Guiding Attention in Cinematic Virtual Reality

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Medialogy group 510, Copenhagen, 2020



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Aalborg University
http://www.aau.dk

AALBORG UNIVERSITY
STUDENT REPORT

Title:
Guiding Attention in Cinematic Virtual Reality

Theme:
Audio-Visual Experiments

Project Period:
fall Semester 2020

Project Group:
510

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Copies: 1

Page Numbers: 77

Date of Completion:
December 18, 2020

Abstract:

This project examines how the attention of a user can be drawn to certain elements in a cinematic virtual reality experience by utilising film theory. An analysis was made exploring these subjects, which lead to the design and implementation of an interactive VR experience. The design facilitated guiding the audience attention with or without the use of visual and audio cues. Two tests were planned for this project, a usability test that most notably showed that test participants were able to understand the visual and audible cues. However, the final test was not performed due to COVID-19 restrictions. Therefore, no conclusion could be drawn upon the final problem statement.

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Chapter 1

Introduction

Virtual Reality (VR) is a technology in growth, increasing in fidelity every year within the field of gaming and experiences. Opposite, the film experience has been largely unchanged in recent history. Slowly, the film experience is making its way to virtual reality, where a viewer has more opportunities to interact with the story.

Furthermore, VR can utilise a 360-degree view and allows the viewer an opportunity to walk around in a scene and interact with the story. This poses some new challenges when implementing "regular" film theories into the world of virtual reality. This branch of virtual reality is known as Cinematic VR.

One of the main difficulties of having this 360-degree view, is that the viewer can have their attention obstructed, or rather, their visual point of interest can be elsewhere than what the director would want. Therefore, the initial motivation would focus on how the user's attention can be guided in VR by utilising theory regarding screen media (films) and game design.

1.1 IPS

How can virtual reality utilize film theory to guide the user's attention in a cinematic experience?

Chapter 2

Analysis

In this chapter an analysis of various research topics related to the initial problem statement will be explored in order formulate a precise final problem statement. The analysis will take a closer look at the following topics - film theory, level design and virtual reality.

2.1 Audio and Visual Cues

According to Bordwell and Thompson [1] visual and audio cues have been used for a long time in film. They are used for directing the viewer's attention to certain events happening on or off screen. They may enhance the effect of one another through a collaboration of their effects. Audio cues might be used to create a bridge between different visual cues in a scene, increasing the relationship between the two.

2.1.1 Audio Cues

Audio cues are made up of a variety of properties. One property is loudness. Loudness or the volume can be used to give a cue about the distance within the visual scene, usually, the louder something is, the closer it is and vice versa. Loudness might also be used to tell something about the environment. If two characters in a scene are standing next to a construction site, there may be varying noise accompanying their conversation, this is done to further the credibility of the scene and its events. Furthermore, the use of audio cues can enhance the effect of no audio, silence, since the viewer may become aware that the lack of audio in a scene foreshadows something happening or at least keeps their attention to the scene. Another property of audio cues is pitch. Pitch is the perceived sound of the audio based on its frequency. Using different pitches for various items that produce

sound in a scene, on or off camera, helps distinguish various events or items from one another. It can create a familiarity between certain objects, actions, and events in a narrative. The final property of audio cues is timbre. Timbre is not measurable in the same way loudness can be measured in decibel and pitch can be measured in frequency. Timbre describes the *sonic texture* of the audio. It may be a dry timbre, which means a low amount of reverberation for example. This might be used in a situation where there is no objects to reverberation the audio, like in science fiction scenes when astronauts float around in space [1].

Ambient sound is the kind of sound that helps set the mood of the scene and it can enhance the feeling inside an environment. Ambient sound can highlight the details about an element in the story that otherwise would have been missed. Ambient sound can be birds chipping on a sunny Sunday morning or the cars driving by on the street out in front of the house.

2.1.2 Visual Cues

Just as the audio cues can be manipulated to convey a certain emotion, control the attention of the viewer and much more, so can visual cues. Visual cues are part of the concept of *mise-en-scène*. Mise-en-scène is basically synonymous with every item/object/event inside a scene that has the possibility to demand the attention of the viewer. This might be a car, an animal, people, the weather, and everything in between. Various techniques are used to produce a scene that has one or more of such objects of significance [1]. These techniques will be explored in-depth in the following section.

Setting

The setting in mise-en-scène help create a narrative and tell the story that the director wants to be told. Settings can be natural and authentic so that if the story is about the fall of the Berlin Wall, the setting will be in Berlin. The setting might be very complex so that it tells a story on its own or it may be very simple so that it leaves the attention of the viewer to be focused on actors instead. A setting might be stylized too, drawing on inspiration from certain genres of art and history. An example of this is Disney's Hercules which is first of all stylized in the same form as other Disney movies from that period, but also inspired by Greek architecture and mythology 2.1.



Figure 2.1: Screen-grab from Disney's Hercules

Furthermore, with the use of green-screens, the set can be produced and changed in post-production, this allows the director an opportunity to add events or items into the setting after recording which in turn can be used to guide the attention of the viewer [1].

Costume and Makeup

Costume and makeup are yet another part of the mise-en-scène. This part is responsible for speaking for the actors on screen before they even utter a word. If you have a man in a suit in the scene, the viewer might expect some professionalism or seriousness from that actor. If an actress is wearing a red dress it might symbolize romance, sexuality, or something completely different. The main point is to tell a story through costume and makeup that the setting or actors either can not tell themselves, or enhance what is already being done 2.2.



Figure 2.2: Screen-grab from The Matrix

Another important aspect of using costumes is telling a story through colours or the contrast of colours. A character might be hardly visible if wearing a dark blue suit in a darkened alley, while another character wearing a red/white jumpsuit might be highly visible, which is used to direct the attention of the viewer, again, by using colour and contrast [1].

Lighting

Lighting is yet another vital part of the mise-en-scène. Lighting can be manipulated in countless ways and this is again being done to convey a mood, highlight an action, obscure detail or create suspense in the scene. Lighting is most commonly manipulated in four different aspects; direction, quality, colour, and source. The direction is most commonly either from the back, back lighting, from the front, frontal lighting, from the top, top lighting, from the side, side lighting, or from below, under lighting. A director will use a combination of these light directions to create the scene they want. They might also only use one of the directions for some dramatic effects. The source of the light is also important. When filming a documentary, the director might only have natural light available, and this might fit the narrative best. But in a horror movie, the only light in the scene might be the moonlight reflecting off the outside environment and into a room. It may also be completely artificial if that is what the scene calls for. In movie production, a key light, a fill light, or a back light is often used to light the scene. The key light is more directional and can be pointed at the actor, for example. The fill light is less directional and simply aims to fill the scene with light, often from the point of view of the camera. The back light can be used to accentuate the silhouette of a character in a scene. The quality and colour of the light are also important, these are both used to convey important actions that demand the viewer's attention or create a certain mood. Blue light might be used to highlight that the setting takes place

somewhere cold, while a golden light might be used to indicate that the setting is in warmer climates [1].

Staging

Staging and acting are what the actors or actresses do in a scene. Their facial expressions, tone of voice, gestures, or the lack thereof, all add up to create the narrative or cinematic experience that the director wants. This is all combined with the other aspects of the mise-en-scène explored above to deliver a story to the viewer [1].

Space

The screen space is what available screen realty the director can use. From film, this is usually a rectangle lying down. How this screen space is used to show characters or events dictates how the viewer will perceive them. The shot might be balanced such that the area of interest is in the middle of the scene, it might also be balanced by having two characters stand on either side of the screen space. In the screen space, theories explored above, such as colour can be used to set up the scene. Bright and warm colours attract attention if the surrounding scene is less colourful or darker in colour. Another important part of the space is the scene space. The scene space is what conveys the fact that the objects on screen have volume, this is done using depth cues. Depth cues such as shadows, shape, and movement all tell the viewer that what they are looking at is three-dimensional and this makes the scene more realistic [1].

Time

The director controls the flow of time in the scene. This may include the speed and movement of objects or characters in the scene. This is important for similar reasons as those stated above, the viewer is susceptible to having their attention manipulated because the viewer will look for changes in the scene related to time [1].

Now that audio and visual cues have been explored and it has become clear that they can be used to guide someone's attention, the next section will take a closer look at attention.

2.2 Attention

When examining attention, it has been shown there are different approaches to interpreting visual attention respectively as attention and awareness. One paper investigating the neural aspects of visual attention constructs two terms presented as change blindness (CB) and inattentional blindness (IB). CB happens when objects change its appearance whether it is the position, color, shape, or disappearance whereas IB occurs when attention is focused on a specific task, thus leading to other items being disregarded [8].

This suggests that attention plays a crucial role when determining what is noticed. Cueing an object of interest before a potential change could prevent CB. However, it is important that the attention is allocated to the object close to the moment of visual change. Attention is a process where some inputs are processed more precisely than others in order to increase visual response to memorise the input into awareness. In other words, you are conscious of various inputs but without attention, it will not be stored and forgotten [8].

While the terms CB and IB stem from a neurological science approach another way of describing these terms is through senses and perception. Steven and Abraham Yantis present the following types of attention.

Your body's sensory system is constantly registering stimuli as physical signals. These signals are categorised and actively divided by your brain into significant or insignificant signals and where your attention is needed [16]. A subcategory of this attention is known as divided attention and is what ensures you do not walk into objects. Focused attention is when the attention is on a specific item, or other items close in proximity. Furthermore, attention can have a bottom-up or top-down approach, where bottom-up is the reaction to a change in the environment and top-down is when the attention is trying to find and memorise information. Therefore, bottom-up leads to subconscious movements whereas top-down takes form is a conscious decision [16].

The difference between these two approaches is covert and overt attention. Covert attention is what visual information you can gather in an environment without the need to actively scan objects with your eyes. As such, this can be voluntarily allocated to a given location based on goals or changes in the visual field. Overt attention, on the other hand, is where the focus of your eye is on a specific item and thus can also be directly registered in form of eye movements [2].

The process of searching for an object that differs from other objects in just one feature is called feature searching. If the feature to find is already known the process of finding the specific object will be faster [16]. On the other hand, searching for something that differentiates with multiple features is called conjunction search.

The conjunction search method is more time-consuming since multiple features have to be considered and therefore not as effective as a feature search. Accordingly, it has been noticed that when presented with objects the search is dominated by colour as opposed to position or shape [16]. Therefore, an object will gather more attention based on colour as opposed to the surroundings due to its visual salience [1].

However, that is not to say motion is not a factor or can do the same. If presented with a clutter of items/objects the one moving in the opposite direction or behaving in an unpredictable manner such as random movements will attain overt attention. Therefore, it can be assumed that an object with colour that contrasts as well as movement would attract the most attention.

After taking a look at Attention and how it works the next step will be to look at level design in order to create an experience in which the users attention can be drawn and tested. A broad look at level design will be made and then a closer look at the state of the art.

2.3 Level Design

Level design is important when guiding the user's attention because it walks the user through the environment by how it is setup or structured. A VR experience can be split into different sections called levels. Each level can contain several numbers of event, objects and environment that the player can interact with. The levels are constructed in a way that should tell a story about where the player is, what they can do. This can also create some expectations for the player, of what will happened in the given environment.

Level designing takes many examples from the real world and then apply these examples in a 2-dimensional(2D) or 3-dimensional(3D) computer generated world. This can be see in the architecture of the layout of different levels, as each of them can help the player an better understanding of how to navigate it [15].

As an example, one level could be based in a city with nightlife and traffic. When the player experiences that level, it comes with a certain expectation of how sidewalks and roads should work and look like.

From an article, written by Jamie Madigan [9]. He explains that immersion seems new to the public, but it has been studied before under another term called presence according to psychologists. The psychologists' definition of immersion is as following:

media contents are perceived as 'real' in the sense that media users experience a sensation of being spatially located in the mediated environment [9]. To ensure that the player is

immersed in the game, there are four steps that can help the immersion process [9], which are as follows:

- Multiple channels of sensory information
- Completeness of sensory information
- Cognitively demanding environments
- A strong and interesting narrative, plot, or story

The first step is about appealing to the senses of the player through visual or audio feedback. Using the example of the city with the nightlife again, there could be cars on the road and pedestrians on the sidewalk to please the visual aspect for the player. To satisfy the audio for the player, they would be able to hear the cars, like where they are coming from and what the pedestrians are talking about if they are talking [9].

The second step is building upon the first step where the player has to fill in something for the area or level they are in. With the city example, how can the player feel that the given city has nightlife. Maybe the player can hear the drunk people around them and roughly hear the music from a nearby club [9].

The third step is about where the focus of the player is directed to. The focus should be on navigating or understanding the game world. By doing so, the player would not notice the problems of the game world and not be reminded that they are in a game [9].

The fourth and final step is having a good plot or story that the player can experience and enjoy. This is mainly used to immerse the player into the game world, but the goal is also to guide the player around in world [9]. This can be done by having a progression in the story that moves the player into different areas simultaneously.

2.3.1 Guide the Player

When the goal is to guide the player to a location in a level, how could that be done? There are many ways to guide the player in a level, like setting up the level in a linear way for one way guidance or having a path that is visible. Other ways to guide the player, could be to use cues like audio (2.1.1) or visual cues (2.1.2) since they can have a different effect on the individual player. Visual cues can be like arrow signs that point to where the player can go or a brick road in a forest, are variations of cues to guide a player's path. There are also more subtle ways of guiding the player, like using light cues. Objects that the player has to interact with, can have a spot light pointing at them. That way, the player can see the object as it stands out, indicating it has some sort of importance to the level.

In case the game is not focused on the visual aspect, they can use spatial sounds to guide the player instead. This will allow the player to hear in any direction around them and the user can be guided, exemplary, with changing the loudness when they are getting closer or moving away from a specific event. When combing both the visual and audio cues, it should be possible to ensure that the player goes in a certain direction.

2.3.2 Virtual Reality Analysis

The following section will resemble a state of the art analysis of how all theories discussed in the previous chapters (2.1.1), (2.1.2) and (2.3) and more are being used in the critically acclaimed virtual reality game Half Life: Alyx. The analysis seeks to find examples, through in-game images, of theories discussed previously. Concerning audio and visual cues it will be relevant to learn more about everything related to the mise-en-scène theory, the use of audio, its properties, and the combination with the level design.



Figure 2.3: Half Life Alyx cover art.

The analysis will be based on a two minute and 18 seconds long video clip which depicts the opening scene of the game, link to the video is in a footnote below. [1].

[1] `https://www.youtube.com/watch?v=KBSokruYsuM&ab_channel=IGN`



Figure 2.4: The first scene/location of the game.

The very first thing the player sees in the first scene of the game is some sort of structure bathed in fog and clouds being lit up from the sun behind it. All the wires that connect to the tower immediately draw attention to the center of the scene. Below the tower is a colourful yet shadowy city. The screen space is balanced around the tower and the scene space or depth in the scene is accentuated by the wires and the depth cues provided by the architecture in the bottom section of the scene. The colours used in the scene are fairly dark except for a bit of red and blue houses and roofs which creates some separation of the ordinary architecture to the foreign architecture being used in the building process of the tower. There are also a few moving objects in the scene, namely helicopters and other flying crafts, smoke billowing from chimneys, and a small population of pigeons. These objects give a sense of time passing in the scene and help create an environment that feels alive. The audio in the scene can be described as invoking a scene of spatial awareness, a helicopter passes by overhead drawing attention to itself, the ambient sounds consist of jet engine sounds from some of the other aircrafts, sparks of electricity, the thumps of large machinery walking around the houses and pigeons cooing.

The transition from this scene to the next main scene involves the game teaching the player how to walk around on the balcony on which the player was standing when introduced to the opening scene analysed above. The balcony has a multitude of props such as a radio, empty cans, bins, chairs, and more. The player then moves into what looks like an abandoned greenhouse or orangery located on the side of the building the player is on from the beginning of the game.



Figure 2.5: The second scene/location.

Inside this new scene, a collection of old TV screens in the corner with a bright yellow hourglass draws the attention of the viewer. As the player approaches the TVs the hourglass turns to a message: *"Incoming Call Eli Vance"*. The player is then prompted to click a button on a microphone that starts to flash as the call comes in, the game relies on visual cues here, colour, and intensity. Once the button has been pressed, all the screens turns to show an older man, the dad of the protagonist, talking to the player. Behind him, a few people is seen moving stuff around which contributes to the feeling of time passing inside the game world. The clothing (costumes) used by the characters on the screen looks worn, mix-matched, and old which hints to the fact that life in this world is not easy. Once the call ends a wall light next to the player turns on and a beep is heard coming from what looks like a makeshift door, the light acts as a visual cue while the beep acts a audio cue.



Figure 2.6: A collection of TVs acting as a communication hub.



Figure 2.7: The attention is drawn to the door using lights and audio. Note the red handlebar that also signifies the object is interactable.

Now that Level design and a state of the art has been looked at the group wants to take a close look at Virtual reality. This will mostly be in regards to the requirements that are recommended when working with virtual reality.

2.4 Virtual Reality

Virtual reality (VR) is perhaps in today's world considered an old technology since it has been around since the 1970s, but it is not many years ago that VR became popular and widely available to buy for the average person. This also sparked a flood of entertainment and content creation for VR devices, which has evolved the technology with which we experience these environments and entertainment.



Figure 2.8: This pictures shows a HTC vive, it is the same model as the VR headset one of the group members owns and will be used for development

2.4.1 Headsets and requirements

When working with VR, there are various ways to display the VR content to a user. The most widespread and popular way of interacting with VR is by using a VR headset. Therefore, this will be the area that will be explored for this project. A VR headset is required to test and develop, but not just any headset will do. When picking a VR headset some minimal requirements have to be fulfilled and some features have to be decided upon. For instance, should the VR headset come with speakers or headphones, and should it be wireless? In regards to the technical requirements for the headset, it should fulfill some minimal requirements to mimic the standards of normal human vision and perception. The reason for this is to minimize the possibility of making users feel sick, disoriented but also to increase immersion. The outline of these requirements has been tested and re-specified as the technology of VR has gotten better over the many years it has existed. In the book "understanding virtual reality" [5], some of the main and most important requirements are described. The book goes over the subjects such as Field of view (FOV), Field of regard (FOR), Latency, and frame/refresh rate.

The average horizontal field of view for the average person is around 200 degrees with an overlap of each eye accounting for approximately 120 degrees, but most VR headsets either have a divider or two separate screens. It is therefore recommended that the minimal field of view in a VR headset should be between 100 degrees and 120 degrees with at least 30 degrees overlap, or, use a single screen inside the VR headset.

Field of Regard (FOR) is the amount of space in the virtual world that is visible to the user at any time. This is important to consider as, if the FOR is too low, objects can get cut off and become either distorted or overlooked. On a typical flat-screen monitor, the FOR is typically lower than 100% which is not optimal for the VR experience, while in a head-mounted display with spacial movement possibilities

is it possible to look around an object and to look past an object and figure out what is behind it, by simply leaning over. The position of the user is therefore also important and should have some feature to track the size and scale of the person using the headset and translate it to a fitting size in VR.

In regards to latency in VR headsets, the goal is to lower the amount of time it takes to update each action to match what the user is seeing with what they are doing. This is to lower the possibility of making the user feel sick, disoriented, and generally confused and frustrated. Within the industry there is a standard of a maximum of 20ms latency.

In regard to frame rate and refresh rate, old animations used to be run in 24 fps and 24 Hz. But later with the modernisation of televisions, the standard was set to around 50-60 fps and Hz. This was found to make some feel nauseated when using head-mounted displays, which made for a new standard at 90 Hz. This is another way to lessen the amount of seasickness and discomfort of users using VR.

These are the overall minimal requirements for a head-mounted display, although when using VR it might be nice to have an environment to move around within. But typically the movement mechanics are related to the brand of head-mounted display and are most often controlled with a controller. Although, with some systems, it is possible to do full-body tracking, which can create a new level of complexity [5].

Now that the minimal requirements for running a good virtual reality experience have been looked at, the next chapter will seek to formulate an FPS and some design/technical requirements will be set up.

Chapter 3

Problem Formulation

In this section the analysis will be concluded and a final problem statement will be produced. This will be done by outlining what was learned in the analysis and how it has helped expand the IPS.

The IPS was: *"How can virtual reality utilize film theory to guide the user's attention in a cinematic experience?"*(section 1.1)

The first topic that was analysed was cues and more specifically audio and visual cues. In the cues section 2.1 gave insight into how cues are used in movies to guide a users attention and how different kinds of cues are used in different situations.

The second topic was attention, where different theories of attention was analyzed such as change blindness (CB) and inattentional blindness (IB), top-down and bottom-up and feature searching. These theories will be applied if appropriate along with the cues discussed previous section 2.2.

In the level design section 2.3, information about how to build an environment, that tells a story, was looked at. Furthermore, how cues can be used to guide a player and how they were used Half Life: Alyx, provided insight for design and implementation of cues.

In the virtual reality section 2.4, a look at the minimal requirements for a virtual reality headset was looked into. This makes the recommended specifications that the headsets should have in order to minimize bad experiences in virtual reality.

Finally, with this information in mind and with the knowledge gained from the analysis, a final problem statement is formulated below.

How can a cinematic VR experience utilising visual and audio cues guide the user's attention to specific elements in the scene?

3.1 Requirements

Based on the analysis the following design requirements were established.

- The VR Experience should draw the users attention to the interactable objects.
- The VR Headset should fulfill the given hardware specifications.
- The VR Experience should introduce an interactive object in each scene.
- The VR Experience should utilise film theory techniques to set the scene, in particular the lighting and audio.
- The VR Experience should provide visual, and audio cues to guide the user's attention.
- The VR Experience should be set in an environment that the user can relate to.

These requirements relate to the minimum requirements demanded from the VR headset that will be used to test and develop with.

- The VR Headset should have a refresh rate of at least 90 Hz(section 2.4).
- The field of view should be between 100 and 120 degrees with a 30 degree overlap(section 2.4).
- The response time should not exceed 20 ms (section 2.4).

Chapter 4

Methods

In this section, the group will go over the methods that will be used in this project in order to develop, test, and design the product. However, it should be noted that the final test was not performed, due to covid-19 restrictions.

Therefore some of the methods below describe which theories, the authors would have used, to analyse test data, had it been possible.

This study will explore how VR can guide a user's attention using audio and visual cues. The testing for this project will be between groups testing with four groups each testing a different version. The independent variable for these tests will be the time they spend between each section, how much time they spend looking at the object before interacting with them, and the time they spend before finishing the experience, while the dependent variable will be the version of the experience they are playing. The four versions are "baseline" (no cues), "No audio" (cues) "No visual" (cues) and "Both" (both cues) [6].

In order to design and implement the product, the agile method will be used along with within-group testing. This way of development focuses on efficiency by developing in short sprints and testing it out alongside. The idea is that mistakes can be corrected earlier and other issues that come up while designing can be addressed [6].

A usability test will be done in order to test if the mechanics are implemented and can be interacted with as intended before the final test. The test will use a Likert scale to indicate any issues or if the experience has been implemented correctly. In this project, the participants will be asked to rank their level of agreement with the statement they are asked from "1" to "7", where "1" is strongly disagree and "7" is strongly agree. Furthermore, the test will allow for test participants to speak

freely and ask any questions or add any remarks both while inside the experience or after [6] & [14].

In the final test, the data that will be collected will be analysed and interpreted using statistics and data analysis methods. Descriptive statistics will be used to quantify the data that will be collected. This data will be visualised using histograms, probability plots, and boxplots. In order to analyse the normal distribution of the data that will be collected, a Shapiro-Wilk test will be done. The Shapiro-Wilk test compares the scores in a data set with that of a normally distributed data set with the same standard deviation and mean. If this test is significant (i.e p-value > 5%) one can assume that the data is normally distributed, however, if the test score is insignificant (i.e p-value < 5%) the data can be assumed abnormally distributed [6]. Another test that will be done is a Levene's test for variance. The test compares the data to the mean and measures how far the collected data deviates from the mean. Depending on the type of data that is collected either a one-way ANOVA test will be done if the data is parametric or a Kruskal-Wallis test will be done if the data is non-parametric. These one-way tests are being performed to test the data for significance. Based on the results of the statistical analysis the hypothesis can either be rejected or approved.

Chapter 5

Design

In the following chapter an examination of how the established requirements will be designed and added into a VR experience will be looked at. The chapter will consist of three sub chapters, each sub chapter will discuss different aspects of the design for the virtual experience. In the first sub chapter, the initial design will be outlined. This is done in order to describe the initial concept for the final product. The second sub chapter will go over the cues and film theory that will be included in the virtual experience. The third sub chapter will look at the 3D models, textures and animations.

5.1 Initial Idea

The design of the experience will be based on findings from the analysis and will aim to fulfill the requirements, which are stated at the end of the analysis 3.1. The design will be based on theory but creative freedom based on these theories has also been taken into the design.

The initial idea for the design of the VR experience was decided upon partially from interests, but also with inspirations and knowledge from the analysis, mostly the analysis of Half Life: Alyx. The idea is that the audience is simulated to wake up in an unfamiliar place, in this case a science fiction/futuristic environment. The user should then find an *interactable* object in the initial scene that they are in, in order to progress the experience. These objects should be things like finding a hidden object, signing in at a hand print scanner or similar kinds of tasks. These objects should then in different testing scenarios be given audio and visual cues that are meant to guide the users attention to that object.

Layout of Scenes

This section will outline the design of the virtual space that will act as a collection of scenes. There will be 5 scenes in total, four of which include interactable objects that will be used to progress the story.

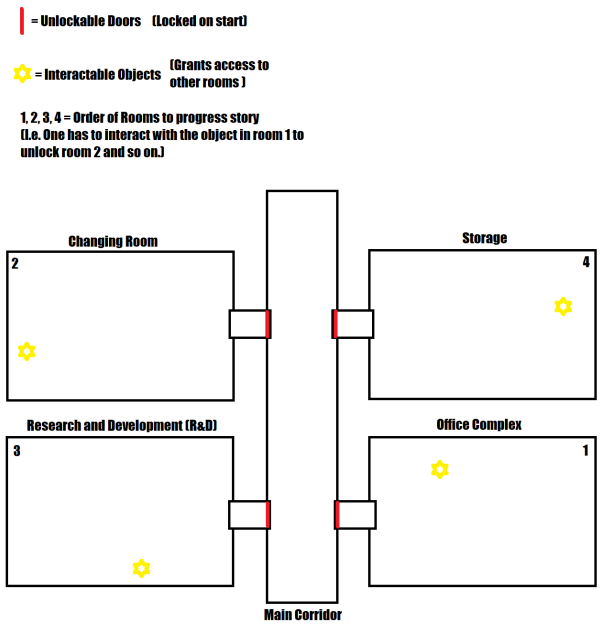

Figure 5.1: The Layout of Scenes

As per the layout above there will be four scenes, the Office Complex, the Changing Room, the Research and Development (R&D) and the Storage.

The Office Complex will be the first scene the audience encounters. They start the experience next to their bed and have to interact with a laptop to get access to the Changing Room scene. The audience will then move through the Main Corridor to the only other open room at this point, the Changing Room. Inside here, the audience will have to interact with a dresser in order to progress and unlock the next scene, Research and Development. The audience once again moves through the main corridor to R&D. Using the face-scanner in this room will allow access to the last scene in the experience, the Storage. Inside this room, interacting with the hand-scanner will end the experience.

5.2 Design of Cues and Film Theory

This section will concern itself with the design of audio and visual cues implemented into the VR experience. These cues are largely based on mise-en-scène theory described in the analysis 2.1.

5.2.1 Audio Cues

When designing the audio cues for this experience some objects had to be picked in order to design the kind of audio that would be played from each object. In each scene of the VR experience, an object would be placed that blended into the room that could be interacted with. These objects, when interacted with, unlock the next room so the participant can proceed, as mentioned as one of the requirements 3.1.

The objects that were decided upon, were picked because they fit the theme of the space station environment and would encourage interaction. The objects are, a laptop computer, an eye/iris/face-scanner, a hand/hand-print scanner ,and a dresser. as mentioned in the requirements 3.1.

For each of these interactable objects, the audio cue from the objects should be believable and natural so that the user knows that the audio could have come from the interactable object.

The first object, the computer, the audio cue that was chosen was "computer noises" that would otherwise not be present in the scene. The computer inside the Office Complex should make both fan noises and a slowly repeating beep sound. The cues should also function according to the elements that were discussed in the cues section in the analysis 2.1.1, where when the user gets closer to the computer the sound should increase in loudness, but not in pitch or timbre. Furthermore, the tempo should also not be increased.

For the second interactable object, the dresser, in the Changing Room scene, several variations of sound were explored. The sound of opening a metal door was initially used as the audio cue for the dresser. However, this turned out to be more confusing than helpful so another looping beep with a slightly different pitch and timbre was used.

The third object, the face-scanner, in the Research and Development scene, and the fourth object, the hand-scanner, in the Storage use similar audio cues as those before it. Using similar audio cues creates a sense of continuity for the audience and should also facilitate learnability and memorability [1]

The soundscape outside of the audio cues is made up of ambient sounds, such as

[1] Link to the audio cue: `https://soundcloud.com/irvinejump/robot-blip-marianne-gagnon`

the sound of wind passing by the outside of the facility, and a somewhat suspenseful track consisting of low-pitched rumbles and tones. Furthermore, the doors make a hydraulic sound whenever they are activated and opened 2.1.1.

5.2.2 Visual Cues & Mise-en-scène

The Office Complex scene

The Office Complex is the first scene of the VR experience and it, therefore, sets the tone for the rest of the experience. When designing the scene, it was important to incorporate props that are familiar to the audience in order for them to relate to the scenery and the experience. It was therefore chosen that the scene should be populated by desks, chairs, laptops, beds, nightstands, and more. The interactable object in this scene, the laptop computer, is placed near the starting point of the experience to help the audience get the experience started without too much trouble. The lighting in this room consists of point lights placed in the ceiling and lamps and spot lights used in desk lamps. The lighting is mostly focused around the starting area and is used to create shadows around the scene. The colour design inside this room is simplistic, mostly grey except for the interactable object, some books, tables, and art. The interactable objects in all of the scenes use colour and motion to draw attention as described in the analysis 2.2.

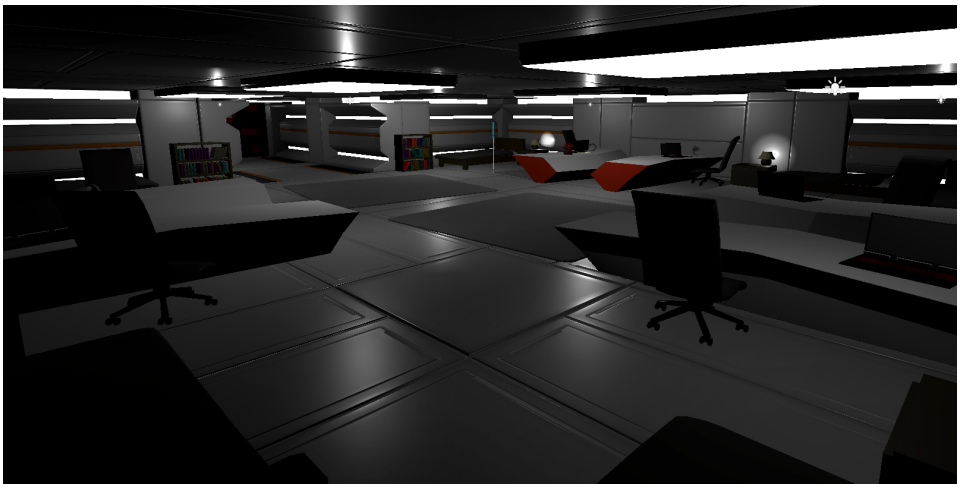

Figure 5.2: The Office Complex scene

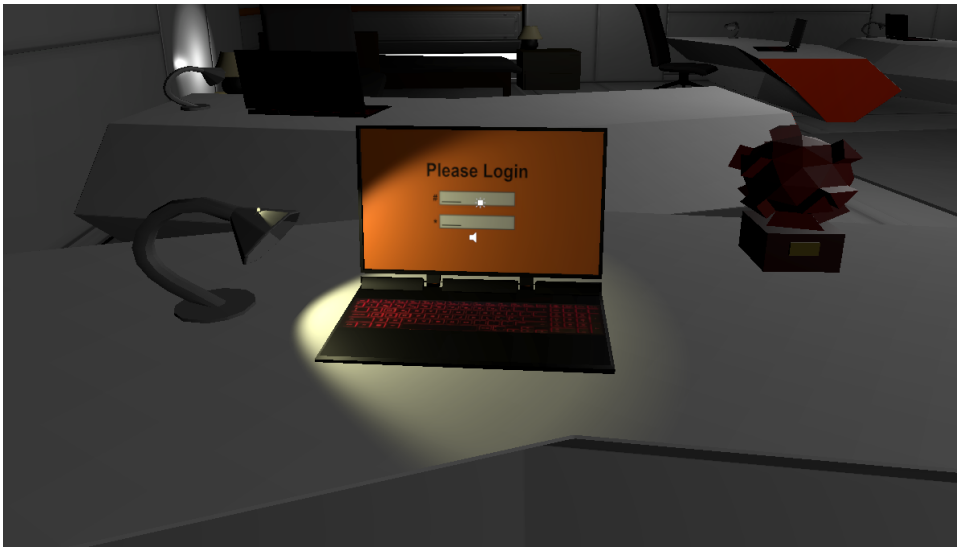

Figure 5.3: The interactable laptop computer

The Main Corridor scene

The Main Corridor is the second scene the audience will find themselves in after unlocking the door by interacting with the laptop in the Office Complex. This scene is sparsely populated in regards to props and only has a bench, some cupboards, and boxes. This is done in order to show the audience that the corridor mainly functions as a hub between different scenes and should not necessarily encourage interaction. The corridor is lit by a row of point lights varying in luminescence, with those furthest away being the dimmest, in order to create a darkened end of the corridor representing the limits of the scene.

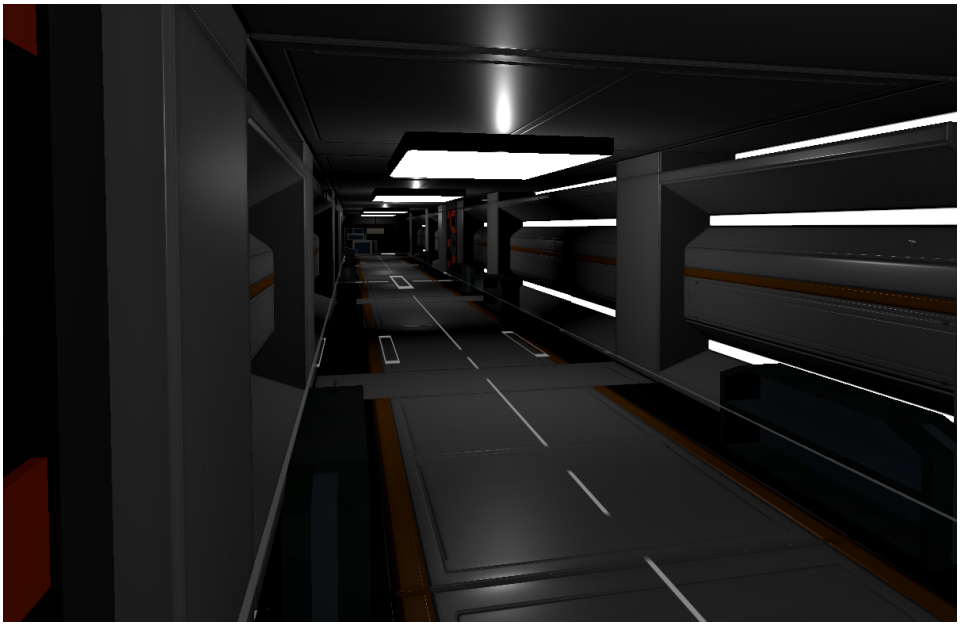

Figure 5.4: The Main Corridor scene

The Changing Room scene

The Changing Room scene is split into two sections by a dividing wall. This is done in order to present the audience with a choice and increase the opportunity for exploration. The Changing Room is populated with various props such as art, plants, sofas, tables, and the dressers, one of which acts as the interactable object. The dressers have lamps attached to the top of them that either has a solid green colour or a slowly pulsating red lamp. Green is supposed to represent that no action is needed, while red is supposed to represent interactability and draw the attention of the audience. The room is dimly lit by point lights placed in the ceiling.

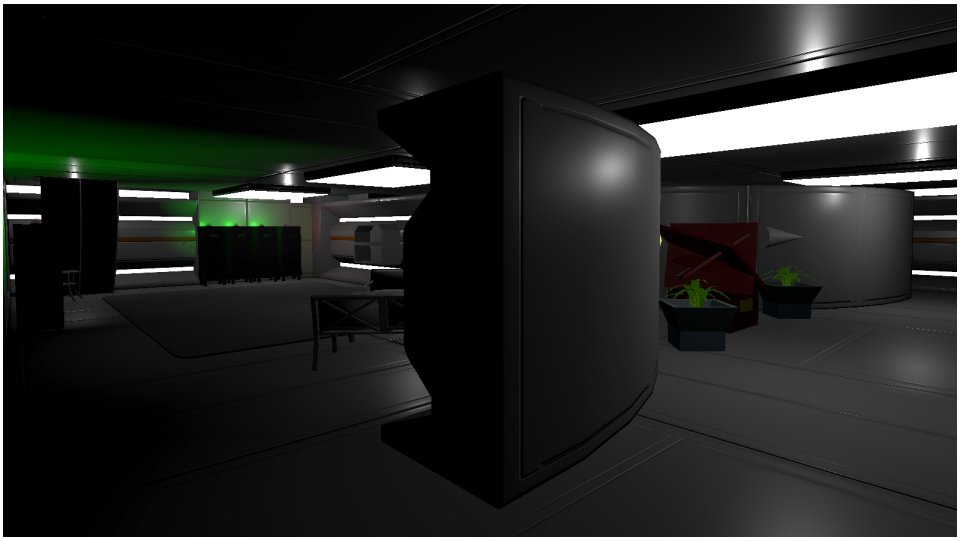

Figure 5.5: The Changing Room scene

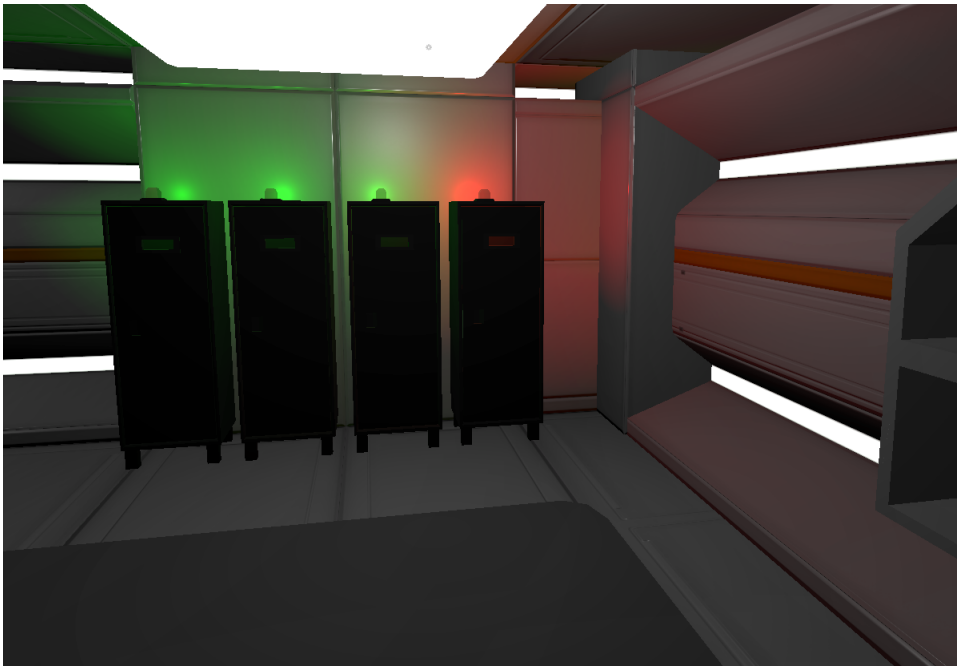

Figure 5.6: The interactable dresser

The Research & Development scene

The R&D scene is well-populated with props such as experiments, glass walls, stairs, desks, art, plants, the interactable objects which in this scene are the face-

scanners. The scene is the most colourful of the scenes and should encourage exploration and act as storytelling elements, however, without any narration or specific story laid out for the audience. The interactable objects has two spotlights each pointed towards the 'eyes' in order for them to light up, see figure 5.8. Another spotlight is added for colour control, again using red to indicate that an action is needed and then green to show that the task has been completed. The scene is lit mainly by point lights in the ceiling which are also used to create shadows around the room, but the scene also includes spotlights on the stairs and underneath desks.

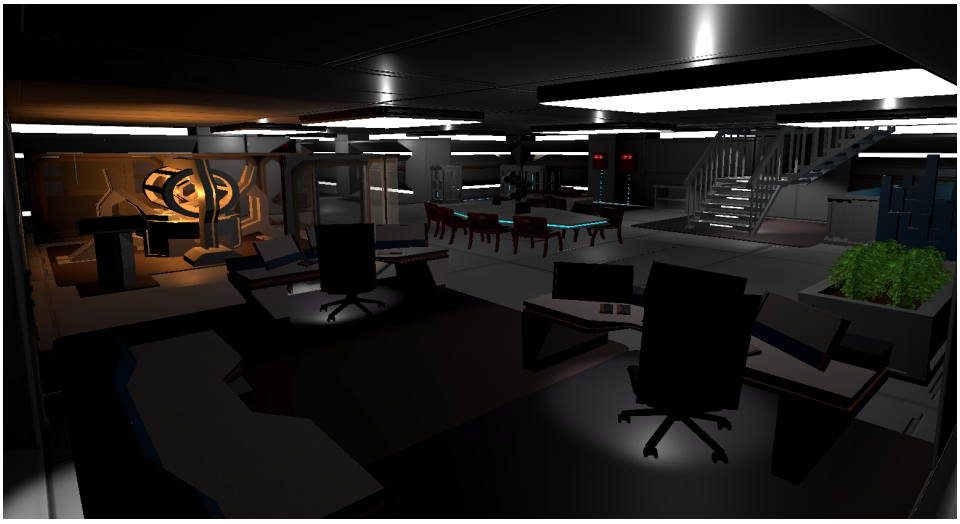

Figure 5.7: The Research and Development scene

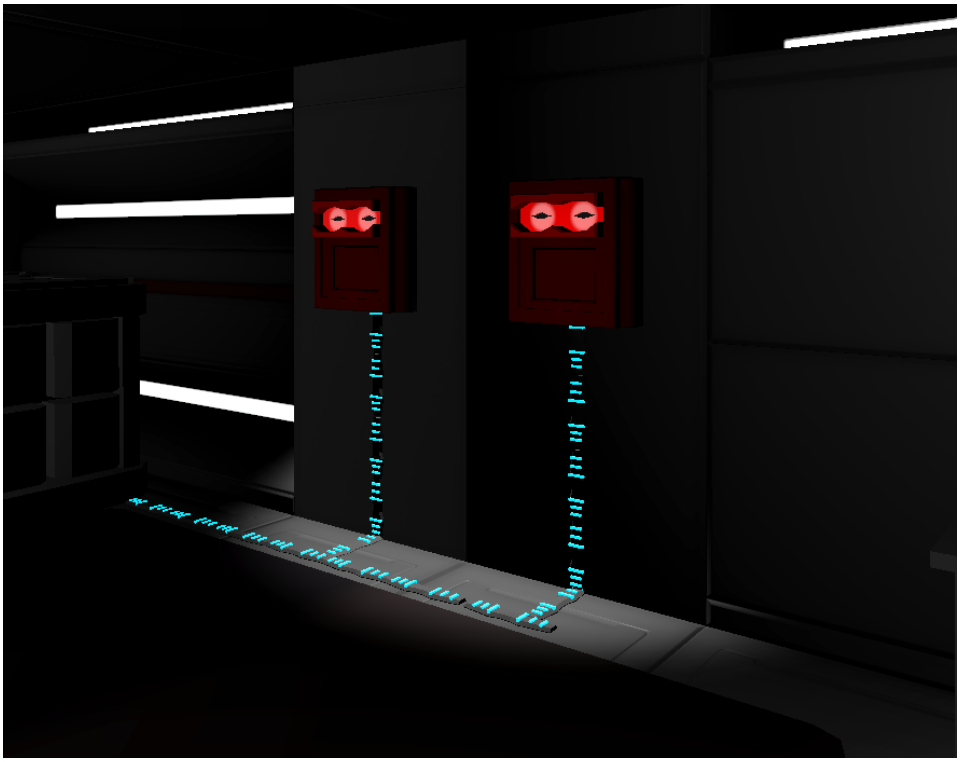

Figure 5.8: The interactable face-scanners

The Storage scene

The final scene, Storage, is accessed by interacting with the face-scanner and moving through the main corridor to the Storage scene. The lighting changes dramatically in the Storage scene where blue/cold light is used to highlight shadows and create an environment that has less visibility than the previous scenes. Point lights are once again used in the ceiling and a few spotlights have been added, one flickering above the final interactable object, the hand-scanner, and one behind a spare door creating shadows along the floor. The scene is full of props such as batteries, boxes, spare building material, and more. The hand-scanner uses the same red-green colour cues to represent interactability.

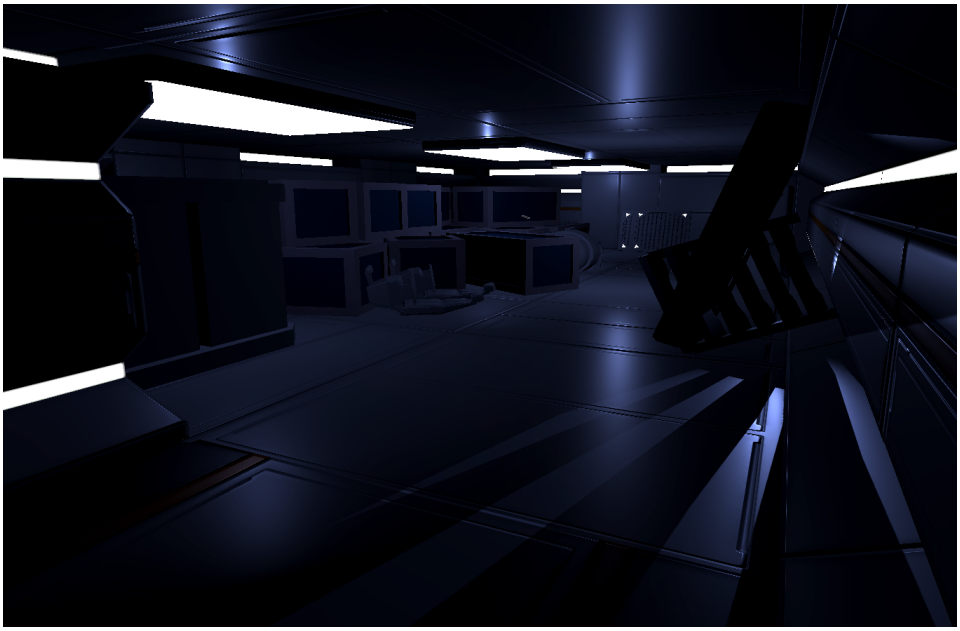

Figure 5.9: The Storage scene

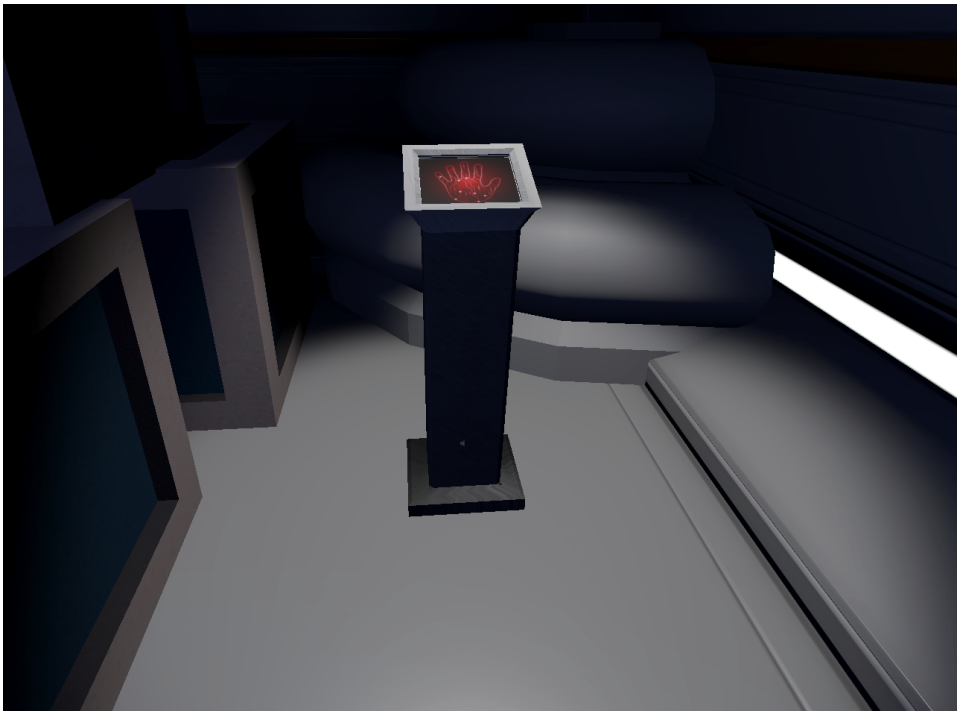

Figure 5.10: The interactable hand-scanner

5.3 Design of 3D models

5.3.1 3D models

For the first iteration design, the experience should contain low-poly models that are simplistic and should be easily recognized by the audience. These models will be everyday furniture that is common for the audience since they should recognize where they are. These models will be the following objects:

- A bed
- A table
- A shelf
- An office chair
- A laptop
- A bedtable
- A door
- A dresser
- An eye scanner
- A face scanner
- And several lamps and books

Since they are low-poly count models, they should be less time-consuming to make while still being able to look somewhat realistic, which is one of the requirements 3.1. This was also done for the group members so that they could re-learn the 3D editing software Autodesk Maya, since they were using it in another course for this semester. The final design will contain the same furniture, but with a higher polycount and more realistic look to them and will come from either a website or the asset store in Unity. Since the group did not feel confident to make models in such high quality with limited time, the downloaded models will replace the created object for that purpose alone. A comparison from the preference to a 3D model can be seen in figure 5.11.



Figure 5.11: Comparison from real life object to 3D model

Animation

Some of the before mentioned models will contain animations. This is being done to build the mise-en-scène for the environment. The objects that will receive animation will be the dresser, the door, and a spot light. The dresser should open its door when it is being interacted with, just like in real life and the same goes for the corridor door. The spot light animation is going to a flickering light, since the group felt an animation like that could help with the visual cues, just like the other animations. The point light with flickering should help the participant to locate the desired object to interact with.

5.3.2 Interacting with the objects

In this experience, the group wants the users to interact with certain objects that they are guided to. Since the HTC Vive was chosen as the VR headset that would be used for development 2.4, and it has a pair of controller that comes along with it, these controllers in VR, works as hands for the user, This can be utilized as the object that interacts with the desired objects. By doing so, the user could be more immersed in the experience. Since the controllers are being used, the headset itself could be tracked as well for the eye scanner model.

Chapter 6

Implementation

In this chapter, the implementation of the VR experience will be explained with images and screenshot from the different applications that was used to develop this experience. It will be split into two section that will explain 3D modeling and code respectively with the focus on completing the requirements that was set in section 3.1.

6.1 3D modeling in Autodesk Maya

In this section, the group will cover how the object went from the idea that was mentioned in the design section 5.3 to a 3D object in the Unity scene for the user to see or interact with. This will cover the modeling onto texturing and lastly, placing the object into the scene.

The furniture that was placed in the scene was inspired by the furniture of the group members own houses. There was made a list of items that should be modeled for each scene. From here, the group members would would either take picture of the furniture or bring it with them to the computer for reference.

When building in a 3D space, objects can be shown by casting light on the object. This creates shadows which are cast from the object. A program that can show sculpting and edit a 3D object is called Maya from Autodesk. In Maya, when an object or mesh is constructed, several new items are made for a given mesh. These items are vertex, edge and face and they control how the object is being presented in Maya [13]. A vertex is the corner where two lines meet and this corner can be seen as a point the 3D space that can be moved in any directions. An example of a vertex for an object can be seen in figure 6.1.

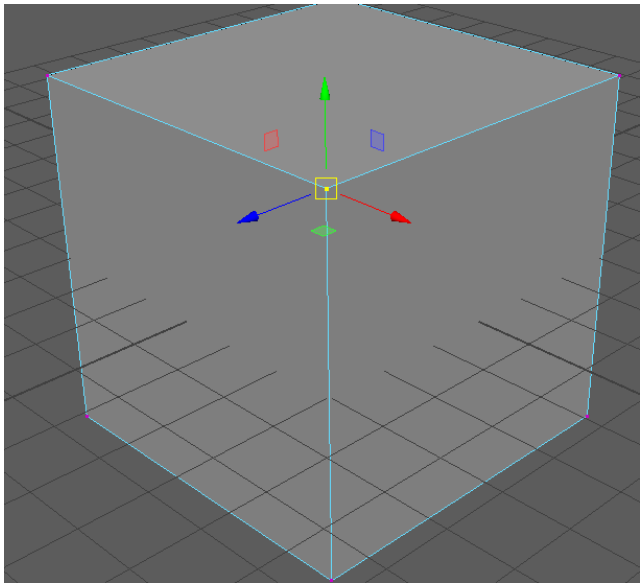

Figure 6.1: Highlighted vertex on the cube

Edges are the connection between two vertices and can be viewed as a line. When moving an edge, the vertices that makes the line, moves as well and can be rotated. An example of an edge for an object can be seen in figure 6.2.

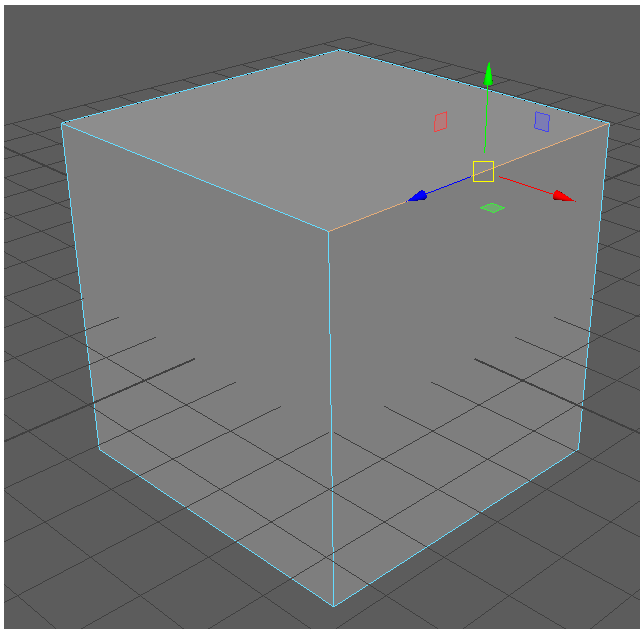

Figure 6.2: Highlighted edge on the cube

Lastly, the face is when three or four vertices are connected, they can display a surface like a plane. These faces can be moved, scaled and rotated in the 3D space. An example of a face can be seen in figure 6.3.

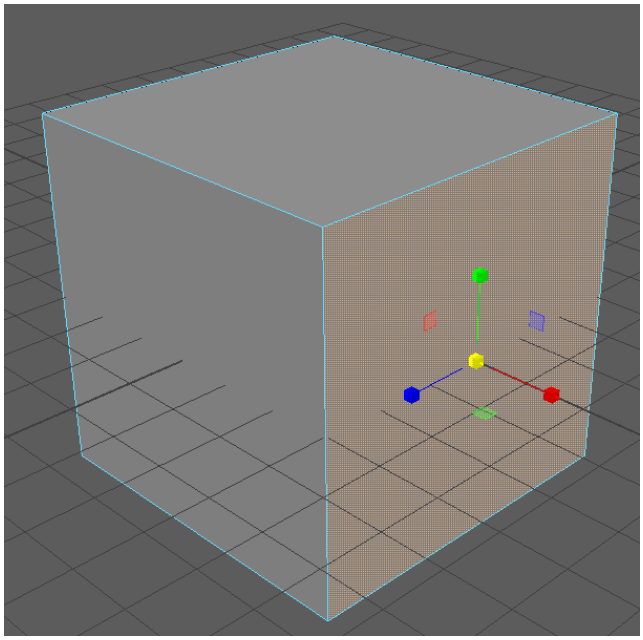

Figure 6.3: Highlighted face on the cube

Once the mesh has been extruded, beveled and smoothed into the object that is desired, the mesh can then be painted and get a skeleton applied.

6.1.1 Shading an object

When the mesh is shaped, it is time to colour the mesh, so it can look more like the given object. This is called shading and is a overlay of the faces from the object. When apply any effect like a texture or colouring, it will become a shader. These shaders can be used on any object, but it can depend on how the overlay is setup. A shader can contain information like, what colour object should be coloured and what texture should be applied. The way of applying a shader to a object is by cutting the 3D object into a 2D image. This can be seen in figure 6.4, where the cube on the right has be folded out to the t-shape on the left side.

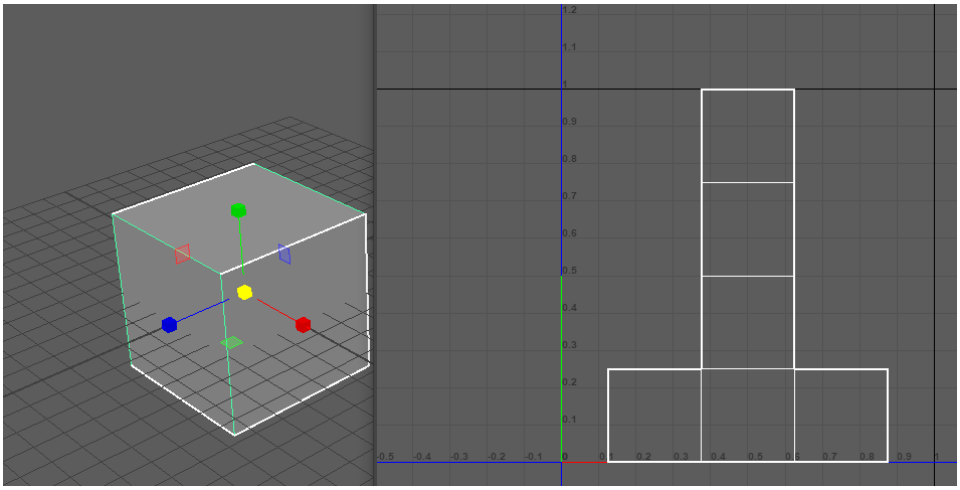

Figure 6.4: 3D object into 2D image

The T-shape can be edited in an image editing program for additional colouring or texturing within the white line, where each square represents one of the sides of the object. The choice of material can be worked on and generally, there are three materials that are being used in Maya. These are as following:

- Lambert
- Blinn
- Phong

These three materials are used in addition with the texture to give extra effect for the texture. For instance the Lambert material gives the texture a matte surface that has less reflection [11]. This is the standard material in Maya and normally used for objects that has no reflection like a tree or a very matte cube as can be seeing in figure 6.5.

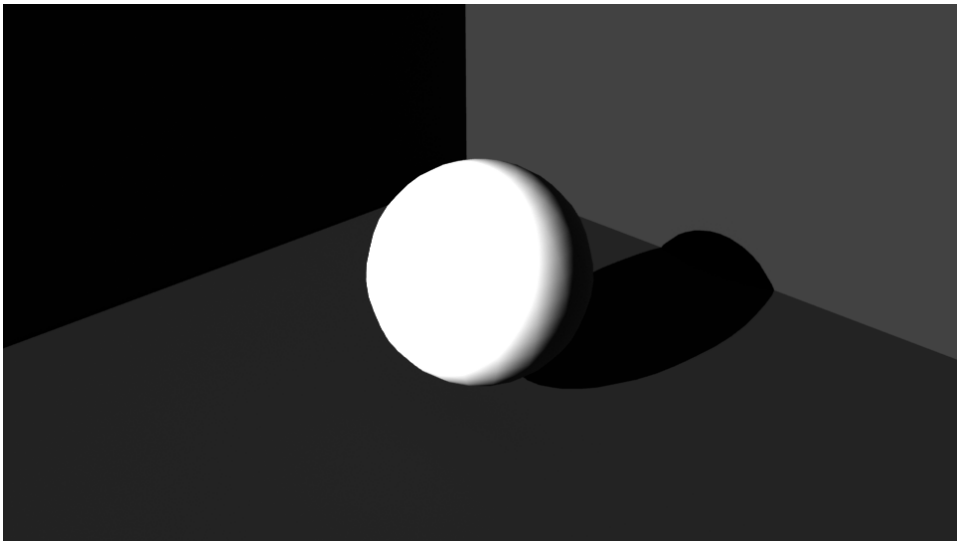

Figure 6.5: sphere with Lambert material in Autodesk Maya

Blinn and Phong are very similar since they both have specular and reflection attributes in them, but the way they reflect is different [12] & [10]. The Blinn material is normally used for metallic surfaces that has a soft specular highlight, so items like copper and aluminum would use this material [10]. An example of Blinn can be seen in figure 6.6

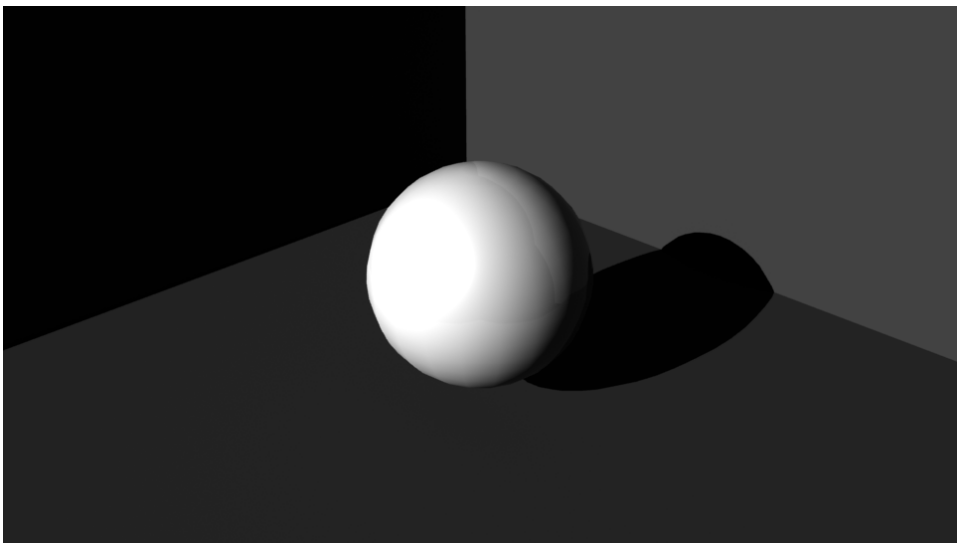

Figure 6.6: sphere with Blinn material in Autodesk Maya

The Phong on the other hand has a more hard specular highlight, which can result

in the object having a more glassy or glossy surface [12]. This can seen on 3D models of cars or telephones, since their surface is very reflected and this can be seen in the figure 6.7

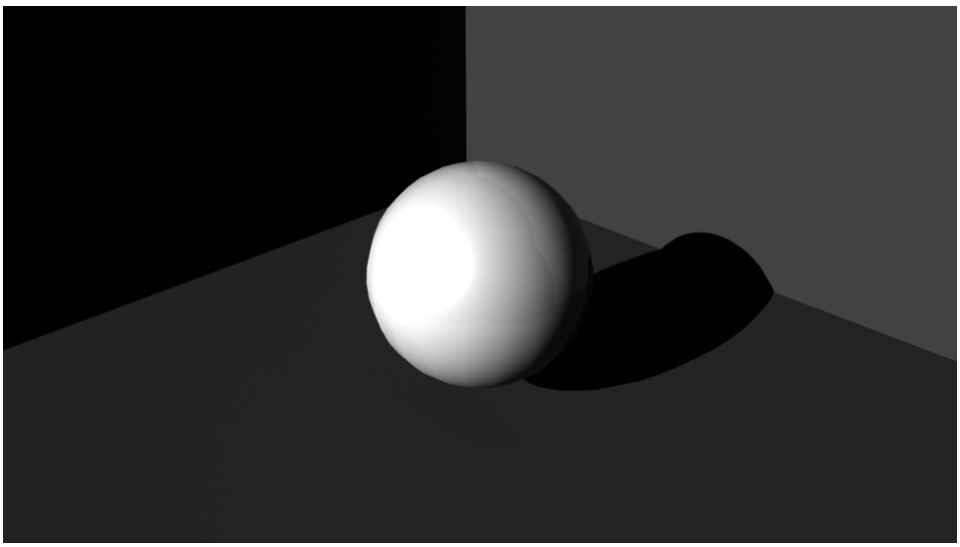

Figure 6.7: sphere with Phong material in Autodesk Maya

Once the texture of the object resembles closely to the real life counterpart, it can be animated with a skeleton if the object is supposed to move.

6.1.2 Animations for models

As mentioned in the design section 5.3, there will be a corridor door, a dresser and a point light as the interactable objects. They should contain an animation, which can be triggered upon interaction. The corridor door and dresser's animation was made in Unity using its animation system as can be seen in figure 6.8. Both of the object require an idle animation for when it not being interacted with and opening animation when interacted with.

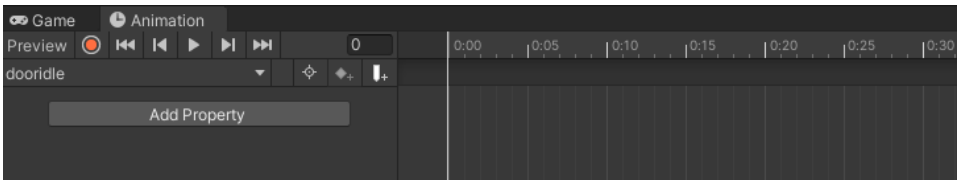

Figure 6.8: Unity's animation timeline

When animating the object, it is possible to access each component and animate a part of given component. The door and dresser's idle animation is simple, since

their position do not change over time. The door's opening animation changes its y-position over time, since it goes from the starting position upwards until it is not visible anymore. The dresser is more tricky, since the door of the dresser needs to move its position and rotate around the hinges. This would require to change the door of the dresser's position and rotation. The last animation is the flickering of the spot light. This is a bit more tricky to make, since it needs randomise the animation. Instead of animation, this was coded. In the script called "flickingLight", there is a start function and an IEnumerator function called "flickering". The start function, a variable called "lightSource", receives the light compontent of the game object and followes by starting a coroutine of the "flickering" function as seen in figure 6.9.

```
8       Light lightSource;
9       public AudioSource flickingLightSound;
10      public float minWaitTime, maxWaitTime;
        Unity Message | 0 references
11      void Start()
12      {
13          lightSource = GetComponent<Light>();
14          StartCoroutine(flickering());
15      }
16
        1 reference
17      IEnumerator flickering()
18      {
19          while(true)
20          {
21              yield return new WaitForSeconds(Random.Range(minWaitTime, maxWaitTime));
22              lightSource.enabled = !lightSource.enabled;
23              flickingLightSound.Play(0);
24          }
25      }
```

Figure 6.9: Flickering light script

In the "flickering" function, there is a while loop that consists of a "WaitForSeconds" function that has a random range between two variables. It is followed by the light being disabled and playing a audioclip that matches a flickering sound of light.

6.1.3 Additional models

As mention in the design section 5.3, the group will find high quality models from another place to either replace the model that was made or find new ones to fill out the scene. It was decided to keep the models that was made and find additional model to create the mise-en-scène in the scene. For the walls, ceiling and such to create the room space, came from Creepy Cat and is called 3D Scifi Kit Starter Kit [3]. The extra object in each of the room is created by karboosx and the asset is called Sci-Fi Styled Modular Pack [7]. Both of these assets can be found online in Unity Asset Store or package manager in Unity program and both of them are free.

Links to both of them can be found in the foot note [1] & [2].

6.2 Code in Unity

In this section, a description of the general programming for the experience itself, and the controller for the events the participants will interact with, will be done. This will introduce the order the program was made in, the problems encountered and how they were solved in order to achieve the desired experience.

6.2.1 Movement in VR

Movement in VR can be difficult to implement without making the participant motion sick. Especially because it was the first time the group had worked with VR, the group did not feel confident in making that. Instead the group used "OpenVR" asset which works with "SteamVR" and the VR headset, HTC vive [4]. This asset includes, multiple scripts for interaction of the buttons on the controllers, movement of the player and physics for player and objects.

6.2.2 Doors

In the experience, there are doors that are closed until the participant have interacted with a given object. This means that a trigger is made for each of the interactive objects that actives the door to proceed next area. For this, a door checker script was made that would check which door was open and which door should be the next to open. To begin with in the "doorChecker" script, an array of gameobjects is made, to store the doors and another boolean array of same length for checking if the participant has activated one or more of the doors.

```
13      public bool[] doorOpen;
14
15      public GameObject[] doors = new GameObject[4];
```

Figure 6.10: Beginning of doorChecker.cs where the two arrays are made

The boolean array is used as a check for the participants progress in this experience. In the update function, there is an if statement for each of the entries in the boolean array. Each of these if statements check on each frame whether or not one of the entries have become true.

[1] https://assetstore.unity.com/packages/3d/environments/sci-fi/sci-fi-styled-modular-pack-82913

[2] https://assetstore.unity.com/packages/3d/environments/3d-scifi-kit-starter-kit-92152

```
141     if (doorOpen[1])
142     {
143         teleportplanes[3].SetActive(true);
144
145         doors[1].GetComponent<Renderer>().materials[3].color = doorlight[0];
146         doors[1].GetComponent<Renderer>().materials[4].color = doorlight[0];
147         doors[1].GetComponent<Animator>().SetBool("opening", true);
148           dresserAnimator.SetBool("opening",true);
149
150         if (!noLight)
151         {
152             lightForObject[2].SetActive(true);
153             lightForObject[1].GetComponent<Animator>().SetBool("triggered", true);
154
155             for (int i = 4; i < lightForObject.Length; i++)
156             {
157                 lightForObject[i].SetActive(true);
158             }
159         }
160
161     }
```

Figure 6.11: one of the if statement from doorChecker.cs

If one of them has turned true, then the next area is available for the player to move to and it will play an animation of the door opening. The animation will be called through the animator component on the door when a boolean for the animator is triggered. This was done, since it was easy to animate the doors going up in the y-direction instead of coding it from scratch and making a more smooth animation. It can be change to make the animation more smooth or alive instead of being static. Additionally, on the door there is a red spot in the middle of them that will change to green. This happens when the participant has interacted with an object that has a trigger script attached to it.

6.2.3 Interactive objects

The objects that the participants has to interact with, is highlighted by a light cue and sound cue. The light is an external spotlight that can be turned on and off depending on how far the participant has gotten in the experience. The object itself has an audio component that has a spatial attribute attached to it that plays the sound in a 3D environment. This will help to indicate the participant with what object they should interact with. Once they are close to the object, they should be able to either use their hand or head depending on the given object. To check if the participant is interacting with an object, the objects has a collider attached to it. This collider triggers a script that checks if the object collider is being hit by something. In the "triggerScript.cs" that is attached to the intractable object is using a function called "onTriggerEnter". In that function, a check happens when something is entering the collider of the object. When something enters, it will check whether the object's tag is named "rightHand" or "head", the name of the object with the script attached and if a given door is still not open. If all of these

three statements are true, then multiple action will happen. When it happens, a boolean entry from the array is set to true. This is followed by muting the object that was interacted with and unmuting the next object while playing the audio from the door. lastly, a boolean from other script is being set to true and that script is called "trackingFromHeadset.cs".

6.2.4 Timer

The group wanted to see the total time the participants spent inside the experience and to see how long they looked at the interact-able objects while tracking the time they spent to complete each area. The first goal is to track the total time the participants spent in this experience and this is done in the "trackingFromHeadset" script. In its update function, a float variable called "totalTimeSpent" is being updated by using the "Time.deltaTime" function. The "Time.deltaTime" tells the amount of time that has past between frames in seconds, and "totalTimeSpent" will keep updating until the next scene is loaded.

The next part will be to check whether they are looking at the interactable objects and for how long. Once more, the "Time.deltaTime" function is excellent at tracking the time for each of the objects, but the problem is the tracking of where they participants are looking at part. A solution for this problem can be handled by using ray casting from the VR headset. Ray casting means that there is an invisible line drawn from the chosen object and this line is being cast in the given direction. By doing this, it is possible to check where the object is facing. In this case, the object is the VR headset in the unity scene and the direction is forward or in the z-direction as seen in figure 6.12 on line 49.

```
49          Ray ray =  new Ray(main.transform.position,main.transform.forward);
50          RaycastHit hit;
51
52          if (Physics.Raycast(ray,out hit))
53          {
54              Transform selection = hit.transform;
55              if (selection.CompareTag(tagLookingFor))
56              {
57                  for (int i = 0; i < interactiveObjects.Length; i++)
58                  {
59                      if (selection.name == interactiveObjects[i].name)
60                      {
61                          lookTimeForObject[i] += Time.deltaTime;
62                      }
63                  }
64              }
65          }
66
67      }
68
```

Figure 6.12: raycasting from trackingFromHeadset.cs

This is followed by an if statement that checks if the ray being cast is hitting something. If it does, a new if statement compares the tag of the object that was hit by the ray to an array that has the interactable objects stored. if that statement is also true, it will store the amount of time in an float array that has a matching index as the object array.

Lastly, there is the interval timer between each object. This should be seen as a lap time from a racetrack, where each lap has their own time which is a part of the total time.

In the update function of "trackingFromHeadset", there is a for loop that updates a float array called "intervalTimer" that has same length as the object array mentioned before. As long as one of the entries from an boolean array called "triggerForIntervalTime" is false, the "intervalTimer" entries will be updated to match the total time. Each of the entries form "triggerForIntervalTime" will become true when the participant has interacted with one of the matching object 6.13.

```
35      for (int i = 0; i < triggersForIntervalTime.Length; i++)
36      {
37          if (!triggersForIntervalTime[i])
38          {
39              intervalTimer[i] = totalTimeSpent;
40          }
41      }
42
```

Figure 6.13: interval timer from trackingFromHeadset.cs

This gives the group a timestamp for how long a participant has spent in each area. This data needs a way to print, so the group can easily write down the result and let the computer do the work.

6.2.5 Data from the participant

The last thing that needs to be done, is to save all of these different times that was gather though the participants' experience. This data can be saved in a text file, so the group can access it easily. In the "trackingFromHeadset" script, there is a function called "wroteFile" will take the data and save it in a text file.

In the beginning the "writeFile" function, a path is being set to where the text file should be created. This is followed by an if statement, that check if there is a text file with a certain name. If that statement is false, then it will create a file with the name "/TestData.txt" as can be seen in figure 6.14.

```
69      void writeFile()
70      {
71          string path = Application.dataPath + "/TestData.txt";
72          if (!File.Exists(path))
73          {
74              File.WriteAllText(path,"DataSet from Test \n\n");
75          }
```

Figure 6.14: Beginning of "Writefile" function fromtrackingFromHeadset.cs

This is followed by writing the total time in the given file with the amount of time they have looked at the objects and the interval time between each area along with text that describes the time. This data can now be used by the group to make an experiment.

Chapter 7

Evaluation

In this chapter, two tests will be outlined, but only one was performed, the usability test. The test results for this test will also be noted in this section. Both tests will state the goal of the test, the setup, procedure but only the usability test will have real results. The final test will have fabricated results as it was not performed due to Covid-19 restrictions.

7.1 Usability test

The goal of the usability test is to test the technical functionality of the objects and interactions inside the experience. Furthermore, the participants will be asked about the look and feel of the game.

Participants

For this test, the test participants will be other students at AAU CPH. This was decided upon due to convenience but also because most people do not own a VR headset, so this way the group can provide the VR headset for testing. Furthermore, Covid-19 has made it difficult to test on the general public. The goal for the usability test is to receive between 6-10 participants, this is due to the fact that it is difficult to find participants and we want to save as many as possible for the final test.

Setup

The test will take place at AAU CPH Campus in the 5th-semester group rooms, where one of the members in the group owns a VR kit, which will be used. The space where the tables and chairs used to be will be cleared so that the sensors can

be set up and the space can be calibrated. Due to covid-19, the group will have to (to the extent that is possible) clean the headset and controller in-between each test and ask the test participants to wear masks. The version the participants will be testing uses both cues (audio and visual).

Procedure

When a test participant arrives for testing, they will initially be asked to wear a mask, use the hand-sanitiser and sign a consent form. Then the test participants will be asked to try the experience. After the participant has tried the experience, which should take about 10-15 minutes, they will then be asked to fill out a questionnaire. In total each test should take 15 minutes for setup, questionnaire, and experience.

The questions that will be asked in the first section will relate to the experience and are used for the group to see if the participants paid attention to the experience. The questions include "In your own words what did you just experience?", "How many objects did you feel you could interact with? and what were they?" and the final question the participants could fill in any additional remarks or comments they may have had.

In the second section, the participants will be asked to fill out a Likert scale. The Likert scale consists of eight statements, that the participants have to rate how much they agree with on a scale from 1 (completely disagree) to 7 (completely agree)(section 4).

7.1.1 Usability test results

The test began on December 7th, 2020 at around 13:00 and ended at 16:30. A total of 9 participants tested and responded to the questionnaire. The full results can be found in the second appendix under "Usability test results"

The first question the participants were asked was "In your own words what did you just experience?". Here the participants most popularly responded that they thought it was a sort of "puzzle", "maze" or "escape room". One participant further stated, "An interactive VR world, with obstacles and a storyline that is player-driven.". Overall the feedback from this question can be seen as positive as the intended feel of the experience was accomplished.

The second question that was posed to the participants was "How many objects did you feel you could interact with? and what were they?". To this question, the participants would respond with some variety, but most participants responded correctly with, "4". A participant brought up a concern that had been verbally brought up by other participants and wrote "I didn’t feel like i could truly interact

with any of the elements", this was due to the fact that in this version of the experience the user just had to be close enough to the object to activate it. This will be iterated in the next version. Other than that concern, the participants seemed to notice the number of objects that they had interacted with.

The final question the participants were asked before the Likert scale was "Do you have any additional comments, remarks, or suggestions?". To this question, the participants responded with some of the issues they had encountered. These issues were linked to the participants not know that they had finished an area and that the interaction could be more active instead of just moving up to the object.

In the second part of the questionnaire, a Likert scale was made up of eight statements which the participants had been asked to rank in order of how much they agreed with the statement. 1 is "Completely disagree" and 7 is "Completely Agree". Now a closer look at the responses. To see all the results check the second appendix under "Usability test results" 10.1.

The first likert item in the likert scale was the statement "The objects were easy to interact with"

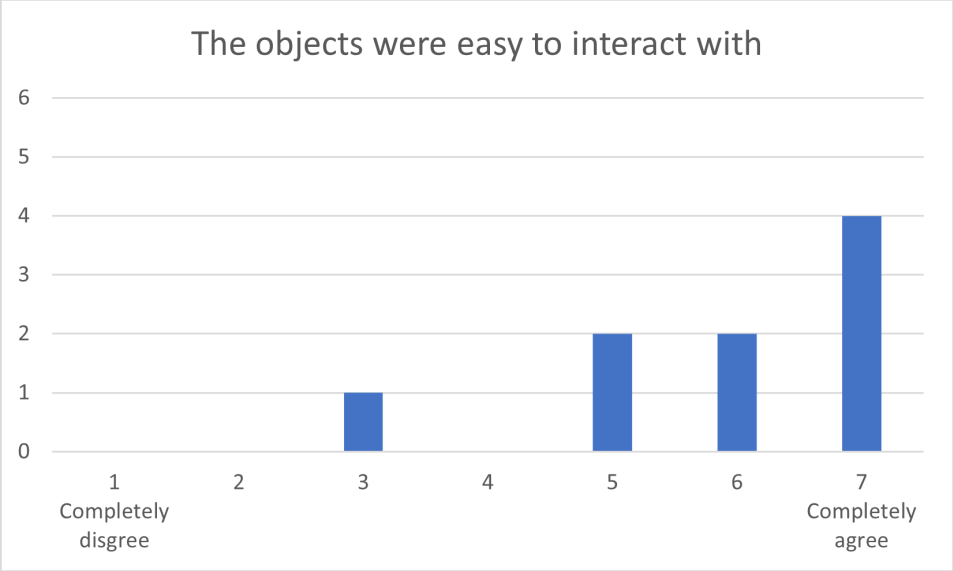

Figure 7.1: The graph above shows how the participants responded to the statement "The objects were easy to interact with". Where 1 is "Completely disagree and 7 is "Completely agree"

The participants responded in a mostly positive way indicating that the objects were easy to interact with, but in the next statement when the participants were asked how much they agreed with the statement, "It was difficult to figure out which objects I could interact with". A majority of the responses were in the lower

half. This indicates that it was difficult to identify the objects that could be interacted with, but that when they were found it was easy to interact with them 7.2.

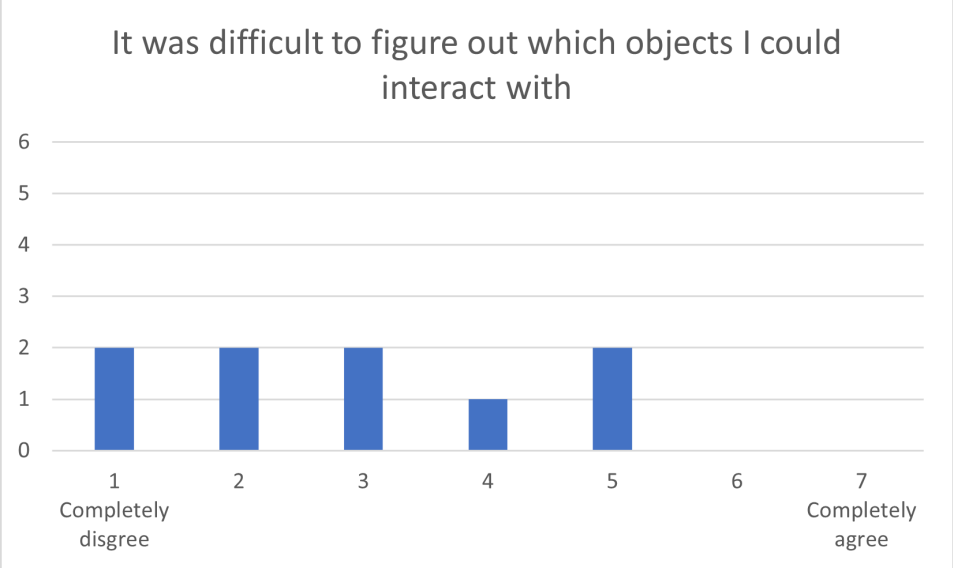

Figure 7.2: The graph above shows how the participants responded to the statement "It was difficult to figure out which objects I could interact with". Where 1 is "Completely disagree and 7 is "Completely agree"

Furthermore, in the fourth statement where participants were asked to rate how much they agreed with the statement "I found the experience difficult to complete" Participants seemingly found the experience easy to complete. Although, there were one participant that tended to agree that it was difficult to complete 7.3. that one participant responded that "It was a little confusing to figure out where I should go." but followed up by saying "But very good use of sound".

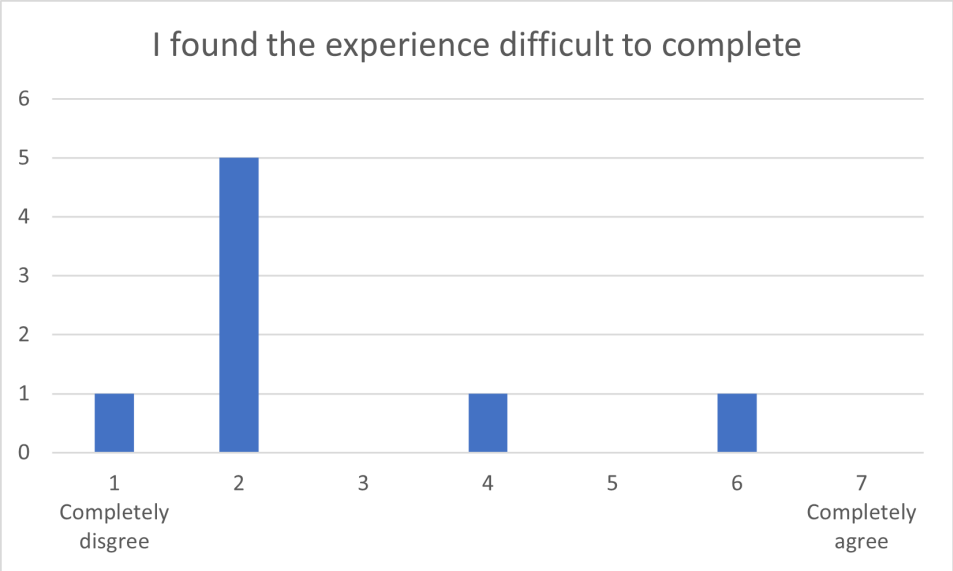

Figure 7.3: The graph above shows how the participants responded to the statement "I found the experience difficult to complete". Where 1 is "Completely disagree and 7 is "Completely agree"

The fifth statement posed to the test participants was "I let myself explore the environment", here the participants responded overwhelmingly that they agreed with the statement 7.4. Only one participant responded lower than six and gave a four.

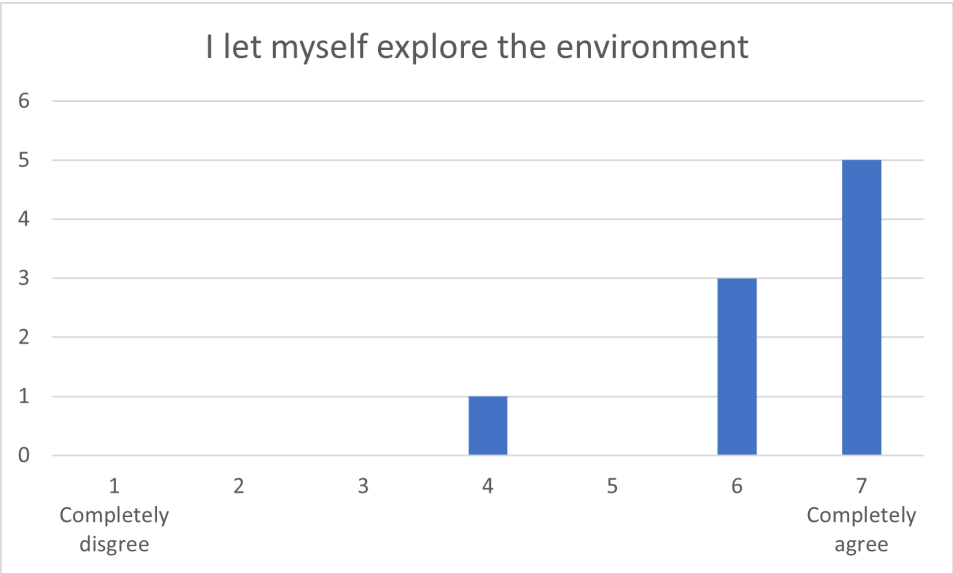

Figure 7.4: The graph above shows how the participants responded to the statement "I let myself explore the environment". Where 1 is "Completely disagree and 7 is "Completely agree"

For questions six and seven the participants were asked about the audio and visual guidance in the game. They have posed the statements "The AUDIO had an impact on what I interacted with" and "The LIGHTING had an impact on what I interacted with".

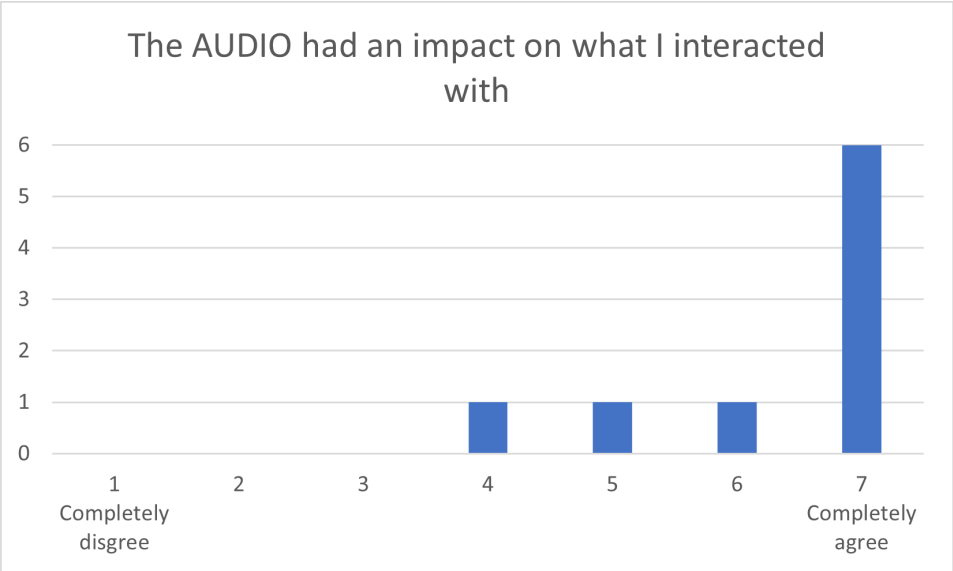

Figure 7.5: The graph above shows how the participants responded to the statement "The AUDIO had an impact on what I interacted with". Where 1 is "Completely disagree and 7 is "Completely agree"

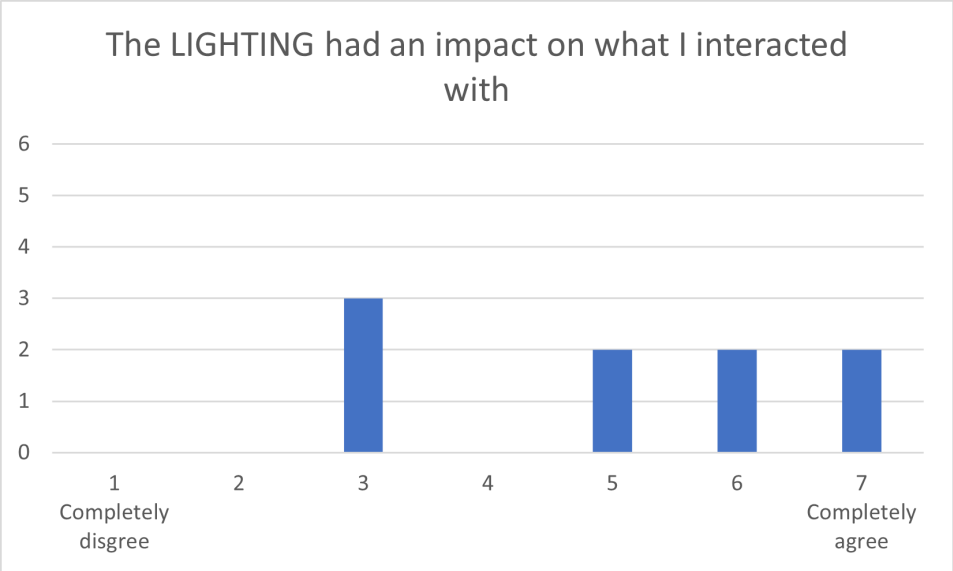

Figure 7.6: The graph above shows how the participants responded to the statement "The LIGHTING had an impact on what I interacted with". Where 1 is "Completely disagree and 7 is "Completely agree"

To this statement, the responses made it clear that the participants were more greatly impacted by the audio cues used in the experience than the lighting. Although, this is not evidence that the lighting is less effective to draw attention but that the participants were more aware of the audio cues 7.5 & 7.6.

The final Likert item was the statement "I felt I was in control of my movements", here participants also tended to agree with the statement indicating that the movement was functioning 7.7.

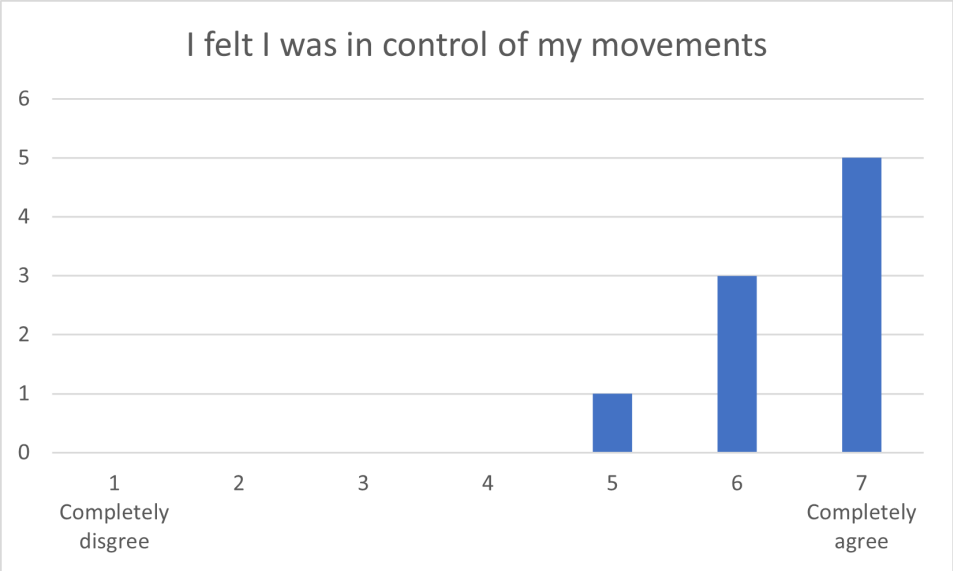

Figure 7.7: The graph above shows how the participants responded to the statement "I felt I was in control of my movements". Where 1 is "Completely disagree and 7 is "Completely agree"

7.2 Final-Test

Due to the ongoing Covid-19 pandemic, the final test could not be performed. The following section on the evaluation of the final test will therefore be purely theoretical and all data used will be fabricated by the authors of this report. The goal of the final test is to test the final problem statement which reads:

"How can a cinematic VR experience utilising visual and audio cues guide the user's attention to specific elements in a scene?"

To do this, the final problem statement will have to be written as a null and alternate hypothesis for each of the variables that will be tested. These reads as follows:

Testing the effectiveness of the audio cues:

Null hypothesis: Audio cues do not increase the amount of attention the audience gives to the interactable objects.

Alternative hypothesis: Audio cues do increase the amount of attention the audience gives to the interactable objects.

Testing the effectiveness of the visual cues:

Null hypothesis: Visual cues do not increase the amount of attention the audience gives to the interactable objects.

Alternative hypothesis: Visual cues do increase the amount of attention the audience gives to the interactable objects.

Testing the effectiveness of both audio and visual cues:

Null hypothesis: Audio and Visual cues do not increase the amount of attention the audience gives to the interactable objects.

Alternative hypothesis: Audio and Visual cues do increase the amount of attention the audience gives to the interactable objects.

The independent variable in this test is the audio and visual cues while the dependent variable is the time in seconds the audience spends looking at the interactable objects. A questionnaire following the test will also be implemented in order to gather qualitative and quantitative data, and support a discussion of the results.

Participants

For the final test, participants would be chosen using convenience sampling. This is once again due to the ongoing Covid-19 pandemic and the restrictions implemented by the Danish government. The goal would have been to receive at least 20 responses in each of the four categories of testing and there should always be an equal amount in each group.

Setup

The setup of the final test will be similar to that of the usability test. However, the final test will take place in a quiet room where test participants have privacy, which was not the case for the usability test that was performed in the group rooms on campus. The VR sensors will be set up and calibrated and a laptop with the questionnaire will be setup. The same standard of cleaning the equipment between each test will be done for both the VR controller, laptop, and headset.

Procedure

The participants will not know that there are different versions of the experience. The participant, once recruited, will be taken to a quiet room, asked to disinfect their hands, be given the VR headset, the audio headset, and a VR controller. The participant will be told that they are about to test a VR experience and that it is possible to progress to other areas outside the starting room, but not how to progress. They will also be instructed on how to move around using the controller. Participants were also encouraged to ask if they had any questions or needed assistance during the experience.

Measures

Even though the final test is merely an exercise in data collection and analysis, the data was fabricated from one of the data points gathered during the usability test. The total time it took for a random usability-test-test-participant to complete the VR experience and the time spent looking at interactable objects. In this case, it was 480 seconds total time, 18 seconds of which were spent looking at interactable objects. From this we extrapolated an approximate 3,5% *interaction percentage*(section 10.2.1). This was then added to act as the median value for the 20 data points of the group testing with both cues. The other 19 data points were somewhat equally spread out around the median. We then took this column of 20 data points and added a random scalar between 1,08 - 1,12 for the group with audio cues, this was done because participants in the usability test said that audio made the biggest impact on their decision making, 1,18 - 1,25 for the group with only visual cues and 1,35 - 1,42 for the baseline group with no cues available. The result of these calculations can be seen in the table below.

participant_id	Both	Audio	Visual	NoCues
1	1,4	1,6	1,8	2,0
2	1,7	1,9	2,1	2,3
3	2,6	2,9	3,2	3,8
4	2,7	3,0	3,3	3,9
5	3,0	3,3	3,7	4,2
6	3,1	3,3	3,8	4,4
7	3,1	3,3	3,6	4,2
8	3,1	3,3	3,9	4,5
9	3,2	3,4	4,0	4,5
10	3,3	3,7	4,0	4,7
11	3,5	3,8	4,2	5,0
12	3,7	4,0	4,3	5,2
13	3,8	4,2	4,5	5,3
14	3,8	4,1	4,6	5,3
15	3,8	4,2	4,8	5,4
16	3,9	4,3	4,7	5,4
17	3,9	4,2	4,7	5,5
18	4,0	4,4	4,9	5,7
19	4,8	5,3	5,8	6,8
20	7,0	7,6	8,8	9,8

Figure 7.8: The four groups and their respective percentage of time spent paying attention to interactable objects.

7.2.1 Final-Test Results

In this section, the data from the four test groups will be reported, then analysed and concluded upon. All four data sets contain 20 data points. The analysis will be done through the methods mentioned in the methods chapter 4 but also includes graphics, plots and graphs to further support the analysis of the data.

Below are the descriptive statistics for all four groups, Both, Audio, Visual and NoCues.

	Both	Audio	Visual	NoCues
count	20.000000	20.000000	20.000000	20.000000
mean	3.456500	3.794480	4.237720	4.889695
std	1.147855	1.244306	1.419227	1.590899
min	1.400000	1.568000	1.750000	2.002000
25%	3.025000	3.301500	3.649150	4.217325
50%	3.395000	3.751750	4.142450	4.839250
75%	3.842500	4.208400	4.697100	5.356300
max	7.040000	7.603200	8.800000	9.785600

Figure 7.9: Descriptive statistics for all four groups

Below, the data is visualised by plotting it into histograms for all four groups.

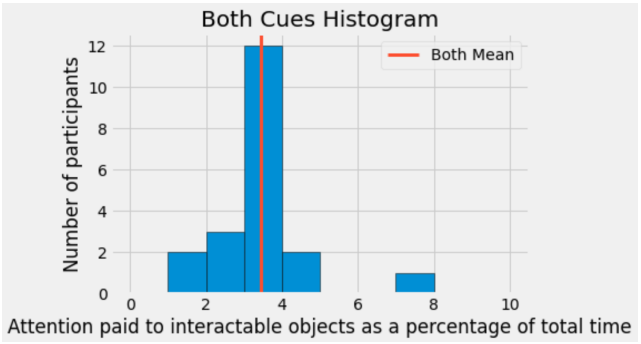

Figure 7.10: Histogram for the group with both cues, red line represents the mean of the data for this group.

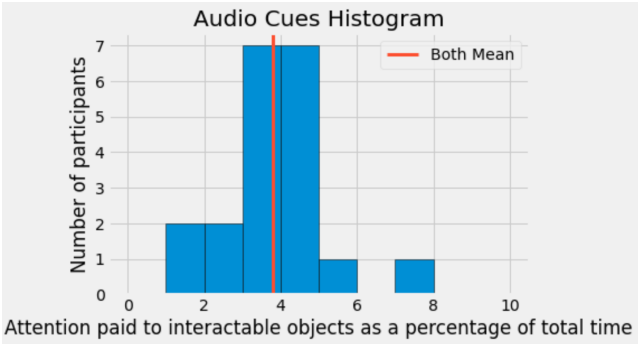

Figure 7.11: Histogram for the group with audio cues, red line represents the mean of the data for this group.

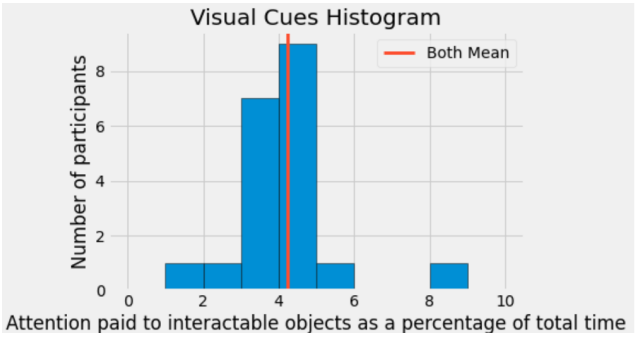

Figure 7.12: Histogram for the group with visual cues, red line represents the mean of the data for this group.

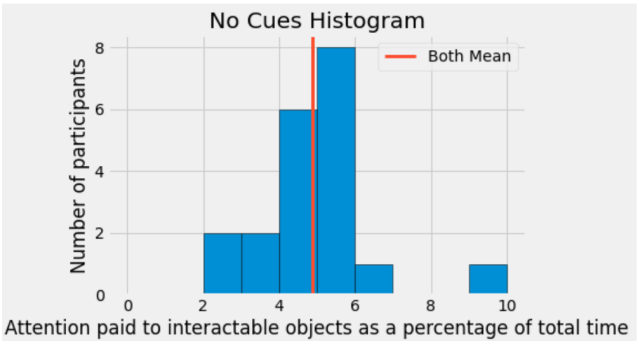

Figure 7.13: Histogram for the group with no cues, red line represents the mean of the data for this group.

The following part of the data analysis will concern itself with testing whether or not the data is parametric, which includes confirming or denying several assumptions about the data. The level of measurement is ratio data since the dependant

variable is measured as a percentage of two time values. Again, the percentage of time spent paying attention to interactable objects compared to the total time spent in the VR experience. To test whether or not the data comes from a population of normal distribution, probability plots and a Shapiro-Wilk test will be done. Below are the probability plots for all four groups of data.

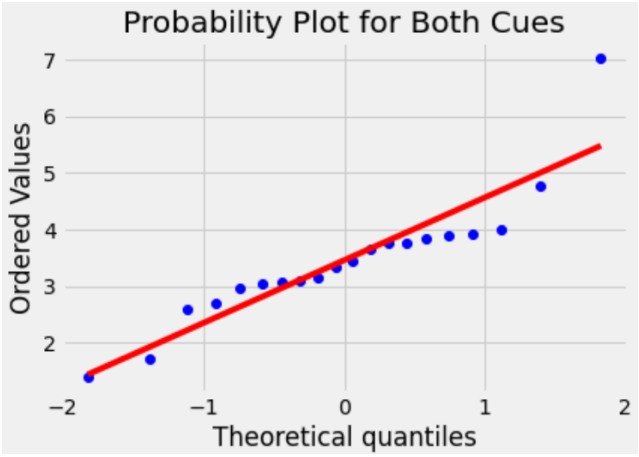

Figure 7.14: Probability plot for the group with both cues, the red line represents the theoretical mean.

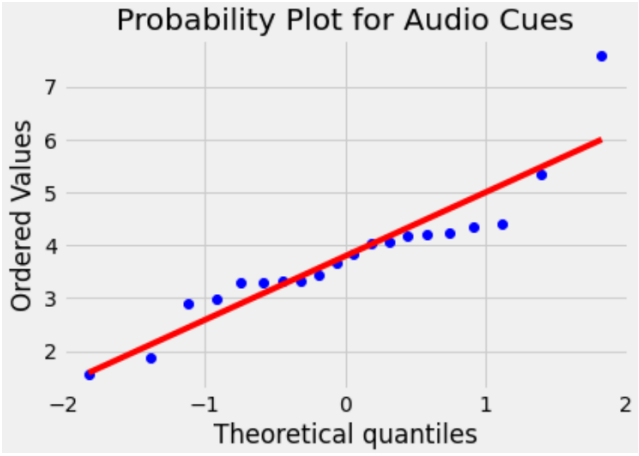

Figure 7.15: Probability plot for the group with audio cues, the red line represents the theoretical mean.

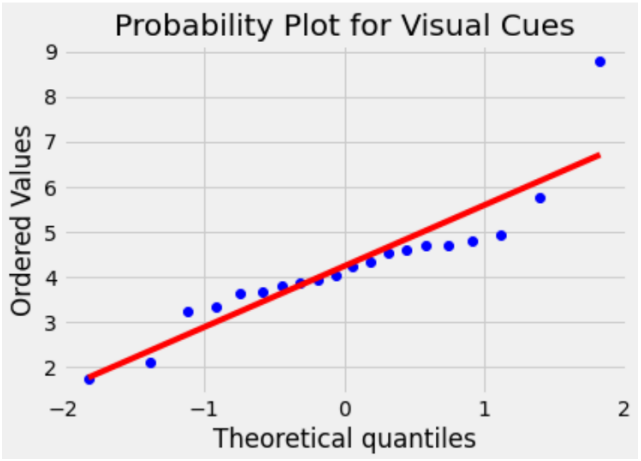

Figure 7.16: Probability plot for the group with visual cues, the red line represents the theoretical mean.

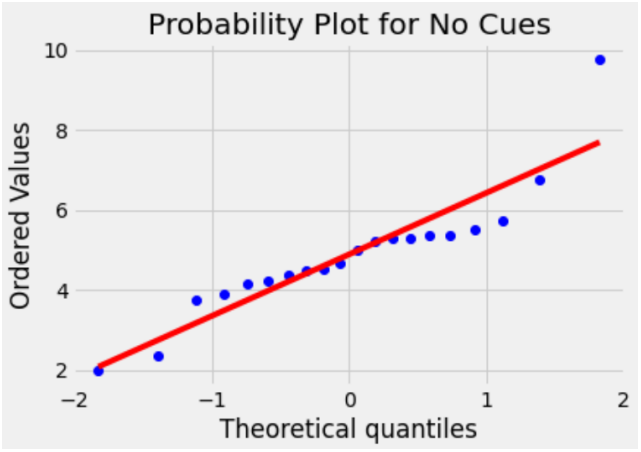

Figure 7.17: Probability plot for the group with no cues, the red line represents the theoretical mean.

In all of the above probability plots, it can be seen that the data somewhat follows a normal distribution except for a few outliers in the 2nd theoretical quantile. To further test whether or not the data is normally distributed, a Shapiro-Wilk test was performed and is shown below.

```
w1,p1=stats.shapiro(data.Both)
print('Both Cues p-value =', "%.3f" %p1)
```

```
Both Cues p-value = 0.012
```

```
w2,p2=stats.shapiro(data.Audio)
print('Audio Cues p-value =', "%.3f" %p2)
```

```
Audio Cues p-value = 0.019
```

```
w3,p3=stats.shapiro(data.Visual)
print('Time A p-value =', "%.3f" %p3)
```

```
Time A p-value = 0.006
```

```
w4,p4=stats.shapiro(data.NoCues)
print('Time A p-value =', "%.3f" %p4)
```

```
Time A p-value = 0.014
```

Figure 7.18: Shapiro-Wilks test with p-values for each of the four test groups.

The Shapiro-Wilk test assumed a 5% significance level and test the null-hypothesis that the data is normally distributed. Since our significance levels are lower than 5%, the null hypothesis that the data is normally distributed is rejected.

Levene's test will be conducted in order to test the null hypothesis that the data is of equal variance, the test is shown below.

```
stat, p = stats.levene(data.Both, data.Audio, data.Visual, data.NoCues)
```

```
print(p)
```

```
0.8251533285047647
```

Figure 7.19: Levene's test with an overall p-value for all four groups.

The Levene's test also assumes a significance level of 5%. The p-value, 0.82, accepts the null hypothesis that the data is of equal variance. However, since the assumptions for normal distribution were not met, the data can be interpreted as non-parametric data.

Below, the standard error of the mean (SEM) has been calculated.

```
boxplotTime = data.loc[:,['Both','Audio', 'Visual', 'NoCues']]
wsem1=stats.sem(boxplotTime)
print('Standard error of mean - Both Cues =', "%.2f" %wsem1[0],', Audio Cues = ', "%.2f" %wsem1[1],',
```

```
Standard error of mean - Both Cues = 0.26 , Audio Cues =  0.28 , Visual Cues = 0.32 , No Cues = 0.36
```

Figure 7.20: Standard error of the mean for all four groups.

Non-parametric Kruskal-Wallis Test Since it was found that the data is non-parametric, a Kruskal-Wallis test will be performed as described in the methods chapter 4. The significance level for this test is 7,703%, and is based on a table of critical values when performing this kind of test, see footnote below. [1] Kruskal-Wallis tests the null hypothesis that population medians across all four groups are equal.

```
stat1, p10 = stats.kruskal(data.Both, data.Audio, data.Visual, data.NoCues)
print('Statistics=%.2f, p=%.4f' % (stat1, p10))
```

```
Statistics=18.09, p=0.0004
```

Figure 7.21: Kruskal-Wallis Test results.

Given our p-value 0.0004, we can accept the null hypothesis that population medians across all four groups are equal.

Finally, the boxplot below visualises the data from all four groups.

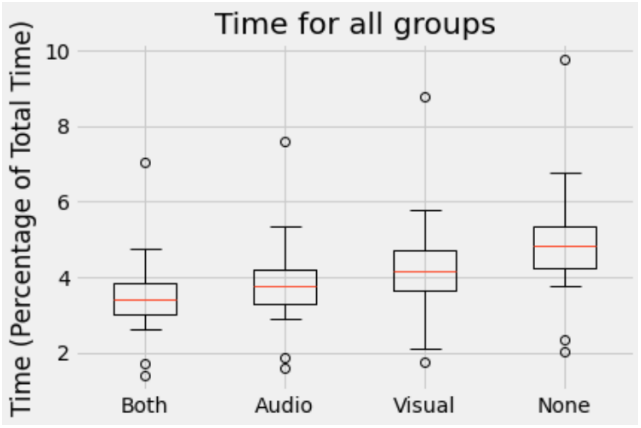

Figure 7.22: Boxplot for all four groups.

The boxplot above clearly show how groups performed with the cues they had available. The variability across the groups is very similar and all four groups contain a similar amount of outliers.

[1] https://www.dataanalytics.org.uk/critical-values-for-the-kruskal-wallis-test/#eq-4

Results Conclusion

Based on the analysis of results above, we can accept all proposed alternative hypotheses at the beginning of this final test chapter 7.2

Chapter 8

Discussion

In the following chapter design, implementation and evaluation will be discussed. Again, most of the discussion regarding the evaluation will be theoretical, since the data it is based on was fabricated.

8.1 Design

One of the main improvements to design in order for the VR experience to come across as an experience more than a regular VR game would be to have focused more on the implementation of *staging* (section 2.1). Staging is an element of mise-en-scène theory that can be manipulated in order to set the tone of the scene. There could for example have been an opening scene including narration that would help the audience understand who they were and what they were doing. The overall design stages of the experience could have been included to show how the group progressed through various iterations of design. Lighting, scaling, audio design, models where all changed through various design iterations, that could have been described to identify any optimisation strategies for future developments.

8.2 implementation

It was discussed early on if the experience should be online and the data gathered from it, could be uploaded to a database. The group have done something similar previous semester where they sent out a guide with instructions on how to run the product for both Windows and Mac, a consent form with a questionnaire. This way the group group gather data, while still following the restriction made due Covid-19. It was consider to have the same procedure, but the group was unsure about the data gathering, since the experience is in VR and they was unsure about

getting enough participants. The group were told there was a connection between universities where they would test VR, since it was mention that connection was used for another VR product.

Another issue with doing it online, would be controlling which version(baseline, no sound, no light, light and sound) of the experience the participant is immerse themselves into. This could be possible with a counter of some sort on the database, where the game would decide by the counter which version it will run. This strategy was done similarly previous semester where they had an id that was random generated in the game, and the game would then change whether the id was an even or uneven number.

Currently, the interaction with the VR controllers is minimal, since they use the trigger box of the colliders of the objects for interaction. Instead, it would be nice the use the buttons on the controller, since the buttons is controller the hand that the participant sees. By doing so, the participant could do different hand sign depending on what the object tells to immerse the participant more into the environment.

Lastly, the group only tested on the HTC Vive and therefore was unsure about if the experience would work on other VR systems. This is more related to the online testing, but it was a concern for the group when talking about testing online as well.

8.3 Evaluation

Since we were not able to perform the final test, a discussion of the results seem like a pointless exercise. However, had we been able to perform the test, we could have discussed bias, there could very likely be a difference between people who have tried VR before and those who have not, for example. There is also bias introduced when testing on fellow students. We could have discussed the procedure of the test, because it no longer seems viable to test in-person for the foreseeable future, so how could we have facilitated online testing that produces reliable and valid data for example.

Chapter 9

Conclusion

In our introduction at the beginning of the project, the initial problem statement was stated as:

"How can virtual reality utilize film theory to guide the user's attention in a cinematic experience?"

The analysis initially went through audio and visual cues and their relation to mise-en-scène theory. Then, attention as part of human perception was examined. Furthermore, to facilitate the design of a VR experience the analysis sought to gain knowledge on various subjects such as level design, user guidance, and VR headset requirements. With this knowledge, a final problem statement was formulated:

How can a cinematic VR experience utilising visual and audio cues guide the user's attention to specific elements in a scene?

To answer the final problem statement, a study design was outlined in the methods chapter. In the design chapter, based on the design requirements put forward after the analysis the idea for the experience, visual design, audio design, animation, and user interaction was decided upon,

The implementation chapter details the assets, scenes, programming, animations, user movement, and data gathering methods.

In the evaluation chapter, the usability test was described, this test most notably showed that participants were able to understand the audio and visual cues and progress from start to finish in the VR experience. The evaluation chapter also holds a, forced by COVID-19, faux final test that showed that the more cues you have available, the longer you spend in total, but also looking at interactable objects. This means the final problem statement is yet to be concluded upon with real data.

Chapter 10

Appendices

10.1 Usability test results

First question "In your own words what did you just experience?" Responses:

Participant 1. A puzzle game where i had to find triggers for opening different doors.

Participant 2. I was running through an area solving small problems like lockers not functioning and more.

Participant 3. A few sets of simple puzzles where I had to identify objects that I needed to interact with within a spaceship.

Participant 4. some kind of a logical maze runner - solve some riddles and challenges in order to get out/escape.

Participant 5. Escape room kinda thing.

Participant 6. A puzzle game in VR that makes you progress with you placing in front of important objects.

Participant 7. An interactive VR world, with obstacles and a storyline that is player-driven.

Participant 8. Exploration of a spaceship I believe? There were some problems with some switches that needed to be turned on, which allowed me to progress through new areas. The red lights clearly indicated that it was off.

Participant 9. Research facility with some issues that needed to be handled, potentially a facility in lockdown.

Second question "How many objects did you feel you could interact with? and what were they?" Responses:

Participant 1. I think there were 2 or 3. But in the beginning I didn't really realise that I interacted with them. They sort of just got triggered when I came close.

Participant 2. i didnt feel like i could truely interact with any of the elements, only that they was influenced by how close i was to them.

Participant 3. About 4 things: A computer screen, some strange devices that I did not fully understand what was, and lastly one button.

Participant 4. the objects that were beeping, I think it was like of them in total? basically only those that made some of the doors open.

Participant 5. Five or something, it was like buttons, i had to turn on.

Participant 6. the computer, the locker, the boxes on the wall and the final button thing.

Participant 7. A computer, Lights, a emergency generator, and a button. So all in all 4.

Participant 8. Only a few objects, the ones that blinked red i felt i needed to interact with by getting close to them.

Participant 9. 4, computer, cabinet, switches on wall and the final switch.

Third question "Do you have any additional comments, remarks or suggestions?" Responses:

Participant 1: It was difficult in the beginning to figure out what to do and where to go. The sound clues helped though.

Participant 2: whenever it came to the elements that had sounds, then i knew they was "interactable". but i thought that the first one, the locker, opened up to something, where as, after learning that it was only touching it that was the goal and not more than this.

Participant 3: The interaction felt a bit lackluster as I had to just move up to the objects to interact with them. Though, it was enough for me to understand that I had an interaction with them.

Participant 4: what was the creaking door noise that shit was spooky and ever since that I was kinda nervous that something's gonna start chasing me lol.

Participant 5: It glitched sometimes, but otherwise it was cool.

Participant 6: fun experience, and the teleport thing worked really well when you found out you could hold in the button to aim, but it was a shame that even when you progressed some areas were still red when you hover the teleporter that was a little confusing.

Participant 7: It was a little confusing to figure out where i should go. But very good use of sound.

Participant 8: Was very nice. I felt very tall tho.

Participant 9: There were sound effects to lead you but overall it did not feel like you had "finished" an area as you interacted with a thing.

10.2 Usability test figures

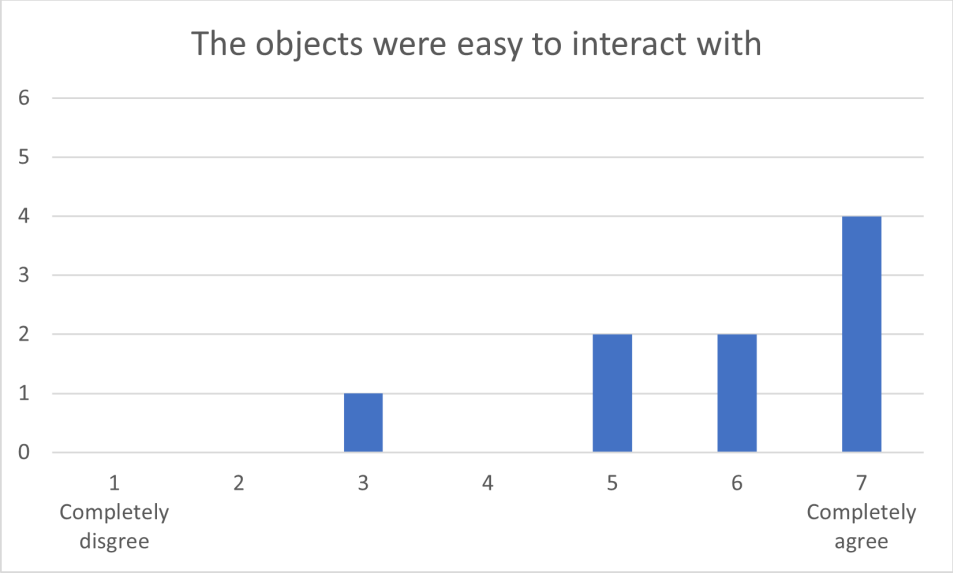

Figure 10.1: The graph above shows how the participants responded to the statement "The objects were easy to interact with". Where 1 is "Completely disagree and 7 is "Completely agree"

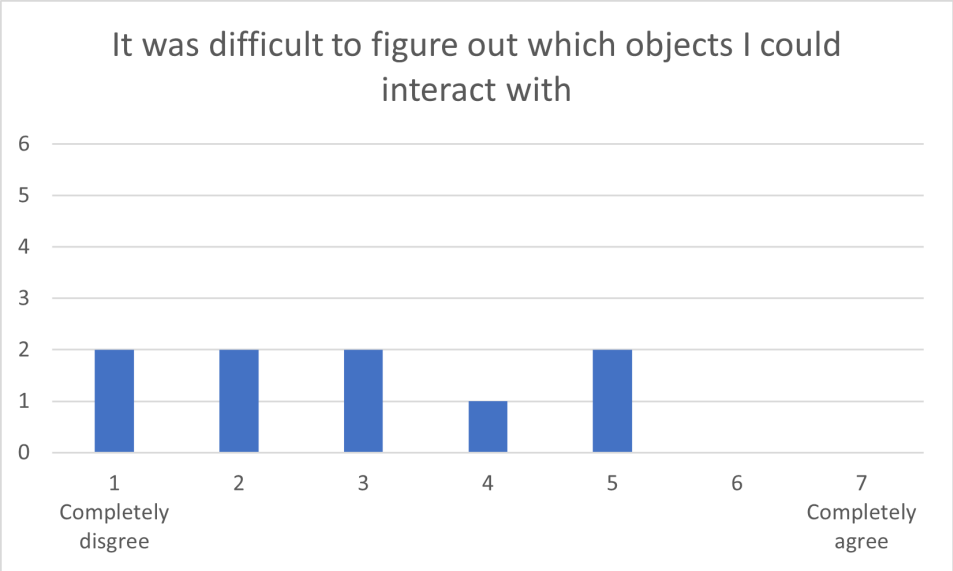

Figure 10.2: The graph above shows how the participants responded to the statement "It was difficult to figure out which objects I could interact with". Where 1 is "Completely disagree and 7 is "Completely agree"



Figure 10.3: The graph above shows how the participants responded to the statement "I felt that my actions had an impact on the experience". Where 1 is "Completely disagree and 7 is "Completely agree"

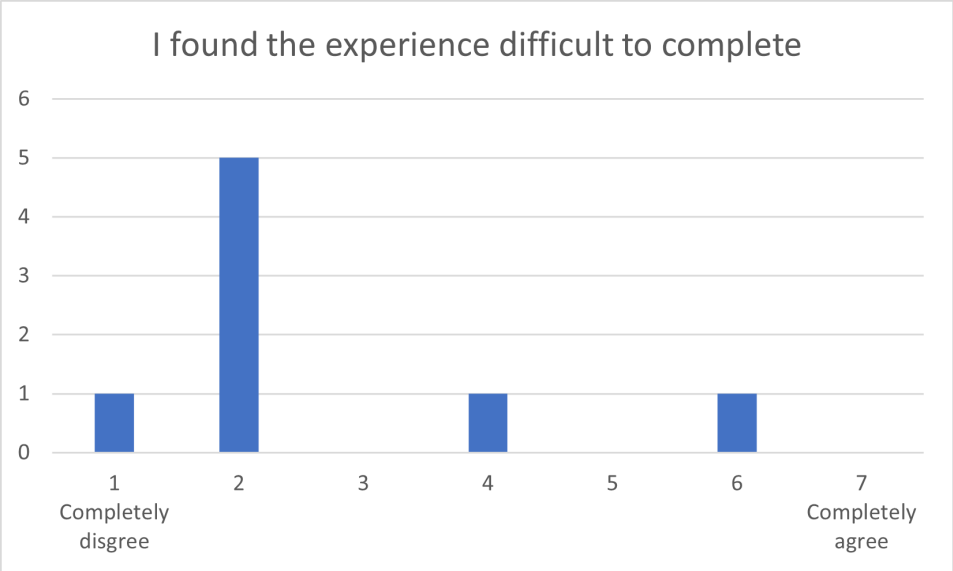

Figure 10.4: The graph above shows how the participants responded to the statement "I found the experience difficult to complete". Where 1 is "Completely disagree and 7 is "Completely agree"

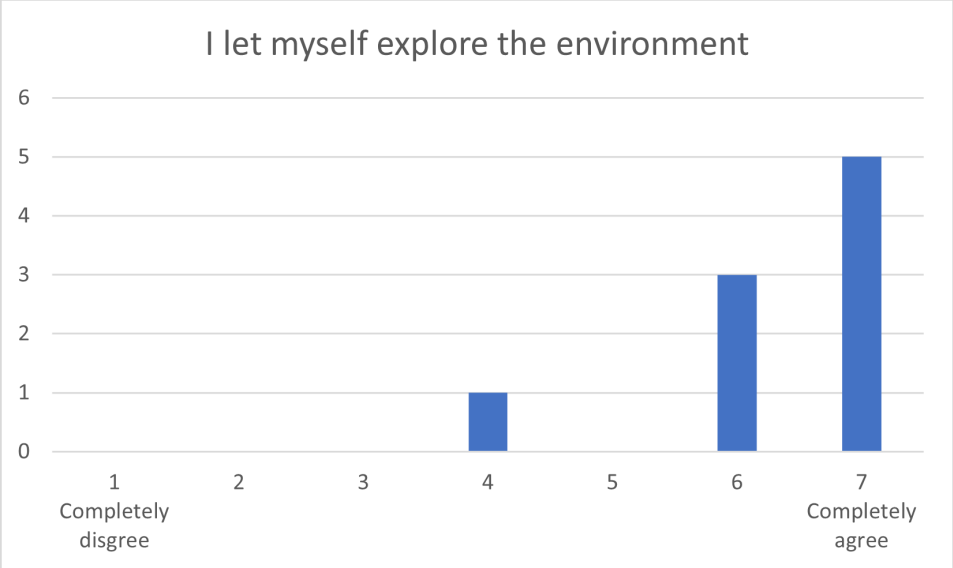

Figure 10.5: The graph above shows how the participants responded to the statement "I let myself explore the environment". Where 1 is "Completely disagree and 7 is "Completely agree"

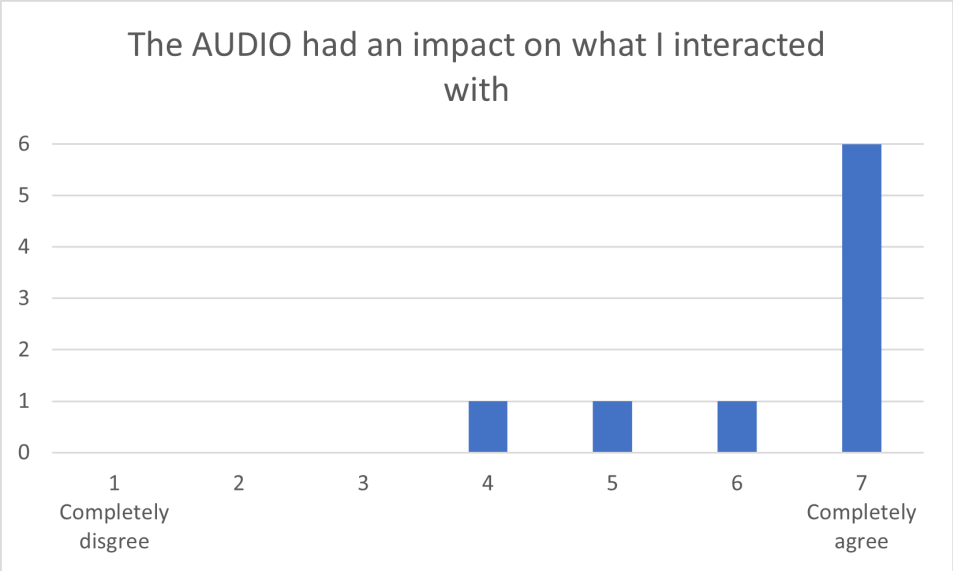

Figure 10.6: The graph above shows how the participants responded to the statement "The AUDIO had an impact on what I interacted with". Where 1 is "Completely disagree and 7 is "Completely agree"

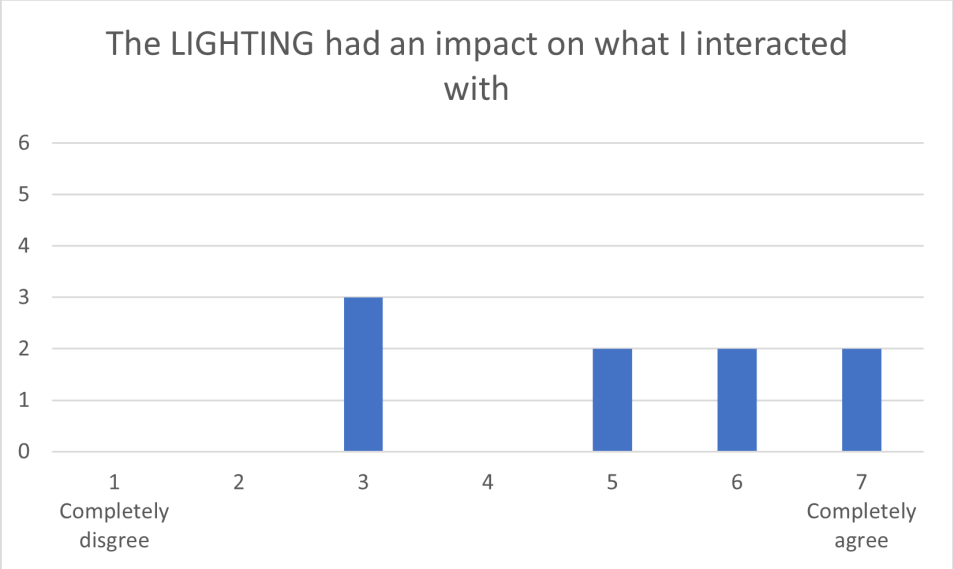

Figure 10.7: The graph above shows how the participants responded to the statement "The LIGHTING had an impact on what I interacted with". Where 1 is "Completely disagree and 7 is "Completely agree"

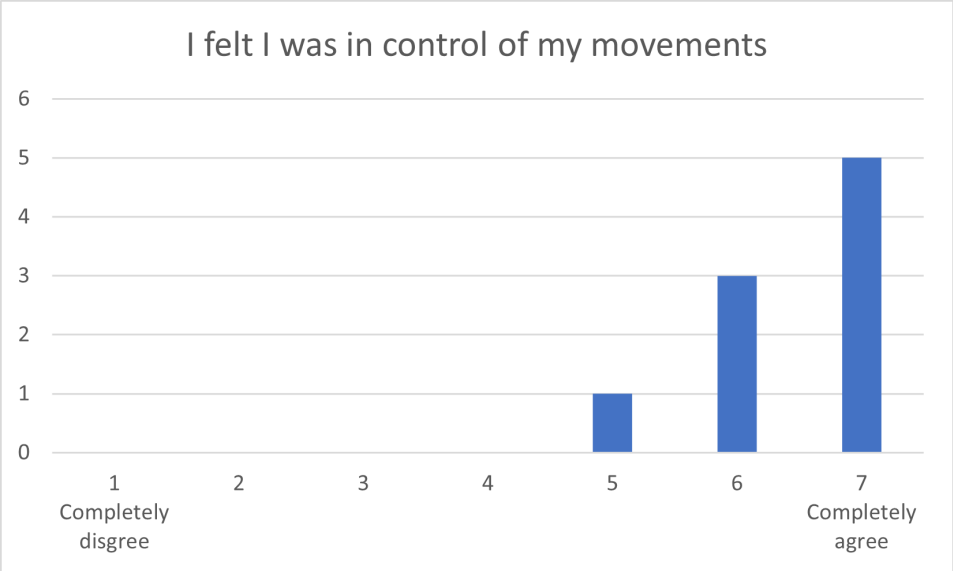

Figure 10.8: The graph above shows how the participants responded to the statement "I felt I was in control of my movements". Where 1 is "Completely disagree and 7 is "Completely agree"

10.2.1 data from usability test

Participant 1:

Total time spent: 480.4306

Time looked at Laptop(interactive): 5.97631

Time looked at HandScanner(interactive): 2.413386

Time looked at FaceScannerLeft(interactive): 0.0891272

Time looked at FaceScannerRight(interactive): 1.569492

Time looked at DresserFBX(interactive): 7.791305

interval time 0: 41.6403

interval time 1: 142.4

interval time 2: 166.9788

interval time 3: 0

interval time 4: 129.3868

Participant 2:

Total time spent: 286.8084

Time looked at Laptop(interactive): 12.78596

Time looked at HandScanner(interactive): 0.945373

Time looked at FaceScannerLeft(interactive): 4.509018

Time looked at FaceScannerRight(interactive): 0.5075158

Time looked at DresserFBX(interactive): 4.55605

interval time 0: 92.64584

interval time 1: 78.34256

interval time 2: 55.43988

interval time 3: 0

interval time 4: 60.35791

Participant 3:

Total time spent: 244.4793

Time looked at Laptop(interactive): 3.082818

Time looked at HandScanner(interactive): 1.270877

Time looked at FaceScannerLeft(interactive): 4.337472

Time looked at FaceScannerRight(interactive): 0.9025658

Time looked at DresserFBX(interactive): 2.187992

interval time 0: 12.49539

interval time 1: 81.91688

interval time 2: 58.18563

interval time 3: 0

interval time 4: 91.85835

Participant 4:

Total time spent: 341.1771

Time looked at Laptop(interactive): 0.9702592

Time looked at HandScanner(interactive): 1.238154

Time looked at FaceScannerLeft(interactive): 4.715366

Time looked at FaceScannerRight(interactive): 1.626284

Time looked at DresserFBX(interactive): 2.555696

interval time 0: 15.48053

interval time 1: 97.42308

interval time 2: 156.0387

interval time 3: 0

interval time 4: 72.21246

Participant 5:

Total time spent: 381.0124

Time looked at Laptop(interactive): 4.353703

Time looked at HandScanner(interactive): 0

Time looked at FaceScannerLeft(interactive): 2.514429

Time looked at FaceScannerRight(interactive): 1.908303

Time looked at DresserFBX(interactive): 4.429952

interval time 0: 38.00818

interval time 1: 82.7272

interval time 2: 96.00285

interval time 3: 0

interval time 4: 164.2176

Participant 6:

Total time spent: 428.3387

Time looked at Laptop(interactive): 6.502795

Time looked at HandScanner(interactive): 1.846835

Time looked at FaceScannerLeft(interactive): 2.140271

Time looked at FaceScannerRight(interactive): 2.803706

Time looked at DresserFBX(interactive): 8.718508

interval time 0: 17.36148

interval time 1: 223.6262

interval time 2: 79.06174

interval time 3: 0

interval time 4: 108.2782

Participant 7:

Total time spent: 313.9799

Time looked at Laptop(interactive): 12.3511

Time looked at HandScanner(interactive): 1.450599

Time looked at FaceScannerLeft(interactive): 3.650751

Time looked at FaceScannerRight(interactive): 0.7264612

Time looked at DresserFBX(interactive): 3.778448

interval time 0: 75.31516

interval time 1: 94.96575

interval time 2: 86.17456

interval time 3: 0

interval time 4: 57.51346

Participant 8:

Total time spent: 312.1786

Time looked at Laptop(interactive): 2.073371

Time looked at HandScanner(interactive): 0.1113012

Time looked at FaceScannerLeft(interactive): 0.9804134

Time looked at FaceScannerRight(interactive): 1.931345

Time looked at DresserFBX(interactive): 8.702241

interval time 0: 59.55425

interval time 1: 95.74704

interval time 2: 93.99232

interval time 3: 0

interval time 4: 62.83707

Participant 9:

Total time spent: 438.8651

Time looked at Laptop(interactive): 0.3273325

Time looked at HandScanner(interactive): 0.5341265

Time looked at FaceScannerLeft(interactive): 2.777125

Time looked at FaceScannerRight(interactive): 0.8373667

Time looked at DresserFBX(interactive): 8.072198

interval time 0: 119.3221

interval time 1: 151.6951

interval time 2: 142.1364

interval time 3: 0

interval time 4: 25.70053

Bibliography

[1] David Bordwell and Kristin Thompson. *Film art : an introduction*. Vol. 10. 2013, pp. 266–307. ISBN: 978-0-07-353510-4.

[2] Marisa Carrasco and Brian McElree. "Covert attention accelerates the rate of visual information processing". In: (Apr. 2001), pp. 5363–5367.

[3] Creepy Cat. "3D Scifi Kit Starter Kit". In: (Aug. 2019). URL: https://assetstore.unity.com/packages/3d/environments/3d-scifi-kit-starter-kit-92152.

[4] Valve Corporation. "SteamVR Plugin". In: (Aug. 2020). URL: https://assetstore.unity.com/packages/tools/integration/steamvr-plugin-32647.

[5] Alan B. Craig and William R. Sherman. *Understanding Virtual Reality*. Vol. 2. Dec. 2019, pp. 258–396. ISBN: 978-0-12-800965-9.

[6] Andy P Field and Graham Hole. *How to design and report experiments*. Sage, 2012.

[7] karboosx. "Sci-Fi Styled Modular Pack". In: (Nov. 2018). URL: https://assetstore.unity.com/packages/3d/environments/sci-fi/sci-fi-styled-modular-pack-82913.

[8] Victor A.F. Lamme. "Why visual attention and awareness are different". In: *TRENDS in Cognitive Science* 7, NO. 1 (Jan. 2003), pp. 12–18.

[9] Jamie Madigan. "The Psychology of Video Game Immersion". In: (July 2012). URL: https://www.psychologytoday.com/us/blog/mind-games/201207/the-psychology-video-game-immersion.

[10] Maya. "Blinn". In: (Aug. 2018). URL: https://knowledge.autodesk.com/support/maya/learn-explore/caas/CloudHelp/cloudhelp/2018/ENU/Maya-LightingShading/files/GUID-13C10DF8-5CB4-49D2-9456-DCC1B7F1653C-htm.html.

[11] Maya. "Lambert". In: (May 2016). URL: https://knowledge.autodesk.com/support/maya/learn-explore/caas/CloudHelp/cloudhelp/2016/ENU/Maya/files/GUID-97B781A0-7F21-42D4-B040-8EB967CB8563-htm.html.

[12] Maya. “Phong”. In: (May 2016). URL: https://knowledge.autodesk.com/support/maya/learn-explore/caas/CloudHelp/cloudhelp/2016/ENU/Maya/files/GUID-3EDEB1B3-4E48-485A-9714-9998F6E4944D-htm.html.

[13] Maya. “Polygonal Modeling”. In: (July 2019). URL: https://knowledge.autodesk.com/support/maya/learn-explore/caas/CloudHelp/cloudhelp/2019/ENU/Maya-Modeling/files/GUID-7941F97A-36E8-47FE-95D1-71412A3B3017-htm.html.

[14] Jennifer Preece, Yvonne Rogers, and Helen Sharp. *Interaction Design*. 4th ed. Wiley, 2015.

[15] C.W. Totten. *Architectural Approach to Level Design: Second edition*. CRC Press, 2019. ISBN: 9781351116282. URL: https://books.google.dk/books?id=PQqWDwAAQBAJ.

[16] Steven Yantis and Richard A. Abrams. *Sensation and Perception (2nd edition)*. Worth Publishers, 2017. ISBN: 1464111707.