse you. Therefore, we wanted to try and explore the look and feel of different horror games. We looked at different art styles in modern commercial horror titles to find one that felt scariest to us. One type of modern horror game that stood out to us was the type that tries to imitate old PlayStation 1 graphics. Old classic PS1 horror games like Resident Evil [4] or Silent Hill [14] have something very eerie, strange, and just plain wrong about them [12]. PlayStation 1 graphics have characteristics like vertexes and meshes jitter as you move the camera, no texture filtering and low-resolution textures, etc. We tried to explore this style by using an open-source shader in Unity, allowing for this style to be added to a modern game engine. Adding this to the corridor level made it feel very unsettling to us. The shader enables vertex jittering using the Universal Render Pipeline's shader graph. On top of that, we downscaled the textures used to a maximum of 128x128 pixels and disabled texture filtering, giving it a very pixelated look and staying true to the PS1 style of graphics (3).

However, translating this graphics style into VR had a negative impact on us in terms of motion sickness, especially because of the vertex jittering when moving the camera because your head is in constant motion in VR. Furthermore, one of the effects of VR is that games feel more like real life, but using the PS1 style has quite the opposite effect and makes it very obvious that you are playing a video game.

Figure 3: Corridor level with PS1 graphics style

Instead, we ended up going a very different route by taking heavy inspiration from some of the most popular horror video game titles instead, like Amnesia: The Dark Descent [9], Layers of Fear [27], and the newer Resident Evil titles [4]. These all use much more modern graphics to create an immersive experience for the player, such as realistic shadows, high texture quality, and polygon count. All of these are absent from the older PS1 style of graphics. To further explore different types of interactions using vision in VR, we created a very simple test environment. The different colored cubes represent different interactions using vision (4).

The main interactions we tested in this environment were:

- See to make an enemy chase you (red cube)
- See to stop the enemy from chasing you (red cube)
- See to make the enemy move away from you (green cube)

We did not find the green cube interaction particularly scary, and we do not think it fits very well in a horror video game context. We think that making the player feel vulnerable makes it more scary. That is why we chose to move forward with the two chase interactions.

So far, we have only dealt with dynamic moving elements, but we also wanted to experiment with the interaction of static horror elements using vision in VR. A common example of a static element in horror video games is paintings. For example, in the games: Amnesia: The Dark Descent [9] or Layers of Fear [27], paintings may change their appearance over time. They might go from a seemingly normal-looking painting to something scary or unsettling. Using this as inspiration, we created our own similar painting in Unity (5). Using a shader that could be manipulated over time, the painting will slowly change appearance over time if

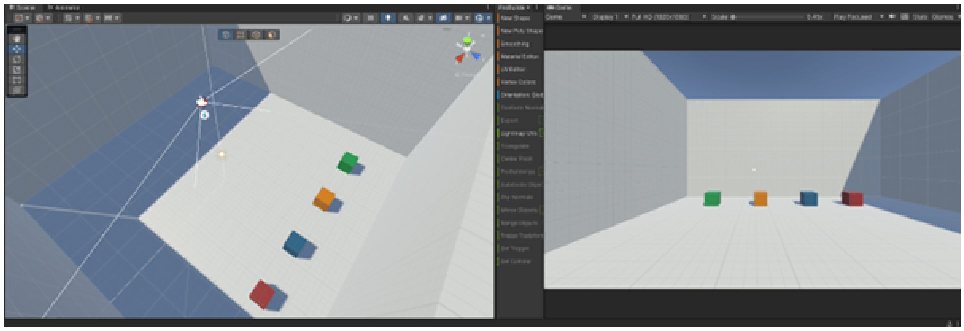


Figure 4: Test environment experimenting with different interactions on dynamic horror elements

looked upon. However, we later ended up using a much more similar interaction as the dynamic element in the user study, allowing us to compare the two different kinds of elements better.

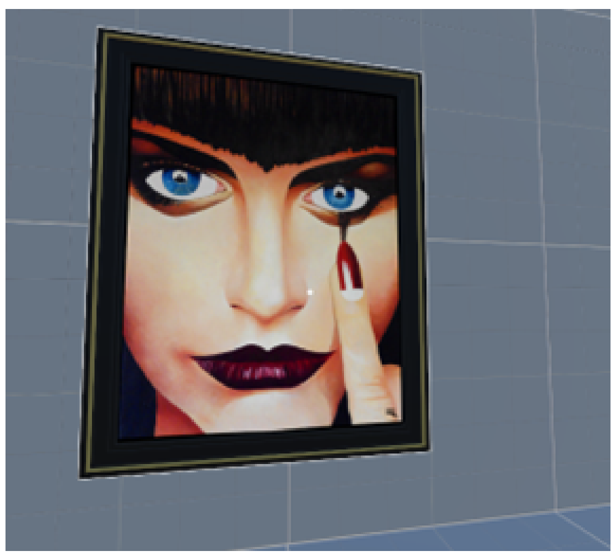


Figure 5: Static horror element in the form of a painting

3.2 Finalizing interactions

3.2.1 Dynamic element

We also explored different parameters for each interaction, such as speed, delay, rotation of the enemy, etc. For example, setting the speed of the enemy too high made it much more difficult to flee from it and made one wrong move much more critical for the player. We ended up setting the speed in the nav mesh agent to 1. This allowed the player to have a much better chance of avoiding the enemy, thus lowering the difficulty. Using rotation on the nav mesh agent made the enemy move more naturally because it would face the player when moving toward it. (See Appendix .3 for nav mesh settings).

In some modern commercial horror game titles such as Resident Evil [4], Ghostwire: Tokyo [3] and even in television (Doctor Who, "Blink" episode [2]), there is a type of horror enemy or antagonist that only moves when you are not looking at it. Reminiscent of the children's game "Red light, green light," also known as "statues" [17]. It felt very natural to try and experiment with this kind of interaction in VR. This became the inspiration for the red cube in our test environment. We found that some of these horror games tend to add a very slight delay to the movement of the enemy when it stops. That way, you are barely able to tell that it moved apart from the fact that it changed position from when you first looked at it. We wanted to explore the effect of this delay in our user study section of the paper. The delay was added to the enemy by using our own custom C-sharp script. With Unity co-routines, you can postpone a function call by any number of seconds. We found that 0.2 seconds made you able to barely notice the delay and that something moved without making it obvious. Similar to the horror titles mentioned. In these horror games, the enemy also moves toward the player if the monster can not see the player. So if something obstructs the path between the player and the enemy, it will move towards the player until nothing is obstructing. The enemy is, therefore, always going to be nearby. We think this adds another sinister layer to the enemy. It feels like it is always watching your every move and knows precisely where you are at all times. We wanted to implement this into our enemy's behavior as well. Using a ray cast between the player and the enemy, we can check if something is colliding in between. If there is a collision, the enemy moves towards the player until there is a clear line between (6).

3.2.2 Static element

Drawing inspiration from the interactions of the dynamic element, we also implemented the same interactions for the static element but instead of chasing the player, it will change appearance (7). For example, one interaction is changing the appearance when not looking and then switching back when looking. Using a slight delay, like with the dynamic interactions, the player is barely able to glimpse that something is off about the painting. In the study, we will explore the effect of such a delay.

4 Study Environment

For the design of the study environment, the goal was to create something as close to a popular commercial horror video game as possible. The inspiration was primarily: Amnesia: The Dark Descent [9], Resident Evil [4], and Layers of Fear [27]. In these titles, you are often navigating rooms that are reminiscent of those in a haunted

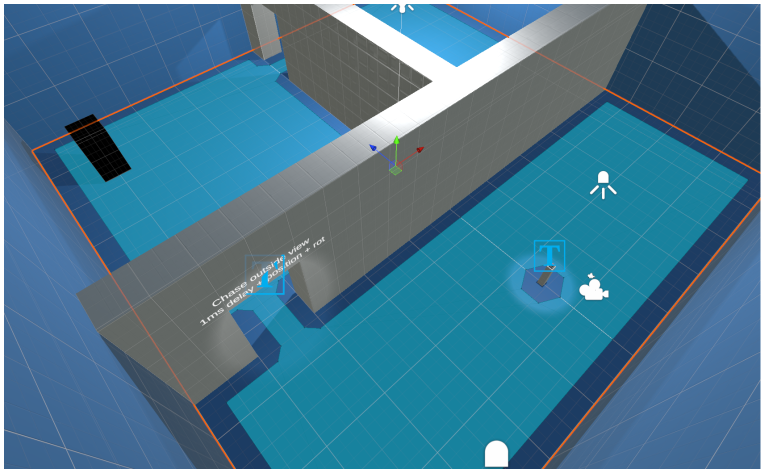


Figure 6: Test environment with the dynamic enemy being able to navigate rooms and move until it is able to see the player

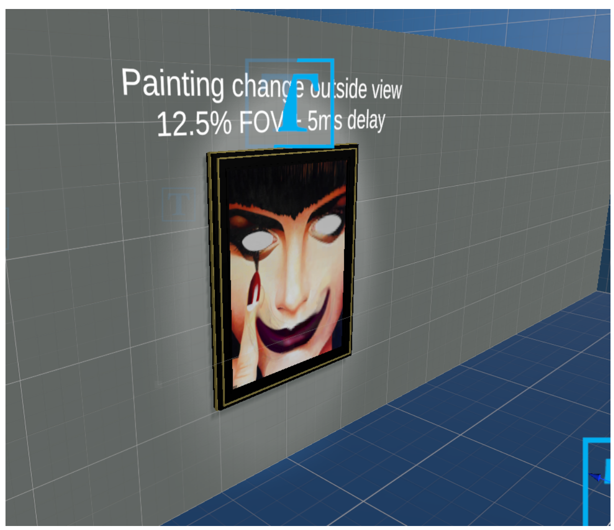
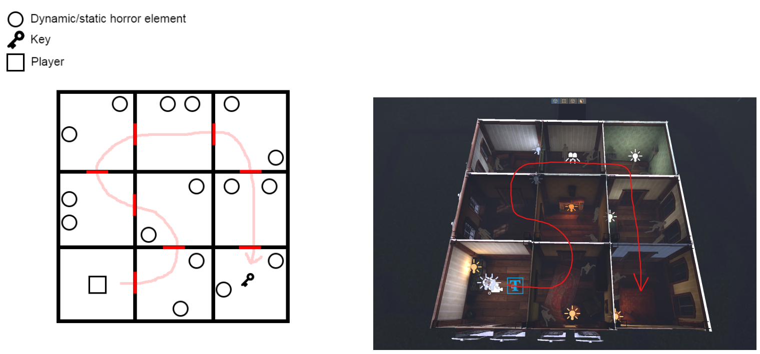


Figure 7: Painting changing appearance when not looking

house. This was the primary inspiration for the level design. The prototype for the study functions like a typical video game, which means the player has a goal or a destination, and there are challenges to face along the way. The goal of the game is to find a key that is hidden somewhere in the level. We made a level for each interaction. There are six different kinds of interactions to test for each horror element (dynamic and static) which makes twelve levels in total. Each level is made up of a 3x3 grid of same-sized rooms, and there is only one path forward because each room only has one entrance and one exit (except for the first and last rooms, which only have one door) (8). To prevent people from getting accustomed to the layout of the rooms and the location of certain elements, thus lowering the element of uncertainty and surprise, we change the position of the rooms and the path through the level and the position of the enemy and key for each level. This is also to prevent players from cheating. You have to go through at least four rooms to find the key, ensuring you will encounter the interaction to test before getting the key and finishing the level. Inside each room, except for the first, are placed two horror elements (either static or dynamic), which is sixteen total. The first room is meant as a safe hub for the player to get started instead of immediately throwing you into the action without first building a sense of presence in the virtual world. It is also a lot brighter than the others. Once you move through the first door, you are no longer safe.



(a) Diagram of the level layout

(b) Implementation in Unity of the level layout

Figure 8: Example of one of the 12 levels in the prototype

The levels are made to scale with CAVI's big blue room in Katrinebjerg, Aarhus. Hence, the users of our study are able to move around in the virtual environment physically (9). We measured the room to be about 7.5 meters in length and 5.1 meters in width. This makes each room of the level approximately 1.6 square meters in real life. To add to the immersive nature of VR, we want people to be able to move in our prototype by physically walking. This is instead of using the controllers' joysticks or a teleport approach using a virtual pointer. When building the prototype, we first implemented a way for testing in a physically small environment using the joysticks. However, this approach proved to be nauseating for multiple people who tried it and caused motion sickness. This is a common side-effect of using VR [6], and to mitigate this and provide a more immersive horror experience, we opted for the physical walking approach. But when you have to move physically to move in the game, you have to have enough space to do so. You are now confined by the real walls or obstacles around you. That is why we rented the large open room at CAVI in Katrinebjerg, Aarhus, to do the user study. At first, the physical room was way too small for our level in the game. To scale the virtual environment up or down to fit the physical boundaries, you can simply adjust the scale of the player object in Unity. We enlarged the player by 75 percent in order to match the physical room. We also adjusted the dynamic and static elements to better match the player's new height and the doors for the player to fit through. When dealing with a physical room, you must ensure the virtual world's rotation or angle is aligned with the physical world. Therefore, we implemented a way for the player to rotate the VR camera using the joysticks. To mitigate misalignment in the virtual environment even further, we turned off all non-trigger collisions with the player object. This means the player can move through anything except the floor. This eliminates the problem of moving physically but not moving in the virtual environment because of a collision causing misalignment between the physical and virtual.

Figure 9: Big blue room for user study in CAVI, Aarhus

4.1 FOV/Ray

The two types of vision detection we are distinguishing from one another and comparing in the study are ray and field of view (FOV). The ray type is a ray cast, which can be visualized as a line. The ray cast goes from the center of the camera view forward in the direction of the camera into infinity. If something intersects this line, we can check what object it is and change that object's state. We are using Unity's OpenXR package [28], which comes with a Gaze Interactor prefab that does precisely this in a very versatile fashion. The other method uses the field of view, which checks if an object with a given object tag is inside the camera's frustum. The camera frustum consists of 6 3D planes. A plane left, right, top, bottom, close, and far. It is basically like a box, but it expands as you move further away from the camera's position. The FOV can easily be changed in the inspector, and ours is set to 60, which is the default for an OpenXR VR camera in Unity. The rooms are carefully designed by us using an asset pack from the Unity Asset Store [7], using high-quality materials and textures. Each room has character and is made to not seem out of place in a horror game, and it is trying to "sell" the idea that someone could actually live there. For example, there is a bathroom containing a bathtub, toilet, and sink. There is also a study, a bedroom, and a dungeon. It also would not make sense to make the rooms all bedrooms, for example. The doors all have a box collider trigger that can collide with the player's collider. In this event, the door will swing open. This means that doors will open automatically when the player is in close proximity.

4.2 Environment atmosphere

As previously mentioned, the atmosphere is quite an important aspect of any horror game [13]. We, therefore, felt it was critical to get this part right. The goal was also to try and achieve a look and feel similar to that of a popular horror title on the market today. Doing this, especially on a VR headset, proved a challenge for us as a small team of only two people. However, we do believe that our prototype lives up to the standard of graphical fidelity seen in modern commercially successful horror video games (10). These games mainly occur at night or in very dimly lit environments, so we chose to mimic this. To also make it much more performant on VR hardware (especially the Meta Quest 2) while still trying to maintain a high level of detail, we opted for a baked global illumination lighting system with ambient occlusion enabled. This means no real-time shadows, as this is very demanding; however, most objects in the scene are static, so this makes the most sense performance-wise. Adding ambient occlusion on top of this can help ground objects more in the scene. To further add to the atmosphere, we wanted the rooms to appear dusty and old. To do this, we enabled a tiny bit of exponential fog to the scene with a light blue tint to simulate light coming from the moon outside. (See Appendix .3 for lighting and fog settings)

We also experimented with polish in the form of post-processing effects such as color grading and bloom for lights and other bright elements in the scene. However, this proved to not be very performant on the VR hardware, so we chose to disable it for a much smoother experience. To make sure we also did not run out of VRAM, we downscaled all textures to a max of 1024x1024 pixels which still provides sharp textures.

4.3 Dynamic element

In the dynamic version, these are in the form of wooden inanimate mannequin figures (11). They are about the same height as a person and as the VR player. Only one of the figures per level will be interactable using the see/not see mechanic, and the player does not know which it will be (this also changes from level to level). Therefore we aim to encourage the user to carefully study each mannequin using their vision in the rooms to avoid getting caught off guard. The dynamic element can navigate the entire scene (using Unity's built-in AI nav mesh system), so the player is not safe anywhere; however, they must first enter the room of the dynamic

Figure 10: One of the rooms of the prototype using baked GI + AO and custom lighting settings

element to activate it. The navigation mesh is baked on the floor object in the scene. It only takes static elements such as furniture and walls into account and ignores other mannequins or paintings in the scene. The doors are also non-static, so the monster is able to move through them; however, the player has always opened the door before the monster moves through. To avoid the mannequin running into the wall and breaking immersion, we have increased the radius of the nav mesh agent, which means the agent will never be too close to the wall. We chose a mannequin as the model for the dynamic horror element because we think it would make much more sense in this particular test where you have multiple identical elements in each room. We think it would not be as believable and perhaps a bit bizarre to have two demons or evil clowns standing perfectly still in each room, for example. Furthermore, because the mannequin is an inanimate object, we think it is scarier; it can suddenly move because it is not in its nature. This inanimate humanoid object is also a relatively common horror element, particularly in video games (recently the anatomy doll in Ghostwire: Tokyo [3] and mannequin house in Resident Evil Village [5], etc.); however, as mentioned, it is also seen on film with the "angels" in the Doctor Who episode: "Blink" [2]. When starting a level, the mannequin figures all take different static poses chosen randomly (three poses total). When the dynamic element starts to move towards the player, it shifts from a static to a dynamic state and changes animation to a running animation. When the element halts, the position and animation freeze. This is done by setting the nav mesh agent and animator's speed to 0. If the dynamic mannequin touches the player, the player is dead and has to start the level over. If you die in the game, the mannequins will disappear, giving you a chance to go back and start over without having to worry about being chased again.

Figure 11: The dynamic horror element in the shape of a mannequin in different poses

4.4 Static element

In the static element part of the prototype, the elements are paintings instead of mannequins (12). Instead of moving/chasing the player when being seen or not seen by the player, they change their appearance. The painting's default state is a seemingly ordinary portrait of a woman with blue eyes. When the paintings switch states, the woman's eyes turn white, and she has a sinister smile. The paintings are all the same; however, behind one of them, there is a key. The paintings are all placed on a wooden easel making it possible to hide a key behind them. The key is hidden behind the paintings because it requires the player to carefully look at each painting to win the game. The key is using a semi-bright unlit material, which makes it much easier to spot in this dark environment we have created. Otherwise, it would have been very hard for the player to find it. To pick up the key, you have to "grab" it by reaching it with your hand and squeezing the trigger on the side of the controller. This tries to imitate grabbing something in real life. To do this, we are using an "interactables prefab" from the unity VR-Interactables sample scene. We chose this way of interaction because it means you have to take notice of the key and purposely interact with it in order to proceed instead of just stumbling into it by accident. When you have the key, the game will display text on the screen saying: "You have the key," and remove any horror elements, just like when you die in the game.

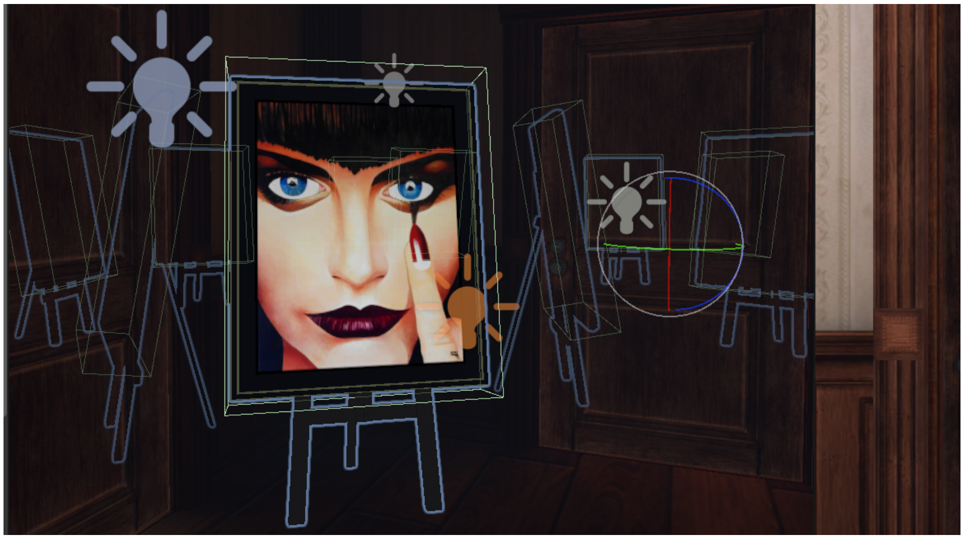


Figure 12: The static horror element in the form of a painting on a wooden easel placed around the level

4.5 Problems and limitations regarding VR game development

VR game development is still a relatively new frontier compared to traditional computer or console game development. Limitations and bugs are, therefore, a thing to be expected. When using Meta Quest 2 [18] for game development in Unity, we encountered several issues. The first issue was simply a hardware limitation. Not being able to run the game with everything turned on in terms of polish (texture detail, high-resolution shadow maps, etc.) and post-processing effects. It might run just fine on a regular PC but struggle on the headset. Another issue we encountered was regarding the ecosystem and software. When developing using a Meta VR product, you are expected to have the following: a meta account, a developer certification, the Oculus app installed on a smartphone as well as on the computer, and developer mode turned on in both. If you do not live up to these criteria, you will not be able to build or simply run your game over Quest Link using a cable. Even with all these criteria, you can still run into problems. We first experienced problems using the Quest Link system. This method allows you to simply press play in the Unity editor and almost immediately play the game on the headset instead of in the player in the editor. This allows for quick debugging and testing. It also had the advantage of being able to use the console and modify objects at runtime inside of Unity while running on the headset. However, for unexplained reasons, our Unity project stopped working using Quest Link from one day to the next, resulting in having to build the entire project each time to test. We think it might have been a Unity package conflict issue; however, we were not able to resolve it, even when using a fresh Unity project. Perhaps the most important takeaway from our time developing using Quest 2 in the Unity game engine, in summary, is that if everything is working as intended on the computer, you simply cannot expect it to work the same way on the headset, and you will most likely run into some sort of unexpected problem. Therefore, we recommend you test using the headset, if not all the time, but at least after doing some important modifications to the project. Also, we think it is generally best practice to use some sort of version control or backup system so you can go back to an earlier version that you know is working if, for some reason, it stops functioning correctly. It can potentially save you a lot of time.

5 User Study

In order to explore the effects of these different interactions, we conducted a user study. The research questions, which we aim to answer through this user study, are:

1. What are the effects of distinct vision-based interactions in VR-Horror games?
2. Can we expect some interactions to be scarier than others?

The study was conducted from 1/6 - 2/6, 2023.

5.1 Methodology

Aiming to explore different vision-based interactions, with differing intricacies, within a VR horror environment, we explore what effect these different interaction methods have on dynamic horror elements. Within this environment, the user moves in real space, interacting with the horror elements by different methods (13).

5.2 Study Design

The study procedure includes the following steps:

1. Demographic questionnaire (age, gender, no sensitive information)
2. The participants are briefly informed about the project and what we are trying to study
3. Main study:
   Get used to wearing and using the headset and the environment
   Users perform the tasks
   Users provide feedback after each interaction

The participants must find a key that is hidden in a room and return to the starting position to proceed to the next interaction. On the way to the key, the user will encounter the horror element we are interested in testing and are required to interact with it in some form to win.

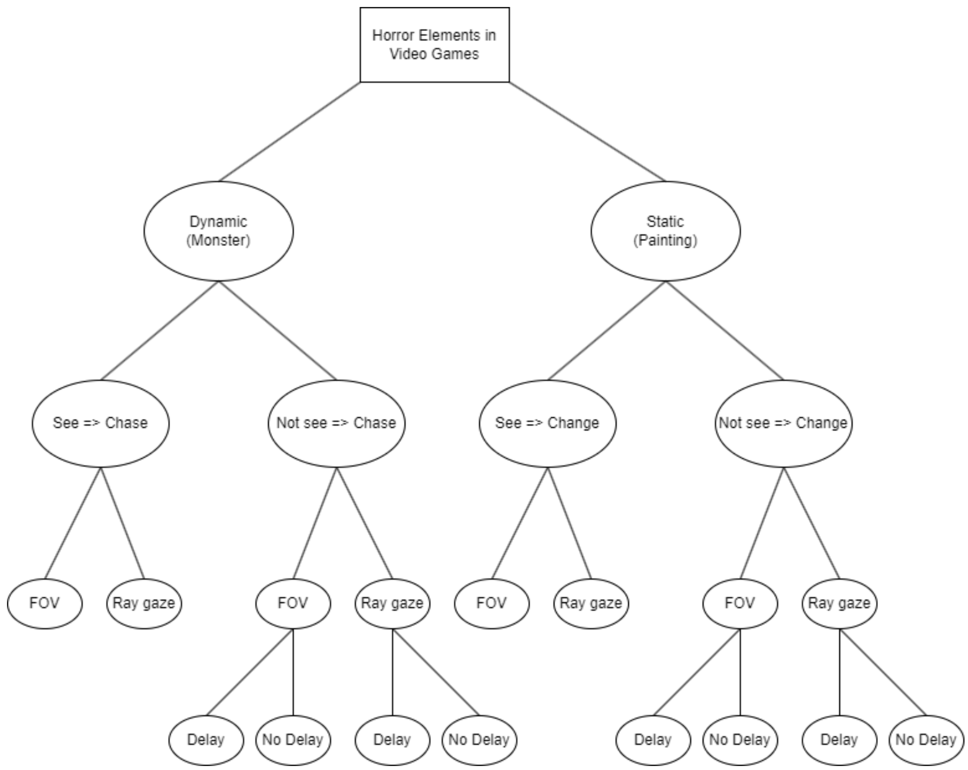


Figure 13: Interaction Tree

Task
The participants must find a key that is hidden in a room and return to the starting position to proceed to the next interaction. On the way to the key, the user will encounter the horror element we are interested in testing and are required to interact with it in some form to win.

Hypothesis
It is our expectation that the interaction most apt at eliciting a strong reaction from the participants of our user study is the dynamic monster, not the static painting. We anticipate the dynamic enemy to create a sense of urgency, with the participant prompting a stronger fear response.

This dynamic enemy possesses differing vision-based interactions. The type of interaction we presume will be the scariest is:
When the participant is not looking at the enemy, the enemy moves. Once the enemy is within the participant's field of view, the enemy will stop moving and freeze. We think it feels as if the monster is "playing dead." We believe that this

behavior could appear more sinister to the participant and is therefore expected to be the most impactful.

We use a questionnaire as the main dependent variable to assess the user experience and the effect of the conditions. It includes the following questions (1 strongly disagree, 7 strongly agree):

STUDY QUESTIONNAIRE							
Score questions between 1-7	1	2	3	4	5	6	7
My experience was scary.							
My experience was intuitive.							
My experience was fun.							
I was calm during the experience.							
I understood how the interactive game elements worked.							
I felt immersed in the VR experience.							

6 Results

The results of the study come from questions answered by six participants (two females and three males, and they are between the age of 20 to 30 years).

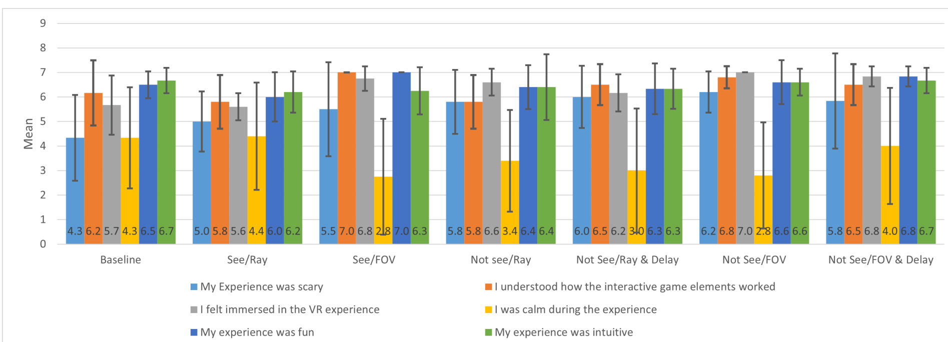


Figure 14: Bar diagram showing mean values and standard deviations from the questions for each interaction of the dynamic horror element

The bar diagram above shows the mean values from the different questions in our questionnaire for each interaction of the dynamic horror element (14). It also shows the standard deviation for each question. On the y-axis, we have the mean value, and on the x-axis, we have the different interaction tests. The names of the different interactions are displayed at the bottom of each bar grouping on the x-axis. Each color of bar represents the different questions of the questionnaire. For each bar, the mean value is presented at the bottom of the bar. The maximum mean value is 7; however, to not cut off the deviation lines, some extra room is added at the top. We see the highest standard deviations with the question “I was calm during the experience," which means they tended to agree the least when answering this question. Perhaps the users in the study had very different subjective ideas of what calm means to them, or it was difficult for some to understand the meaning behind the question. The mean value of this question across the different interactions was also the lowest overall, showing a clear tendency that people were not particularly calm during the test, which we think is to be expected. Perhaps you might argue that this is part of the goal of a VR horror game. The participants tended to agree on how intuitive they found the experience with a very low standard deviation and quite a high mean value being very close to the maximum across the tests. The mean value also stayed within 0.5 of each other between the different interactions. We also see a similar result with how fun the experience was. We see a small drop in terms of immersion in the first two tests (Baseline and See/Ray) compared to the rest of the tests. Perhaps this was caused by some immersion-breaking technical errors that were not present or as frequently occurring in the other tests. Otherwise, we see a tendency of the participants to be very immersed in the environment with relatively high mean values. The participants also seem to have a high understanding of how interactive game elements work in the game.

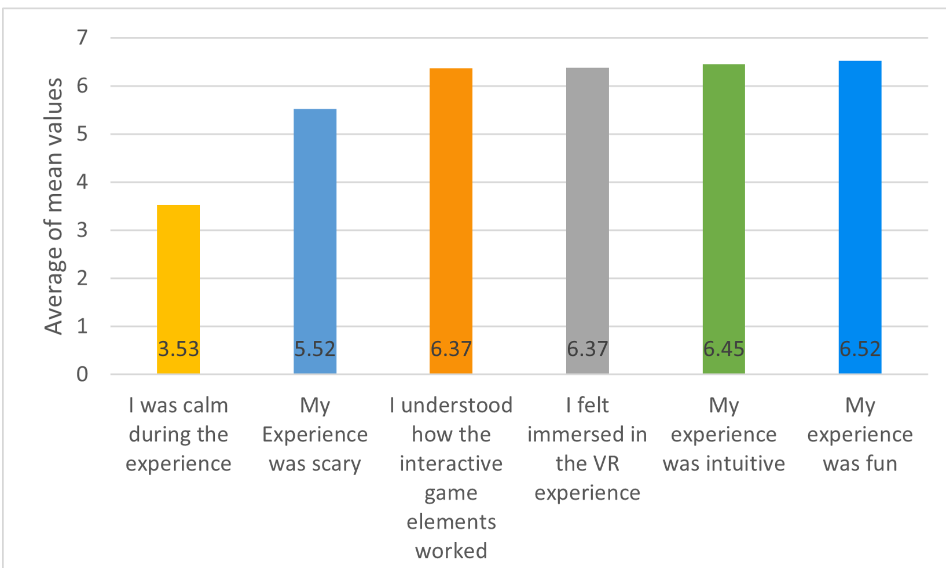


Figure 15: Bar diagram showing the averages of the mean values from all the interactions

Looking at the averages of the mean values (15), there are primarily two outliers. "I was calm during the experience" and "My experience was scary." The rest of the averages are within 0.15 of each other. Because the test was primarily focused on how scary the experience is, we believe that these two questions were the one's that the participants had to contemplate the most. We think the other questions might have felt similar and less important for the participants; thus, we see a very similar result here.

Let's take a look at each interaction individually in terms of how scary the experience is. We see that the baseline test was the least scary on average, having the lowest mean value (M = 4.3, SD = 1.75), followed by See/Ray (M = 5.0, SD = 1.22), See/FOV (M = 5.5, SD = 1.91), Not see/Ray (M = 5.8, SD = 1.30) and Not see/FOV Delay (M = 5.8, SD = 1.94) which are tied and lastly Not See/FOV (M = 6.2, SD = 0.84) which is the scariest. In ranking how scary the experience is, the participants tended to find the "Not see" interaction the scariest compared to "see"; however, not by very much. This also aligns with our hypothesis that being chased while not looking is scarier than being chased while looking. It also aligns with the hypothesis that the FOV rather than ray interaction is scariest; even though the difference in these values is admittedly very negligible, there is still a slight tendency. However, adding a delay to the "Not see/FOV" interaction is valued at 0.4 less than without any delay, making it scarier without any delay. (See Appendix .1 for all aggregated data used in the graphs and Appendix .2 for the t-tests)

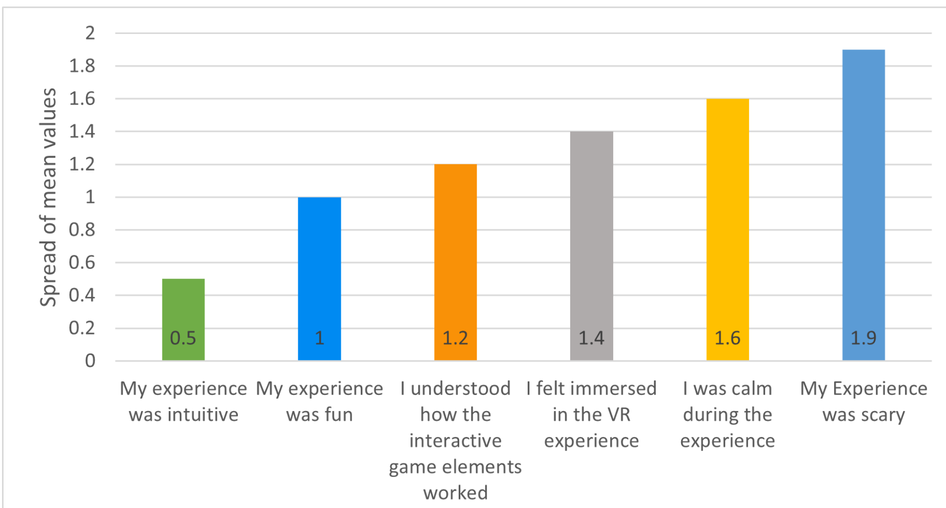


Figure 16: Bar diagram showing the spread of mean values for the different questions

The highest spread of mean values (16) is "My experience was scary" (1.9), followed by "I was calm during the experience" (1.6), "I felt immersed in the VR experience" (1.4), "I understood how the interactive game elements worked" (1.2), "My experience was fun" (1.0) and "My experience was intuitive" (0.5).

We also wanted to check for the significance of different hypotheses by doing t-tests on the data. To do this, we first create a null hypothesis (H_0) and an alternative hypothesis (H_a). The null hypothesis, in this case, is: "There is no difference in how scary it is after placing horror elements in the scene" (baseline vs. non-baseline test) ($\mu = 4.3$). The alternative is: "It is scarier after placing horror elements in the scene" ($\mu > 4.3$). Our significance level is 0.05 or 5 percent ($\alpha = 0.05$). Calculating this shows a p-value of: 0.06, which is very close but not lower than the significance level. Therefore we can not reject the null hypothesis, and we do not have evidence for the alternative. Another example is to check the relationship between the "See" interaction and the "Not See" interaction. Null hypothesis (H_0): "There is no difference in how scary the 'See' and 'Not see' interactions are." The alternative H_a): "The 'Not see' is scarier than the See interaction." This shows a p-value of: 0.11, which again means we can not reject the null hypothesis because our significance level is: 0.05. We also have collected demographic data such as age and gender; however, most participants were within the same age group (1 or 2 years difference), and because our sample size is quite small, we do not see a big enough reason why it would be interesting to check if the demographic data has an effect on the questionnaire data.

7 Discussion

Taking a look at some of the results from the previous section, one interesting observation is that the questions "My experience was scary" and "I was calm during the experience" have the most amount of spread of mean values and also the lowest average of mean values. It was also the questions with the highest standard deviation. The rest of the questions were very similar. As previously argued, we believe this to be caused by the participants seeing these questions as of higher importance than the rest because they are testing a horror game. They might think that these questions are the most relevant questions to ask. In terms of the deviation, we presume that the cause of the high disagreement among the participants is because what scares you might be a more subjective thing. We also think that being calm and being scared share a common connection. For example, we would argue that if you are more scared, you are perhaps less calm overall and vice versa, so in that case, it also makes sense to us that these two values are frequently grouped together in the data analysis.

Initially, we had thought that adding a delay to the interactions would make them scarier. It does not seem to be the case judging from the mean values. The scariest is the "Not see/FOV" without delay interaction. As mentioned, we set the delay to be 0.2 seconds. Perhaps this value was too low, making it hard to distinguish or even notice at all. Of course, it could also be that our hypothesis was simply not the case. The delay is a subtle difference and effect, but we think that it is in this subtlety that lies the scary part. We presume that there is a reason for big game studios to implement it into their games ([3] [5]).

In the previous section, we mentioned that both null hypotheses could not be rejected. We do, however, believe that, given the low number of participants, it is a lot less accurate test. We believe that having more participants would have given us a lower p-value overall. Nevertheless, in terms of the first null hypothesis, the baseline test without any horror elements was also surprisingly scary for the participants. Had it been the last of the tests, it would probably have received a much lower score.

Going into more detail about the baseline test, it had the lowest mean value in terms of how scary it was. We think this makes good sense as there are no horror elements trying to scare you. However, there is a relatively high standard deviation, and what we observed was that some participants were very frightened during the baseline test even though they knew nothing was going to scare them. Perhaps it being the very first test, and thus the first time experiencing the environment, is a contributing factor to this. Some of the participants also mentioned that it was their first time trying VR, which could also affect their scores. The mean value is also not that far off from the rest of the tests, which could suggest that atmosphere and level design alone can go a long way in terms of the scare factor. This tendency reflects what is previously stated in the report in terms of the vital part of the atmosphere in horror games [13]. An unexpected observation we made was how all the participants got very scared of the automatically opening doors. Perhaps this could also contribute to a higher mean value of the baseline as it is the first time encountering these doors and how they work. The doors open very quickly when you are close to them, and sometimes they open inwards towards you instead of outwards away from you. This unexpectedness made some participants jump up in horror and let out a scream, especially when they opened inwards towards you. It might have been less frightening having the participants open the doors themselves or decrease the speed at which they open. We also did not mention the doors before the test because we did not expect such a big reaction from people. The doors were only there not to allow the player to peek ahead and see what was in the following few rooms. And also for the activation of the dynamic element to happen when you open the door of the room, it is in.

If you look past all the issues surrounding it, using the physical world to move the virtual player around the environment worked very well. When it worked, it felt much more natural and immersive by adding a better sense of presence. Multiple of the participants also said specifically that it was very fun being able to walk around the environment physically. One of the participants even tried the joystick controls instead afterward and was shocked at how big of a difference it made in terms of how scary it was. We think it adds to the feeling of being present in another world, which might also be the central point of VR. As mentioned previously, one of the reasons why we chose to do this was to try and mitigate motion sickness, which is a common side effect of using the VR headset [6]. Multiple people, including ourselves, before the user evaluation had said that using the joysticks to move was making them feel very nauseous and motion sick even just after the first half minute of playing. None of the participants in the evaluation mentioned feeling nauseous in any way, and they had the headset on for a lot longer than that. We believe this way of moving physically might be the number one reason for this.

We'd like to discuss the previously mentioned related work and its relation to these results. Regarding the ability to create frightening horror environments using vision-based interactions, our results concur with Fernandes et al.[8]. While the scope of the thesis is mainly the technological implementations and capabilities of the platform and tools utilized, their vision-based interaction approach is similar to ours. Their results show that their vision-based interaction triggered anxiety, excitement, and fear in several participants[8, p.54-55].

Furthermore, we experience some of the "unexpected" with our vision-based interactions. As previously mentioned, Gomez et al.[21] explored the unexpected "not looking" within gaze interactions, employing a framework from which to visualize this phenomenon (1). Our game events elicited some of these unexpected interactions, especially during player distress. While players, for example, with the "see" interaction with a dynamic element, are supposed to sense and discover who the enemy is within the level, some players simply kept their heads down and refused to interact with any element but the key. As we have previously discussed, there is a difference between said article and this project with regard to intentionality. Keeping this in mind, it is still insightful to consider that we discovered what is effectively similar to that of the goal said article had. We discovered a potentially unintentional aversion interaction within the study environment. Now, while Gomez et al[21, p.3] study participants were intentionally using some degree of aversion; ours is organically unintentional.

The results potentially show us occurrences of the plausibility illusion(PSI)[16, p.3]. While some participants partook in the evaluation and encountered an enemy, if possible, some began to see if they could outrun this enemy. From observation, it would appear that their attempts to escape the frightening element elicited a visceral reaction, prompting them to immediately distance themselves from the element. Expanding upon this, the feeling of being chased or stalked in VR could be a contributing factor to player fright[16, p.10]. The case for this could potentially be strengthened by the observation that only a single participant briefly broke through the walls of the test environment just to see if they could. This could support the idea that the "Place Illusion"(PI)[16, p.3] has an influence on the participants, making the participants, in essence, treat or respect the VR environment as a real one instinctively. Furthermore, these results provide an interesting perspective on forewarning and suspense in video games. We previously mentioned Perron[20] and the potential to create more frightening moments in video games using forewarning and suspense. Even while omitting the dynamic element entirely, with the baseline test, some degree of scare was still observed. Some participants would go as far as to doubt the intentions of the evaluators. They would become scared that since they were told no monsters were present, they would be lulled into a false sense of security, only to be scared even more severely.

This could tie into the conclusion made by Perron[20, p.9]. Not only does forewarning cause a greater emotional response to the frightening element, but it also increases anxiety about events in which outcomes are unsure. To this end, even though there is no intention to frighten the player or cause anxiety, quite the opposite might occur anyways.

7.1 Evaluation limitations and issues

We encountered a few bigger problems that may have affected the user's opinions and, therefore, could potentially have altered the result of the study. One such problem was a Quest 2 position tracking issue, we believe. Multiple users reported the headset suddenly moving or "teleporting" them to another room in the game while playing. We had never experienced this issue before in our testing phase, and it never happened when using the joysticks on the controllers to move. Therefore, we think the issue has something to do with having to move around physically. This issue forced us to take the headset off the user and restart the level because of misalignment with the physical room and immersion breaking. Another issue was regarding the ray interaction. Because it is such a small point in space that has to hit the monster exactly, it can be hard to perfectly center the monster in your view for the ray to hit the monster's box collider. Sometimes users experienced that the dynamic horror element did not stop even if they felt they were looking straight at it. This never became a problem with the FOV interaction because it detects collisions in a much larger area and is, therefore, much easier for the user to control. Because the size of the room in CAVI matched the virtual level almost precisely, the slightest misalignment could ruin the experience for the user by not being able to proceed through a door because of a physical wall. A physical room that is much larger than the virtual level could potentially eliminate this issue entirely. In this case, there would have to be serious misalignment for it to break the game. If we had further scaled down the level to give us more space to move around, the level and assets would start to look like a tiny dollhouse (the scale was 75 percent smaller than the original). The different assets, such as chairs and tables, were already quite small in comparison to the player, which could also have affected immersion and how scary it was. That was why we felt it was especially important to increase the scale of the horror elements to match as well for them to be more intimidating and perhaps more frightening. Because of the limited time we had the CAVI room available to us and the troubles we had building the project to Meta Quest 2, we did not have the time to do a proper pilot study beforehand. This could have helped a lot in terms of fixing technical issues or at least making us aware of them, making the study take less time and perhaps giving us a more accurate evaluation of the different interactions. One significant limitation of the study was the number of participants. We initially had more scheduled; however, we found out that for each person, it took around one and a half hours, which is about 15 minutes per interaction. This was almost five times as much as we had initially thought and planned for. Due to time constraints, we needed to cut the number of participants down. Six participants were the bare minimum for us because there are six interactions to go through in terms of counterbalancing, but we would have liked to have seen 12. We think the time for each interaction was also increased further by the bugs and issues mentioned in this section. Nevertheless, even without issues, it still took a lot longer than anticipated. This is also why we chose not to include the static painting horror element in our study. Having a static element to compare to a dynamic element would have been very interesting. We even had all the levels with the paintings done and ready to test, but the study, unfortunately, would have been too ambitious for our small team and the participant's time. Furthermore, when testing the levels of the static painting element according to the interaction tree (13), we found that particularly the no-delay FOV interactions (both "not see" and "see") to be rather pointless. This way, the user would never see a change in the painting's state. If we had more time and more participants available, we would have liked to see a big spread in age and gender to give a better general and more fulfilling understanding of people's opinions. With our six participants, we had a quite narrow age group; however, in this case, the number was so low, we do not think it would have made a great difference otherwise.

8 Future Work

Concessions had to be made for the project's user study to be successful. While eye tracking was a focus early on in development, it was quickly during the prototyping process found to require significantly more engineering and testing to be implemented successfully. It also requires more advanced and expensive hardware that is not as widely available and accessible. While the necessity to implement an eye-tracking solution is mitigated[25], this does not eliminate the interest in such an implementation. The development of the study environment allows eye tracking to be implemented quite easily using the Unity OpenXR package, should the pricing of eye tracking headsets decrease, availability increase, and interest arise. A larger study environment could be very beneficial to mitigate position-tracking issues. The scale of the study environment had to be scaled too far below the original size, reaching a critical point where it was not yet possible to scale it down any further. Should an environment be big enough to traverse without the need for significant down-scaling, this could be more immersive for the user.

Furthermore, the static element saw no user study involvement, and its evaluation is thus non-existent. Upon revisiting static elements of this project, efforts could be made to explore different interactions further, more specifically tailored towards static elements, such as implementing a sanity mechanic like in Amnesia: The Dark Descent [9], as well as devising a study environment in which they could be evaluated by users.

9 Conclusions

We have seen several examples of exploratory research on the topic of gaze interactions and the nature of VR and horror. As has been mentioned, while several other approaches have been made to evaluate different interactions, none evaluate both parts of the dichotomous "look" and "don't look." While we are not able to comment on how effective vision-based interactions mimic genuine gaze interaction, this study could serve as a reference point for comparison. The study environment, despite its limitations, provided participants with the ability to move through the VR environment in real space. we were not able to reject the null hypothesis that there is no difference between the "see" or "not see" interaction with a significance level of 0.05; we did, however, see a slight tendency that "not see" is the scariest of the two. These results could, however, be skewed by the number of participants in the study. We explored both "look" and "don't look" vision-based interactions within this study, and as such, hope that this study could be used as a reference point from which one could explore the effectiveness of vision-based interactions, as well as their relation to eye tracking and gaze interaction.

10 Appendices

.1 User study datasheet

Mean values

	My Experience was scary	I understood how the interactive game elements worked	I felt immersed in the VR experience	I was calm during the experience	My experience was fun	My experience was intuitive
Baseline	4.333333333	6.166666667	5.666666667	4.333333333	6.5	6.666666667
See/Ray	5	5.8	5.6	4.4	6	6.2
See/FOV	5.5	7	6.75	2.75	7	6.25
Not see/Ray	5.8	5.8	6.6	3.4	6.4	6.4
Not See/Ray & Delay	6	6.5	6.166666667	3	6.333333333	6.333333333
Not See/FOV	6.2	6.8	7	2.8	6.6	6.6
Not See/FOV & Delay	5.833333333	6.5	6.833333333	4	6.833333333	6.666666667

Standard deviation

	My Experience was scary	I understood how the interactive game elements worked	I felt immersed in the VR experience	I was calm during the experience	My experience was fun	My experience was intuitive
Baseline	1.751190072	1.329160136	1.211060142	2.065591118	0.547722558	0.516397779
See/Ray	1.224744871	1.095445115	0.547722558	2.19089023	1	0.836660027
See/FOV	1.914854216	0	0.5	2.362907813	0	0.957427108
Not see/Ray	1.303840481	1.095445115	0.547722558	2.073644135	0.894427191	1.341640786
Not See/Ray & Delay	1.264911064	0.836660027	0.752772653	2.529822128	1.032795559	0.816496581
Not See/FOV	0.836660027	0.447213595	0	2.167948339	0.894427191	0.547722558
Not See/FOV & Delay	1.940790217	0.836660027	0.40824829	2.366431913	0.40824829	0.516397779

Spread of mean values

	My experience was intuit	My experience was fun	I understood how the interactive game	I felt immersed in the VR experie	I was calm during the ex	My Experience was scary
	0.5	1	1.2	1.4	1.6	1.9

Averages of mean values

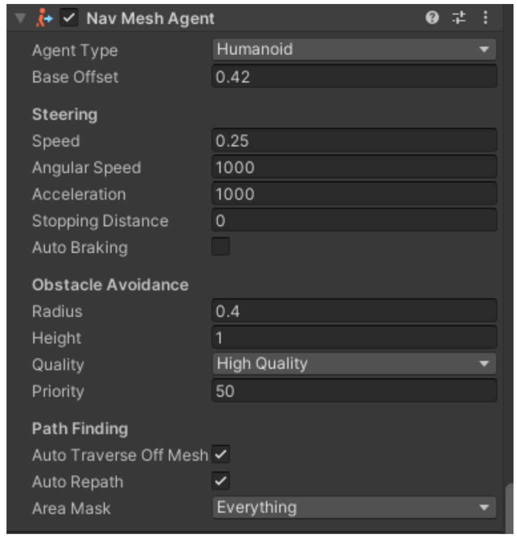
	I was calm during the exp	My Experience was scary	I understood how the interactive game	I felt immersed in the VR experie	My experience was intu	My experience was fun
	3.526190476	5.523809524	6.366666667	6.373809524	6.445238095	6.523809524

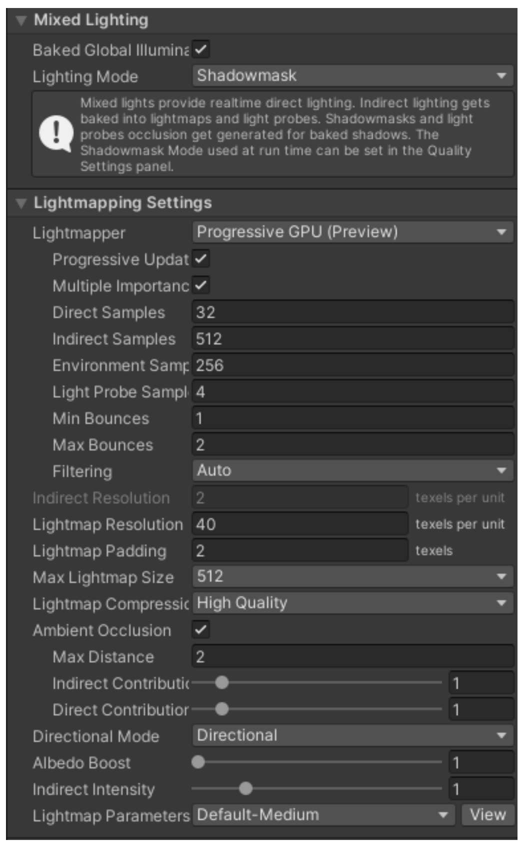
.2 T-tests

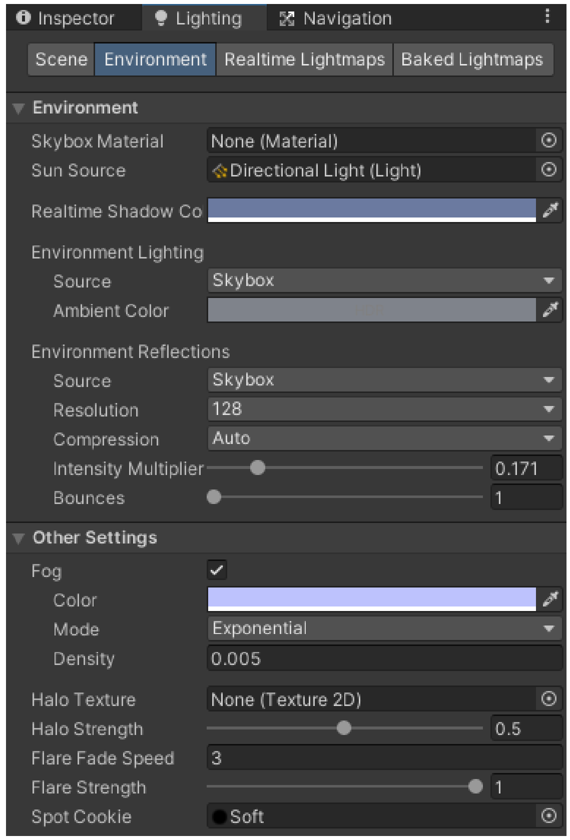
t-test 1		
	Variable 1	*Variable 2*
Mean value	4.33	5.74
Variance	3.07	1.93
Hypothesis for difference in mean value	0.00	
fg	6.00	
t-stat	-1.86	
P(T<=t) one-tailed	0.06	
t-critical one-tailed	1.94	
P(T<=t) two-tailed	0.11	
t-critical two-tailed	2.45	

t-test 2		
	Variable 1	*Variable 2*
Mean value	5.22	5.95
Variance	2.19	1.76
Hypothesis for difference in mean value	0.00	
fg	14.00	
t-stat	-1.29	
P(T<=t) one-tailed	0.11	
t-critical one-tailed	1.76	
P(T<=t) two-tailed	0.22	
t-critical two-tailed	2.14	

.3 Unity settings






Inspector
Lighting
Navigation
Scene
Environment
Realtime Lightmaps
Baked Lightmaps
Environment
Skybox Material
None (Material)
Sun Source
Directional Light (Light)
Realtime Shadow Co
Environment Lighting
Source
Skybox
Ambient Color
Environment Reflections
Source
Skybox
Resolution
128
Compression
Auto
Intensity Multiplier
0.171
Bounces
1
Other Settings
Fog
Color
Mode
Exponential
Density
0.005
Halo Texture
None (Texture 2D)
Halo Strength
0.5
Flare Fade Speed
3
Flare Strength
1
Spot Cookie
Soft

References

[1] Adobe. *Mixamo*. 2023. URL: https://www.mixamo.com/.

[2] BBC. *Doctor Who S3.E10 Blink*. 2007. URL: https://www.imdb.com/title/tt1000252/?ref_=tt_eps_top.

[3] Bethesda. *Ghostwire: Tokyo*. 2023. URL: https://bethesda.net/en/game/ghostwire-tokyo.

[4] Capcom. *Resident Evil*. URL: https://game.capcom.com/residentevil/en/.

[5] Capcom. *Resident Evil Village*. 2021. URL: https://www.residentevil.com/village/en-asia/.

[6] Eunhee Chang, Hyun Taek Kim, and Byounghyun Yoo. "Virtual Reality Sickness: A Review of Causes and Measurements". In: *International Journal of Human–Computer Interaction* 36.17 (2020), pp. 1658–1682. DOI: 10.1080/10447318.2020.1778351. eprint: https://doi.org/10.1080/10447318.2020.1778351. URL: https://doi.org/10.1080/10447318.2020.1778351.

[7] Art Equilibrium. *Horror Mansion 3D Environment*. 2023. URL: https://assetstore.unity.com/packages/3d/environments/horror-mansion-254104.

[8] Andrew Fernandes et al. "Don't Look Back: Horror in Virtual Reality". In: (Dec. 2021), p. 104. URL: https://digital.wpi.edu/downloads/ns0649157.

[9] Frictional Games. *Amnesia: The Dark Descent*. 2010. URL: https://www.amnesiagame.com/.

[10] GoodbyeWorld Games. *Before Your Eyes*. 2021. URL: https://www.beforeyoureyesgame.com.

[11] Supermassive Games. *The Dark Pictures: Switchback VR*. 2023. URL: https://www.thedarkpictures.com/switchback-vr.

[12] Joseph Kime. "Why are PS1 graphics in horror games so scary?" In: (Apr. 2023), p. 3. URL: https://www.ggrecon.com/articles/why-are-ps1-graphics-in-horror-games-so-scary/.

[13] Jamie K King. "An Analysis of the Methods and Techniques Used to Create an Unsettling Atmosphere in Horror Games". In: *University of Abertay Dundee Doctoral Dissertation BA Thesis* (2015).

[14] Konami. *Silent Hill*. 1999. URL: https://www.konami.com/games/silenthill/gate.

[15] Konami. *zombie with spikes Free low-poly 3D model*. 2022. URL: https://www.cgtrader.com/free-3d-models/character/fantasy-character/monster-4-f5757b92-dc9c-4f5e-ad0d-593203d14fe2.

[16] Jih-Hsuan Tammy Lin. "Fear in virtual reality (VR): Fear elements, coping reactions, immediate and next-day fright responses toward a survival horror zombie virtual reality game". In: *Computers in Human Behavior* 72 (2017), pp. 350–361. ISSN: 0747-5632. DOI: https://doi.org/10.1016/j.chb.2017.02.057. URL: https://www.sciencedirect.com/science/article/pii/S0747563217301383.

[17] Tanja Mcilroy. *Red Light Green Light Children's Game*. 2023. URL: https://empoweredparents.co/how-to-play-red-light-green-light/.

[18] Meta. *Quest 2 VR Headset*. 2020. URL: https://www.meta.com/dk/en/quest/products/quest-2/.

[19] Meta. *Quest Pro VR Headset*. 2022. URL: https://www.meta.com/dk/en/quest/quest-pro/.

[20] Bernard Perron. "Sign of a threat: The effects of warning systems in survival horror games". In: *COSIGN 2004 Proceedings* (Jan. 2004).

[21] Argenis Ramirez Gomez and Hans Gellersen. "Exploring the Sensed and Unexpected: Not Looking in Gaze Interaction". In: *Proceedings of the Halfway to the Future Symposium 2019*. HTTF 2019. Nottingham, United Kingdom: Association for Computing Machinery, 2019. ISBN: 9781450372039. DOI: 10.1145/3363384.3363479. URL: https://doi.org/10.1145/3363384.3363479.

[22] Argenis Ramirez Gomez and Hans Gellersen. "Looking Outside the Box: Reflecting on Gaze Interaction in Gameplay". In: *Proceedings of the Annual Symposium on Computer-Human Interaction in Play*. CHI PLAY '19. Barcelona, Spain: Association for Computing Machinery, 2019, pp. 625–637. ISBN: 9781450366885. DOI: 10.1145/3311350.3347150. URL: https://doi.org/10.1145/3311350.3347150.

[23] Argenis Ramirez Gomez and Hans Gellersen. "SuperVision: Playing with Gaze Aversion and Peripheral Vision". In: *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*. CHI '19. Glasgow, Scotland Uk: Association for Computing Machinery, 2019, pp. 1–12. ISBN: 9781450359702. DOI: 10.1145/3290605.3300703. URL: https://doi.org/10.1145/3290605.3300703.

[24] Argenis Ramirez Gomez and Michael Lankes. "Towards Designing Diegetic Gaze in Games: The Use of Gaze Roles and Metaphors". In: *Multimodal Technologies and Interaction* 3.4 (2019). ISSN: 2414-4088. DOI: 10.3390/mti3040065. URL: https://www.mdpi.com/2414-4088/3/4/65.

[25] Ludwig Sidenmark and Hans Gellersen. "Eye, Head and Torso Coordination During Gaze Shifts in Virtual Reality". In: *ACM Trans. Comput.-Hum. Interact.* 27.1 (Dec. 2019). ISSN: 1073-0516. DOI: 10.1145/3361218. URL: https://doi.org/10.1145/3361218.

[26] Sony. *PlayStation VR 2*. 2023. URL: https://www.playstation.com/da-dk/ps-vr2/.

[27] Blooper Team. *Layers of Fear*. 2016. URL: https://layersoffears.com/.

[28] Unity. *Open XR Interaction Toolkit 2.3.1*. 2023. URL: https://docs.unity3d.com/Packages/com.unity.xr.interaction.toolkit@2.3/manual/index.html.

[29] Melodie Vidal et al. "The Royal Corgi: Exploring Social Gaze Interaction for Immersive Gameplay". In: *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*. CHI '15. Seoul, Republic of Korea: Association for Computing Machinery, 2015, pp. 115–124. ISBN: 9781450331456. DOI: 10.1145/2702123.2702163. URL: https://doi.org/10.1145/2702123.2702163.