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A Virtual Spectacle

Faculty of
Department of Game Design
Author(s): Christopher Fisher & Rishi Krishnan Sherly
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Supervisor: Henrik Warpefelt
Examiner: Magnus Johansson
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Abstract

Our goal was to create an enhanced spectator experience to better engage the rapidly growing audience for Esports, through the use of Virtual Reality (VR) technology. In this study, we delve into the ways in which VR can do this. To test this hypothesis, we created a VR spectator add-on for a game and gathered data using semi-structured interviews. The data from the interviews were then analyzed using thematic analysis. The results of our study show that VR provides more engagement through a combination of possible factors including proximity to the action, novelty of VR experiences and the harder controls in VR. The results also show that the terms "immersion" and "spatial presence" were quite possibly used interchangeably by the participants and also that there may not be a correlation between the terms "engagement" and "spatial presence". In conclusion, we believe that the increased sense of engagement through VR technology can be taken even further and has the potential to be something more than what traditional modes of spectating can offer.

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1 Introduction

1.1 Spectatorship

A field with explosive growth in recent times is that of spectating Electronic Sports (Esports). According to statistics from Newzoo (2018), the audience for Esports has increased from 281 million in 2016 to 380 million in 2018. Although Esports fans can choose to attend sporting events live, they are still, ironically, spectating a match on a large two-dimensional screen. Spectatorship has, in these cases, gone from a traditionally immersive three-dimensional space, to a two-dimensional, flat screen. What could be improved here, is the depth, and this is where the potential for using Virtual Reality comes in.

Spectating competitive video games can be potentially improved by using the enhanced illusion of spatial presence of Virtual Reality. One of these expanded offerings comes in the form of being able to place a spectator directly inside of a match. According to Hartmann et al. (2015), *Spatial Presence can be defined as the subjective experience of a user or onlooker to be physically located in a mediated space, although it is just an illusion.* A study by Hoffman et al. (2003) shows that immersive Virtual Reality (VR) can create a strong illusion of presence, despite environmental constraints (the immobilized head and loud ambient noise due to an fMRI magnet). By coupling Virtual Reality technology with spectatorship, we can create this new offering and explore some of the ways this would actually function.

1.2 Research Area

The advances in Virtual Reality make it possible to create an experience with a higher degree of spatial presence than the traditional Esport spectator experience of watching on a screen. With this, an opportunity presents itself to create a more engaging experience for the hundreds of millions of Esport enthusiasts.

1.3 Research Question

This leads us to our research question: In what ways can Virtual Reality be used to provide a more engaging spectator experience?

1.4 Method Overview

We believe that the enhanced sense of presence from Virtual Reality technology can increase the engagement of spectators. In this study, we test this hypothesis by creating a VR spectator add-on for the game Nova Factor (BloodBerry Games 2019). Both the game and the add-on are described further in Section 4.2. We conducted semi-structured interviews, which were then analyzed for patterns through thematic analysis as mentioned in Cote and Raz (2015).

The reason we chose qualitative in-depth interviews is because *they allow researchers and informants to discuss topics in a naturalistic, free-flowing way, yielding new ideas and interesting observations* (Cote and Raz 2015). Thematic analysis provides a method for isolating keywords from the free-flowing interview text, which could then be analyzed for patterns in a coherent and structured manner.

2 Theoretical Framework

2.1 Background

Esports is generally displayed on a flat screen. In these instances, spectators can only view the game matches through that medium. In spite of this limitation, the number of Esports spectators continues to grow (Newzoo 2018). But, what exactly is a spectator (in terms of Esports)? *Spectators are people who follow the in-game experience, but are not direct participants in the game* (Cheung and Huang 2011). It can be inferred from the rapid growth in Esport spectating, that there is already a degree of engagement in spectating Esport matches.

2.2 Spatial Presence

Hoffman et al. (2003) conducted an experiment where each subject was placed horizontally in an MRI scanner with a custom made VR helmet to display images. Subjects could interact with an icy virtual environment using a trackball. The environment itself alternates between a low-tech and a high-tech version at 30 second intervals, during a six minute fMRI scan. The low-tech version had a white cross in the middle that obstructed part of the view, while the high-tech version had an unobstructed view. The conclusions of their study show that subjects could experience a strong illusion of presence, despite the constraints of the setup (loud noise and immobilized head).

2.3 Factors affecting spatial presence

Coelho et al. (2006) categorizes the variables affecting the feeling of presence into those of the user and those of the medium. For the purposes of this study, we focus on the media characteristics. Or more specifically, the subcategory of Media Form in the article. According to Coelho et al. (2006), Media Form is *the technological or system characteristics that play an important role in the experience of presence.* We also discuss the Media Content subcategory (the content of the media experienced by the user), but these aspects were not implemented in the VR spectator experience. The article groups these variables that affect the sense of presence as: sensorial channels, pictorial realism, system response time, control, vision field, body representation and the presence of others.

Sensorial Channels Sensorial channels refer to the inputs and stimuli given to the different senses. According to the various studies referenced in the article by Coelho et al. (2006), adding tactile, olfactory or auditory elements to the virtual experience (in addition to the traditionally common visual elements) can increase the sense of presence. This is especially relevant in the case of sound.

Pictorial Realism The interesting aspect of this, for our study is that the rendering of visual depth has a positive relation to presence and that the stereoscopic view through VR glasses can greatly enhance the illusion of depth, as per the conclusions of Coelho et al. (2006).

System Response Time Lag, the time delay between an actions of the user and the effect on the virtual environment. If this delay is too high, it can negatively impact the feel of presence. According to Coelho et al. (2006), the interval between the two should be no longer than 0.1 seconds.

Control Control, in this context, refers to the ability of the viewers to impact and affect the virtual world. Coelho et al. (2006) suggests that both the ability to change the environment and the ability to anticipate what is about to happen will increase the sense of presence. This aspect is not implemented in the spectator experiences we created, because the primary purpose of these experiences is to observe the game without affecting it. This will be explained in further detail, in sections 4.2 and 6.3.

Vision Field As explained in Coelho et al. (2006), a larger field of view provides more compelling visual motion cues and a restricted vision of the real-world environment provides less distractions and conflict with the images from the virtual world. Both aspects increase the sense of presence in VR environments and immersion.

Body Representation The body works as an interaction, communication and self identification system, according to Coelho et al. (2006). As such, the sense of presence will depend on the representation of the user's body in virtual space. Unfortunately, since such technology is not easily available, this aspect is not part of our add-on.

Presence of Others According to the studies mentioned in Coelho et al. (2006), the differentiation and experience of the self can be enhanced if other people exist in the virtual world, a concept based on the premise that the likelihood of a virtual world existing is increased with the number of people in it. One of the conditions for this to happen is mutual awareness.

2.4 Simulation Sickness

As mentioned in Coelho et al. (2006), head mounted virtual reality displays have a tendency to cause motion sickness, which in turn reduces the sense of presence by diverting attention away from the Virtual Environment. As such, it is of great importance to avoid such discomforts as best as possible. For the purposes of this study, we will use the guidelines from Epic Games (2019b), which includes:

1. Maintain a high framerate (90 FPS for HTC Vive).
2. Avoid anything that takes control of camera movement away from player
3. Do not override Field of View
4. Do not have camera shaking or bobbing.

Most of these guidelines are already implemented by the default VR PAWN in Unreal. *A Pawn is the physical representation of a player or AI entity within the world*, as explained in Epic Games (2019a). These aspects will be discussed in further detail in Section 4.

2.5 Immersion

Immersion is a term often used to describe VR experiences. However, the varied definitions of this idea has the potential to cause ambiguity and (sometimes) contradiction. As such, it is beneficial for the purposes of this study to define immersion within this context. Bartle (2004) defines immersion as *the sense that a player has of being in a virtual world*, where virtual worlds are *places where the imaginary meets the real.* Sanders and Cairns (2010) defines immersion as *the sense of being "in a game" where a person's thoughts, attention and goals are all focused in and around the game as opposed to attending to being concerned with anything else, such as what is going on in the room around them.* The similarity in both definitions is the sense or feeling of being inside the world of the experience.

The interesting aspect of immersion is the similarity it shares with spatial presence, in terms of definition. All these definitions mention the sense of "being in a location", whether it be a game or a virtual world. We believe that in the context of this study, the terms *spatial presence* and *immersion* are used to describe the same thing. Further evidence and details to support this can be found in second 6.1.

2.6 Engagement

The term engagement is defined in various ways across multiple studies. Brown and Cairns (2004) splits immersion into three stages and characterizes engagement as the first stage, *the lowest level of involvement with a game.*

Bouvier, Lavoué, and Sehaba (2014) defines engagement as *the willingness to have emotions, affect, and thoughts directed toward and aroused by the mediated activity in order to achieve a specific objective.* They explain the requirements for engagement in the statement: *engagement occurs if players' expectations (perceptual, intellectual, interactional) are fulfilled.* Furthermore, Bouvier, Lavoué, and Sehaba (2014) connects presence and engagement through the statement: *we consider presence as a state that may occur after engagement.*

Chen et al. (2011) provides a third definition of engagement as *a sustained level of involvement caused by capturing a person's interest, holding the majority of a person's attentional resources, and placing the person in an immersive state.*

Lastly, we consider the definition of engagement as a process with distinguishable attributes inherent at each stage, by O'Brien and Toms (2008). They further explain the steps as:

Point of Engagement The initiation of the engagement process by the resonance of aesthetic or informational composition of the system interface with users' interests.

Period of Engagement The period of sustained engagement, marked by participants' attention and interest being maintained in the interaction.

Disengagement What occurs when the user makes a decision to stop the activity or when external environment caused them to cease being engaged.

Reengagement What happens sometimes after disengaging, where the user returns to the activity later on. This was the result of positive past experience with the activity or application.

Nonengagement Users are not always engaged or encountered barriers to becoming engaged. Content that overwhelmed or failed to interest users and usability issues with the technology were barriers to engagement.

O'Brien and Toms (2008) also mention the attributes of engagement as: challenge, affect, endurability, aesthetic and sensory appeal, attention, feedback, variety/novelty, perceived control and interactivity.

Both Brown and Cairns (2004) and Bouvier, Lavoué, and Sehaba (2014) define engagement as something that leads to immersion or presence. Chen et al. (2011) also defines engagement in terms of immersion. Based on these three definitions of engagement, we assume that there is some form of correlation between the two, although not necessarily in the same cause-effect order as the theories. This aspect is discussed further in section 7.

2.7 Spectators

Since spectatorship is an integral part of our study, the term *spectator* needs to be further defined. For the purposes of this study, we will defer to the article by Stahlke, Robb, and Mirza-Babaei (2018). The article classifies spectators as passive viewers and interacting spectators (the authors of the study call them spectator-players). Passive viewers are individuals that watch the game in the same way that one might watch a movie. On the other hand, spectator-players are those who actively engage in the broadcast, in some way, whether it be chatting with other spectators and the player or influencing the gameplay in some way.

According to the studies mentioned in Stahlke, Robb, and Mirza-Babaei (2018), members of crowds were seen to participate in synchronized activities, such as the emergence and escalation of songs and gestures in support of their favored team. This indicates that spectating is more than just watching a game, that it is also a social experience. Adding the possibility of social interactions to spectating could serve to satisfy this as well as the expectations of those who prefer to be interacting spectators. The mechanics suggested by Stahlke, Robb, and Mirza-Babaei (2018) for improving interaction for spectators are: chat messages, voting, affiliation, betting, cheering, donation incentives, commentary and player interviews, viewer participation/lotteries, viewer-created content and game modifications.

Unlike the article by Stahlke, Robb, and Mirza-Babaei (2018), both this study and the spectator experiences in this study will focus on the passive viewers. However, the design suggestions in the article, for creating an interactive experience for those who would prefer a more active role in spectating, are still relevant. The relevance of this article to our study will be explained further, in section 6.3.

2.8 Virtual Reality

Virtual Reality (VR) is a technology that evolved over the years, advancing from the View Master of 1939 to the Oculus Rift of 2016. Current VR headsets, such as Oculus Rift and HTC Vive have a display panel that is viewed through two lenses (one for each eye). These headsets also have tracking for the orientation of the head mounted displays and the hand held controllers. For the purposes of this study, when we refer to VR, we mean it in the context of the "realities" rendered in these modern headsets.

2.9 VR Spectating

The studies by Hoffman et al. (2003) and Coelho et al. (2006) show that VR Experiences can create an enhanced sense of presence, under the right constraints and conditions. In this study, we planned to test if this increased sense of presence can lead to a more engaging spectator experience by creating a VR spectator add-on for the game Nova Factor (BloodBerry Games 2019), following the guidelines for enhancing the feel of presence and minimizing the risk of simulation sickness. Both the game and the design aspects of the add-on will be discussed in detail in Section 4.2.

3 Method

3.1 Structure

We gathered data using a VR spectator add-on for the game Nova Factor (BloodBerry Games 2019). We had two setups for spectating:

Type A consisted of a computer screen and a hand held controller. A Nova Factor match was displayed on the screen. The participants were able to watch the screen and fly around freely in the map through the use of an XBOX 360 controller. The participants could also jump to predetermined camera positions which were setup to provide a wide viewing angle in different locations within the map.

Type B consisted of an HTC Vive Headset and associated controllers. A Nova Factor match was played out and the participants were able to view the match using an HTC Vive Headset. The controllers allowed the participants to either teleport around in the map or jump to the same predetermined positions as in the type A spectator experience. The participants were also able to look around using the tracking built into the headset, during the whole experience.

Both types of spectatorship let the players move around freely allowing them the freedom to decide what they want to watch and what position they want to watch from. Half of the participants started with the type A spectating mode and the other half started type B. After each match they were switched to the other type of spectating mode. We also provided the participants with headphones during both types of spectator experiences.

3.2 Data Gathering

After completing both spectator modes, a semi-structured interview was conducted to gather responses on their experiences. We created an interview guide based on Cote and Raz (2015), consisting of an introductory script, leading into substantive and demographic questions.

3.2.1 Introductory Script

The interview opened with informing the participant that their participation is voluntary, that they could leave at any point and that the interview would be recorded but anonymous. They were also informed that all interview recordings would be deleted on conclusion of the study.

3.2.2 Substantive Questions

These open-ended questions were designed to attempt to elicit as much information as possible about their experience with each portion of the study. We were interested in any feelings of spatial presence, the levels of engagement in the match, levels of investment in the match and amount of control they felt.

To this effect, these are the questions that were always asked:

1. How would you describe your experience of spectating the match on the screen?
2. How would you describe your experience of spectating the match in VR?
3. Did you experience any discomfort while using the VR headset?
4. How would you describe the difference between the two spectating modes?
5. How would you describe your ability to follow the action in the match?
6. How would you compare the engagement in the two different experiences?
7. How present did you feel in the two experiences?

3.2.3 Demographic Questions

We also asked basic demographic questions that covered Age and Nationality.

3.3 Data Analysis

The results of the interviews were transcribed into text and were analyzed for patterns through thematic analysis and coding as mentioned in Cote and Raz (2015). This data was broken down, commonly known as "coding and categorization" (Cote and Raz 2015), to look for broad patterns and to identify repeating ideas and themes. We followed the example coding scheme that was outlined in Cote and Raz (2015), which included the line number from the transcript, the quote, the specific topic, the themes, and the broad category the quote falls under.

3.4 Alternate Methods

We did consider alternate methods for conducting this study, such as quantitative analysis with surveys or structured interviews instead of semi-structured, but, we ultimately decided on qualitative analysis with semi-structured interviews and thematic analysis. This is because of the exploratory nature of this combination, which affords a wider investigation into a relatively new concept. Quantitative analysis would have given us data on a specific aspect, but it would be hard to determine what that specific aspect should be to begin with. Commercially available VR head mounted displays are still relatively new. As such, we probably lack the necessary information to determine a specific aspect to narrow our focus to. This is also one of the reason we picked semi-structured interviews over structured interviews. In a semi-structured interview, we can ask more details about interesting aspects that the participants mention, instead of sticking to a fixed script and possibly missing out on unexpected insights.

4 Nova Factor

Nova Factor is a 1v1 first person shooter by BloodBerry Games (2019), made during the Vertical Slice course in Uppsala University, Campus Gotland. This game was created in the Epic Games Unreal Engine 4 game engine. Both the authors of this study were part of the development team and have a familiarity and access to the source code, hence the choice of this game. In this section, we go through the details of both the game and the design considerations for the add-on.

4.1 Nova Factor : Game

The game is played out in five rounds with the winner of the last round winning the match. The matches are played in an outdoor circular area with three floors. The first round is a simple 1v1 first person match in the game arena, with nothing unusual.

The interesting aspect of the game happens from the second round onwards: starting from this round, a REPLAY spawns along with each player and re-executes the actions each player made in the previous round. If the execution of these actions are interrupted, the REPLAY becomes an UNSHACKLED AI.

The AI go around the map and try to find and attack the opponent's team. Also, players that die while they have an AI available can take direct control of the AI and continue playing.

4.2 Nova Factor : Spectator Add-On

The VR spectator add-on works by creating an invisible spectator character in the same arena as the players. The spectators can move around the map and see the other players, but apart from this, there is no interaction possible between the players and the spectators. The players can neither see nor interact with the spectators in the game. The spectator experiences were designed this way to avoid unfair strategies using the spectators, such as body blocking and distractions. As mentioned in section 3, we had two types of setups for spectating. Both types had the option of switching between pre-defined cameras that were placed in positions with a wide view of the map. Both experiences were designed for the passive spectator as defined in Stahlke, Robb, and Mirza-Babaei (2018). As such, neither experiences had any UI or ways in which spectators can interact with the player. The rest of this section will focus on the specific design considerations for minimizing simulation sickness and maximizing the feel of presence.

4.2.1 Vision and Sound

Coelho et al. (2006) mentions both high field of view and sense of depth as factors increasing spatial presence. As mentioned in the article, both of these are inherent in Virtual Reality headsets. The HTC Vive we used for the study has stereoscopic rendering (which is a part of virtual reality headsets to begin with) and a Field of View of 110°. Following the specifications in Epic Games (2019b), the field of view of the camera in the add-on was left unchanged, so that Unreal Engine can automatically adjust it to match the headset used.

We did not explore tactile, olfactory or gustatory senses. We did however implement directional sound in the game, which works in both types of spectator experiences.

4.2.2 Movement and Camera

Differences in movement between the player and the VR camera in the experience, have a tendency to cause motion sickness. The guidelines by Epic Games (2019b) mentions avoiding anything that takes control of camera movement away from player and avoiding camera shakes or bobbing. All of these are taken into consideration in the default VR PAWN in Unreal Engine 4.

We decided to use teleportation as the movement system in VR, to make it possible to navigate the map without causing a disconnect between the views of the player and the headset. Additionally, the camera view was blacked out during the teleportation. Further, we added the option of switching between fixed camera positions, using the same system as the teleport (blacking out the camera before and during the movement of the VR PAWN).

5 Results and Analysis

The transcription of the interviews revealed 13 themes, divided into 4 categories as shown in Table 1. This section explains how these categories arose, based on quotes from the interview participants and also provide context for these categories, based on previous theories.

Category	Themes
Engagement	Amazement, Engagement, Expectations
Presence	Immersion, Spatial Presence, Spatial Sound
User Interactions	Camera, Input, UI
User Experience	Familiarity, Learning Curve, In Control, Simulation Sickness

Table 1: Categories and Themes

5.1 Demographic

We conducted ten semi-structured interviews with students of Game Design from campus Gotland of Uppsala University (not including a pilot test interview). The participants were between the ages of 18 and 29, and were mostly Swedish. The specific demographic details (not in participant order) are listed in table 2.

Age	Nationality
18	Swedish
19	Swedish
20	Dutch
20	Swedish
21	Swedish
22	Swedish
23	Czech Republic
23	Swedish
23	Swedish
29	Swedish

Table 2: Demographics

5.2 Engagement

The purpose of this study is to explore the ways in which VR can help create a more engaging spectator experience. This category consists of the responses that help answer this question. It also includes two additional themes: "amazement" and "expectations".

The first of these, deals with comments that convey a sense of "amazement" about the VR experience, potentially due to it being rare. This theme is best exemplified through a comment by participant 9, *It's definitely more epic*, in response to the interview question about describing the VR experience. In the context of our theoretical framework, O'Brien and Toms (2008) does mention "novelty/variety" as a factor for engagement.

After the interviews, we noticed a few comments that seemed to indicate that participants wanted something *more*, than the traditional spectating. This feeling was best described by participant 7, in the comments *I felt like I was a player that couldn't be killed in VR than like a spectator with the controller I just... hoping I can have a gun. That's what I was hoping to have with VR* and *Come on, turn around, he's over there, let me shoot him for you. Oh no, I can just, walk through that person. It felt more like a game and the other felt more like a spectator sport with the controller.* In addition to this, there were a few comments about a lack of interaction while in the spectator experiences, with both on-screen and

VR modes, as illustrated in a quote (about the on-screen experience) by participant 2, *That felt like me looking at other people... like I felt like less than a bystander*. These *expectations* of wanting something more, of wanting more *interactions* are similar to what the spectator-players, mentioned in Stahlke, Robb, and Mirza-Babaei (2018), would want. This aspect will be discussed in greater detail, in section 6.3.

Finally, the main theme within this category consists of comments specifically about engagement itself. The concept of engagement is essential to the research question. To this end, we always asked a fixed question about engagement, asking for a comparison of the engagement felt in the two experiences. An interesting aspect is that all mentions of the term "engagement" were in response to the specific question in the interview about engagement. In any case, we received mixed responses to this question. Some described as being more engaged with the on-screen experience, such as participant 2, stating *I think I'd say I was more engaged with the controller*. Others felt more immersed in VR, such as participant 6 who stated *I was engaged in the action in an entirely different way because I was... I needed to find different viewpoints all of the time.*

Some of the interesting quotes and comments in this category are listed in table 3.

Theme	Participant	Type	Quote
Amazement	Participant 7	VR	One is more a novelty. (Which one?) VR. It's something new and it's fun.
Amazement	Participant 9	VR	It's definitely more epic.
Engagement	Participant 2	Both	I think I'd say I was more engaged with the controller.
Engagement	Participant 4	VR	But VR was a bit more engaging once you actually get to the action.
Engagement	Participant 5	VR	Higher engagement definitely in the VR. It is the sense of "you are in the action" instead of "on the sidelines watching". So like being engaged going up close to the combat.
Engagement	Participant 6	VR	I was engaged in the action in an entirely different way because I was... I needed to find different viewpoints all of the time.
Engagement	Participant 11	VR	I don't know if it was because it was my first time experiencing vr, but it, that's what engaged me the most and where I had the most fun for sure.
Expectations	Participant 7	VR	I felt like I was a player that couldn't be killed in VR than like a spectator with the controller I just... hoping I can have a gun. That's what I was hoping to have with VR.
Expectations	Participant 7	VR	Come on, turn around, he's over there, let me shoot him for you. Oh no, I can just, walk through that person. It felt more like a game and the other felt more like a spectator sport with the controller.
Expectations	Participant 2	On-Screen	That felt like me looking at other people... like I felt like less than a bystander
Expectations	Participant 8	VR	I didn't feel like I was doing much

Table 3: Engagement

5.3 Presence

One of the main concepts in our theoretical framework is that of spatial presence. Many of the aspects mentioned in Coelho et al. (2006) were implemented in the VR spectator experience and this category

contains the comments that show the results of this. Several of the participants mentioned presence, both in response to the specific question about it and unprompted.

The comments about immersion are also included in this category, because the way it was described seems very similar to the concept of presence. For example, participant 8 describes the VR spectator experience in the comment: *VR felt a lot more immersive, I felt I was there, actually spectating the game.* This comment was before the interview question about presence, and is an example of an unprompted comment about presence.

Most of the participants did feel a sense of presence and this was a lot higher in VR. An example of this is the statement by participant 9: *I felt more present with the headset, because like, it's more like you are actually there and with controlling the screen, it feels more like controlling the camera... with the headset, it feels more like you are there instead of just a camera.*

There were also some comments about how sound helped with navigation in VR, such as the one by participant 5: *It was easier to find action in it because you would have a 3D sense of view where the actual sound is coming from, in another way. So it was easier to just swing your head around, "OK, there is the action. Perfect. Just follow that".*

Table 4 details the quotes in this category that are of interest to this study.

Theme	Participant	Type	Quote
Immersion	Participant 5	VR	It's a lot more immersion. Its a lot more action based. You are in the action instead of a spectator on the sideline. Because you are standing in the middle of the fight and you can look left, look right, you can see the guys firing in between you. You can stand behind his shoulder, "OK, what does he see?"
Immersion	Participant 8	Both	VR felt a lot more immersive, I felt I was there, actually spectating the game
Spatial Presence	Participant 4	Both	Not really its almost the same level of presence there because in both modes you are almost as you are flying.
Spatial Presence	Participant 5	VR	You have a 360...at the moment when you have the headset on, it is your reality. That's all you see. Your peripheral is the game. Your focus is the game. Everything is happening around you...you are a part of it...You turn around and you do stuff and sometimes you forget that, "Oh yeah this isn't real. I can peek my head through the wall". But you are in it, in the moment.
Spatial Presence	Participant 9	Both	I felt more present with the headset, because like, it's more like you are actually there and with controlling the screen, it feels more like controlling the camera...with the headset, it feels more like you are there instead of just a camera.
Spatial Presence	Participant 11	VR	Because I was right there, like, I was looking at the characters, like, you can look around and see the guy coming to your side and the action unfolding...next to you and...yea...It was nice.

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Theme	Participant	Type	Quote
Spatial Sound	Participant 5	VR	It was easier to find action in it because you would have a 3D sense of view where the actual sound is coming from, in another way. So it was easier to just swing your head around, "OK, there is the action. Perfect. Just follow that."

Table 4: Presence

5.4 User Interactions

The user interactions category deals with the comments about the ways in which participants interacted with the spectator experience. This includes the details about viewing the game and moving around in the two experiences. Comments relating to the lack of UI, such as problems caused by it and suggestions to fix it are also listed in this category, since they deal with ways in which interaction can be improved.

In terms of camera, participants mentioned that it was convenient and easy to look around by turning their head in VR. For example, participant 5 stated: *That one is easier to do in VR because you can turn your head a lot faster than you can do with a joystick, for example.* Some mentioned that it was not possible to see what the player was seeing and that this led to missing out on seeing the first contact, while others had the opposite, commenting about the possibility to go up to a player and see details that wouldn't be noticed as easily while spectating on a screen. This is best illustrated through the quotes by participants 2 and 5. Participant 2, when talking about VR, said: *When that player saw something, I wouldn't see what they saw unless I got up to them. So I missed that first contact every time.* Participant 5 on the other hand, mentioned: *You can go up to see... OK, what is he seeing? What is going on right now? You get those details you wouldn't notice, when you are just spectating on a screen.* Another aspect about this theme is that some participants had trouble positioning themselves in a good way to view the action. Participant 9 explains this in the statement: *But, it's also more difficult to position yourself correctly, because you have to like, turn around with the camera and then like aim and you have to find some grounds to stand on.* This aspect is also related to the input theme.

According to most of the participants, it is easier to traverse the map in the on-screen experience with the controller, than the VR experience with teleport. This is best illustrated through a comment by participant 9: *With the controller, it is easier. With the vr, like, at least I had some clunky mistakes that you click but then you teleport down instead of to the other level. So you lose out on some action. But with the controller, you know where you are flying.* Reasons for this pattern include the possibility of zooming back in the on-screen experience and the teleportation range in the VR experience. Participant 7 mentions the possibility of zooming out, in the comment *Coz I can go zoom back every now and then, when I kinda lost someone.* Participant 4 talks about the teleport range in the comment *But at points when I see something on the far end of the map but the teleport range meter just doesn't reach that... But when I get there the action is already over.*

The last aspect of this category are the comments we received on the lack of UI and how to improve it. These include suggestions to include a minimap and other UI elements to both spectating experiences as well as comments about aspects that were difficult to determine, such as: player positions, distinguishing player from bot and figuring out when the rounds started or ended. Comments that illustrate this include: *I tried following one of you during each round but it... it always turned out to be... oh it's a bot so I have to follow someone else*, as stated by participant 6 and *Minimap, view cone, stuff like this helps a lot so you can see some of them being shot and he just dies and you look round, "OK, where is it?"*, as stated by participant 5. The comments on a lack of UI were also a possible indication that the spectators wanted to have more interactions within the experience, similar to the spectator-players defined in Stahlke, Robb, and Mirza-Babaei (2018), even though the UI suggestions by the participants and the article are different. See section 6.3 for details.

The themes and quotes in this category are detailed in Table 5.

Theme	Participant	Type	Quote
Camera	Participant 2	VR	When that player saw something, I wouldn't see what they saw unless I got up to them. So I missed that first contact every time.
Camera	Participant 5	VR	You can go up to see... OK, what is he seeing? What is going on right now? You get those details you wouldn't notice, when you are just spectating on a screen.
Camera	Participant 5	VR	That one is easier to do in VR because you can turn your head a lot faster than you can do with a joystick, for example.
Camera	Participant 9	VR	But, it's also more difficult to position yourself correctly, because you have to like, turn around with the camera and then like aim and you have to find some grounds to stand on.
Input	Participant 3	VR	If there was a point where I could just teleport to where something happened that would push it even further.
Input	Participant 4	VR	But at points when I see something on the far end of the map but the teleport range meter just doesn't reach that... But when I get there the action is already over.
Input	Participant 7	On-Screen	Coz I can go zoom back every now and then, when I kinda lost someone.
Input	Participant 9	Both	With the controller, it is easier. With the vr, like, at least I had some clunky mistakes that you click but then you teleport down instead of to the other level. So you lose out on some action. But with the controller, you know where you are flying.
UI	Participant 5	Both	Minimap, view cone, stuff like this helps a lot so you can see some of them being shot and he just dies and you look round, "OK, where is it?"
UI	Participant 6	VR	I tried following one of you during each round but it... it always turned out to be... oh it's a bot so I have to follow someone else.

Table 5: User Interactions

5.5 User Experience

The last category from the thematic analysis is User Experience. This category deals with the experiences of the participants from using both modes of spectating. It includes the feelings of familiarity and being in control, that participants mentioned. In addition to pre-existing familiarity with the systems in the experiences, there were also comments about familiarity gained through the use of the spectator experiences, which are mentioned in the "learning curve" theme.

The feeling of inherent familiarity was more prominent with the on-screen spectating, while the learned familiarity was mentioned in relation to both types of spectating. Examples of comments about the former include: *With the controller, it was very intuitive, because I can... I could free form camera, it's like playing a game almost*, as stated by participant 11 and *it felt like... you know what you typically see in... like tournament spectating and so on*, as stated by participant 2. Examples of the learning curve

theme include the statement by participant 6 about the VR spectator experience: *After a few goes it turned into this very familiar feeling of just jumping around following someone and the different controls became intuitive* and the statement by participant 8 about the on-screen experience: *I kinda got a feel for the map a bit more.*

The theme of being *in control* deals with both the feeling of *being in control* and of *having control*. Participants have reported this feeling in the use of both experiences. For instance, participant 6 mentioned: *So it was more intense and it was more, you know, I was more in control of the camera rather than standing still*, about the VR experience. Participant 7 had a similar comment about the on-screen spectator experience, stating: *I felt like I had more control... since it was kind of fast paced I think that with the control I could react much faster, "Oh, they are going over there now" and then just being omniscient and going there.*

Table 6 details the quotes in this category.

Theme	Participant	Type	Quote
Familiarity	Participant 2	On-Screen	It felt like... you know what you typically see in... like tournament spectating and so on.
Familiarity	Participant 5	On-Screen	I would say that one is a lot more laid back spectating. Namely just the normal screen one... You can actually just sit down and watch a game in peace and quiet, so to say.
Familiarity	Participant 11	On-Screen	With the controller, it was very intuitive, because I can... I could free form camera, it's like playing a game almost.
In control	Participant 6	VR	So it was more intense and it was more, you know, I was more in control of the camera rather than standing still.
In control	Participant 7	On-Screen	I felt like I had more control... since it was kind of fast paced I think that with the control I could react much faster, "Oh, they are going over there now" and then just being omniscient and going there.
Learning curve	Participant 6	VR	After a few goes it turned into this very familiar feeling of just jumping around following someone and the different controls became intuitive.
Learning curve	Participant 8	On-Screen	I kinda got a feel for the map a bit more.

Table 6: User Experience

5.6 Comparisons

This study focuses on thematic analysis with qualitative data. As such, the statistics of how many times a theme occurs is less relevant. However, we would like to mention the preferences of the participants in some of the key areas, to provide a bit of context.

Figure 1 shows the data about which spectating mode the participants felt more spatially present in. Figure 2 compares the experiences in terms of which is more engaging. Lastly, figure 3 shows which experience felt easier to navigate.

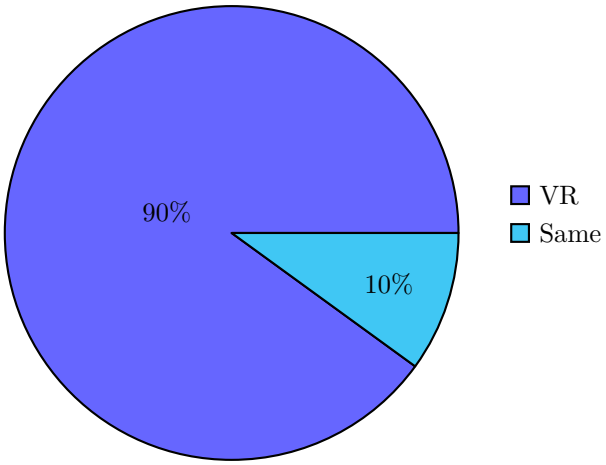

Figure 1: Spatial Presence

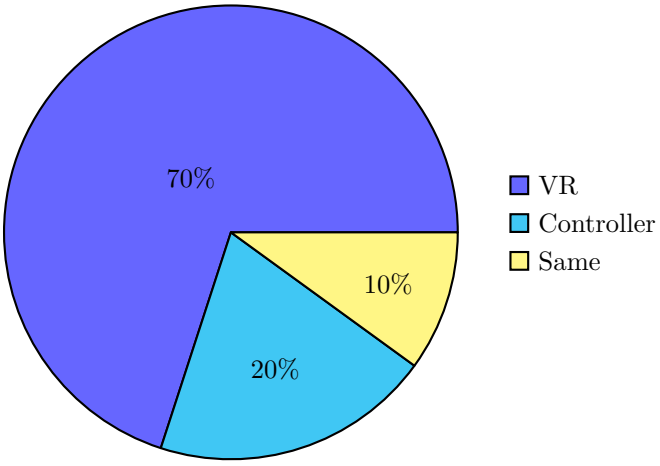

Figure 2: Engagement

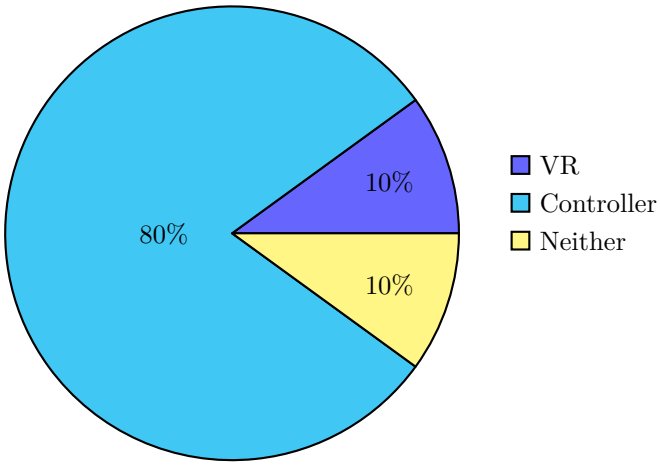

Figure 3: Ease of Navigation

6 Discussions

Our research question is: In what ways can Virtual Reality be used to provide a more engaging spectator experience? Through the study, we found the following factors affecting engagement when spectating in VR:

- VR allows the spectator to be closer to the action, which participants found to be more engaging.
- Participants found it harder to navigate in VR, which generally led to a decrease in engagement. However, this sometimes increased engagement indirectly, because the harder controls meant a higher requirement of involvement to follow the action properly, which in turn led to better engagement.
- Some participants found the experience more engaging because VR was something new for them.
- Some participants felt more engaged with the character or the environment, instead of the gameplay.

In addition to the findings about engagement, the study also revealed some interesting aspects:

- The term immersion was used by a lot of the participants, unprompted. Their use of the term and context surrounding it indicates that they used it to mean the same thing as spatial presence.
- There may not be a correlation between engagement and spatial presence in this context.
- We attempted to minimize simulation sickness and discomfort as much as possible, but they were still present.

This section will discuss all of these aspects in further detail.

6.1 Presence and Immersion

Almost all participants experienced a sense of presence in the VR spectator experience. The VR spectator experience implements several of the guidelines by Coelho et al. (2006), and the results we got are in agreement with their study.

The addition of 3D sound served to enhance the sense of presence, as expected from the conclusions about sensorial channels in the study by Coelho et al. (2006). The same can be said about vision field, as illustrated in a comment by participant 5 in Table 4: *You have a 360... at the moment when you have the headset on, it is your reality. That's all you see. Your peripheral is the game. Your focus is the game. Everything is happening around you... you are a part of it... You turn around and you do stuff and sometimes you forget that, "Oh yeah this isn't real. I can peek my head through the wall". But you are in it, in the moment.*

In section 2.5, we suggested that immersion and spatial presence may be used interchangeably in the context of this study. The comments from the participants suggest that this is indeed the case. For instance, take the quote by participants 5 and 8 in table 4. Participant 5 describes immersion, saying: *It's a lot more immersion. Its a lot more action based. You are in the action instead of a spectator on the sideline. Because you are standing in the middle of the fight and you can look left, look right, you can see the guys firing in between you. You can stand behind his shoulder, "OK, what does he see?".* The relevant part of this quote is the description of being "in the action". Participant 8 describes the same in less words, stating: *VR felt a lot more immersive, I felt I was there, actually spectating the game.* In section 2.5, we mentioned some similarities in the definitions of spatial presence and immersion. These quotes also contain said similarities. This serves as further evidence to "spatial presence" and "immersion" being synonymous in this context. Another point of interest about immersion is that it was never mentioned in the interview questions. Participants volunteered this term unprompted. However, this could be because the participants were all students of a Game Design education.

6.2 Engagement

The comparison of engagement revealed mixed results. Some felt more engaged with the character or environment, as opposed to the gameplay. Some felt more engaged with the controller. Some felt equally engaged with both spectator experiences.

An interesting aspect in the comments, is that both participants 2 and 8 felt less engaged with the VR experience but more present, while participant 4 felt more engaged in the VR experience but equally present. Going into the details, participant 8 felt immersed in the experience, as noted in the comment: *VR felt a lot more immersive, I felt I was there, actually spectating the game.* However, when asked about engagement, participant 8 responded with: *I didn't feel like I was doing much.* An example of the opposite is participant 4 who felt more engaged in the VR experience but did not feel any additional sense of presence. This can be seen in the quotes: *But VR was a bit more engaging once you actually get to the action* about engagement and *Not really its almost the same level of presence there because in both modes you are almost as you are flying* about presence. This goes against the definitions of engagement by Brown and Cairns (2004), Bouvier, Lavoué, and Sehaba (2014) and Chen et al. (2011). Brown and Cairns (2004) and Bouvier, Lavoué, and Sehaba (2014) define engagement as something that leads to either immersion or presence, which was not the case for participant 8, who felt immersed without the engagement that the theories propose leads to it. Chen et al. (2011) mentions that engagement places the user in an immersive state, which was not the case with participant 4. This conclusion also goes against our earlier assumption from section 2.6, that there is some form of correlation between engagement and presence.

Another interesting aspect is what participant 6 stated about engagement in the VR experience, *I was engaged in the action in an entirely different way because I was... I needed to find different viewpoints all of the time.* The interesting part about this, is that VR being more difficult to navigate and control (according to most of the participants), may have led to an unintended increase in engagement. This is connected to the definition of engagement by Chen et al. (2011), *a sustained level of involvement caused by capturing a person's interest, holding the majority of a person's attentional resources, and placing the person in an immersive state.* The key points in this are "involvement" and "holding the majority of a person's attentional resource". This is also connected to the statement by Sanders and Cairns (2010), *the sense of being "in a game" where a person's thoughts, attention and goals are all focused in and around the game as opposed to attending to being concerned with anything else, such as what is going on in the room around them*, even though they discuss immersion and not engagement. The connection, is in the mention of "thoughts, attention and goals" being "focused in and around the game". These theories state that focus, attention and involvement on the task are requirements for engagement or immersion. Participant 6 mentioned being engaged because of being focused and involved with the task. In other words, the difficulty with the controllers led to a higher level of involvement and focus which may have led to more engagement! This is in fact, in agreement with the theories, because they define focus or attention as requisites for engagement. What the theories do not mention is how difficult controls can lead to an increased level of involvement to get it working. Two points of further interest in this, are that the quoted response was before the interview question about engagement and that participant 6 was the only one to mention engagement unprompted.

Lastly, we noticed several comments along the lines of "VR is cool". Since it is a relatively new and uncommon technology, it is likely that most people have very little experience with it. This could have contributed to an increase in engagement as well, as mentioned in the comment by participant 11, *I don't know if it was because it was my first time experiencing vr, but it, that's what engaged me the most and where I had the most fun for sure.* This is in agreement with the attributes of engagement suggested by O'Brien and Toms (2008), especially "novelty/variety".

6.3 Interaction

As mentioned earlier, we disabled all interactions between player and spectator, to avoid distractions and interferences. The spectator experience was focused on passive spectators. As a consequence, both the engagement and presence were reduced for some participants, as illustrated in a comment by participant 8: *I didn't feel like I was doing much.* To explain this, we need to look at multiple theories from section 2.

To start with, Coelho et al. (2006) describes the representation of others, control over actions in the virtual world and actions that have an impact on the virtual world as factors affecting presence. Both O'Brien and Toms (2008) and Bouvier, Lavoué, and Sehaba (2014) also mention interaction, as a factor affecting engagement. The conclusion that some participants felt a reduced sense of presence and engagement is in accordance with all 3 of these theories. The conclusion is also in agreement with the study by Stahlke, Robb, and Mirza-Babaei (2018), especially in the description of interacting spectator-players. We did have "direct viewer participation" as suggested by Stahlke, Robb, and Mirza-Babaei (2018), to some

extent through the use of VR. Participants felt that they were "in the match". However, we did not have the interaction part of the mechanic. The theories suggest that spectators, especially those who prefer an active role, will end up wanting something more, due to the lack of interaction. The best illustration of this is participant 7 who mentioned wanting to get a weapon in the VR experience and jump into the match!

This topic is also connected to the lack of UI. Many of the design suggestions by Stahlke, Robb, and Mirza-Babaei (2018), require some form of UI. Although many of these are not suited for VR directly, the lack of UI does limit the possibility of interaction. However, it would have been beneficial to add some form of UI to both spectator modes. This includes a mini-map to see the other players, outlines to see them through walls, a way to distinguish bot and player, round status info and so on. The lack of these have been noted by many participants, including participants 5 and 6. Their specific quotes in this matter can be found in section 5.4. The reason we did not have any UI elements was because of the design considerations for making VR compatible stereoscopic UI. But this could have been mitigated by attaching the UI to the in-game visualization of the controller. This could have opened the possibility of adding elements like minimap and round info, and several of the mechanics suggested by Stahlke, Robb, and Mirza-Babaei (2018).

6.4 Simulation Sickness

Several aspects of the guidelines established by Epic Games (2019b) to minimize simulation sickness were already implemented in the unreal VR PAWN (Epic Games 2019a). This did help to some extent, in that no one felt any nausea or motion sickness. However, some participants did feel disoriented in the VR experience, some felt a level of discomfort when too close to the edges and one had a slight headache. Based on this, we conclude that the guidelines are just that, guidelines. They serve to reduce simulation sickness, but it cannot always be avoided completely.

7 Conclusions

Based on our findings, it is reasonable to assume that VR can provide a more immersive and engaging spectator experience. It is also reasonable to assume that users feel an increased sense of presence in VR. However, the engagement can be enhanced even further, by adding more interactions and UI elements to better accommodate spectators who prefer a more active role, as stated in Stahlke, Robb, and Mirza-Babaei (2018). Other aspects such as movement systems and maps could also be improved, to enhance engagement.

We also found that engagement may not always be related to immersion or spatial presence, since some participants felt more present and less engaged in VR and vice-versa. This shows that some of the definitions for these terms may not be entirely accurate in this context. This also shows that our own assumption in section 2.6 about a correlation between spatial presence and engagement is not always accurate. As for spatial presence and immersion, the participants used the two terms to describe similar sensations. Based on this, and the similarities in the theoretical framework, we conclude that the two terms may be used interchangeably in this specific context.

In terms of simulation sickness, none of the participants experienced any nausea, but one did feel a slight headache. This shows that it may not be possible to completely remove all forms of discomfort with VR, for all people. It is most likely that the guidelines do help minimize simulation sickness, but it does not remove it completely.

Finally, we found reasons to suspect that unexpected factors like difficulty with the movement in VR and novelty of VR may have also led to an increased sense of engagement. This is based on quotes such as *I don't know if it was because it was my first time experiencing vr, but it, that's what engaged me the most and where I had the most fun for sure*, by participant 11 and *I was engaged in the action in an entirely different way because I was... I needed to find different viewpoints all of the time*, by participant 6. These indications are also in agreement with both the attributes of engagement by O'Brien and Toms (2008) and the definition of engagement by Chen et al. (2011).

In conclusion, we believe that VR spectating can evolve into something that affords more engagement and interaction than traditional spectating.

8 Future Work

This study explores some aspects of VR spectating, but there are several unexplored topics which are beyond our current scope. As such, we propose the following topics for future research:

8.1 Different audience and fields

This study was based on a very specific combination of game, genre and participant population. It would be interesting to test if the same results are obtained in different settings. There are many game genres and types out there and a common solution for spectating everything seems unlikely. For example, we conducted our tests using a First Person Shooter game and this may not fit any other genres. It may not even fit other First Person Shooter games. Different genres of games will need to be tested for suitable interactions. Similarly, it might also be possible to introduce Virtual Reality to traditional forms of spectating. It would also be interesting to broaden this study to include a wider range of age and experience with games.

8.2 Correlation between Presence and Engagement

Our conclusions show that there may not always be a correlation between presence and engagement. This goes against the definitions of engagement in Brown and Cairns (2004), Bouvier, Lavoué, and Sehaba (2014) and Chen et al. (2011). It also shows that our assumption about this, from section 2.6, is inaccurate within the context of this study. But the question remains as to what caused this in the first place. Was this because the participants understood the terms engagement and presence in a different way than the definitions in the theories? If so, was that influenced by an education in Game Design? Do the theories themselves need a revision perhaps? However, all these aspects are beyond the scope of this study and are left for future research.

8.3 Correlation between Engagement and Familiarity

As mentioned earlier, the engagement with the VR experience might be related to the "novelty" of the technology. This is in agreement with the factors of engagement suggested by O'Brien and Toms (2008). This could be tested through a prolonged study with the same participants, to see if they become less engaged in VR spectating with time and the resulting familiarity. However, such a study would require a prolonged research on a longer timeframe than possible within the scope of this study. As such, it is also left for future research.

8.4 Spectator Interactions

In order to satisfy the spectators who prefer an active role, we suggest two changes in the add-on. First, the possibility for multiple spectators to see the match and communicate with each other, in accordance with the social aspect of spectatorship by Stahlke, Robb, and Mirza-Babaei (2018) and the virtual representations of others aspect by Coelho et al. (2006). And second, adding more UI elements such as those suggested by Stahlke, Robb, and Mirza-Babaei (2018), including: chatting, voting and cheering. However, further research needs to be conducted, to test if these suggestions do create additional engagement.

8.5 Better movement systems for VR

The main reason we used a point and teleport method for movement was to avoid simulation sickness as much as possible. However, several of the participants still complained about it, for various reasons. Studies could be conducted on the different movement schemes and how they impact the spectator experience and simulation sickness. Also, further research could be conducted on creating a brand new way of navigating in VR.

8.6 VR as a promotional device

We mentioned earlier that the VR experience left some participants wanting more. One of the participants even wanted to grab a weapon and join the game. This immersive quality of VR could potentially be used as a promotional device for marketing games.

8.7 VR Eye-tracking to identify points of interest

Eye-tracking technology has been employed to create heatmaps of areas that are most viewed on a screen. This could be applied to VR spectating, to better learn how the spectators observe a match while in VR and compare it to when they would spectate on a screen. This data could then be used to identify points of interest within the map, to potentially improve the quality of both the map and the spectator experience.

9 Final Thoughts

Aspiring for Virtual Reality as a concept, rather than a technology, seems to be more of a meaningful pursuit. This could lead to an amalgamation between Augmented Reality glasses and Virtual Reality headsets as a more promising direction to explore, in terms of providing an enhanced experience for spectators. For instance, this will allow the possibility to overlay additional information on the real world itself! However, information overload is a thin line to walk and in terms of both Virtual and Augmented Realities, this line becomes even thinner.

Finding the balance between providing information to a spectator and allowing the actual spectating unhindered, is a source of constant testing and refinement. With this in mind, we hope that VR and VR spectating will evolve to provide a better experience for both passive and interacting spectators alike. We hope that this study will help in the creation of the next evolution in VR spectating.

References

Bartle, Richard A. (2004). *Designing Virtual Worlds*. New Riders Games Series. New Riders. ISBN: 9780131018167. URL: https://books.google.co.uk/books?id=z3VP7MYKqaIC.

BloodBerry Games (2019). *Nova Factor*. URL: https://bloodberry-games.itch.io/nova-factor.

Bouvier, Patrice, Elise Lavoué, and Karim Sehaba (2014). "Defining Engagement and Characterizing Engaged-Behaviors in Digital Gaming". In: *Simulation & Gaming* 45.4-5, pp. 491–507. DOI: 10.1177/1046878114553571. eprint: https://doi.org/10.1177/1046878114553571. URL: https://doi.org/10.1177/1046878114553571.

Brown, Emily and Paul Cairns (2004). "A Grounded Investigation of Game Immersion". In: *CHI '04 Extended Abstracts on Human Factors in Computing Systems*. CHI EA '04. Vienna, Austria: ACM, pp. 1297–1300. ISBN: 1-58113-703-6. DOI: 10.1145/985921.986048. URL: http://doi.acm.org.ezproxy.its.uu.se/10.1145/985921.986048.

Chen, Mark et al. (2011). "Modeling but NOT Measuring Engagement in Computer Games". In: *Proceedings of the 7th International Conference on Games + Learning + Society Conference*. GLS'11. Madison, Wisconsin: ETC Press, pp. 55–63. URL: http://dl.acm.org/citation.cfm?id=2206376.2206383.

Cheung, Gifford and Jeff Huang (2011). "Starcraft from the Stands: Understanding the Game Spectator". In: *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. CHI '11. Vancouver, BC, Canada: ACM, pp. 763–772. ISBN: 978-1-4503-0228-9. DOI: 10.1145/1978942.1979053. URL: http://doi.acm.org.ezproxy.its.uu.se/10.1145/1978942.1979053.

Coelho, Carlos et al. (2006). "Media presence and inner presence: The sense of presence in virtual reality technologies". In: *From Communication to Presence: Cognition, Emotions, and Culture Towards the Ultimate Communicative Experience : Festschrift in Honor of Luigi Anolli*. Ed. by L. Anolli and G. Riva. Vol. 9. IOS Press. Chap. 2, pp. 25–45. ISBN: 9781586036621.

Cote, Amanda and Julia G Raz (2015). "In-depth interviews for games research". English. In: *Game Research Methods: An overview*. Ed. by Petri Lankoski and Staffan Björk. Chap. 7.

Epic Games (2019a). *Pawn*. URL: https://docs.unrealengine.com/en-US/Gameplay/Framework/Pawn.

Epic Games (2019b). *Virtual Reality Best Practices*. URL: https://docs.unrealengine.com/en-us/Platforms/VR/ContentSetup.

Hartmann, Tilo et al. (2015). "Spatial presence theory: State of the art and challenges ahead". English. In: *Immersed in Media: Telepresence Theory, Measurement & Technology*. Ed. by Matthew Lombard et al. Springer International Publishing. Chap. 7. ISBN: 9783319101903.

Hoffman, Hunter G. et al. (2003). "The Illusion of Presence in Immersive Virtual Reality during an fMRI Brain Scan". English. In: *CyberPsychology & Behavior* 6.2, pp. 127–131. ISSN: 10949313.

Newzoo (2018). *Newzoo's Key Numbers*. URL: https://newzoo.com/key-numbers/.

O'Brien, Heather L. and Elaine G. Toms (2008). "What is user engagement? A conceptual framework for defining user engagement with technology". In: *Journal of the American Society for Information Science and Technology* 59.6, pp. 938–955. DOI: 10.1002/asi.20801. eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1002/asi.20801. URL: https://onlinelibrary.wiley.com/doi/abs/10.1002/asi.20801.

Sanders, Timothy and Paul Cairns (Oct. 2010). "Time perception, immersion and music in videogames". In: pp. 160–167.

Stahlke, Samantha, James Robb, and Pejman Mirza-Babaei (Jan. 2018). "The Fall of the Fourth Wall: Designing and Evaluating Interactive Spectator Experiences". In: vol. 10. 1. Hershey, PA, USA: IGI Global, pp. 42–62. DOI: 10.4018/IJGCMS.2018010103. URL: https://doi.org/10.4018/IJGCMS.2018010103.