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Jussi Nousiainen

Exploring movement and enjoyment in VR games

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Author: Jussi Nousiainen
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Supervisor: Juho-Pekka Mäkipää
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ABSTRACT:

Physical activity and health is declining globally as more and more people adopt increasingly sedentary lifestyles. This decline comes with many health-related risks in people of all ages and demographics. Video games are often seen as a large cause of this, which is why many game developers and companies have attempted to combat this stigma by creating games and systems that provide means of exercise while gaming. These types of games are commonly known as exergames, and Virtual Reality is the newest technology that is attempting to make use of exergaming with immersive and engaging games.

Performing physical activity that has a high potential to be effective, engaging, and enjoyable for users, from the comfort of their own homes, is a proposition that VR gaming has the potential to fulfill for many. For this purpose, this research seeks to explore the possibilities of enjoyable physical activity in VR exergames and find answers for which design themes are especially effective for enjoyable movement and long-term engagement.

The research was done with a basis on phenomenology and phenomenography, which are both studies heavily based on experiences of specific phenomena. Five different VR games were chosen for testing for the study and analyzed based on the provided movement and activity, as well as enjoyment. This data was measured and gathered via heart rate tracking, and a focus on the experiences of flow in VR. Additionally, an open written interview was performed with a participant with years of previous experience in VR gaming to gather more data for an outside experience view. The results of these experiences and feedback were then analyzed and compared to previous research on the subjects of VR enjoyment and exercise.

The conclusions gathered from the research were formed into a list detailing beneficial design themes that help improve enjoyability and engaging movement in VR exergames. The provided list can serve as a helpful tool to both developers and future research on the matter of enjoyability and engaging movement in VR games, from a user experience perspective. Furthermore, Virtual Reality games can be said to positively increase engagement and enjoyability for physical activity when designed well. Future research can expand on this study by widening the scope of participants and including a larger variety of VR games to gather more data on user experiences.

KEYWORDS: Virtual Reality Gaming, Virtual Reality Exercise, Enjoyment in VR, Exergames

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TIIVISTELMÄ:

Fyysinen liikkuvuus ja hyvinvointi on laskusuunnassa maailmanlaajuisesti, sillä yhä useampi henkilö adoptoi elämäntyytlejä, joissa liikkuvuus on vähäistä. Tämä tuo mukanaa monia hyvinvointiin liittyviä riskejä kaikille ikäluokille. Videopelit nimetään usein yhdeksi isoksi syyksi yleiseen liikkuvuuden vähentymiseen maailmalla. Pelintekijät ja pelifirmat ovat pyrkineet taistelemaan tätä vastaan kehittämällä systeemejä ja pelejä, jotka yhdistävät pelaamisen ja liikkumisen. Tämän tyyliä pelejä kutsutaan yleisesti nimellä exergames, joka tulee englanninkielen sanoista exercise, eli liikunta, ja game, eli peli. Virtuaalinen todellisuus (VR) on uusin teknologia, joka pyrkii hyödyntämään liikkuvuutta peleissä.

Idea kotona suoritettavasta tehokkaasta ja nautinnollisesta fyysisestä liikkunnasta, joka viehättää käyttäjän mukaansa on ehdotus, jonka VR pelaaminen mahdollistaa monelle. Tämä tutkinto pyrkii tätä tarkoitusta varten tutkimaan liikkuvuutta ja nautintoa VR-peleissä, ja löytämään pelimekaniikkoja ja teemoja, jotka mahdollistavat suuremman nautinnon ja tehokkaamman liikkumisen näissä peleissä.

Tämän tutkimuksen menetelmänä toimii yhdistelmä fenomenologiaa ja fenomenografiaa, jotka ovat laajalti omiin ja muiden suoriin kokemuksiin perustuvia laadullisia menetelmiä. Tutkimukseen on otettu testattavaksi viisi eri VR-peliä, joita tulen itse pelaamaan ja keräämään tietoa ja kokemuksia niiden nautinnollisuudesta ja liikkuvuudesta. Liikkuvuudesta kerätään tieto sykemittarin avulla, ja nautinnollisuuden kokemusten perustana toimii laajalti tutkittu flow-malli, joka mittaa erilaisia tuntemuksia aktiviteeteissä. Tämän lisäksi tutkimuksessa suoritetaan kirjallinen haastattelu ulkopuolisen henkilön kanssa, jolla on vuosien kokemuksia VR-peleistä. Näistä tutkimuksista löydetyt tiedot kerätään ja analysoidaan, sekä verrataan aiempiin tutkimuksiin ja löydöksiin VR liikunnan alalla.

Tutkimuksen löydöksistä luotiin lista, jossa luetellaan hyödyllisiä teemoja liikkuvuuden ja nautinnollisuuden suhteen VR-peleissä. Pelintekijät ja tutkijat voivat hyödyntää tätä listaa vertausarvallisesti pelinkehityksessä ja muissa VR liikuntaan liittyvissä tutkimuksissa. Nämä teemat antavat erityisesti käyttäjäkokemuksellisesti hyödyllistä tietoa VR-pelien liikkuvuudesta ja nautinnollisuudesta. Tämän lisäksi tässä tutkimuksessa voidaan vahvistaa löydöksiä VR liikunnan yleisestä hyödyllisyydestä nautinnollisen ja houkuttelevan liikunnan edistämisessä. Jatkotutkimuksissa voidaan testata useampia VR-pelejä sekä laajentaa osallistujamäärää ja kerätä laajemmin käyttäjäkokemuksia.

AVAINSANAT: Virtual Reality Gaming, Virtual Reality Exercise, Enjoyment in VR, Exergames

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1 Introduction

Maintaining a sufficient level of physical activity in day-to-day life is an important factor in lowering the risks of many health-related issues, such as heart disease, stroke, and diabetes (WHO, 2022). Yet, current estimates show that physical activity levels are largely insufficient on a global scale. WHO (World Health Organization) (2022) estimates that one in four adults, and up to 81% of adolescents do not do enough physical activity globally. In 2018 U.S National Health Interview Survey found that only 28% of men and 21% of women in the U.S reported sufficient amounts of physical activity to meet health guidelines (ODPHP, 2018). A large increase in sedentary lifestyles across the globe is seen as one major cause of this.

One large contributing factor to the increase in sedentary lifestyles is often said to be video games. Many studies go back and forth on the exact effects and causality of video games and increased levels of inactivity. Studies like Kracht, et al. (2020) have found inconclusive evidence on the causality between video gaming and obesity in children, but other studies like Puolitaival, et al. (2020) show evidence of adolescent men having less physical activity if they play video games regularly. While studies regarding this matter remain inconclusive, it is fair to say that the public opinion at large tends to favor that gaming is seen mostly as a sedentary activity, that an estimated 3.24 billion people partake in, in some form (Statista, 2021).

To promote a healthier lifestyle and increased physical activity in gaming, video game developers have launched various devices and games throughout the history of video games that allow for interactive physical movement while playing. The act of using these types of devices and games has become known as exergaming: combining the benefits of exercise, with the enjoyment of video games, often in the comfort of one's own home. While not the first video game company to launch exergames, Nintendo was the first to successfully push the concept of exergaming at home, with their release of the Nintendo Wii -game console in 2006. The motion-controlled peripheral could be used to simulate various movements in the games, and the console even launched with an exergame

included: Wii Sports. The trend of exergaming continued with Nintendo when in 2016 their intellectual property 'Pokemon' was used to create a mobile game called Pokemon Go. The game uses real-life locations and maps in Augmented Reality (AR) that allow players to physically move between places to catch different Pokemon and engage with other users, encouraging a very physically active playstyle. To date, the game has accumulated more than 620 million downloads since its release in 2016 (Sensor Tower, 2021).

While Pokemon Go made millions of people go out and explore the real world with AR, three different Virtual Reality headsets launched in the same year in 2016, to encourage people to explore the virtual world. While VR gaming is unlikely to ever obtain the same global reach as mobile gaming does, it has steadily increased in popularity over the years, with approximately 16,5 million headsets sold as of 2021, and an estimated 34 million total by 2024 (Statista, 2022a). Many developers have already started to notice its potential in one specific aspect of gaming. With total immersion, 360-degree viewing angles, full-motion tracking, and motion controllers, VR offers unprecedented possibilities in the sphere of exergaming. As the technology advances and adoption rates increase for both developers and users, it has the potential to help millions in increased engagement in physical activity, and there are already various studies that show this to be true. VR integrated exercise can help with various health benefits, such as stress relief, exercise engagement and adherence, and better enjoyment (Gao et al., 2020 p. 6-7).

The aim of this study, in particular, is to discover and research the question: "What are the best qualities and themes for Virtual Reality exergames to be effective in providing opportunities for enjoyable active movement for the player". The key characteristics here are enjoyment and movement in VR, and how they come together. Sinclair et al. (2007, p. 292) make note of two aspects in achieving success in an exergaming system: effectiveness of the exercise it provides, and attractiveness of the activity performed. Studies in the field of VR exercise tend to usually focus on elderly or disabled demographics, non-commercial or expensive VR exergame programs, and machinery and are generally done as quantitative research in controlled settings. There is currently a

lack of studies that focus on home-based VR exercise, with user experience focused research, which is why this research focuses on qualitative, experience-based research with commercial VR headsets and games. In this way, I hope for the results of this research to be more generally applicable to real-life scenarios and real experiences by users, with VR devices and exergames that are available commercially for everyone for reasonable prices. And since there is already an adequate amount of research done on the beneficial physiological effects of VR exercise, this study will instead seek to answer what qualities and themes in VR games can trigger, or help facilitate these positive effects.

For this research, I will be choosing five VR games to play and test myself. The chosen games are selected based on criteria that will be explained later in this study, but all five could be categorized as exergames. My focus while playing and testing these games is on the movement and enjoyability aspects primarily, with heart rate tracking used to gather additional data to better evaluate the game's effectiveness on physical activity, and a focus on flow-based experiences to better help evaluate enjoyment. In addition to my testing, I will be conducting a written interview for a secondhand experience with VR gaming. The method used in this research is a combination of phenomenology and phenomenography, which focus mainly on the reflection and analysis of experiences. In the analysis of these experiences, this study hopes to generate a list of game qualities and themes that best promote enjoyable physical activity in VR exergames. These qualities will also be compared with previous research in VR exercises, to see what commonalities can be found, and what else can be learned. These listed themes will hopefully provide a helpful checklist for VR game developers, to further increase the effectiveness of VR exergaming.

In the next chapter, I will explain the fundamentals and history of the Virtual Reality ecosystem and VR headsets in particular, and some of the challenges this technology faces. The following chapters will lay out the literature and research on enjoyability and movement in VR, and the detailing of this study's research methodology and approach. Those

are followed by the research results of the game testing and interview and their analysis and discussion, ending with the conclusions of the study.

2 Fundamentals of Virtual Reality

As a concept, Virtual Reality has been popular in science fiction literature and entertainment for decades, with novels like ‘Neuromancer’ by William Gibson, movies like ‘The Matrix’, and many more. The interest in truly immersive 3D spaces has been in the general consciousness of humanity for a long time. The term Virtual Reality itself was coined in the 1980s by researcher Jaron Lanier (Pope, 2018, p. 5). Many different digital technologies have been referred to as Virtual Realities in the past, but today the term is mostly used for technologies that aim to immerse the user’s senses and surroundings in audiovisual virtual environments. However, often in research, the term can be divided into immersive and non-immersive VR, and sometimes the distinction is not made. Immersive VR indicates the use of headsets or CAVE systems (cave automatic virtual environment) that surround your senses, while non-immersive VR is used for technologies that let you interact with virtual environments through flat screens using different input devices, essentially what we simply call video games. In some cases non-immersive VR is used to indicate flat-screen video games that specifically use motion-controlled devices for interaction, making the distinction even more difficult. Hassan et al. (2020, p. 1998) specify that VR today, “denotes the use of stereoscopic 3D visual output technology that aims to produce the psychological experience of ‘being there’ ”. This experience is achievable today by anyone via commercial head-mounted displays (HMDs), otherwise known as VR headsets, such as Oculus Quest, Valve Index, and PSVR.

2.1 VR headsets

The history of head-mounted displays (HMD) for VR can be traced back to the 1950s before the term Virtual Reality was even commonly used. The first such headset was called the Telesphere Mask, developed by Morton Heilig, though it did not include any motion tracking. Heilig also created a machine called Sensorama, which was a closed viewing cabinet that would immerse the user in a film by encompassing all senses. (Pope,

2018, p. 5) Over the next few decades, many companies would continue to develop and improve VR technology.

In 1995 video game company Nintendo attempted to usher in a new age of 3D gaming with the first-ever commercial VR device for video games that boasted the possibility of true 3D graphics, the Nintendo Virtual Boy. Unfortunately, it was a commercial failure and was discontinued from production and sales the following year. (Edwards, 2022.) For several years, the failure of Nintendo Virtual Boy would keep the VR gaming scene quiet, as the technology for a truly immersive VR machine was not yet possible, but in 2010 a prototype for a VR kit was created by a man known as Palmer Lucky. This would be the beginning of the device known as Oculus Rift, which would kickstart the Virtual Reality technology into mainstream commercial use. In 2013 it was first released as a developer's kit version, and in early 2014 Oculus was bought by Facebook for 2 billion USD. This was a monumental purchase at a time when there was no guarantee that VR would become a massive commercial success, but Palmer and Facebook CEO Mark Zuckerberg saw a potential for Oculus to not only become a device for VR gaming but a platform to share experiences with other players. (Rubin, 2014.)

After a few years of additional development, in 2016 Oculus Rift was released commercially. Thanks to the groundbreaking technology and potential shown by Oculus, other parties had also become interested in the new VR boom, and in the same year two other devices were released for sale: HTC corporation's PC headset, HTC Vive; and Sony PlayStation's console headset, PSVR (see picture 1). With sleek designs, increased resolutions, and accurate motion tracking, these advancements allowed users to finally experience free movement in virtual environments and added a new layer of immersive physical activity to gaming.



Picture 1. From left to right: HTC Vive, Oculus Rift, and PSVR (Bradley, 2018).

In the current year 2022, the market has continued to grow rapidly. Facebook has released a total of 3 wireless headsets over the years, and an upgraded PC headset Oculus Rift S, in 2019. The Rift S model has however already been discontinued, as Facebook – now known as Meta– focuses all their efforts on wireless headsets with their 2020 released fully wireless and self-functioning Oculus Quest 2. As the technology continues to expand, in the future we can expect new features like eye-tracking, as well as further improvements in refresh rates, resolutions, image and audio quality, and more.

2.2 Challenges of Virtual Reality use

As with all technology, and especially those that break new ground and introduce innovations, they come with their own sets of challenges and barriers that need to be addressed and mitigated as best as possible. Many of these barriers can be overcome with proper design in hardware and software, while some, like simulation sickness, can, unfortunately, be unavoidable to certain people unless a breakthrough in technology happens. (Hamilton, 2018, p. 64) In the next segment, I will discuss two major barriers to

Virtual Reality exercise, out of the four brought up in Hamilton's (2018) research: simulation sickness and physical restrictions. Hearing loss and visual impairments are the other two discussed challenges in the research, but since they are more specific disabilities, I will not discuss them here. Like Hamilton's own research, this is not intended to be a comprehensive list of the issues present for the Virtual Reality platform, nor an in-depth analysis of the challenges I bring up, but rather a representation of the ones that affect the accessibility of VR the most.

2.2.1 Simulation Sickness

Simulation sickness, otherwise also known as cybersickness or VR sickness (Saredakis et al., 2020, p. 2), works on the same principle as regular motion sickness, but in reverse. Whereas motion sickness is a person's visual system saying they are stationary when in reality they are moving, simulation sickness occurs when a person's visual system is saying they are moving, when in reality they are stationary (Hamilton, 2018, p. 65). It has the same characteristics in symptoms, which include dizziness, eye fatigue, headaches, and nausea.

This is the barrier to Virtual Reality accessibility that usually comes up first for most users unless disabilities inhibit use in other ways. It is a significant challenge that can impair the use, or lessen the enjoyment of VR gaming for anyone regardless of their ability to otherwise use the technology. Yildirim (2019, p. 39) found results in his study that indicated cybersickness to have direct negative effects on the level of enjoyment found in VR gaming. It is also the barrier that offers the most potential solutions to lessen or completely remove the problems for users. Hamilton (2018, p. 66) brings up a list of techniques and solutions to combat simulation sickness, such as locomotion and camera movement that closely follows the player's movements and can fully be controlled by the player; reducing the players' field of view as they are moving; keeping movement stable by avoiding unnecessary acceleration and deceleration; keeping a stable high frame rate and low latency. In my experience with VR, the most important aspect of

mitigating simulation sickness is to start with programs that offer a variety of movement and camera options, most importantly teleportation via pointing and clicking, as well as a snap camera movement option where the camera can be rotated incrementally, for example in 45-degree increments. These are options that an ever-increasing amount of VR games offer, as you can often find an option for several comfort settings in VR games. Yildirim (2019, p. 42) also notes that those new to VR gaming may benefit from starting with games that offer no artificial movement in-game.

With time, it is possible to adapt to the VR space to lessen or even remove the effects of simulation sickness. For some, it can take hours, for some days, but for others, it may never happen. Simulation sickness is a challenge that unfortunately does not have a single solution to it, and the solutions that are offered are not always guaranteed to work. It is something that everyone must experience and overcome on their own, to find out which solutions work for them.

2.2.2 Physical restrictions

Motor impairments often prevent the proper use of many technologies, as our hands and feet are crucial tools for most aspects of life. Physical restrictions in the traditional gaming context often focus on specifically the use of hands and fingers to operate controllers and other accessories for gaming. With VR gaming, this problem is increased significantly, as the movements required to operate the headset and controllers in their intended way are much larger in both range and difficulty. (Hamilton, 2018, p. 67.)

VR games are often best experienced while standing up to allow for movements like walking, ducking, and dodging, and while there are games that can –or are even intended– to be played while sitting, it is an exception rather than a rule. The headsets themselves are usually quite bulky and heavy, which can cause strain in continuous use. The controllers will require large sweeping, complex, or precise motions that use the entire range of the player’s arm and hands.

As with any technology, there are some barriers when it comes to physical restrictions that cannot be overcome. But solutions exist to help ease many of the issues even when it comes to VR gaming. Options that are common in VR games these days include the ability to adjust your height and orientation, and bind things like movement and turning fully to the controllers. Another option to better allow those with limited hand mobility to experience VR is to allow the use of standard or even specialized controllers in place of motion controlling. It will not provide the full VR experience but works as a good compromise in many cases (Hamilton, 2018, p. 68). In the future, eye tracking can be used to allow even greater mobility without the use of controllers or head movement. The upcoming new VR headset by Playstation, PSVR2, boasts use of this feature and would be the first mass-marketed commercially available headset to do so (Playstation, 2020).

While Virtual Reality presents many unique challenges and barriers for users, there are new solutions presented yearly as the technology improves, and the growing interest prompts developers to focus more on accessibility at the software level. For many, there will be barriers among these challenges that are simply impossible to overcome, but that is the unfortunate and unavoidable truth when dealing with a technology that is this unique. Future innovations however have the potential to remove many of these barriers, as VR is still in relatively early stages as a technology.

3 Enjoyment in VR games

Virtual Reality headsets offer a unique experience that encapsulates the user fully into the virtual environment of the game in a way that is not possible for a traditional way of playing video games through a display, whether it is a PC monitor, or a TV, or a phone screen. VR allows users to engage and interact with a virtual environment that immerses most of the users' senses by blocking the outside world through the use of the head-mounted displays, and by providing audiovisual as well as haptic feedback. Mütterlein (2018, p. 1407) describes VR as "the sum of the hardware and software systems that seek to perfect an all-inclusive, immersive, sensory illusion of being present in another environment". For this, we must also acknowledge the importance of the motion tracking controllers that are paired with VR headsets, as they allow the user to interact with the virtual environments.

Enjoyment of any activity has been widely linked to increased engagement and adherence to the activity performed. Wankel (1993) hypothesizes in his research that emphasizing enjoyment in physical activities can have a positive effect on the level of commitment given to that activity. To properly analyze my experiences of enjoyment in this research, I will first talk about some concepts that research supports as important for increased enjoyment of VR gaming. Mutterlein (2018) brings up the concepts of immersion, presence, and interactivity as key features for VR that influence the users' satisfaction. These characteristics have been presented regularly in research as integral parts of the VR experience, though definitions and the concepts themselves often vary. Witmer & Singer (1998) measure the effectiveness of virtual environments based on the concepts of presence, immersion, and involvement. They describe involvement as a state of being focused on an activity that gives such significance and meaning that their attention is fully fixated on it and thus become more involved in it (p. 227). This definition however is very similar to those of both telepresence and immersion, which is why I believe interactivity to be the better concept to gauge effectiveness.

3.1 Interactivity, Telepresence, and Immersion

Cambridge dictionary (2022) defines interactivity as “the involvement of users in the exchange of information with computers and the degree to which this happens”. Involvement being a keyword here further supports the idea that interactivity is the better gauge for VR experiences, as involvement is already integrated into the definition. Higher interactivity with a virtual environment means more exchange of information and higher involvement in the game. Mutterlein (2018, p. 1408) explains interactivity as “the degree to which users of a medium can influence the form or content of the mediated environment”. Gaming is all about interacting with the environments, characters, and mechanics of the game, without interactivity you are simply watching a movie or passively exploring an environment. A high level of interactivity is said to lead to higher states of presence, immersion, and flow (Mutterlein, 2018, p. 1409). Interactivity in VR should, in most cases, also elicit higher activity and movement in the user, thus providing better physical activity.

Presence in a VR context can be said to describe the experience of feeling you are in an environment that is outside your own reality. When this state of presence is achieved through a medium, the term telepresence is used. (Mutterlein 2018, p. 1408.) Winkler (2020, p. 1511) also describes telepresence as the extent to which individuals feel present in a virtual environment, and Yildirim et al. (2018) relate telepresence to “temporarily experiencing the game reality as their own reality”(p. 126). Following these descriptions, it can certainly be surmised that telepresence plays a crucial role in a player’s engagement in a VR game, and Hassan et al. (2020, p. 1196) even go on to note that telepresence is arguably the essence of VR. Regardless of the exact definitions used, a common notion is that telepresence directly affects the level of immersion achievable, and vice versa. Yildirim et al. (2018, p. 126) note in their study of user experiences in VR games, that immersive environments directly affect the sense of presence, and that consequently leads to more enjoyable user experiences.

Immersion is a concept that is often used as an all-encompassing term for most user engagement that deals with presence, interactivity, and such. Even most researchers cannot come to a clear consensus on what it entails. Mutterlein (2018, p. 1409) says the definitions of immersion often relate to being caught up in another world. This definition however sounds very similar to that of telepresence, and Mutterlein even goes on to note that the terms are often interchangeable (Mutterlein, 2018, p. 1409). To distinguish between these two concepts, some researchers, like Slater et al. (1996, p. 165) view immersion from a more technical standpoint, seeing different VR technologies to be more or less immersive than others based on their technical fidelity. This entails features such as field of view, motion tracking, resolution, and graphical fidelity.

While this definition sets it apart from telepresence, it does not make much sense from an experience-based viewpoint. How can two completely different VR games be equally immersive just by playing them on the same device. This definition seems to fit the concept of interactivity more closely, as higher fidelity in technology allows for better tools to interact with the virtual environment. Indeed this reinforces that immersion must be a subjective experience, one that can certainly be affected by the technical merits of the hardware, but ultimately depends on the users' experiences with the virtual environment itself. Winkler (2020, p. 1511) describes the experience of being immersed as losing track of time while having a high concentration and total involvement in the activity. This description often comes up when discussing flow, which we will get into next.

3.2 Flow in VR

Flow is a concept that has been studied for years, but research has never seemed to come to an understanding of what precisely flow is and how it emerges. What can be generally agreed upon is that flow is a focused state of consciousness you get when doing an activity. Hassan et al. (2020) explain flow as experiences where the user is fully immersed in an activity to the point where most other realities are excluded from thought, and hours can feel like minutes. He adds that it can also be characterized by heightened

concentration for the current activity (p. 1197). Mutterlein (2018, p. 1408) also relates flow to a “state of optimal experience where one is completely absorbed and immersed in an activity”. Flow is sometimes characterized as an aspect of immersion or a completely detached concept from the rest, but it shares many of the same characteristics.

Flow is not a state that is unique to VR, and the means to gain a state of flow as such may also differ between different mediums. Sweetser & Wyeth (2005, p. 5-6) presented a modified version of flow that specialized in video games, and the components brought up in the presentation are laid out in the table below.

Table 1. List of components that represent a modified version of a flow model called gameflow, as presented by Sweetser & Wyeth (2005, p. 5-6)

1. Concentration	Games should require concentration, and the player should be able to concentrate on the game.
2. Challenge	Games should be sufficiently challenging and match the player’s level of skill.
3. Player skills	Games must support player skill development and mastery.
4. Control	Players should feel a sense of control over their actions in the game.
5. Clear goals	Games should provide the player with clear goals at appropriate times.
6. Feedback	Players must receive appropriate feedback at appropriate times.
7. Immersion	Players should experience deep but effortless involvement in the game.
8. Social interaction	Games should support and create opportunities for social interaction.

In the previous section, I brought up the different characteristics that are thought to be integral to the VR experience: immersion, telepresence, and interactivity. Some

researchers closely relate flow in VR to immersion, while others view it as a fourth integral concept. Winkler (2020, p. 1511) sees immersion as an antecedent to flow. Thus I suggest flow in VR to be a state that can be achieved by the interplay of these three concepts. Not necessarily a completely divorced concept, but a state where telepresence, immersion, and interactivity all play a role. Hassan et al. (2020, p. 1198) enforce this thinking by noting that the experience of flow in VR comes from the manifestation of efficient telepresence and immersion. The addition of interaction to this context as brought up by Mutterlein (2018) rounds out the experience perfectly, as interacting with the virtual environments is one of the core aspects of VR gaming. A state of flow can be said to often lead to positive experiences when there are distinct goals and explicit feedback in activities, which games usually do (Hassan, 2020, p. 1197).

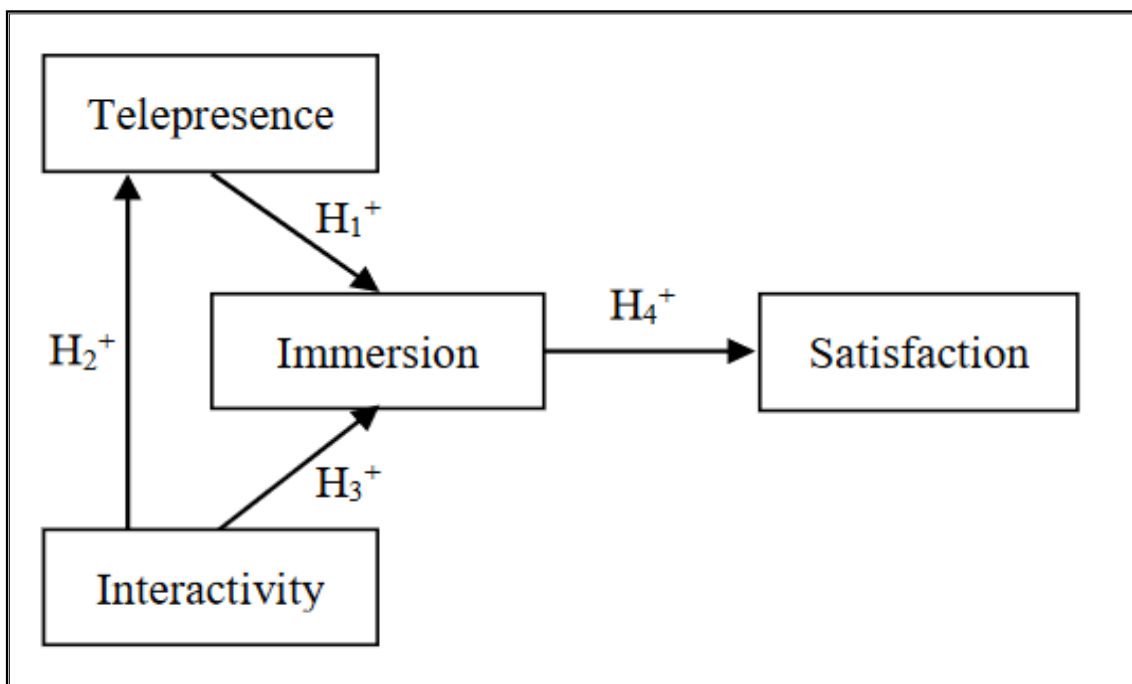


Figure 1. Mutterlein's Research model (Mutterlein, 2018, p. 1409)

When it comes to the interplay of all these concepts and their relation to user satisfaction, Mutterlein (2018, p. 1409) explains his hypothesis (see figure 1) as follows: "I assume that telepresence influences immersion, interactivity influences telepresence as well as immersion, and immersion influences consumers' satisfaction with a VR

experience.” I prefer to use the word enjoyment instead of satisfaction here, and based on the different research on the subjects as well as my interpretation and experiences, I would make the following distinction: Telepresence and immersion both influence each other; Interactivity influences both telepresence and immersion; and all three influence flow. The four concepts together influence user enjoyment on various levels.

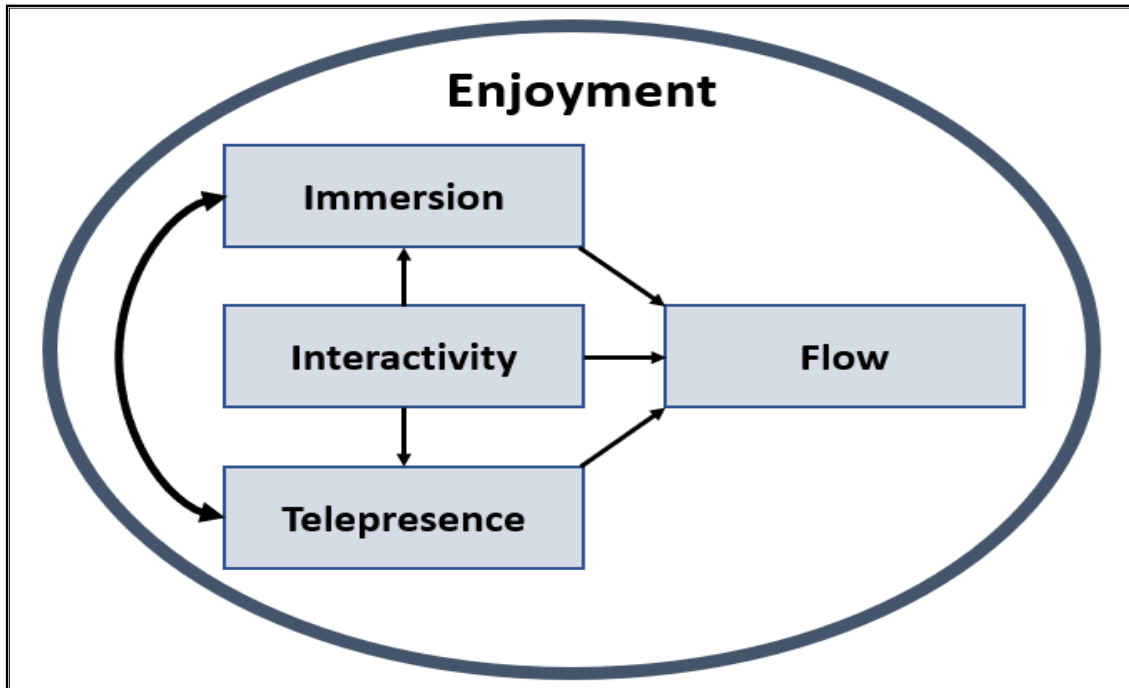


Figure 2. Relationships of key VR concepts and their relation to enjoyment.

There can certainly be many other subjective aspects to enjoying VR games than the concepts brought up here, but I believe if a user experiences high levels of interactivity, telepresence, immersion, and flow, it naturally leads to greater enjoyment of the games. Hassan (2020, p. 1197) also notes how it is very likely that an experience of flow in VR games can lead to longer session times and overall more frequent VR use. Although there are proficient studies for these elements in affecting enjoyability, from a user experience standpoint it can be difficult to describe how or when a user experiences these feelings. For this reason, more detailed lists like Sweetser & Wyeth’s (2005) are important to clarify and break down the components one might find within these elements of flow.

4 Movement in VR games

In this chapter, I will discuss different systems of movement within VR games and how they translate to player freedom and physicality while playing. I will also bring up research on the benefits of VR exercise, and the different forms of exercise that VR allows within its ecosystem of software and hardware.

4.1 Categorizing VR movement modes

The uniqueness of the VR space and technology allows for a variety of different movement systems by combining uses of both artificial and real movement. Cenydd & Headleand (2018) aptly named four different systems of movement in their research, categorized as Turret, Pilot, Motion, and Avatar movements (p. 31-32). These four categories offer a comprehensive view of the movement possibilities in VR games when it comes to freedom of movement and the physicality of movement

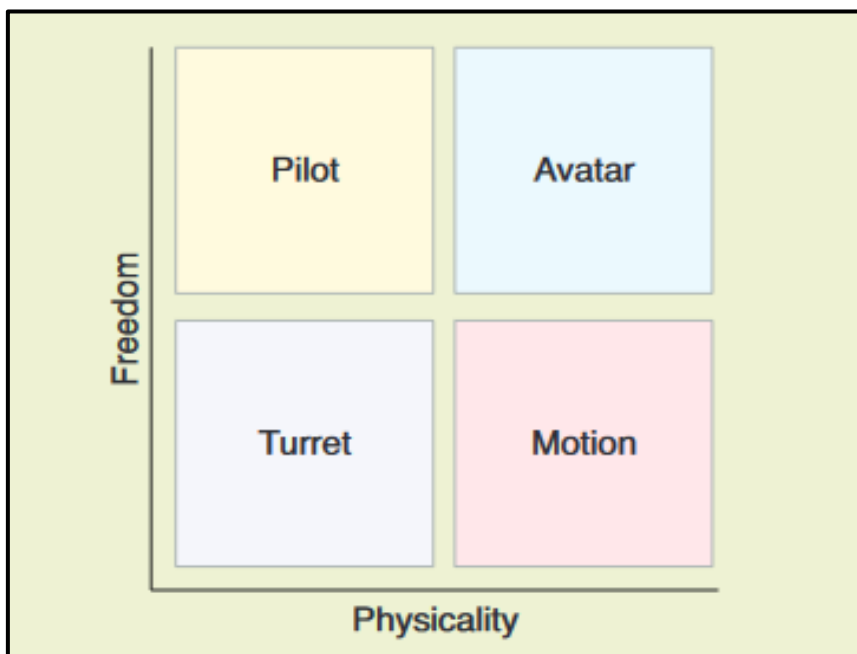


Figure 3. The diagram of the four movement modality categories, based on their freedom and physicality (Cenydd & Headland, 2018, p. 32).

The Turret system explains a category of movement where the players' position is completely fixed in the virtual environment, with only head movement allowed for looking around, much like riding a roller coaster (Cenydd & Headland, 2018, p. 31). This is the simplest form of movement for VR gaming. It requires low physical movement, but in return offers low freedom of movement. For any research studying the efficiency of VR exercise, this mode of movement is insufficient and lacking. It serves as an effective system of movement in static experiences, like movies or 'ride' type VR experiences most commonly found in amusement parks or arcades. No games tested in this research use this mode of movement by default.

The Pilot system allows the player free movement in the virtual environment through artificial movement systems, usually performed via controller inputs. Head movement can still be controlled freely, but physically the player is still essentially locked in place in the virtual environment (Cenydd & Headland, 2018, p. 31). This form of movement can often be seen in applications that offer select points of interest for the player to explore, such as virtual tours, or in games where movement is meant to be restricted by certain boundaries that physical movement in the virtual environment might break. The artificial movement can be continuous via joystick input akin to normal video game movement, or motion-controlled either via grab-and-drag type movement, or point-and-click type teleportation. Often motion control movement is used to lessen the effects of simulation sickness. It offers a higher level of freedom in movement compared to Turret motion, but generally still lacks the physical aspect of movement. One game tested in this research uses this method of movement primarily, albeit with certain nuance that I will get into later in this chapter.

The Motion system is the opposite of Pilot movement, where the player has no method of artificial movement via controller inputs but is physically able to move within the boundaries of the virtual environment, and of course, the players' own physical play

space (Cenydd & Headleand, 2018, p. 32). While the player is restricted to the boundaries of his own physical space, this form of movement could be said to offer the highest potential of immersion in a VR environment. The absence of artificial movement can lessen the feeling of being inside a virtual environment and as such increase the feelings of presence and immersion. Because of this, it is also the most effective form of movement to eliminate simulation sickness in the player, as physical movement is always tracked and replicated precisely in the virtual environment. This method of movement is often seen in games that don't contain large virtual environments to explore, and can generally be fully playable in a room-sized or smaller environment. Due to the restrictive freedom of movement, these types of games often benefit from, and sometimes even require large play spaces from the user, or are tailor-made experiences for specific 'VR rooms'. There are however exceptions to this, for in this research three of the five chosen games use this method of movement primarily and none of them require especially large play areas.

The Avatar system offers the highest level of freedom and physicality for the user, as it allows both physical movements within the play area, and artificial movement via controller inputs. In essence, it is a combination of the Pilot and Motion systems of movement (Cenydd & Headleand, 2018, p. 32). Most modern VR games fall under this system of movement, with the Motion system arguably being the second most used. Since this movement allows the most freedom for the user, it also means that you are granted the most options in the way you want to approach the game. In my experience with VR games, this usually translates to larger movements within the game being done artificially, while smaller more precise movements can be done with physical movement. In this research, one out of the five tested games uses this as a primary method of movement.

Aspects of these movement systems can also be mixed within the same game, with some areas allowing one form of movement, and another area a different form. Some games may also allow for a certain method of movement, but not necessarily require it in basic

gameplay. Earlier I mentioned a nuance in the movement of one game with the Pilot system, as technically this game allows for the Avatar system of movement, but due to the mechanics of the gameplay, physical movement is not encouraged nor needed in most instances of gameplay.

4.2 Exergaming

Exergaming is a portmanteau of the words exercise and gaming and is often used to denote exercise by the means of some type of video game. The term has been around for a long time and is by no means unique to VR gaming. The earliest example of exergaming with video games was in the 1980s with video game company Atari's 'Joyboard' peripheral, a balance board for video games. Some years later in the late 80s another video game company, Nintendo launched the 'power pad' mattress with 12 separate sensors you could step on for inputs. Different prototypes and arcane machines were created over the years as exergaming started to gain more ground, including the first VR exergame using an exercise bike 'Tectrix VR Bike', though the use of VR here –and often in VR exergaming– does not indicate immersive VR. In 1998 Konami launched the Dance Dance Revolution (DDR) arcade machines in Japan. These machines gained massive popularity within shopping centers and arcades and showed that there was a big market for exergaming. (Finco & Maass, 2014, p. 1-3.)

Although many attempts were made over the years, exergaming did not truly reach mainstream commercial popularity until the release of the Nintendo Wii -home console in 2006. It was the first-ever commercial video game console to use motion controls as a primary way of playing. Launching with the exergame 'Wii Sports' included, it soared to mass popularity all over the world, and quickly became one of the highest-selling game consoles of all time, with an estimated sales figure of over a 100 million units as of 2022 (Statista, 2022b). A year later Nintendo released the Wii Fit add-on (see picture 2), a balance board peripheral that could track your weight and exercises, with several games designed for its use, and in 2010 Microsoft launched their own exergaming

peripheral with Xbox Kinect, a sophisticated camera that could track your entire body movements, voice, and gestures for games. Xbox Kinect did not end up seeing the same success as the Nintendo Wii platform, but these technologies were a steppingstone for future exergames, and today VR gaming represents the newest technology to push exergaming to new heights.



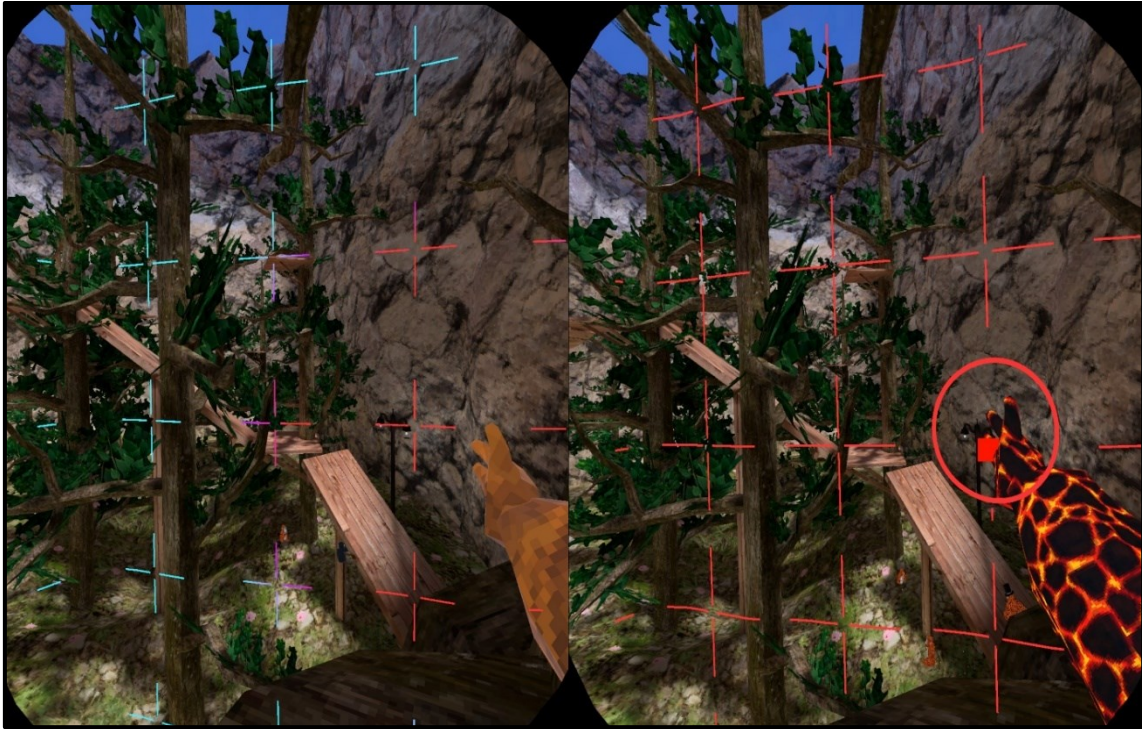
Picture 2. A demonstration of exergaming using the Wii Fit device (Sayers, 2018).

Exergaming has seen a large number of studies done over the years to explore the potential benefits it has on things like exercise engagement and adherence, healthcare, and rehabilitation. Gao et al. (2020) studied the benefits of VR-based exercise on older adults and found that participants tended to enjoy exercising on a stationary bike significantly more when coupled with a VR environment. Zeng et al. (2018) and Qian et al. (2020) both performed systematic reviews on the effectiveness of VR-integrated exercise equipment compared to traditional non-VR exercise equipment use, and both found largely positive outcomes in favor of VR exercise in enjoyment, engagement, and potential treatment for anxiety and depression. In another study example, Plante et al. (2003)

performed a study with 88 participants that compared results of VR and non-VR exercise and concluded that combining VR with exercise machines can both reduce feelings of tiredness, and increase relaxation, engagement, and enjoyment, and in general enhance the psychological benefits of exercise. One issue with many of these research is that they often do not distinguish between immersive and non-immersive VR, but their effects and effectiveness can differ greatly. Ijaz et al. (2017) and Ijaz et al. (2020) did two studies on VR exergaming, comparing non-immersive VR with a static user interface, and immersive VR with an open world environment. Both studies concluded that immersive VR provides higher enjoyment and engagement in physical activity.

4.3 Limitations of movement in home-based VR

The first and most important movement limitation for playing VR at home is of course the player's available space. VR is a movement heavy activity, and the sense-surrounding immersion of HMDs only helps to facilitate the ease of crossing the boundaries of that available space. Most modern HMDs have a system in place to help players with this. For Oculus devices it is called the Guardian System, and for HTC Vive and Valve Index it is called the Chaperone System. These systems allow the user to map out their play space inside the VR home interface by drawing the area of their play space with the controllers. The inside-out tracking cameras of these devices allow the user to see their actual environment while drawing, much like Augmented Reality. Once the system is in place, it should automatically be active in all games played through that device. If the player approaches the edges of the play space they have set, the device will start to show an outline of the boundary inside the virtual environment, warning the player that they are about to step outside it. For Oculus devices, this system shows a blue outline that will slowly turn red as the player gets closer to the boundary with either the controllers or the headset itself, as shown below.



Picture 3. Oculus Guardian, with the left image showing proximity to the border of the set play area, and the right image breaching it (images captured from the game Gorilla Tag)

This system is extremely useful for games that require a lot of movement, as it can be easy to get so immersed and engaged in activities inside the games that you forget your surroundings and shift away from the center of your play area. Some games also come with specific settings that can show the center of your play space at all times in-game, usually by some marking on the floor. These days players have the option of playing VR completely wirelessly, which fully unlocks the potential play area, but can also make it even easier to forget your surroundings. It is important to be mindful of your play space, and your movement within VR games, as injuries are prone to happen if a player gets too carried away by a VR game. It is equally important for VR games to keep in mind these limitations and movement modes in their design, as movement plays an important role in both the state of flow and the level of physical activity that is achievable in the games. In the next chapter I will discuss the methodologies I base this research on, my data gathering methods and choices, and how I apply the theories of flow and enjoyment in my analysis. Lastly, I will go through the structure of the next steps of this research

5 Methodology and data gathering methods

The primary methodologies used in this research are a combination of phenomenology and phenomenography. I have chosen five VR games to play and test thoroughly and get firsthand user experiences that I can analyze in terms of enjoyability and physical activity. In addition to my own experiences with the chosen games, I will also be conducting a written interview with a participant who has years of experience with VR gaming with multiple games and different devices. This interview will be performed via the Discord chat application and will act much like a discussion to get a better depth of data and have the possibility to change or add more information if necessary. The phenomenological part of this research comes from my testing and reflecting on my experiences with the games and the qualities of the games themselves. While the phenomenographic part of the study comes from the experiences of the interviewee.

Phenomenology and phenomenography are qualitative research approaches that are both closely related to each other, as they both deal with phenomena, as their name suggests. The key difference between the two approaches is that phenomenology is focused on the structure and meaning of the phenomenon itself, while phenomenography focuses on other people's understanding and experiences with the phenomenon. (Larsson & Holmström, 2007, p. 55.) These methodologies both deal with interpretations of the person's own experiences and consciousness, without taking established ideas or theories into account. As Boland (1985, p. 183) notes in his Phenomenology research, it is a science that focuses mainly on *what* things are, while positive science tends to research *how* things work. He adds that phenomenology deals with describing things that are immediately presented to consciousness. That ideology is at the core of this research, as user experience is very much a descriptive research approach, and the research question in this study is concerned with the 'what', instead of the 'how'. This research method is used to add a different perspective to VR exercise, that positive sciences often do not study, and as Boland (1985, p. 183) says regarding phenomenology; "In the end, a phenomenological study cannot claim to have a proof of its findings, only a reliance on its method and the hope that others will 'see' its descriptions as true and accurate".

The game testing part of this research will be performed with the Oculus Rift S headset. It is a commercial headset with inside-out camera tracking and motion controllers with joysticks, face buttons, and triggers. As of 2022, this headset is unfortunately discontinued from sale, but it is essentially the same product as the Oculus Quest 2, only with slightly lower technical specifications, and it is not wireless. The experiences of enjoyment in the games will be largely based on measuring feelings of immersion, presence, interactivity, and flow, as brought up in the literature section. A certain amount of subjectivity is to be expected, but as a participant, I will also weigh in my years of experience in VR gaming. To allow for a more natural flow of discussion, I will be detailing the criteria of my game selections in the next chapter, which is followed immediately by the reviews themselves.

Something many studies into VR exercises have in common is their rigid setting. These studies are often performed quantitatively, in controlled settings, and with equipment that is not available commercially and is often outdated by today's technology standards for VR. They provide large amounts of data but are rarely applicable in more general real-world settings. Using integrated equipment for VR exergaming is not a plausibility for most, and this type of equipment can cost upwards of 1000 USD or more (Zeng, et al., 2018, p. 10). While Nintendo Wii made exergaming an affordable possibility for millions, current VR headsets are starting to offer the same affordable options these days, with HMDs like Oculus Quest 2 available for 299 USD, cheaper than most video game consoles. In the future, their availability will only increase as the technology advances and the prices go down. Furthermore, integrated equipment and specific exergame machines usually have strict limitations for movement by design. They focus on a specific set of movements like cycling, running, climbing, and such. With home-based VR gaming, these limitations are lessened through the variety of choices the user has for games, though some limitations are unavoidable. As this study deals with a subjective matter of enjoyment, descriptions of experiences can offer findings and perspectives that quantitative studies are not able to provide, and a less rigid setting of home gaming allows for a more

natural forming of experiences. As Sinclair et al. (2007, p. 294) note in their study of exergame design, monitoring user experiences for exergaming can be effective in determining areas of fun and effective gameplay and should be investigated further.

The phenomenographic approach comes in the form of a phenomenographic interview. It is a specialized form of the qualitative research interview, and has characteristics such as: seeking to understand the interviewee's experiences of the research phenomenon; being qualitative and descriptive, with a focus on a certain phenomenon; being open to ambiguity and change; taking place in an interpersonal interaction (Bruce, 1994, p. 49). With these qualities in mind, I wanted to conduct an interview that was flexible and open-ended, with the possibility of changing and adding information as needed. The participant for the interview was a 28-year-old female. A single participant was chosen for this interview partly due to time restraints, but also because of previous knowledge of this participant's experience with VR games, and familiarity with the participant, which allowed for an in-depth and extended interview. The interviewee was not given any advice or in-depth knowledge of the study before answering questions, besides the fact that the answers should be solely based on her own experiences.

The majority of the interview was conducted within a weekend timeframe in May of 2022, and a further two weeks were allotted for additional follow-up questions, potential editing of questions and answers, and additional information for questions and answers if needed. Overall a total of 31 questions were asked and answered, with no questions left unanswered. Due to the open-ended nature of the interview, the participant was able to answer questions in detail, elaborate on follow-up questions, as well as edit answers or add to them if needed. The questions were formed partly based on literature with game design perspectives, such as Sweetser & Wyeth's (2005) study on video game specialized flow charts, and Faric et al. (2019) thematic analysis on VR exergame reviews, and partly based on my own experiences with VR games.

As an additional data gathering method, and to obtain information regarding the movement aspect of VR games, I will be tracking my level of physical activity in the games via a fitness watch tracker. The watch used here is a Polar Ignite 2 fitness watch with continuous heart rate (HR) monitoring and training programs that track heart rate via beats per minute (BPM) and activity levels during training. I will mostly be focusing on the activity levels to give a reasonable estimate of the physical exertion in my gaming sessions, and what a player can generally expect from that game in terms of activity. I usually set myself a play time goal of between 45 minutes and 60 minutes when playing VR. For this research my measured playtimes range between 20 minutes to 60 minutes, this varies depending on my engagement, level of physical activity, and the time goal I set for myself. My fitness watch has calculated my maximum heart rate at 190bpm. From this, it calculates activity levels based on percentage breakpoints I reach during exercise. For a further reference point, I am a 30-year-old, average-weight male with low to moderate daily activity outside VR exercise, and my resting heart rate is usually around 60bpm.

Table 2. Activity levels based on heart rate during exercise, where 100% would be 190bpm.

Max HR %	HR Breakpoints	Activity Level
90%	171bpm	Level 5
80%	152bpm	Level 4
70%	133bpm	Level 3
60%	114bpm	Level 2
50%	95bpm	Level 1

This data will be analyzed alongside my experiences of enjoyment based in large part on the feelings of immersion, presence, interactivity, and flow in the games. These two data points, in addition to the data from the interview, can then be used to determine how movement and enjoyment correlate in VR games, and what qualities in these games best

manifest them. Previous research on VR exercise research will also be presented for comparison.

6 Experiencing movement and enjoyment in VR games

In this chapter, I will explain my criteria for selecting the VR games for this research, and then provide individual reviews of my experiences with the games I chose. The game reviews will all follow a similar structure: first I will give a brief explanation of what the game is and how it is played, then I will discuss the enjoyability of the game, based on my experiences and the literature laid out in chapter three, then I will discuss the movement of the game, based on the data I have gathered from the fitness tracker and the movement modes available in the game. After my reviews, I will go over the results of the interview.

The current marketplace for VR games is vast, and thus it was no easy task choosing the games for this research. The scope of this research, unfortunately, did not allow for a deep and thorough look at movement in multiple virtual reality games to further review the selections, but I believe the chosen games represent a sufficient variety of movement and gameplay for this research. Furthermore, the interview will allow for a more open-ended discussion of VR games in general, not locked to the selection presented here. The selection of games was primarily based on two important factors: First, does the game allow the player to express a suitable level of movement and activity in the gameplay, and have it correlate similarly to the players' movement; and second, is it plausible for me to obtain and sufficiently test the game within budget and time restraints.

For the first part, my main criteria were that you can control your movements freely in the game, in whatever manner that the provided gameplay intended, and that the provided gameplay is active enough to the point where it has the potential to increase the player's heart rate to a level that could be considered at least a moderate exercise. As an example, one of the chosen games is a Table Tennis simulator. The range of movements the player needs to perform is limited, but they are fully in the player's control. You are even able to add spin to the ball with specific positioning and speed of the serve.

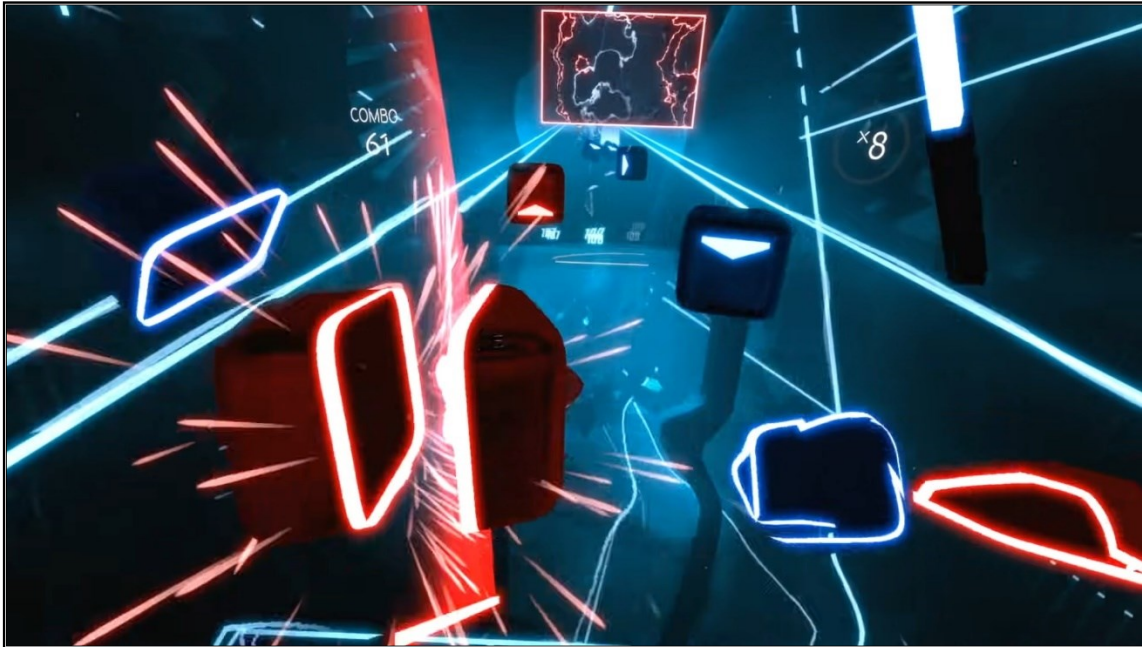
For the second part, I had set a budget of around 30€ per game for myself. I wanted this research to represent the habits of a normal consumer that might want to test out VR games for themselves, and thus all the games in this research can be purchased for 30€ maximum, but the average price is closer to 20€ for the full price, not counting for any discounts or bundle packages. All of the chosen games are also available on both Steam and Oculus marketplaces, the two largest and most important marketplaces for VR games. As for the time restraint, I wanted to be able to fully experience the range of gameplay and movement that the game offers within around 5 hours of play time. Overall I played these games for approximately 5 hours or more each over multiple sessions, totaling over 30 hours played within the testing period alone.

A third factor that also played an important role in my selections was for the games not to have overly complex gameplay or story modes. I wanted a selection of relatively casual games that you can jump into and play without having to think too much. This is essentially how most exergames should function. Out of the chosen games, I had previous experience with two, Gorilla Tag and Beat Saber. I did not consider this to affect my reviews negatively, as I could still vividly remember my early experiences with these games.

6.1 Beat Saber

Beat Saber is a rhythm-based VR game where the player uses both controllers that act as sort of 'light sabers' in-game, and attempts to hit oncoming blocks in the rhythm of the music track of each stage. As seen in picture 1 below, both the sabers and the blocks are colored red and blue, and each block has to be hit by the corresponding saber color, and the angle that the hit must be done from is indicated by a white arrow on the block. The more blocks the player manages to hit correctly in succession, the bigger combos and points they will get. Some stages include added difficulties in red wall obstacles that need to be either dodged or ducked under, as seen in the distance of picture 1, as well as black spiky bomb-shaped objects that the player needs to avoid hitting to keep their combo going. Stages in the game come with 5 difficulty settings, easy, normal, hard,

expert, and expert+. Each difficulty will alter the number of blocks and the difficulty of the formations, as well as the number of obstacles in the stage. The game also has an aspect of multiplayer that allows you to challenge other players in songs for scores.



Picture 4. Beat Saber gameplay (Youtube, 2022).

6.1.1 Enjoyment in Beat Saber

Beat Saber offers varying levels of difficulty and challenge, so the learning curve is smooth and can always be adjusted by the player to fit their level of skill more closely. Different songs also present varying levels of challenges even when played on the same difficulty, so the challenge extends past the set difficulty options of the game. This ensures that the player will always find a suitable challenge for their level of skill, and is a great incentive for increased engagement. Because the premise of the game is simple, it is easy to pick up and play. Referencing the gameflow list presented in chapter 3 of this study (see table 1.), I found that Beat Saber achieved sufficient level in all the mentioned components, especially in concentration, challenge, player skills, feedback, and immersion. Feedback is given in the form of scores at the end of each song, but it is also

constantly present during songs in the haptics of the controllers. Subtle vibrations let you feel when you successfully hit the correct blocks or hit an obstacle, this enhances the feeling of rhythm and flow within each song, and subsequently gives the player stronger sensations of interactivity and immersion. Telepresence is slightly more difficult to properly gauge in this game, as the environment mostly consists of flashy neon lights and different moving shapes. It does make you feel like you are outside your own reality, but it is a different type of presence, as you are not distracted by things to explore and observe, but rather by the immersive nature of the gameplay itself.

The simplicity of the gameplay, ease of access, and engaging challenge all make the game very appealing to both casual enjoyers and dedicated players looking to improve their skills or enjoy a fun workout. The songs in the game range from less than a few minutes to over 8 minutes long, so you are freely able to choose your play time without feeling like you have to quit out in the middle of a session, by playing as many or as few songs as you like. The enjoyment of this game is high enough to enjoy long sessions and have long-term engagement over multiple years.

6.1.2 Movement in Beat Saber

Table 3. Beat Saber heart rates and activity levels for 5 sessions

Beat Saber	MAX HR	MAX LEVEL	AVG HR	AVG LEVEL
30 minutes	145bpm	3	121bpm	2
30 minutes	130bpm	2	108bpm	1
45 minutes	142bpm	3	118bpm	2
45 minutes	139bpm	3	107bpm	1
60 minutes	140bpm	3	114bpm	2

The table above shows my maximum and average heart rates and activity for 5 different sessions of Beat Saber, played at a game difficulty level of expert and expert+. The game provides me a healthy workout at these difficulties, maintaining an average activity level

between high 1 and low 2, with level 3 being very common during particularly fast sections of songs. The level of activity naturally increases as you go up in difficulty, as well as based on the played songs. For a small comparison with difficulties, I did a 15-minute session in both normal and expert, playing the same 3 songs for both. In the normal difficulty, my average heart rate was 85bpm, and a maximum of 112bpm. Playing the same songs on expert gave me an average of 101bpm and a maximum of 132bpm. Outside the numbers, I can say from experience that playing at expert and expert+ for over 30 minutes will usually make me moderately exhausted, and at over 60 minutes I am usually sweating and breathing quite heavily, and my performance starts dropping drastically, though enjoyment in the gameplay remains the same.

The type of movement in the game can be categorized as Motion movement (see figure 3). The player can physically move to position himself in the virtual environment and swing the sabers, but no artificial movement is possible, nor needed. The game includes a footprint marker on the ground that can be used as a reference point for the player to center themselves on the play area. The gameplay does not require the player to move significant amounts from this center, as the majority of gameplay consists of hand movements, and leg movement is used for minor dodging and ducking of obstacles.

Regarding accessibility, which is an important factor, especially in VR, the game offers a variety of options to increase comfort and accessibility for the player. These options include player height adjustment, play space position adjustment, controller position adjustment for the sabers, and adjustments for reducing effects and screen clutter. Additionally, there are different gameplay modifiers that either add or remove some of the challenge from the game, such as letting you continue songs after you would normally fail, slow or speed them up, remove obstacles, and more. Simulation sickness is also less prominent in this type of movement, as you never have to physically move, except for occasional steps to dodge and duck obstacles.

6.2 Gorilla Tag

Gorilla Tag is a free roam type multiplayer game where you use your hand movements to traverse the in-game world as a Gorilla. Both controllers act as the players' hands, which you then use to push or swing yourself forward, climb trees and cliffs, and other obstacles. Joysticks on the controllers are only used to help the player rotate their view if needed. The game is divided into multiple different open areas that you can freely explore, with forest, cave, desert, city, and snowy mountain areas being the current maps you can enter. Once you enter one of these areas, a multiplayer lobby is automatically searched and you will be added to a lobby with other players, as long as there is room. You can also manually enter a private lobby to play alone or with friends.

The main game mode of Gorilla Tag is a game of tag called 'Infection', where one player is randomly selected as the 'infected player', and turns into a black and orange textured gorilla generally called a 'lava monkey' in the game community. The goal is to then tag other players by touching them, which in turn will turn them into lava monkeys and they can then tag other players as well. This continues until all the players –at a maximum limit of 10 per lobby– are turned into lava monkeys, after which the game resets and a random player is chosen again. The gameplay loop is very simple. There is no scoring system, and the only additional mechanic to the basic movement that all the players share is that the lava monkeys have a slight bonus to their movement speed, or more accurately they can launch themselves further with their hands. The visual complexity and art style of the game is very simplistic, as can be seen from picture 5 below, which makes the game playable on older PCs and standalone VR headsets, and easy on the eyes. The actual gameplay is experienced from a first-person perspective.



Picture 5. View of the forest map during a winter-themed update (image captured from the game Gorilla Tag).

6.2.1 Enjoyment in Gorilla Tag

Because of the simple nature of the gameplay and objective, players are encouraged to simply enjoy the movement and traversal of the maps, and engage with other players in the lobby via gestures or voice chat. The game also offers a casual mode where the tag aspect is completely removed, and a competitive mode, which offers no changes to the basic tag mode, but acts as an option for players who wish to engage in the tagging aspect of the game more seriously. Each mode has its separate lobbies of players. While the game does not offer any actual incentives to improve your skills and challenge yourself in scores or rewards, the intuitive and free-form movement of the game can act as an incentive in itself. Quite simply, the feeling of movement is incredibly enjoyable, and the more skilled you become in it, the more enjoyment you can extract. In my own experiences with VR games, Gorilla Tag presents some of the most enjoyable and satisfying forms of movement I have experienced. To put things in perspective, my total playtime for this game stands at over 150 hours, when my average playtime in most VR games is most certainly under 10 hours.

What makes the gameplay so satisfying to me is the freedom of movement and the surprising difficulty to perform some of the 'parkouring' within the maps. Once you get a good grasp of the movement and can hop from branch to branch without breaking movement, the feeling is almost euphoric. The game does not hold the player's hand in any way, instead, you are simply cast into the virtual world and told to go and explore it. For some, this can be a turnoff, as the game does not offer any accessibility settings for easier movement. If the player feels like they are not advancing their skills fast enough to enjoy the traversal, or feel like the movement itself is not a sufficient reward to keep engagement, it can turn the experience from fun to irritating or boring. Regarding the gameflow list (see table 1), this game succeeds in demanding concentration, offering challenges and room for improvement, giving the player full control of their movement and actions, immersing the player in the world, and having many opportunities for social interaction. The areas where it falls a bit short are clear goals and feedback. The feeling of being transported into a different world is also quite strong despite the simplicity of the visuals, this is in large part because the gameplay and movement are immersive, and interactivity is the key aspect of the movement itself, as every surface in the game world can be used to push the player forwards.

One aspect that many criticize the game for is the player community. As this is a free-to-play game with multiplayer and voice chat, and the prevalent age group of players is pre-teens and teenagers, it is unfortunately quite common to run into 'toxic' individuals: a term used in online communities to refer to people that are rude, hateful or otherwise harass other players. To combat this the game offers options to both mute and report other players, and the developer actively bans people that harass, cheat or otherwise break the 'Gorilla code of conduct' listed within the game. However, as a free-to-play game, it is near impossible to create an environment that is completely free of these issues.

6.2.2 Movement in Gorilla Tag

In terms of physical activity, the game provides low to moderate exercise for a typical session. This is something that will vary from player to player, as the only real limit to the intensity of the game is the player itself, but generally speaking, the game does not require too demanding movements once you get past the initial learning curve for basic traversal, and there will usually be plenty of downtime within game sessions as you simply interact with other players or take a breather after reaching a certain area. Movement in the game is primarily done by hand movements, and the acceleration and velocity of these movements will affect the speed of the player in-game. The player can also physically move in the environment, but this only offers limited use as vertical movement is often more prevalent than the horizontal type. There are some exceptions where it can prove useful, however, like gaining that extra bit of distance to reach a platform or branch. The freedom of activity and goals in the game is a two-way street when it comes to exertion and largely depends on the mindset of the player when going in.

Table 4. Gorilla Tag heart rates and activity levels for 5 sessions

Gorilla Tag	MAX HR	MAX LEVEL	AVG HR	AVG LEVEL
30 minutes	134bpm	3	103bpm	1
45 minutes	121bpm	2	91bpm	0
45 minutes	155bpm	4	109bpm	1
60 minutes	122bpm	2	99bpm	1
60 minutes	124bpm	2	96bpm	1

As you can see from this table, the average heart rate mostly stays near the level 1 activity breakpoint of 95bpm. The peak levels can however reach up to activity level 4, and I have noticed that I usually average higher heart rates across the board when playing with a friend, as it tends to turn the sessions more competitive. Because the tag aspect is not enforced by any scoring or extra game mechanics, it makes for a very beginner-friendly experience, as you do not have any pressure to perform up to any standard, and can take

your time learning the movement of the game and simply enjoy the traversal. Those that have become more accustomed to the movement and wish to challenge themselves can then more seriously engage in the tagging, or simply test out their skills in the various obstacles within the maps, which offer significant nuance of movement. Ultimately, the lack of clear challenges and rewards can lessen the potential exertion that a player is willing to push themselves into for this game, but the tagging aspect and multiplayer opportunities give ample incentive for even demanding exercise for those that are willing.

6.3 Sprint Vector

Sprint Vector is an arcade-style racing game where you skate along different tracks against other players or AI (Artificial Intelligence) enemies, with both vertical and horizontal movement and different obstacles along the way. Along the tracks, you can pick up different power-ups that provide effects like missiles, speed boosts, and more to help you gain an advantage against the other players. The method of skating is performed by swinging both your arms front to back in turns, much like you would while running or skating normally. The controller trigger must be pressed while the swinging motion starts, and then released once your arm has swung to the back. The harder you swing and the better you time your trigger release, the faster you will skate. The game itself consists of 12 different maps to race in, with each map having a difficulty level of basic, intermediate or advanced, that introduces more obstacles and mechanics needed to maintain good speed. In addition to races, there are separate challenge maps where you can compete for faster times while practicing different mechanics, and when browsing the main menu of the game, your character is placed in a large skatepark where you can freely roam and practice the movement of the game away from the menu (see picture 4).



Picture 6. Floating In-game menu within the free-roam skatepark (image captured from the game Sprint Vector).

6.3.1 Enjoyment in Sprint Vector

Sprint Vector offers the steepest beginner challenge out of the tested games. There are various movement mechanics in the game for the player to learn, such as climbing, air control, drifting, braking, and much more. The game provides a comprehensive tutorial for the player to learn the basic, intermediate and advanced tutorials for some of the more nuanced mechanics. To be able to properly race in all the maps, however, the advanced tutorials are more than likely mandatory, unless you can figure out many of the mechanics by yourself. The biggest enjoyment of the game comes from finally starting to grasp some of the more nuanced mechanics and being able to maintain a high speed during the races, at that point, it becomes a very engaging and adrenaline-filled game with fun arcade-like mechanics added. It took me to my third session with the game before I got sufficiently used to most of the mechanics, and this is something that can potentially dissuade many players from long-term engagement, as VR experiences tend

to be quite front-loaded, as session times are shorter, and first impressions are made faster than typical video games.

Due to the increased challenge and complexity of mechanics, it is harder to reach a state of flow within the game, but in the moments where everything falls into place, the game can reach a high state of flow and enjoyment, as the adrenaline-filled and fast-paced action immerses the player. Interactivity and control are the strongest aspects of the game, with the various movement mechanics and gameplay elements providing constant opportunities to influence your actions and those of other players or AI. Telepresence and immersion are heavily reliant on each race and the player's success in them. At best it offers great immersion and presence in the world, but at worst it makes you feel irritated and disconnected. The game does offer a great challenge for those that wish to reach for higher scores on the leaderboards, but once you have completed the 12 maps of the game, there is not much to keep you engaged beyond that, but the game does offer clear goals and feedback for the content it has. Unfortunately, social interaction is low despite the game having multiplayer. As the game does not offer much long-term engagement, the player base is very low and I could not find a single multiplayer lobby in my testing.

6.3.2 Movement in Sprint Vector

Table 5. Sprint Vector heart rates and activity levels for 5 sessions

Sprint Vector	MAX HR	MAX LEVEL	AVG HR	AVG LEVEL
20 minutes	129bpm	2	101bpm	1
25 minutes	139bpm	3	120bpm	2
25 minutes	131bpm	2	114bpm	2
30 minutes	134bpm	3	106bpm	1
30 minutes	127bpm	2	104bpm	1

As the table above shows, this game provides a good level of activity and movement, with an average activity level between 1 and 2, and high periods of up to level 3 activity. Since you have to swing your arms constantly to gain and maintain speed, there is very little downtime in players' activity during the races, with only slight pauses in movement during jumps and air control. This also makes longer sessions quite exhausting to play unless you take breaks between, and I averaged around 25-minute sessions overall. Part of the reason for low session times is also the fact that the races did not provide me enough continuous engagement to enjoy longer sessions, and the monotony of movement for the player itself can tire you more easily. Additionally, the game does not play very intuitively with a corded headset, as races require you to turn quite often, and while turning is possible with the controller joystick, it is hard to manage in a fast-paced race, and oftentimes you end up in weird, contorted positions as you try to keep your line of sight within the racetrack. Physical movement within the environment is possible in the game but does not provide any real benefit or practical use, thus the game functions essentially with Pilot movement.

Overall, Sprint Vector is mostly an enjoyable experience for short bursts, and playing with friends can make the experience a lot more engaging, but among the tested games here, I would have to rank it lowest in terms of enjoyability and engagement. There is not enough variety in player movement, as you spend most of the races simply swinging your arms as fast as you can, and the fast-paced action where quick turns and fast reactions are often needed can turn out to be stressful at times, especially for longer sessions. The different maps and game modes provide a decent amount of content even without the online, but in the end, this leaves the game slightly lacking. However, for those that enjoy the feeling of fast-paced movement and racing with different interesting mechanics, this game can provide a lot of enjoyment and an especially good amount of physical activity.

6.4 Eleven Table Tennis

Eleven Table Tennis is –as the name suggests– a table tennis VR simulator. The game allows you to play online against other players, or against an AI opponent that can be adjusted in difficulty. The main selling point of the game is its highly realistic physics that feel surprisingly close to the real thing, and allow you to truly immerse yourself in the sport. The game also boasts an advanced AI opponent that feels great to play against whether you want to practice, play casually, or challenge yourself. The AI difficulty can be adjusted incrementally from 1 to 100, with specific breakpoints moving you between easy, medium, hard, world-class, and legendary difficulties. In addition to normal play, the game also has a few minigames for practice, such as practicing your serves, hitting the ball into specific zones on the enemy side of the board, playing against a wall, hitting the ball into cups, or practicing returning different types of serves from the AI opponent.

In terms of customization, the game offers a good deal of options. The playing table can be freely positioned up and down, as well as closer or further away, you can adjust your floor position via touching the controllers to the ground, and the game will attempt to set the optimal height and distance for the table. There are options to customize the paddle as well as the ball, your player avatar that the avatar of the AI opponent, and the play area also has four different choices for a change of scenery. There is also a developer debug menu that allows you to fine-tune many settings like tracking, AI, haptics, and more, but these settings are best left untouched unless you know what you are doing. The UI of the menus itself is rather plain, as you can see from picture 5, and may cause some confusion at first.



Picture 7. Starting menu and view (image captured from the game Eleven Table Tennis).

6.4.1 Enjoyment in Eleven Table Tennis

I have played a good amount of Table Tennis in real life and racket sports have always been among my favorite sports to play casually, so when I first tested out the game I was hopeful, but also a bit skeptical of its claim of ‘ultra-realistic physics’. For a game where fast-paced actions and accurate ball physics are the most important aspect of enjoyment, Eleven Table Tennis has successfully managed to live up to its claims. The physics truly mimics real life as close as I could have expected. Every action in the game: from tossing the ball for a serve, to the position and angle of the paddle, and the direction and force of a serve, are all manually done by the player, and realistically affect the ball. You are even able to create different spins on the ball to make it curve, granted that you are skillful enough for it. These physics show that great care and love has been put into the game by the developers, and it makes for a truly enjoyable experience for anyone that is even remotely a fan of the sport or simply wishes to test it out.

Interactivity and control are the main aspects of enjoyment in this game, as one could expect from this type of game. The precise controls, physics, and added haptics give a realistic and satisfying feel to every contact with the paddle and ball, which also help the player to immerse themselves in the game and the virtual environment. There are moments where it truly feels like you are playing real table tennis. Concentration, challenge, and player skills are all at a strong level, and players should find themselves struggling against the higher levels of AI difficulty even after hours upon hours of practice. The areas where this game suffers slightly are having clear goals and sufficient feedback. In a way, it mimics real table tennis as accurately as possible, as there are no additional rewards or incentives to reaching higher levels of skill, other than reaching higher levels of skill. For many, this is enough, as the satisfaction of improvement creates engagement in itself, but for players that are looking for a more 'video game-y' experience, they may find themselves losing interest. Multiplayer adds a further element of social interaction and enjoyment to the game.

One unfortunate issue with the game is the game's UI (User Interface). It is quite plain and confusing, and many options have limited or no explanation of what they do. This is something that could use some streamlining for a more comfortable experience. It can also give off an image of an unfinished product, and as such may turn off some people who look for a cleaner and more polished end-product. A more fleshed-out UI can also offer additional rewards in terms of goals and feedback, with things like player levels, earnable cosmetics, and other unlocks being available.

6.4.2 Movement in Eleven Table Tennis

Table 6. Eleven Table Tennis heart rates and activity levels for 5 sessions

Eleven Table Tennis	MAX HR	MAX LEVEL	AVG HR	AVG LEVEL
30 minutes	106bpm	1	86bpm	0
35 minutes	149bpm	3	105bpm	1

40 minutes	123bpm	2	93bpm	0
45 minutes	140bpm	3	98bpm	1
45 minutes	128bpm	2	95bpm	1

When it comes to physicality, this game ranks among the lowest of the ones tested in this research, being around level 1 activity on average. However, it needs to be noted that I did not reach a sufficient skill level to challenge the higher tiers of AI difficulty. Despite playing the game for hours over many sessions, and being overall very familiar with the sport, I reached around level 50-60 which is the Hard difficulty, before the AI opponent started getting too challenging for my skills. Thus the higher levels of challenge are likely to also provide higher levels of physical activity. The movement itself in the game is simple as one might expect, using the Motion type of physical movement only, with the extent of it varying depending on the difficulty. Higher levels of AI launch more difficult shots that may require more side-to-side moving, and player skill can vary a lot in multiplayer. The game provides a high level of engagement with its realistic physics, practice modes, and greatly adjustable challenge for the AI opponent, and almost 6 years after release there is surprisingly still an active player base and I never had problems finding online matches, which indicates that long-term engagement is high for this game.

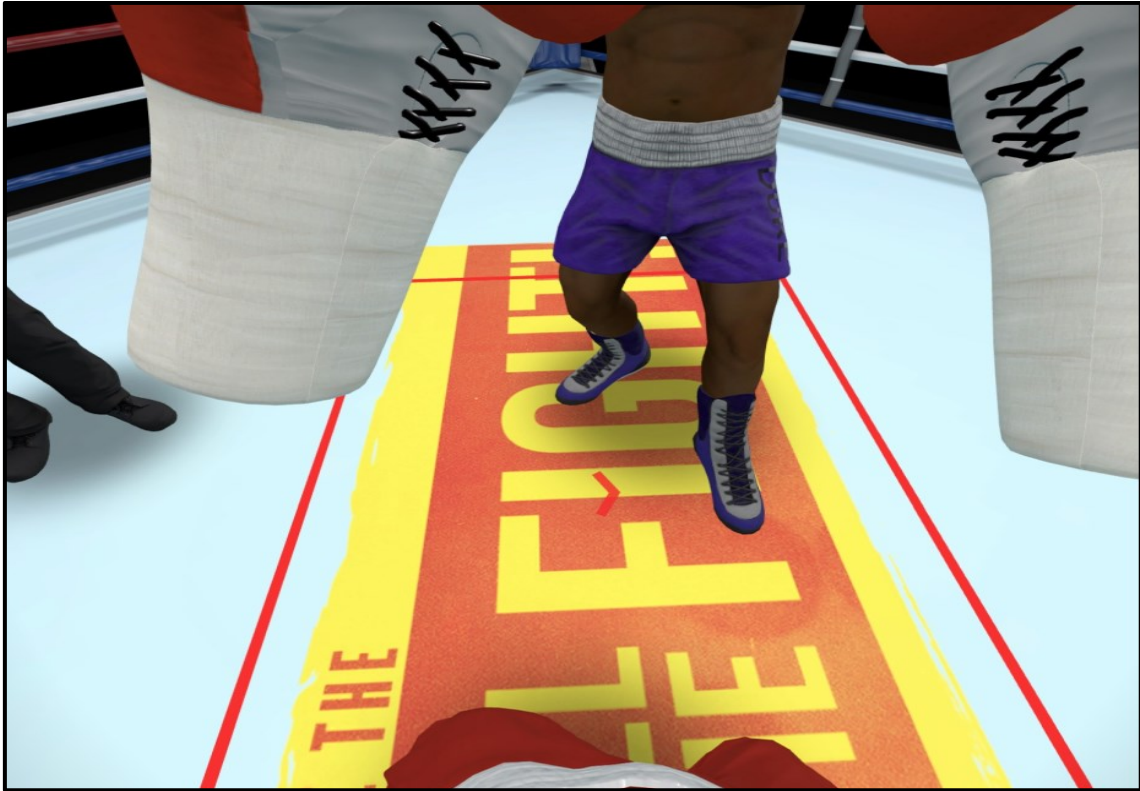
Online play however runs into an issue when it comes to the network latency between the opponents. For the most part, all my online matches played fairly well, but they all have some moments where the ball would skip ahead slightly. This is of course an issue that is almost impossible to completely fix, but it does mean that playing against opponents with a weak internet connection, or greater distances between you, can become an issue. The game does indicate network quality between opponents as you challenge them, so you can always try to choose opponents with the lowest latencies.

6.5 The Thrill of the Fight

The Thrill of the Fight is a VR boxing simulator. Similar to Eleven Table Tennis, this game also boasts realistic physics, practice minigames, and AI opponents of varying levels that can be adjusted with multiple options. The game is a purely single-player experience, however, so you cannot play against other players online. Progress in the game is made in a gauntlet or tournament style, where you must defeat one opponent to unlock the next. There are a total of 9 opponents in the game, and each one will provide an increased level of challenge to the player. Once an opponent has been defeated in either easy or normal difficulty, you unlock customization for that opponent. In customization, you can freely adjust multiple different parameters to decrease and increase the opponent's stats to your liking. You can create a brutal fighter that requires true boxing skills to defeat, or you can create a more 'arcade-style' experience by weakening the foe. To help you improve, the game offers different training modes: a training dummy for practicing enemy weak points; a heavy bag for practicing force of swings; a speed bag for practicing speed and hand-eye coordination; and a focus bag for practicing accuracy and reactions. After fights, you also get a summary of the rounds, which shows your number of successful and missed punches and their force and accuracy, as well as your blocking and dodging.

6.5.1 Enjoyment in The Thrill of the Fight

Hand tracking, haptics, and enemy AI are all excellent in the game. It is extremely easy to get immersed in the fights and quickly exhaust yourself with rapid movements. For this reason, the game requires you to have a play area of at least 2x1.5 meters at a minimum. My play area is around 2x2 meters, which means I have limited space to move around in the boxing ring. The game shows a designated play area on the floor marked as a red box to indicate where it is safe to move and punch freely, which you can see in picture 8. And while it can feel slightly constricted in smaller play areas, it did not hinder my enjoyment that much overall.



Picture 8. Designated play area for the boxing matches (image captured from the game The Thrill of the Fight).

The enemy opponents all feel different from each other in their movements and fighting styles, which creates a nice variety. And the realistic physics and good AI mean that you have to try and learn proper moves and punches, as swinging wildly will quickly both exhaust you and likely make you lose. This gives the player a good challenge as well as plenty of room to improve, and it is always possible to return to previous opponents and practice modes to further improve skills, or just to have an easier time. The controls are simple and intuitive, punching feels authentic with the controller haptics, and enemies realistically respond to hits, often attempting to block or dodge themselves and perform counter-strikes. Enemies also have realistic weak points where hits will wear them down more, and eventually, it is possible to knock out opponents, which feels like a well-earned reward every time. Feelings of immersion and telepresence are mainly created through the interaction against the opponents and the flow of the battles, as there is nothing particular to look at or explore besides this. The game provides clear goals with the distinct opponents, and the summary system offers great feedback on how well the

player performed in matches. A multiplayer mode would add more long-term engagement and a social aspect to the game, but is, unfortunately, missing at this stage, however, the base gameplay and the matches offer plenty of enjoyment, as long as you have the stamina to punch it out.

6.5.2 Movement in The Thrill of the Fight

Table 7. The Thrill of the Fight heart rates and activity levels for 5 sessions

The Thrill of the Fight	MAX HR	MAX LEVEL	AVG HR	AVG LEVEL
15 minutes	160bpm	4	129bpm	2
20 minutes	166bpm	4	129bpm	2
20 minutes	172bpm	5	133bpm	3
25 minutes	142bpm	3	109bpm	1
25 minutes	167bpm	4	131bpm	2

This game provided the highest level of physical exertion out of the tested games by a rather large margin. I was consistently averaging level 2 activity in all my sessions, with high activity periods of level 4 and even up to level 5 spikes. Some sessions would even leave me sore for the following day or two. Stretching is heavily recommended before and after playing this game. Due to this, the session times also remain quite short, with around 20 minutes being the point where I was already sweating a good deal and quite exhausted, this makes the game very effective for short bursts of high activity. Hits feel great due to the precise hand tracking and added haptics, which further increases engagement and makes you want to exert yourself even harder to perform well. The game uses physical tracking for movement with the Motion movement mode and is one of the best examples of this type of movement used to its full potential.

Due to the high activity and decently sized play space this game requires, it can provide difficulties for users with limited space or physical limitations to fully enjoy it. Headsets that are connected to the PC via a cable can also prove to be an annoyance as the game

makes you move on your feet and thus you can get tangled up on the cable, and in the worst-case scenario even trip on it. Being aware of your surroundings and making sure you are centered in your play area is very important when getting into this game. The game does offer some help with this by letting the player adjust the orientation of their play space with the boxing ring. This means you can choose to orient yourself in a manner in the play area that gives you the most open space directly in front of you. For those that are comfortable with their headset and play space, it is a rewarding and enjoyable experience that can provide an effective and hard workout, without really even realizing it.

6.6 Interview

The initial questions at the beginning of the interview were used to establish the participant's extent of experiences with VR devices and games. The interviewee said to have first been familiarized with VR in 2014 with early testing on an Oculus Rift prototype, and later in 2016 she bought a Playstation VR device and has largely played VR on and off ever since. The interviewee mentions her current primary VR headset to be the Oculus Quest 2, which she prefers over the PSVR due to being more technologically advanced and having a larger selection of games. She mentions that she plays on average 3 to 4 times a week with sessions of around an hour or slightly under, but session length may vary depending on the game. The interviewee estimated to have played around 35 different VR games in total with varying genres and plays VR in a living room setting with a play space of around 2x3 meters.

The proceeding questions were formed to gather info on the participants' experiences with VR immersion, what motivates the participant to play VR games, how does the participant view VR exercise and different movement aspects of VR games, and in general what mechanics and aspects of VR games are positive and negative in the participants' eyes. The results of this interview were in large part similar to those of my own experiences. The interviewee brought up that she often plays VR games for exercise and

enjoyment purposes, and that she finds VR gaming to be a helpful tool in enjoying physical activities more, claiming to be easily bored with exercise otherwise. The interviewee also mentions immersion, motion controls, and the alternate perspectives of VR environments to be some key factors that make VR games exciting compared to traditional video games. In the next chapter, while synthesizing the results of this research, I will bring up relevant answers from the interviewee to compare her findings to my own experiences.

7 Synthesizing the results

The game testing and interview provided a lot of useful information about mechanics and design decisions that influence both the enjoyment and physical activity achievable in VR games. To synthesize these results in a more structured manner, I will break down the results into two categories: decisions that primarily affect the player's movement in VR games; and decisions that primarily affect enjoyment in VR games. I say primarily because many aspects can naturally affect both since it is widely proven in research that exercise can lead to positive increases in mental health factors, and enjoyment can lead to better engagement and adherence to exercise. In these categories, I will discuss the findings of my own experiences, the answers, and experiences of the interviewee, and the findings that previous research has presented. After synthesizing these results, I will provide a list of themes in VR games that can be seen to provide more enjoyable gameplay, better engagement in the physical aspects of the games, and a stronger feeling of flow.

7.1 Results on VR movement

7.1.1 Importance of movement modes and design

Different movement modes allow for a varying degree of freedom and choice in VR games, and it is important for the movement options and methods to feel intuitive and easy for the player to grasp. Avatar movement allows for most choice in movement, and when asked about movement modes during the interview, the participant also said that she prefers the Avatar type of movement for its freedom and choice. Generally speaking, this type of movement should always be the best choice, since it allows for both physical and artificial movement, but this is not always plausible, or even preferable in VR games. The interviewee brings out a great point about the different movement modes and why it may not always be best to grant players the most freedom, stating:

For example, the game *Rush of Blood* is a "Turret" Horror Shooter game. You are stuck on a cart on a railway and you have to protect yourself. Making the game *Pilot* only would completely remove the uncertainty and surprise of the game, basically changing the whole thing.

If a game is designed to be played with certain restrictions in movement, granting the player too much freedom can break aspects of the game and lessen the experience. There is no movement option that is unquestionably the best and this is why VR games need to be designed with a set movement at its core so that all the gameplay and mechanics are centered around that type of movement. If a game allows for several different types of movement, it needs to make sure those movements are supported by the game design. *The Thrill of the Fight* was restricted to physical movement only, but since the game was designed fully for this type of movement, it did not lessen the experience. Only the game *Gorilla Tag* in this study made full use of both physical and artificial movement, but that alone did not automatically make it the most enjoyable game in terms of movement. In addition to marrying movement to game design, it is important to remember hardware and user restrictions as well. The interviewee points out that the PSVR headset uses frontal light tracking from a separate camera, meaning that the headset loses tracking if the player faces away from the tracking device, rendering full 360-degree movement impossible. Games that adopt a room-scale Motion movement type must be aware that many users may be physically restricted by their play space or other means. Headsets also come in wired and wireless forms, creating differences in freedom and technical limitations.

Choosing an appropriate movement mode is only the first step in creating enjoyable movement in a VR game. The developers must also consider the design of the movement, the environment where the movement happens, how the gameplay is tied around those designs, and how different mechanics of the game support that gameplay. *Gorilla Tag* is designed to allow full freedom of movement in large environments, and for this purpose, we can see how the different design choices support this: The artificial movement is motion-controlled from a first-person perspective and feels intuitive and immersive; the environments are sufficiently large to allow for exploration, and there are various

obstacles and environmental objects that users can use as platforms for more imaginative and enjoyable movement; the gameplay is easy to learn but hard to master, which allows players to freely explore and get accustomed to the movements at their own pace; the game has almost no additional gameplay changing mechanics, which works perfectly for this type of gameplay and movement. All of these design choices work in good harmony and for a specific purpose, to have enjoyable and engaging movement. When asked about different types of gameplay that would be nice to see in more VR games, the interviewee mentioned the freedom of movement in Gorilla Tag as a primary example.

Many of these design principles are shared by all the games in this study, but some also present examples where the movement and mechanics reveal some unfavorable designs. Beat Saber offers enjoyable and engaging movement for the most part, but sometimes introduces mechanics and design changes in certain levels that can confuse or distract gameplay. The interviewee mentions some criticism for Beat Saber: “The patterns can be very hard to do if you have short arms which can make some songs very frustrating to complete. There are also some default background environments/colors that make it very hard to see properly”. The game has regular updates that add new content and fixes, and while generally this is seen as a good thing, sometimes it can introduce changes or additions that unnecessarily complicate the base gameplay. Sprint Vector can offer enjoyable fast-paced movement in some moments, but the complex mechanics and rapid gameplay make the initial learning period long and frustrating. The design of the back and forth swinging movement lacks variety and becomes monotonous after a while. In the interview, the participant also mentioned that the game would stop providing sufficient challenge once you mastered the movement.

7.1.2 Different levels of physical activity and engagement

The tested games provided varying degrees of physical exertion in the activity level tracking and provided some good insights into the relationship between engagement and

exercise. Challenging content and skill expression proved to be an important aspect in both engagement and enjoyment. Graduality and choice were clear positives when it came to challenging gameplay. Beat Saber offers dozens of options to modify the difficulty of songs, and improvement in skill to gradually attempt and complete higher levels of difficulty feels rewarding and satisfying. VR experiences can easily be overwhelming, especially when first starting with a game, so having a simple concept of movement that can be gradually increased in difficulty as the player increases in skills is vitally important. This is something that most of the tested games in this study achieved with great success. Sprint Vector proved the most difficult game to learn the movement early on, but also did not seem to challenge the player that much in the long term. This was one of the key reasons it turned out to be the least enjoyable experience as well, despite having great potential for exercise, and many gameplay aspects that could typically be attributed to more enjoyment, such as fun powerups, colorful environments, and great overall polish.

This goes to show that a VR game being well suited for exercise is not enough for players to want to engage in it. The game needs to be accessible enough to not intimidate the user from the start, and offering gradual challenge and skill expression leads to both higher enjoyment and long-term engagement. The interviewee valued replayability for exercise purposes, which comes from engaging and enjoyable content. Offering variety in challenges is also beneficial to accommodate different levels of users as well as different goals when playing. Ijaz, et al. (2020, p. 1201) found in their study of player satisfaction in VR exercise, that participants could be divided into two separate groups: those that focused on the entertainment aspect of VR, and those that focused on the exercise aspect of VR. They noted the importance of meeting the needs of both types of groups. The interviewee also noted that they found variety in movement important, as VR session goals would often change between exercise focus and relaxation focus. My own experiences corroborate with these findings, as my goals in gaming with VR could change drastically depending on the day. Some days I was in the mood for a heavy exercise and would choose a game that allowed for this, other days I was feeling less energetic and would choose a game that allowed for more relaxed gameplay.

A well-designed exergame offers enjoyment for both ends of this spectrum, and this became apparent in this study as well. The Thrill of the Fight was the most physically demanding VR game tested in this study by quite a large margin, but it did not automatically become the game I would choose even when I felt like exercising heavily. Similarly, Eleven Table Tennis was the least physically demanding game in this study, but I would still choose other games often when wanting a more relaxing session, as sometimes I might feel a burst of energy during gaming, and a game like Eleven Table Tennis did not offer the possibility for me to increase the intensity of the exercise to a demanding level. When asked about feelings of immersion in VR gaming, the interviewee mentioned that often moments of high intensity and concentration would give the best immersion. Overall, in terms of games that satisfied both ends of the spectrum, Beat Saber and Gorilla Tag proved to offer the greatest gameplay and movement to allow for it.

Ultimately, the best results for exercise, especially in the long term, are not necessarily found in the VR games that offer the most incentive to exert yourself, but rather in games that offer gameplay with diverse challenges and enjoyable movement that allow the players to fully express their skills and not be instantly intimidated by difficult or demanding mechanics. When these themes are present in a game, it can provide enjoyable exercise with long-term adherence and benefits. McClure & Schofield (2019) proposed that VR exercise can potentially be more appealing than traditional exercise due to providing distractions from bodily sensations. These results can be seen in this study over the dozens of hours of playtime spent on games like Beat Saber and Gorilla Tag when I typically avoid and dislike normal methods of exercise. Additionally, I felt more and more comfortable with VR gaming the more I played and could exert myself further through every session of exercise. These same results were provided by the interviewee, who has noticed improvements in endurance and increases in muscle mass through VR exercising over several years and also noted to get easily bored with normal exercise methods.

7.2 Results on VR enjoyment

Like the previous segment shows, a significant amount of enjoyment can be found in a well-designed movement when it comes to VR games, especially exergames. Intuitive movement, challenging gameplay, and skill expression are all attributes that can greatly enhance enjoyment. While enjoyable movement and opportunities for physical activity can be attributed to any VR game, these attributes are most often found in exergames, and all the games tested in this study can be categorized as such. This naturally leads to movement being one of the most important factors in the enjoyment of these games. The interviewee stated that her main attraction to VR gaming over the years shifted from curiosity and new experiences, to exercise and enjoyment. Users' goals and motivations can change, and that makes it important for VR games, even exergames, to have other aspects of enjoyment. These are often aspects that can be attributed to good video game design overall.

First, it is important to mention that basic accessibility and comfort features are critical in creating any VR game that is looking to gain the largest possible player base. Many challenges require hardware-based solutions, but the largest accessibility feature that developers can affect is diminishing simulation sickness. While simulation sickness is not an issue that came up in my testing, its potential effects on enjoyment in VR gaming cannot be diminished. Common basic features to help against it include teleportation movement, snap camera rotation, field of view reduction in movement, and re-orientation of the camera and player view. Faric et al. (2019, p. 6) mentioned motion sickness (termed differently but with the same meaning) as one of the key themes that negatively affected virtual reality exergame reviews. The effects of simulation sickness can diminish over time. This was the case for me, and also that of the interviewee when asked about it. But for new users of VR, it can create such discomforting experiences that they may be turned off from further attempting VR gaming at all.

Moving back to my experiences in testing, one attribute that I found to greatly increase the enjoyment in my experience was gameplay options and customization that added

new flavors to the gameplay or environment. These could be changes to game mechanics, visuals, or anything else that managed to renew interest in the game and give something new to try out or see. In Gorilla Tag, the game environment sees periodical changes depending on seasons and holiday events, like making environments snowy during winter (see picture 5) or doing other environmental changes like adding nighttime cycles and lamp posts. In terms of gameplay, the different maps in Gorilla Tag can change the way players approach their movement style. A forest map allows for precise movement when going from branch to branch, while a large desert canyon map leans more towards fast and big movements. Eleven Table Tennis offers different minigames and environmental locations to play in, while Beat Saber offers different gameplay modifiers for songs and even custom color palettes for the visuals. The different options do not need to change gameplay or visuals in drastic ways, just enough to make it feel different and allow the player to change things up once in a while.

Another aspect that closely relates to gameplay options and customization, is new content additions for games. New content can add longevity to a game and increase the player base through increased relevance and staying power. Beat Saber offers both official purchasable song packs, but also provides the possibility of user-made content within the PC platform. This type of content can greatly increase the longevity and appeal of a game, and user-made content especially offers virtually limitless opportunities for new content, as long as it is supported by the game. Gorilla Tag started offering visual cosmetics that can be earned through playing daily or by buying with real money. These types of purchases, which are often called microtransactions, can be risky attempts as there is a lot of scrutiny over microtransactions in gaming, but the most important aspect of any added content is the perceived value by the users. Gorilla Tag is a completely free-to-play game, which can greatly affect players' willingness to spend money on things they perceive to be within the value they have gotten from the game. Pricing of the games themselves is thus important to manage players' perception of the value they give, and Faric et al. (2019, p. 6) mention this in their list of themes as well. This was an experience that both I and the interviewee also shared. The interviewee mentions that

the price of a VR game can alter the expectations of quality, and it is easier to forgive shortcomings for cheaper games, and thus have increased enjoyment, while more expensive games come with higher expectations and can more easily disappoint.

Multiplayer and social interaction can enhance the player experience when designed properly. Playing games with friends usually brings more enjoyment, but also having other players to interact with and compete against can bring life to a game. Some games, like Gorilla Tag or Sprint Vector, will be designed with multiplayer as the main gameplay focus, while others use it as a complementary game mode, like Beat Saber. While social aspects can often increase the value and enjoyment of a game, the implementation must be done properly to function within the game. Adding a multiplayer simply for the sake of adding it will often lead to half-measured designs and a fragmented player base. Furthermore, when social interactions within a game include communication, active moderation and rules of conduct are critical for punishing and decreasing toxic behavior. Gorilla Tag is an enjoyable experience at its base, and social interactions can often increase that enjoyment, but also decrease it based on the type of interactions you have. When asked about social interactions in the interview, the participant mentioned that she tends to prefer single-player experiences and does not often engage in interactions even when available, unless needed for that particular game. She notes that a large part of this reason is due to toxicity in gaming communities, especially towards females. Lastly, she does add that playing with friends will cause her to interact and socialize more, and those experiences are usually positive.

Another issue for games that lean on multiplayer aspects is the need to support long-term engagement. Sprint Vector gameplay is primarily aimed at a multiplayer experience, but the player base has diminished to the point where finding other players is almost impossible. This was the case in both my testing on the PC platform and the interviewees' testing of Spring Vector on the Playstation platform. Eleven Table Tennis is an example where engaging gameplay and active development of the game can keep multiplayer alive for several years. This active development and communication is also a key part of

keeping games with multiplayer alive. If a game is abandoned shortly after release by the developers, players will tend to lose interest quickly and move on to other games. This is not an issue if a game is intended to be played as a one-off experience, but when it comes to multiplayer aspects and exergames, long-term engagement is very desirable.

Visuals of a game are another aspect that often gets brought up in discussions about game quality. Faric et al. (2019, p. 6) mention graphics as another aspect that can affect VR experiences both positively and negatively, however, my experiences did not match visual quality and graphics to enjoyment in the tested games. This is an attribute that I think mostly affects video games with strong exploration and story aspects. In exergames and movement-focused VR games, I never felt the need to admire the visuals or crave more realism. This is one aspect that will be highly subjective, and the interviewee also finds graphics to be important, especially for the initial impressions but clarifies that this is also partly due to her previous studies in that domain. Overall, I do not place much importance on graphical quality when it comes to enjoyment in exergames, and lower visual quality often means more accessibility and a smoother experience for different computer setups. This is not to say that graphics and visuals should be disregarded when designing VR exergames, as video games are a visual medium at their core. Pleasing visuals can always be seen as a positive, but past a certain point, they did not add too much extra value in my opinion.

One aspect regarding visuals and gameplay that does hold great importance is bugs and glitches being present in games. These can be summarised as errors in programming that can cause undesired effects in both visuals of the game, as well as the gameplay itself, and Faric et al. (2019, p. 6) mention this as yet another aspect that can affect games negatively. These errors can range from minor annoyances to fully game-breaking disasters, or –as the interviewee mentions– sometimes funny experiences when they cause an error that does something unexpected without breaking gameplay. These types of errors happen in nearly all games, and they highlight the importance of keeping games updated with patches that fix these issues and improve the game further.

7.3 List of positive themes for VR exergames

With these aspects and designs explored and synthesized, we can put together a list that details some of the most important themes in VR exergames. It is important to note that these findings may not represent themes that apply to all VR games. The focus of this study is on VR games that present strong possibilities for physical movement. These types of games are usually characterized as VR exergames but can include other genres with movement-focused designs. Similarities with other lists of video game themes are still highly likely, as many of these attributes are universally desirable. The themes here are listed in a perceived order of importance based on the research and were all discussed to some degree in this chapter.

Table 8. List of themes for positive exergame experiences

<u>Theme</u>	<u>Explanation</u>
Intuitive fusion of gameplay and movement.	Movement in the game and for the player matches the gameplay in a way that makes it feel intuitive and natural.
Allow varied skill expression.	The game should provide challenges to players of varying skill levels to make sure gradual learning and higher skill acquisition are smooth and rewarding.
Simplicity and quality of basic gameplay.	The basic gameplay mechanics should be simple enough to grasp quickly, and enjoyable in themselves, as VR games can generate very front-loaded experiences for players.
Options and customization that enhance the experience.	Games that offer options and tweaks that can change the gameplay or give it new flavors often provide a better and more engaging experience.

Accessibility and comfort.	Basic accessibility and comfort features for VR gaming are important to diminish the effects of simulation sickness in players.
Price.	The price of a game and its content can potentially influence the perceived value, which can lead to higher or lower enjoyment.
Additional content.	Adding new content to games is a great way to increase player retention and long-term engagement. Content should be priced based on perceived value, and free content is almost always a positive experience.
Updating the game.	Bugs, exploits, and other criticism of a game can quickly turn experiences sour, so developers need to keep the game consistently updated with fixes.
Social aspects.	Social aspects in VR exergames can increase competitiveness and enjoyment, leading to greater engagement. Implementation requires careful consideration, as negative effects can arise from harassment and toxic behavior.
Developer communication.	This relates especially to games that have social aspects. Communicating with the community over changes and issues is important to maintain customer happiness and to maintain long-term engagement.
Visual quality.	Visuals and graphics are always an important aspect of video games, and VR games especially can benefit from strong visuals for immersion and presence. But past a certain point, they do not hold great importance for exergames.

Movement and exercise-based themes were found to be of greatest value in VR exergames, as they improve both the physical aspects of the game while increasing enjoyment at the same time. The first five aspects already represent a well-designed core VR exergame with all the important blocks in place. Further below are themes that can all give additional value to enjoyment and engagement, and these themes can rise and fall in importance depending on the severity of the issues within the design. Mestre et al. (2011, p. 13) make note that the enhancement of performance in VR exercise is a combination of complex interactions between the intensity of the exercise and different sensory information. The themes in this list are similarly all linked together in interaction and importance.

Some themes that do not appear here, but are discussed in Faric et al. (2019, p. 6) study on user reviews of VR exergames, are real-world feeling, immersion, appearance, and music. I will give a short explanation of the reason and the differences in the findings of this study. Real-world feeling was described as body movements that mimic real-world sports or activities. I did not find any correlation between this theme and increased enjoyment or appeal in my experiences. Two of the tested games in this research were sports simulations that closely mimicked the real sport, and while both had engaging and enjoyable movement, they did not prove to be any more appealing than movements in Beat Saber that do not particularly mimic any real-world movements. Immersion does not fit a list of game design themes, as it is not something you can directly design into a game. Immersion comes from the combination and harmony of other well-executed design aspects listed here.

Appearance was described as the feeling of how you look while playing (Faric et al., 2019, p.6). This does not hold any particular relevance to movement or enjoyment and never came up as a point in my experiences or the interview. Music is something that games generally always adopt in some capacity. Games like Beat Saber and many other rhythm-based VR exergames include music as a key aspect of the main gameplay, but it is not an aspect that equally affects exergames as a whole, and as such it does not feel reasonable

to single this theme out for those instances. However, it should be noted that music can be an important and powerful motivator in exercise, as is also noted by Mestre et al. (2011, p. 13) in their study on VR exercise.

8 Conclusions

In this study, I sought to find out what aspects and themes of VR exergames are most effective in providing opportunities for enjoyable active movement for the player. Data gathering was done via user experience testing and activity tracking of five different VR games, and a written interview of a participant with years of experience in VR gaming. The results of this study came through the analysis and synthesizing of the data, as well as results shown in previous studies. Over 30 hours in total were spent on playing and testing the games alone, and the interview was conducted over the course of two weeks, which gave opportunities to gather more data. These results were formed into a list of design themes for VR exergames that should prove beneficial for enjoyable and engaging movement.

The purpose of this list is not to provide a thorough and complete checklist of design themes for developers to create a VR game, but rather a list that supports game development in a way that prioritizes certain themes and designs that can be seen as especially beneficial for enjoyable gameplay and movement systems. The results presented in this study coincide in large part with the findings of Faric et al. (2019) in their thematic analysis of VR exergame user reviews. Both studies found evidence of intuitive and well-designed movement systems and skill expression via gradual challenges to greatly increase enjoyment in VR exergames. Furthermore, examinations of previous research and the results found in this study affirm that VR exergaming can increase engagement and enjoyment of physical activity in users compared to traditional exercise. Faric et al. (2019, p. 10) and Qian et al. (2020, p. 14) both comment in their studies that further exploration into the long-term engagement of VR exergames should be focused on in further studies. In this study, positive proof can be found on both the effectiveness of and adherence to VR exercise in the long term, which is a factor that most research in this field has not been able to properly study, and only alluded to.

This research contributes a significant help for both developers and researchers of VR exergames with its qualitative and user experience-focused findings. As noted by earlier

studies, this is a field that still lacks research, and thus the results here can further help contribute to the ever-growing studies into VR exercise and its benefits. VR exergames can be used for a variety of health-related benefits, and platforms like the Nintendo Wii have proven that there is a significant market out there for exergaming. The design themes provided in this list through user experience research should help both developers in designing better VR exergames for VR users, as well as researchers in identifying key aspects of VR exergames in testing and analysis. However, due to the limited scope of both tested games and user feedback from others, the results found in this study will need further peer-reviewing.

Future research can expand on the focus of user experience with a larger variety of tested games, especially games that provide more varied body movement, and a feedback section with a wider scope of participants to be interviewed or questioned. It is also important to note that the results found in this study are primarily limited to VR exergames or similar VR games with a strong focus on movement. These results may not be replicable for other genres of VR games, and there is evidence from studies like Yildirim et al. (2018) and Carroll et al. (2019) that indicate no significant differences in the user experience of VR gaming and traditional gaming in certain genres like FPS (First-Person Shooter), Strategy and Racing. Lastly, as the technology of VR headsets and the complexity and design of developed games improves and evolve, the research in this field must also consider breakthroughs and innovations that can affect future results and studies.

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Appendixes

Appendix 1. Interview questions

Q1: How long have you approximately been playing VR games?

Q2: How many times/hours do you play per week on average? (Estimate is fine)

Q3: What device or devices do you play on? And do you have a primary or preferred device?

Q4: If you have a preferred device, is there a particular reason why you prefer it?

Q4.1: As you said your main device currently is the Quest 2, which is a wireless device: Do you usually play VR wireless or linked to a PC with the link cable accessory?

Q4.2: If you have experience with both wireless and wired, do you find a big difference between them?

Q5: As an estimation, how many different VR games would you say you have played for at least a few sessions?

Q6: Out of all games, do you have a preferred genre or game type? For example, adventure, sports, fighting, shooter, sandbox, puzzle, etc.

Q6.1: What would you say makes rhythm VR games so re-playable?

Q7: Do you experience any simulation sickness when playing VR games? (Effects include, nausea, dizziness, headache, and fatigue)

Q7.1: If you answered yes, are you able to pinpoint any specific motions, gameplay, or visuals that cause it or may make you more susceptible to it.

Q8: Do you ever experience states where you forget your surroundings while playing VR games?

Q8.1: To further go into this point, do you sometimes/often feel like you are immersed in VR to the point you shut off the outside world in a sense?

Q9: Do you ever experience states where you lose track of time while playing VR games?

Q10: On average how long are your VR sessions? (You can elaborate if it varies)

Q11: What would you say are the biggest advantages of VR gaming compared to traditional video games?

Q12: What is usually your main goal(s) in playing VR games? For example, is it for relaxation, enjoyment, exercise or simply to have new experiences, etc.

Q12.1: Going a bit further into this, what do you think makes VR games especially motivating for exercise?

Q12.2: Also, how often would you say your VR sessions end with you being moderately/highly worked out physically? Do you ever start VR sessions with the sole purpose of making an exercise out of it?

Q13: VR games often have different modes of movement: The four general ones can be categorized as Pilot, Turret, Motion, and Avatar. In Pilot movement, you can freely look around, but the movement is fully done on the controller, and physical movement does not move your avatar in-game. In Turret movement, you are also able to look around freely, but the movement is completely automatic, like in a roller coaster. In Motion movement, you are constricted to your physical play space size, but can freely move your character in it, there is no controller movement. And lastly, in Avatar, you have complete control of both physical and artificial movement within the game world. Reading these descriptions, are you able to choose a preferred mode of movement for yourself? Do you think it's important for VR games to offer these different types of movement options?

Q14: Speaking of different games, this research includes the following games as part of a test group: Beat Saber, Gorilla Tag, Eleven Table Tennis, Sprint Vector, and The Thrill of the Fight. Which of these games are familiar to you?

Q14.1: Out of the games you are familiar with, how would you describe them in terms of enjoyability and the active movement they provide? Do you have any criticism that comes to mind for any of them?

Q15: Many VR games are starting to have multiplayer/social aspects included in them. If you have experience with games that have them, do you usually participate in them, or do you prefer to play VR on your own?

Q16: Is there any game mechanic/playstyle/gameplay loop you would like to see used more of in VR games?

Q17: Is there any game mechanic/playstyle/gameplay loop you wish would be used less in VR games?

Q18: Have you ever physically hurt yourself while playing VR games?

Q18.1: Would you say these injuries are more due to the immersive nature of the games, or due to the intensity of physical movement they require?

Q19: Do you feel like technical aspects of VR games (like framerate, bugs, graphical realism) greatly affect your enjoyment of the games?

Q20: Can you remember instances where the price of a VR game may have influenced your experience and enjoyment of that game in some way?

Q21: Have you noticed any increased levels of physical fitness in yourself as a result of playing VR games?

Q22: How big of a play space do you have for VR?