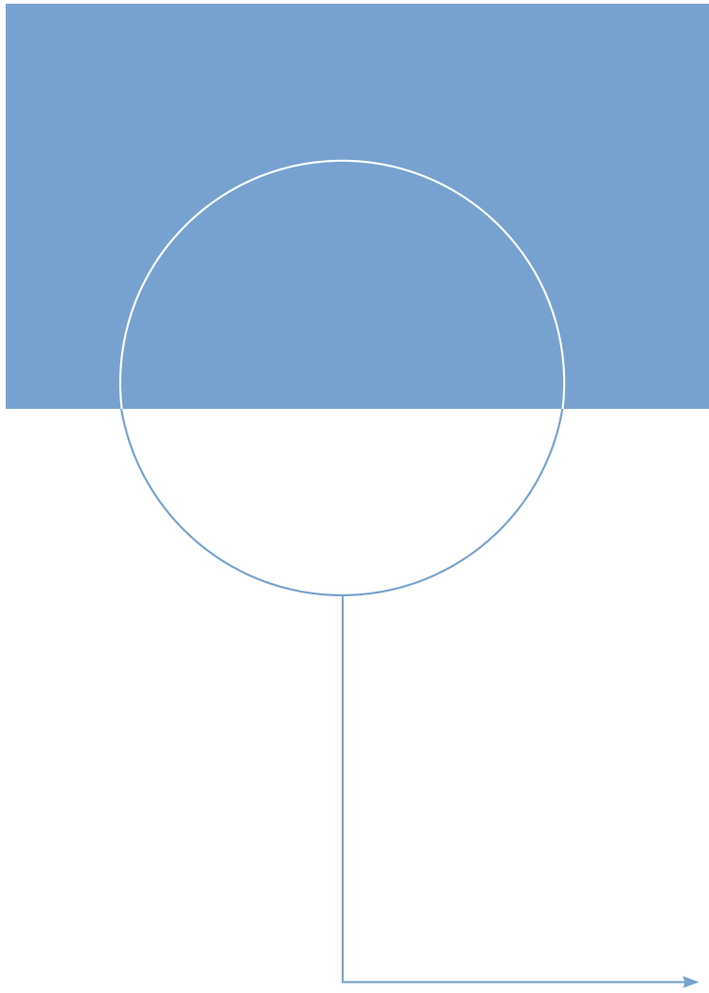

Master's thesis

2020

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Lane Rider

An Exploratory Study on the Benefits of Exergaming

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An Exploratory Study on the Benefits of Exergaming

Emil Petter Schrøder
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Master of Science in Informatics
Submission date: June 2020
Supervisor: Alf Inge Wang

Norwegian University of Science and Technology
Department of Computer Science

Abstract

In this day and age, a growing concern of inactivity and obesity among the youth is being raised by academia and media in general. The Covid-19 pandemic has reinforced and actualized the complication of a sedentary lifestyle worldwide. Exergames, a combination of traditional video games and physical exercise, have shown potential as an enjoyable incentive for the younger population to be more physically active. This thesis investigates the effects of exergames by creating a game for indoor cycling complying to the standards of high-intensity interval training.

A pre-study on the concept of exergames were conducted, focusing on existing exergames, technologies, exercise types, game mechanics and genres. This provided the basis for the creation of new exergame concepts, where one was chosen to prototype. This prototype was named Lane Rider.

The prototype was tested on 16 participants with various levels of physical activeness and gaming experience, throughout three sessions. The experiment examined players' perception on enjoyment, motivation and social interaction, along with the quality of physical exercise provided by the game. The results were obtained using a heart rate monitor to document the benefit of training, a questionnaire to reveal participants perception and observations to substantiate the findings.

The results show that Lane Rider is enjoyable, motivating, with an exercise equivalent to moderate intensity, and that the social interaction provided by the game possibly enhances the total experience. Additionally, the results indicate that physically active participants are more stimulated by the social interaction embedded, and that participants that often play games expect more from the exergame but, at the same time, learn to play the game faster. The intensity of the exergame is not vigorous enough to satisfy the criteria for high-intensity interval training. However, the Fitbit Charge 3 used in the experiment, appears to underestimate the heart rate data, indicating that the intensity is higher than measured.

Sammendrag

I dagens samfunn er det av media og akademia fremmet en økende bekymring for inaktivitet og overvekt hos den yngre befolkning. Covid-19-pandemien har forsterket og aktualisert problemene tilknyttet en stillesittende livsstil i en global sammenheng. Exergames, en kombinasjon av tradisjonelle videospill og fysisk trening, har vist potensiale som et morsomt insentiv for den yngre befolkning til å være mer fysisk aktiv. Denne masteroppgaven undersøker effekten av exergames ved å lage et spill for ergometersykling som følger kriteriene til høyintensitets intervalltrening.

Et forstudium av konseptet exergame ble gjennomført med fokus på eksisterende exergames, teknologier, treningstyper, spillmekanikk og sjangre. Dette la grunnlaget for ideer til nye exergame-konsepter, hvor et ble videreutviklet til en prototype kalt Lane Rider.

Prototypen ble testet på 16 deltakere med ulik spill- og treningserfaring, over tre økter. Testen undersøkte spillernes oppfatning av glede, motivasjon, sosial interaksjon, i tillegg til treningsutbytte. Resultatene ble innhentet ved hjelp av en pulsmåler for å dokumentere graden av treningsutbytte, et spørreskjema for å avdekke deltakernes oppfatning, og observasjoner for å underbygge funnene.

Resultatene viser at exergamet er morsomt, motiverende, med en treningsintensitet som tilsvarer moderat intensitet, og at den sosiale interaksjonen mest sannsynlig forsterker den helhetlige opplevelsen. I tillegg viser resultatene at fysisk aktive deltakere er mer stimulert av sosial interaksjon, og at deltakere med lengre spillerfaring forventer mer av spillet, men samtidig lærer spillet raskere. Intensiteten til spillet er ikke høy nok for å tilfredsstille kriteriene til høyintensitets intervalltrening. Fitbit Charge 3, som ble brukt i eksperimentet, ser ut til å underestimere hjertefrekvensen, noe som indikerer at intensiteten er høyere enn målt.

Acknowledgements

We wish to express our sincere appreciation to our supervisor, Alf Inge Wang, for the support and valuable recommendations during the writing of this thesis. The door to the office was always open whenever we encountered problems or had questions. We also appreciate all the assistance we got after the Covid-19 outbreak occurred, arranging new test facilities and frequent supervisory meetings on Zoom.

We are also grateful to, Terje Røsand, for all the help we got to organize the room used during the development of our exergame, and to Playpulse for providing the exercise cycles and other necessary equipment.

Lastly, we would like to thank the participants for their cooperation on the experiment, especially because of the dire circumstances caused by Covid-19. This could not have been done without you.

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Part I

Introduction

The first part presents the motivation and context of this project, as well as covering the research questions we pursue to answer. It also presents how the research will be conducted and structured.

Chapter 1

Motivation

Physical inactivity has become an accelerated problem in the younger population of developed countries. Along with a higher amount of excessive screen time in daily life, people are conforming to a more sedentary lifestyle [74]. This is not likely to change, given the growing influence of technology in quotidian life, such as smartphones, computers and home-automation. Inadequate activity levels and excessive sedentary time are two of the leading causes of overweight and obesity, which consequently can affect personal health through medical disorders and chronic diseases (e.g. type 2 diabetes, metabolic syndrome, hypertension and cardiovascular disease) [28] [74].

Video gaming is a popular and enjoyable activity among youths and young adults, but are often implicated in discussing responsibility for the upsurge of a more sedentary lifestyle [77]. Although video games, in general, are criticized for contributing to the deterioration of physical health, the field of video games vary, and players activeness is not always limited to sedentary activity. Some video games involve physical movement and can actually help motivate and encourage exercise. This introduces us to a partly new concept, *Exergame*, which, by combining video games and training, turns video games into a healthy activity and thus reveals an untapped potential in combining entertainment with exercise [78]. The significance of Exergames can, in this respect, be argued to have increased by the worldwide spread of Covid-19. While writing this, it was reported by Aftenposten that 40% of the world population was in quarantine and encouraged to stay

home [21], thus upholding sedentary behaviour with less physical activity. As a result, exergame products have become increasingly popular during the Covid-19 crisis, as illustrated by the exergame *Ring Fit Adventure* tripling in sales [46] and even sold out across the US [80].

We, the authors, experience the lack of motivation for exercise ourselves, and much of our daily life is comprised of sedentary behaviour. We are, however, deeply engaged with video games, and use several hours a week on this activity. Making an exergame that we and others can enjoy and benefit from, is a meaningful motivation to why we wish to explore the realm of exergames.

Chapter 2

The Project

The initial project description was created and provided by Alf Inge Wang, a professor at the Norwegian University of Science and Technology. The project was intended for master students' final thesis and is part of NTNU's research effort on exergames. The problem description is as follows:

[ExerGames] Multi-player pedal-game
The goal of this project is to design and develop new game concepts for a game where an exercise bike is used as a game controller in addition to traditional game input through mulitple buttons. In addition to input from buttons, the player should control the game through using her/his fit moving the pedals. The goal of the game is to both to have fun that can last over time as well as getting a physical exercise. The game should be implemented in Unity using a provided API for the exercise bike controller. The goals of this project is: Research existing exergames and games that could fit this purpose, Design and implement a prototype game, provide input on the API for the exergame framework used, and evaluate the game through user experiments.

Our project will follow the guidelines introduced in the description. The first part will cover the pre-study phase, following the creation of a potential exergame. The last part will evaluate the experiment conducted.

2.1 Implication from Covid-19

As mentioned in Section 1 above, the Covid-19 outbreak had a severe impact on society. The outbreak lead to NTNU closing its campuses, consequentially affecting our progress on the master thesis. We had nearly finished implementing our game and had started planning the experiment when it happened. How this influenced the experiment will be described in further detail in Chapter 20.

Chapter 3

Research Questions and Methodology

This chapter will introduce the research goal of this project, and a deduced list of research questions assisting the evaluation and direction of this thesis. In order to answer these research questions, the appropriate research process and strategy are established.

3.1 Research Questions

The ulterior motive of this project is to give individuals an incentive to exercise by creating an exergame that harnesses players' enjoyment of training experiences. In order for us to develop such an exergame, we intend to examine what types of game design elements enhance enjoyment in exergames, as well as providing a reliable increase in the players' physical activity. This knowledge will then be applied to the development of our exergame, which will be integrated into an exercise bike with controllers connected to the pedals and buttons on the handlebar.

In essence, our **research goal** is to develop and evaluate an enjoyable exergame that provides physical exercise benefits. In order to clarify the objective, the research goal is divided into eight research questions, whereas two of these have an integrated sub-question:

RQ1: What kind of game genres are suitable in exergames?
Balancing the focus on efficient physical exertion with enjoyment can be a complicated task since it is not necessarily perceived as a corresponding occurrence. Game genres can have an impact on both of the aspects found in exergame, and this research question will, therefore, investigate which game genres promotes a coherent solution.

RQ2: How does social interaction affect players' experience in our exergame?
This question will look into how the interaction between players' may promote or hinder their exergame experience, particularly towards their motivation and enjoyment.

RQ3: How does our exergame influence players' physical activity?
This research question investigates to what degree our exergame supports physical performance. It will be answered during the user test by monitoring the participant's heart rate, responses from a questionnaire, as well as observations.

RQ3.1: How does our exergame influence players' physical activity over time?
As a sub-question to research question 3, this question will investigate how the exercise effect lasts over time. To answer this, the user tests will be monitored over a set period, comparing participants fitness progression.

RQ4: How does our exergame affect players' enjoyment?
Players willingness to continue playing a game may rely on their enjoyment at playing the game. This question will investigate to what extent individuals enjoy our exergame, and if it can stimulate players towards a state of flow. This will be answered by using a questionnaire and observations during user tests.

RQ4.1: How does our exergame affect players' enjoyment over time?
As a sub-question to research question 4, this question will investigate how players enjoyment lasts over time. It will be answered by using a questionnaire and observations, comparing players responses over a set period.

RQ5: How does our exergame affect players' motivation?
This question will investigate to what extent players feel motivated to play our exergame and how this compares with their motivation for traditional exercise.

RQ6: How well does our exergame with its game mechanics, support high-intensity interval training?
For players' to gain positive fitness progression, high-intensity interval training is advised. This research question will investigate whether or not our exergame supports such training.

RQ7: How does physical active players' enjoy the exergame compared to non-active players?
This question will investigate if there is a difference in enjoyment between physical active players and non-active players, and if such is the case, discuss why that is.

RQ8: How do gamers enjoy the exergame compared to non-gamers?
This question will investigate if there is a difference in enjoyment between gamers and non-gamers, and if such is the case, discuss why that is.

3.2 Research Methodology

This section presents the methodology of our research. It gives an overview of the research process, along with a presentation of the main components utilized. The chosen data generation methods and data analysis are only briefly described. These components are highly related to the experiment, and therefore more thoroughly explained in Chapter 20, together with the organization of the experiment and sample.

3.2.1 Research Process

Research theory from the book *Researching Information Systems and Computing* outlines the components comprised in the research process [61], as shown in Figure 3.1. The main components applied to this thesis are identified with yellow borders.

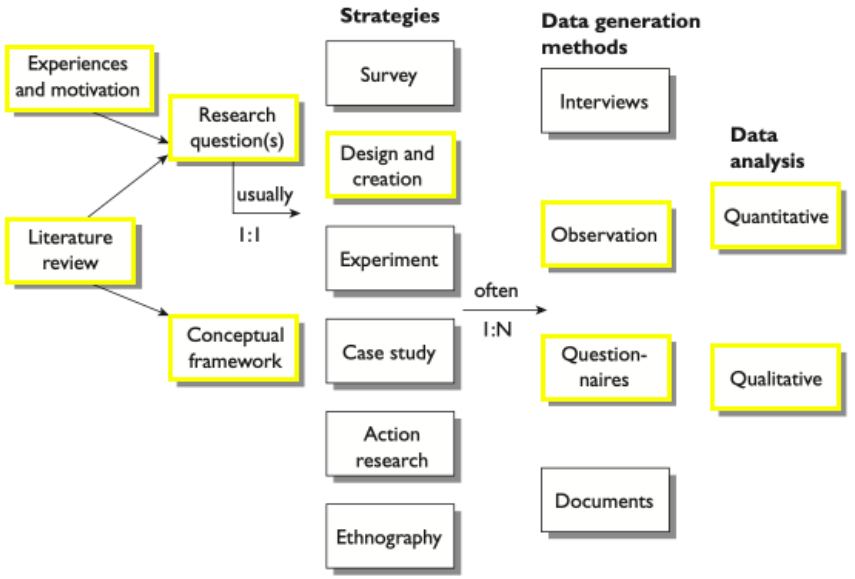


Figure 3.1: Model of the research process [61]. Yellow borders indicate adopted components.

The research process started with a pre-study phase defined by *experiences and motivation*, to why doing the research, which directed the thesis to the

field of study. To explore and gain insight on the topic, a *literature review* was conducted, investigating relevant academic theory and studies. Based on the literature review, the *conceptual framework* was formed, identifying and arranging the approach essential to the research inquiry. In accordance with existing literature and motivation, *research questions* were created to ascertain further knowledge to the field of study.

After the creation of research questions, *design and creation* was chosen as a suitable research strategy, facilitating the answering of the questions. To produce substantial empirical data, the data generation methods *observation*, *questionnaire*, as well as heart rate monitoring, were adopted. Based on primarily *quantitative* data of the questionnaire and heart rate, results were statistically analyzed and discussed in regards to the research questions, further substantiated by the *qualitative* data from observations and feedback.

3.2.2 Literature Review

A literature review is a study into academic sources on a specific topic. It can be used in the early stages of a research process to uncover relevant material, research ideas and topics in-demand for more research, in order to establish the research problem. A literature review is also used after the research problem is established, persisting throughout the end of the project, in order to be up to date with new and present knowledge to the field. In light of this, the literature review can be said to construct the foundation, and assist in establishing the conceptual framework, for the research.

A literature review is divided and performed by six parts: Searching, obtaining, assessing, reading, evaluating and critically writing. *Searching* is the process of identifying relevant and precise concepts, keywords and terms to narrow the findings down to the desired information. When searching, authors that reappear in research, can reveal an area of expertise to the topic, and lead to other cited work that might be relevant. *Obtaining* is to acquire the resources discovered when searching. This can be done by visiting a library or getting access to resources available online. After obtaining the resources, it must be *assessed* to consider its credibility. This can be done by investigating the author's, journal's and publisher's legitimacy and qualifications to the field. Research articles should also be peer-reviewed,

verifying its credibility. The next step is to *read* the literature. To get an overview of the content and its essence, it is effective to focus on the abstract, introduction and conclusion sections of the work. After reading, the work has to be *evaluated*, looking at what it offers and if there are any flaws or deficiencies. Finally, a review has to be *written*, relating the research to the objective and research topic.

In this project, the literature review was used throughout the project. The literature was in part provided by our supervisor or found searching the internet. Both Google Scholar and Oria, which are digital libraries available for students, were used to find theory and research on relevant topics. The credibility was assessed by looking for acknowledged authors and publishers. Articles were also assessed by checking for peer-reviews. The quality of the information found while searching the web were controlled by looking at the consistency against other resources.

3.2.3 Strategy - Design and Creation

Design and creation is a strategy which focuses on the development of new IT systems, also called artefacts. In this strategy, the line of focus is divided into four types of artefacts:

- **Constructs** - Concepts and vocabulary relating to the IT domain.
- **Models** - Combination of constructs to assist understanding problems and solutions.
- **Methods** - Instructions on how to use models and process stages to facilitate solving problems with IT.
- **Instantiations** - Implementation of an IT system demonstrating ideas, genres, constructs or models in IT.

Design and creation was chosen as the strategy since the project involves the implementation of a new IT system, an exergame prototype, in order to answer the research questions presented in Section 3.1. The implementation correlates with the artefact, instantiations, demonstrating how an exergame can influence players enjoyment, motivation, exercise effect by playing.

In design and creation, a set of principles need to be considered when conducting the strategy in an iterative manner. *Awareness* is the understanding and definition of a problem, by looking at literature, or new development to locate what needs to be addressed. *Suggestions* is when creating an idea or concept on how to solve the problem. *Development* is where the idea or concept is developed into a working prototype. The development process relies on what kind of IT-artifact is being planned. *Evaluation* is when the artefact made is being examined and assessed. Lastly, *Conclusion* is where the results are identified and presented. Eventual inexplicable results are feasible as further research.

In our project, the awareness was established by looking at current research on the theory of exergame, along with existing solutions and technologies, presented in Part II. The suggestion for our problem, creating an exergame as an incentive to exercise, was part of the project description (see Chapter 2). Nevertheless, suggestions to exergame ideas and genres were up for suggestions and covered in Part III. Considering that this project focuses on the creation of a new game concept with few preconditions, the development process was more exploratory and prototype oriented. Game requirements were continuously improved upon and changed to support a creative approach and are therefore not emphasized in this report. The development is presented in Part IV. Finally, the evaluation and conclusion were conducted with results gathered from an experiment. The evaluation is presented in Part V, while the conclusion is presented in Part VI.

Chapter 4

Report Outline

The thesis consists of six parts, and a total of 25 chapters.

Part I introduces the thesis, presenting the problem description and guidelines for the project to follow. This part appeals to readers interested in the research context and topic.

Part II contains a pre-study on existing exergames, technologies, exercise types, enjoyment in videogames, game genres and social interaction. This part appeals to readers seeking further insight into theory, existing solutions and relating research.

Part III covers ideas for game genres, new exergame concepts and our initial chosen game idea, that was discontinued due to technical limitations. This part is appropriate for readers who seek further knowledge of the underlying structures promoted by genres and the creative perspectives of exergame ideas.

Part IV consists of the final exergame concept for this project, demonstrating its underlying mechanics and dynamics for both the game and the exercise. A description of the development proceeding is also outlined. This part is appropriate for readers wanting to know more about the prototype and its design.

Part V consists of the data generation methods and the results. It covers the experiment conducted to test and evaluate the implemented game. This part suits readers interested in the procedures of the experiment and the results.

Part VI presents the analysis of the data gathered and the outcome of this project. This part is for readers who are interested in the verdict from the experiment and potential further work.

Part II

Background Study

The second part presents a literature review of the concepts of exergames. This includes an introduction to exergames with existing examples, showing both technologies and exercises being used. In addition theory on video games is presented through game mechanics, game genre and game modes.

Chapter 5

Introduction to the Concept of Exergames

Bogost defines exergame as a *combination of exercise and videogames* [9]. Traditional video games typically use controllers that are associated with finger movement, hence largely comprised of buttons and joysticks. With exergames, physical exertion and movement are required in order to progress throughout the gameplay, thus giving a higher form of physical activity than just finger movements. Put differently, physical exertion is incorporated into the game mechanics and converted as game controller input. This type of input is usually collected with sensory and monitor equipment, tracking bodily activity and movement.

The term exergame has been considered a new phenomenon by the media in recent years, showing its potential as an exercise-motivator in the fight against obesity [9]. However, the concept of exergame has existed since the 1980s, such as with the creation of a movement pad, called Foot Craz, in 1987. This game was developed for Atari 2600, which together with Nintendos NES, were perceived to be the two most influential game consoles at that time. The year after Nintendo released its own more complex version of the Atari movement pad, called Power Pad. Both these games are regarded as the predecessor of the highly successful arcade dance game Dance Dance Revolution (DDR), first released in Japan in 1998 [40]. DDR is considered to be a game involving serious exercise, a claim supported by becoming the worlds first computer game to be registered as a sport in

Norway in 2003.

Nintendo is still perceived as one of the most influential contributors when it comes to exergaming [9], with both the Wii and Nintendo Switch console. Both consoles enable different types of motion controllers to the platform, thus giving a wide variety of exercise types to perform. As mentioned in Chapter 1, Ring Fit Adventure has become a very popular alternative as an in-house activity. It illustrates the relevance and prospects of exergames today, and in the future. A more comprehensive treatment of DDR, Wii Fit and Ring Fit Adventure, along with other exergames, will be given in Chapter 6.

Chapter 6

Existing Exergames

In this chapter, we will investigate various existing exergames, looking at their game concepts and relating them to studies outlining health and enjoyment benefits. Some of the exergames have been studied more in-depth than others, depending on its release date and availability, cf. commercialized or research-based.

6.1 Dance Dance Revolution

Figure 6.1: Dance Dance Revolution

Dance Dance Revolution (DDR) (see Figure 6.1) is performed by stepping on arrows pointing in several directions, at the arcade pad. Players have to hit arrows corresponding to what is shown on the game screen, and timed

according to the beat of the music being played. The arcade game consists of different songs and difficulty settings, making it suitable for both new and experienced players. DDR also offers two pads side by side, making it a two-player game. Considering DDR is an elaborate dancing game, generating physical activity, it is regarded as one of the initial exergames.

A study of 35 children with Endothelial dysfunction (EDF) investigated if the activity from DDR could help improve their condition, also related to overweight in children [56]. The study, lasting over 12 weeks, found promising effects on vascular endothelial functions and aerobic fitness, as well as an enjoyable exercise experience of the test subjects. Another study examined body compositions and enjoyment effects of playing DDR [87]. The results showed a positive attitude from participants playing the game, combining a high level of enjoyment with an improvement in body composition and a significant reduction in body fat, similar to other moderate to vigorous physical activities.

6.2 Wii Fit

Figure 6.2: Wii Fit

Wii Fit (see Figure 6.2) is a fitness platform to the game console Nintendo Wii [63]. It includes a balance board with sensors to measure weight and centre of balance, which the user stands on during the game. Several types of minigames are featured on the platform and are comprised of different exercise forms, like, e.g. yoga, strength training, aerobics and balance. The games vary between traditional and intriguing gameplays, such as bob

sliding and tennis, and more exercise focused gameplays, with a digital instructor guiding players through the activities.

Research has been undertaken on Wii Fit to investigate the exercise effect and degree of player enjoyment. A small exploratory study, comprised of two participants, looked at how Wii Fit could engage people with a risk of obesity, to be in more physical activity [5]. The study showed that Wii Fit encouraged the participants to exercise, increasing time spent on active bodily movement. Another more comprehensive study looked at the effect on muscle activities on the trunk and lower extremities using Wii Fit, comparing a group using the Wii Fit balance board with a group balancing a stable surface [65]. The study showed that Wii Fit significantly increased muscular activity for parts of muscle regions. Although Wii Fit has shown potential for some positive activity gains, the exercise intensity can be regarded as light. An article compared physical effect and enjoyment from Wii Fit with ordinary aerobic exercise in three populations [32]. The result showed, for all populations, that the heart rate from Wii Fit was lower than treadmill exercise, eliciting light to moderate-intensity activity. During aerobics, heart rate was lower than the recommended intensity for cardiorespiratory fitness. The game still showed that participants enjoyed the activity. Similar results have been observed, showing player enjoyment, but little to no change in health-related fitness measurements, indicating to not substitute regular exercise in daily life [63].

6.3 Ring Fit Adventures

Figure 6.3: Ring Fit Adventures

As of 21. of October 2019, Nintendo launched a new fitness game called Ring Fit Adventures (see Figure 6.3) [82]. It is said to be a successor to Nintendos previous fitness platform, Wii Fit. The game comes with two physical components: A flexible ring, called the Ring-Con, and a leg strap. Both of these items connect to a Joy-Con, the game controller of a Nintendo Switch, which tracks and reacts to players motion. The main gameplay is in the role-playing genre, where players takes the role of an athlete battling against a demon ruling the world. The player manoeuvres through set paths in the world with obstacles and monsters along the way. To move forward, the player runs on site, sensed by the leg strap, and jumps by pressing the Ring-Con. Shooting happens by aiming the Ring-Con and pressing it. When fighting monsters, players have to use more traditional exercise activities to execute actions and attacks. The exercise activities are divided into four fitness skill categories: arms, core muscles, legs and yoga movements. Players can also choose minigames which only focuses on one type of exercise at the time.

Since Ring Fit Adventure is a new product, there are few recorded results of the effectiveness in regards to exercise outcome and improvement. Nevertheless, the game appears to have more extensive and various exercises, in comparison to the Wii Fit, which may indicate an improved exercise outcome.

6.4 Holopoint

Figure 6.4: Holopoint

Holopoint (see Figure 6.4), is a virtual reality game taking place in a Japanese dojo [101]. Virtual reality, also known as VR, is where individuals steps into a simulated world. The objective in Holopoint is to hit targets with bow and arrows. For the player to be able to shoot arrows, they have to mimic the real muscular movements when doing archery. All from grabbing the arrows from the back of your shoulder, to stretching the bow with an arrow, and finally letting go. Targets will appear anywhere in the room, resulting in players having to move in all direction in order to hit all targets. When a target is hit, the target will shoot a projectile towards the player that must be avoided. If the player uses to long time, the target will explode and shoot the projectile at a higher speed which makes it harder for the player to dodge. As the player progresses through each wave, targets become increasingly harder to hit, ranging from easy hitboxes to challenging ninjas.

One study has evaluated the actual and perceived exercise effect on ten participants with four different VR games, in which Holopoint was included [101]. The activity from Holopoint showed the perceived exercise level to be low, but with an average heart rate at 78% of the maximum heart-rate, indicating a moderate intensity. Holopoint was also regarded as the most enjoyable game out of the four games included. Another study, from the same authors, have mapped which muscle groups are active during the Holopoint Activity [102]. The study showed that arms, legs and steps had a physical movement equivalent to moderate activity levels. The participants average max heart-rate was recorded at 151 bpm, close to 80% of their average max heart rate. Although the research mentioned is limited and not

conclusive, it illustrates potential benefits in terms of exercise effect and player enjoyment.

6.5 Pokemon Go

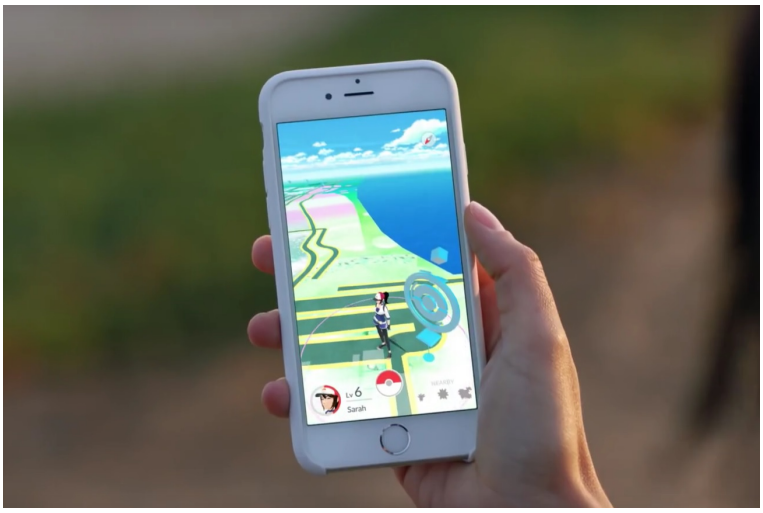


Figure 6.5: Pokemon Go

Pokemon Go (see Figure 6.5), a mobile game app based on the popular Pokemon franchise, was released with enthusiasm worldwide in the summer of 2016. By the end of the year, it surpassed 500 million downloads, making it one of the most popular mobile games [29]. Pokemon Go is made with augmented reality, thus combining the virtual world with the physical world. The objective is to acquire monsters with different abilities and use them to fight against monsters of other players. The overlap between virtual and physical world lets the player interact with game elements located all around the physical world using GPS location. This means players have to walk around in the real world using a map on the phone to locate the interactive game elements. A restriction to speed is applied, ensuring the only way of movement is walking. Also, the implemented game dynamics rewards players after certain distances of walking, by hatching eggs, obtaining more items or gaining levels.

A research with 444 participants, investigated how gaming motives influenced time played on Pokemon Go, and an eventual exercise outcome [42]. The result showed that player motivation and enjoyment towards Pokemon Go influences time spent playing and the amount of physical activity in daily life. The study also described how physical and social interaction in Pokemon Go is a motivation for playing in itself. A study has looked at 644 university students, grouped into players, ex-players and non-players, investigating frequency and duration on outdoor activity, before and after playing Pokemon Go [98]. The results showed that players were more active outdoors than ex-players, but all had similar activity levels. The report indicated that Pokemon Go suited players that are overweight and/or have a sedentary lifestyle since they benefited the most from the light intensity walking Pokemon Go elicits. Another extensive study investigated actual and perceived physical activity between students being active users (n=36), partially-active users (n=24) and non-users (n=227)[100]. The results showed that the partially-active and active users walked less than the non-users, with the non-users showing higher levels of physical activity. The research still proposed using Pokemon Go to encourage and introduce sedentary individuals into a more active lifestyle.

6.6 Location Invaders

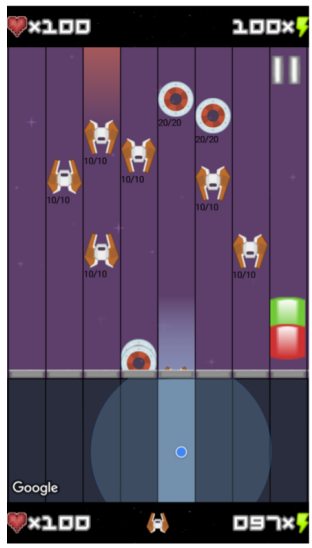


Figure 6.6: Location Invaders

Location Invaders (see Figure 6.6) is an exergame inspired by the classic arcade game, space invaders [4]. The gameplay is comprised of two players competing against each other, using their smartphones as controllers. The playing area is predetermined with four GPS coordinates creating boundaries for where the player can move. There are 8 lanes within these boundaries where the players can navigate between based on the location of the GPS on their phone. There are three different kinds of spaceships the player can use, one fast with 5 health, one medium with 10 health and one slow with 20 health. This will cost the user the same amount of energy as the health of the spaceship to send towards the opponent. To protect, the player has to send spaceships that have equal or more health in the same lane as the opponent sent theirs. The energy will slowly increase, and therefore creates the need for tactics for where and when to send. The lanes at each side will occasionally generate power-ups the user can pick up to get more energy or health. In order to win, the player needs to kill the opponent by shooting different spaceships towards the player through the different lanes.

Research investigating exercise intensity, motivation, engagement and enjoyment from playing Location Invaders has been conducted [4]. The study

showed that all of the participants were engaged, becoming less aware of their surroundings while playing. In terms of enjoyment, all participants expressed high levels, with 73% stating they would play it again. All participants highlighted social interaction as an enjoyable factor, while 90% indicated that the social aspect of competition made the game more motivating. Lastly, the exercise effect indicated a low to moderate exercise intensity, with an average heart rate of 107.1 BMP, thus not achieving high-intensity interval training, as desired. However, the results showed that participants intensity varied based on playing style.

6.7 Exermon

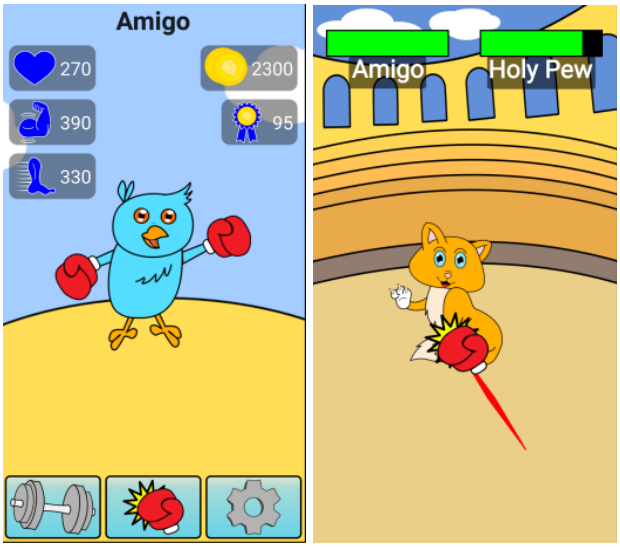


Figure 6.7: Exermon

Exermon (see Figure 6.7) is a smartphone exergame that involves players performing strength exercises in daily life [37]. In the game, player chooses a monster as their main character, inspired by the game Tamagotchi. The objective is to constantly evolve the monster, increasing its stats in order to beat other players monsters or game-generated monsters in battles. A monster evolves when the player performs different sets of strength exercises, which are monitored by the smartphones motion sensor.

A review has been conducted on Exermon, looking at exercise, motivation, engagement and enjoyment on 24 participants from playing the game [94]. The exercise results showed that 40% of the participants increased their amount of weekly exercise, and with a perceived strength improvement from playing the game. The results also showed that 90% were motivated to exercise because of the game, but found room for improvements to strengthen further interest, such as incorporating more social interaction into the gameplay. In terms of enjoyment, 90% of the participants felt the game was enjoyable the more they played the game, and 80% liked the fantasy aspects of the game. Lastly, 90% of the participants found the game engaging, in which 80% were fully focused on the task at hand. Although the game showed great potential, some critical issues were noticed, mainly the possibility to cheat by not performing the strength exercises correctly. This shows that the technology, with the use of smartphone motion sensor, can pose as a challenge.

6.8 Zwift

Figure 6.8: Zwift

Zwift (see Figure 6.8) is a simulation platform for cycling and running at home [104]. It requires a bicycle and cycling trainer if cycling, or a treadmill if running, and a screen. In Zwift players work out in a digital environment simulating the real world, offering different type of terrain and landscape with distance and speed as in real life. Players can do solo rides

or join events, competing against other players to the finish line. While cycling or running, players accumulate experience points that can be used to upgrade players avatar and equipment. In competitions, players get power-ups at every checkpoint that can be used to advance in racing position. The power-ups give different types of boost effects or make a player invisible in order to sneak past opponents. Although Zwift offers some typical game characteristics, it can be regarded as a realistic exercise simulation rather than a typical video game.

Research on the exercise outcome and enjoyment from Zwift are few. However, since the exercise experience is imitating the real-life exercise experience, it can be argued to have positive exercise effects and enjoyable for individuals experienced with outdoor cycling.

6.9 Pedal Tanks

Figure 6.9: Pedal Tanks

Pedal Tanks (see Figure 6.9) is a multiplayer exergame developed as part of a master thesis, with the goal of making an exciting and enjoyable experience while exercising [35]. The game is comprised of up to four players divided into two teams, where each player controls a tank. The goal of the game is for each team to capture the opponents' flag and bring it back to base. During gameplay, teams can attack each other by shooting cannons, leading to fewer opponents on the battleground. Pedal Tanks have various

tanks to choose from, with different traits and features. Tanks are unlocked gradually as players are progressing, maintaining replayability. The game uses exercise bikes with sensors attached as controllers. When using the pedals the tank moves forward at a speed determined by players pedalling intensity. Different buttons on the bike's handlebar controls the movement of the tank to the left and right, shooting and other custom abilities.

The initial study done on Pedal Tanks with 8 participants mapped exercise effect and player enjoyment over three executive sessions [54]. The study showed a positive exercise effect, with an average heart rate at 163 BMP, excluding restitution breaks in between game rounds. The exercise effect showed potential, similar to high-intensity interval training. The participants also found the game experience highly enjoyable, even though the exercise was perceived as intense. Furthermore, the enjoyment did not change significantly in between sessions. A study from 2016 indicates the same traits, from an experiment lasting over three sessions [34]. The study showed that enjoyment was high, with no significant change during all three sessions, and an intensity level meeting the standards of high-intensity training.

6.10 Pedal Kart

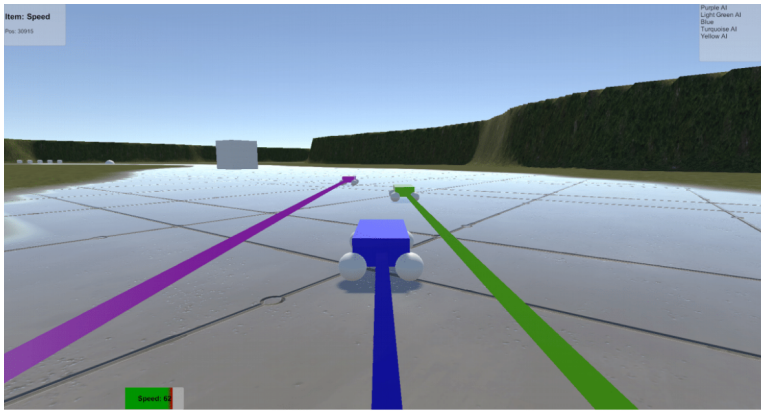


Figure 6.10: Pedal Kart

Pedal Kart (see Figure 6.10) is inspired by Mario Kart, a game from the Nintendo universe, and developed as part of a master thesis at NTNU [81]. Players compete in a car race to cross the finish line. Opponents are both computer-controlled and individual players. During the gameplay players can pick up items along the way, used to improve position. For instance acquiring boost, weapons or shields. Just as with Pedal Tanks, Pedal Kart uses exercise bikes as controllers. Moving the pedals causes the car to accelerate, and buttons on the handlebar move the car left and right, and activating items.

The master thesis involved an experiment with four participants, looking at player enjoyment and exercise effect from playing Pedal Kart [81]. The results showed that the participants found the game highly enjoyable, but no clear signs that the game would encourage them to exercise more. In terms of exercise effects, the result can be regarded as limited because of the inaccurate data monitored by a Fitbit 3. Although perceived exercise effect reported by participants, and observations can indicate an intense exercise that fulfils the recommended weekly amount.

6.11 Summary

This chapter has reviewed different examples of exergames, illustrating the diversity in type of gameplay and exercise possible within the field of exercise and gaming. The review also showed that exergames have the potential of giving players a positive exercise outcome. Two of the most essential details we uncovered from this review, was that most of the exercise practised in these exergames were endurance training. Endurance training appears to be compatible and adaptable to different game types, and therefore shows promise for the use in exergames. The last essential detail was that even though many of the games reviewed indicated a positive exercise outcome, the majority evokes low to moderate intensity. This might illustrate the lack of exergames with high exercise benefits and is something that should be explored further. We would also like to point out the social interaction some of the exergames provided. Users of Location Invaders seemed to enjoy this, and is something we would like to further explore. The examples presented here will be used later in the report to investigate what kind of game genres are suited for an exergame.

Chapter 7

Technologies

In this chapter, we discuss the different technologies exergames are using. It will be a general introduction into the technologies, the most known manufacturers and the use cases some of the technologies offer beside gaming.

7.1 Virtual Reality Headset

Virtual reality, also known as VR, is a technology that has become more available in recent years, mainly used for gaming and simulation. A Virtual Reality headset consists of a screen which is put in front of the eyes like googles. It usually has sensors such as cameras or gyroscopes that tracks the head movement, simulating movement in the virtual reality. There are also some manufacturers that include controllers that allow hand movement to interact with the virtual environment.

The most popular brands are Oculus Rift, HTC Vive, Sony PlayStation VR and Valve Index. There are also VR headsets where the cellphone is used as a screen, thus cheaper and more consumer-friendly. Example of these kinds of VR headsets is Google Cardboard, Google Daydream View and Samsung Gear VR. Oculus and Lenovo have recently launched wire-free VR headsets which gives the user more freedom and removes the disturbance of tripping on wires. Overall, a lot of VR technologies exists at different price points which make VR available for almost everyone, from regular consumers watching 360 degrees videos and playing games, to NASA

training astronauts in real life situations (see Figure 7.1).

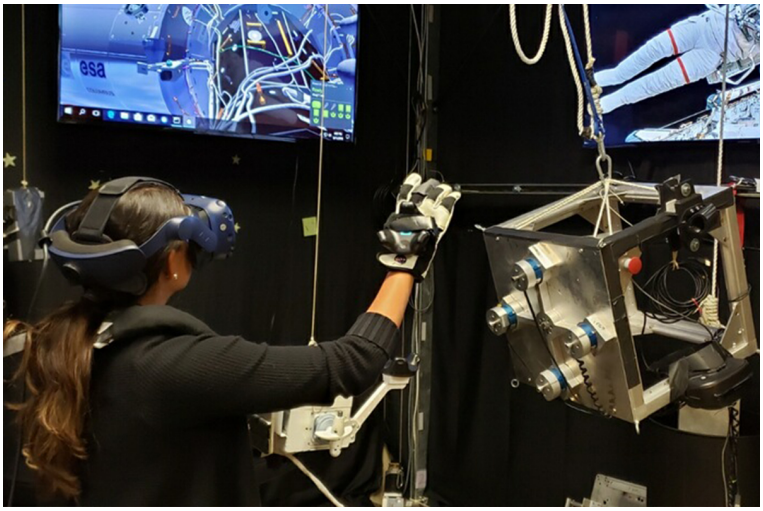


Figure 7.1: VR headset used by NASA for training purpose.

Computer-generated realities are very beneficial, and it will only grow in the time ahead. In Aviation only, the market value of VR was in 2019 valued at USD 78 million and is foreseen to be worth USD 1.3 billion in 2025 [70]. One of the exergames that takes advantage of VR is Holopoint (see Section 6.4).

7.2 Augmented Reality

Augmented reality (AR) is computer-generated objects, often auditory or visual, put into a real-world environment using a camera. It is accessible via a smartphone and is therefore available for consumers at a low cost. However, there are systems more expensive and custom-made for AR. Microsoft HoloLens and Magic Leap One are two of the most popular brands and both provides wire-free glasses that can be customised to each use case. Microsoft HoloLens 2 costs $3500 and are made for businesses, thus not targeted for consumers just yet [72]. Magic Leap One is more focused on developers and consumers. However, the price is set to $2295 and therefore not available for the regular consumer [49].

Even though the prices for AR specific products are high, smartphones are cheap and available for the regular consumer and shows great potential. Niantic, the company behind the most successful AR game, Pokemon GO (see Section 6.5), have now launched a developer platform. Niantic invites other developers and third parties, to *The Niantic Creator Program* where they collaborate with Niantic by taking advantage of their technology platform to create new and better experiences [75].

Augmented reality has several different use cases other than for gaming purposes. An example is Equinor that uses HoloLens and tablets to see through walls, look at 3D models of the equipment to see if it was mounted correctly (see Figure 7.2) and find the nearest exit route in case of emergency [3].

Figure 7.2: Equinor employee using AR on a platform

Augmented reality can create game experiences not possible before. It can put anyone's favourite characters from TV-series, video games, movies, comics and books into the real world. The only thing missing is a consumer-grade tool that utilise the technology to its full potential.

7.3 Location Sensitive Technology

Games based on location takes advantage of the world as its playground, thus creating many possibilities for game developers. The most used location technology is GPS (see Figure 7.3). GPS has been in mobile phones since 1999, yet has not been used for games until later years. Its potential was demonstrated when Pokemon Go entered the market in 2016 (see Section 6.5). Geocaching is a similar location-based game where users explore geographical points where physical objects are hidden [33]. In order to locate the object, a navigation device is used such as a phone or a GPS tracker. When the object is found players can sign a logbook located with the object, hide the object again and then mark it as found in the application or on the web page. It is also possible to make games more close-quarter like Location Invaders (see Section 6.6) where the playground is a predefined area the user can move within.

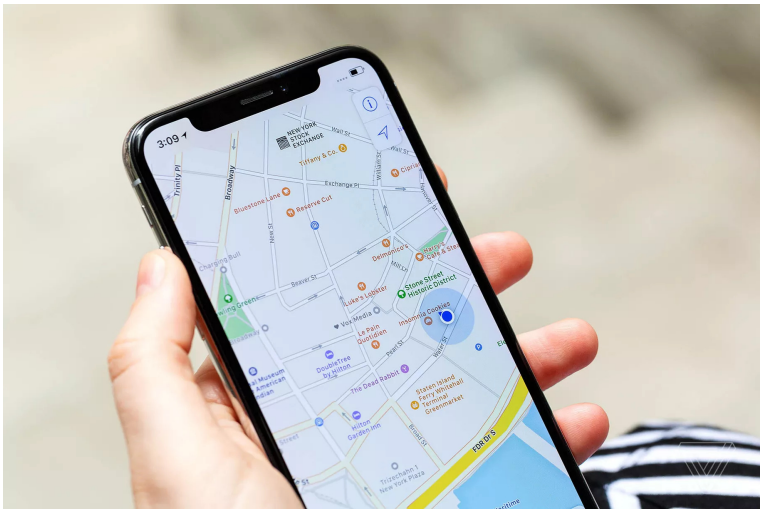


Figure 7.3: Illustration of GPS usage in Google Maps

GPS is the most frequently used location technology due to its precise location accuracy with a mean of 4.9 meters [93]. Other options such as LTE and Wi-Fi are usually not precise enough for games. LTE has an accuracy between 50 and 200 meters [50] and Wi-Fi has a median accuracy between 13-40 meters [13].

7.4 Motion Controllers

Figure 7.4: Example of motion controllers

Motion controllers (see Figure 7.4) uses motion sensing technologies to recognise movement. It uses a 3-axis accelerometer to detect movement, and has a higher focus on hand and whole-body movements [88]. It will therefore not detect movement in other parts of the body where the controller is not connected. The motion controllers can be used to simulate movements to control a game object or player on the screen.

There are several different products in the commercial market. The most popular being Nintendo Wii with over 101 million units sold with its successor the Nintendo Switch selling over 55 million units [60]. These units have motion controllers included and differentiate from the PlayStation Move which is sold separately.

One of the games that takes advantage of this technology is Ring fit adventures (see Section 6.3) which uses one controller to detect motion in the legs and one controller to detect motion in the arms.

7.5 Dance Pad

Figure 7.5: Example of a soft dance pad

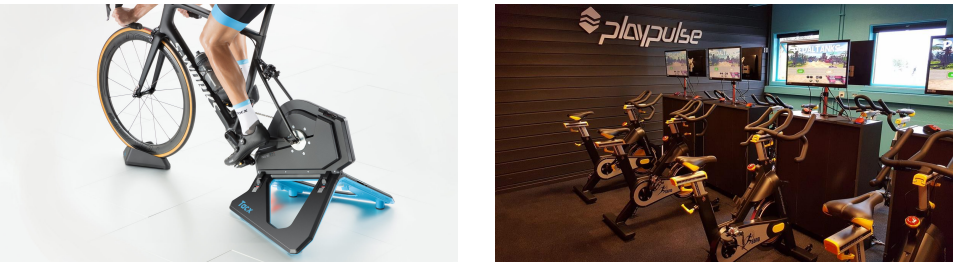
The dance pad works as a controller with arrows pointing in several directions that the player interacts with by placing their feets on. There are three different types of dance pads: soft pads (see Figure 7.5), hard pads and solid-state pads, in which soft and hard are the most common. The soft pads are the cheapest solution with a price range from $10 to $100. This type of pad are made of plastic and are usually pretty thin. The hard pads

are a more expensive solution with a price range starting on $100 up to several thousand. The reason for the higher price is mostly because of the materials used, often wood and metal, together with more advanced technologies inside. Solid-state pads are the least common and uses proximity sensors instead of buttons in order to recognise steps. The price range is the same as for the hard pads due to the use of the same material.

Dance pads can, although their name, be used to play other games. Most commonly they have four buttons, but some have up to eight, offering a wide range of possibilities of games to play.

Dance Pads became popular with the arcade game Dance Dance Revolution (see Section 6.1) and in 2007, 6.5 million sales of the game were reported [78]. Dance pads are an old technology and not compatible with newer consoles like the PlayStation 4, Xbox One and Nintendo Switch, but still compatible with computers using adapters.

7.6 Playpulse Platform & Cycling Trainer



(a) Example of cycling trainer **(b)** Playpulse

Figure 7.6: Player controls

Both the Playpulse platform (see Figure 7.6b) and cycling trainer operate by transforming pedaling intensity into input and visualising the actions onto the screen. Compared to another exercise apparatus, a tread mill, a stationary cycle offers easier balancing and dexterity, that are beneficial when exercising and playing a game at the same time.

There are some differences between Playpulse and a regular cycling trainer, where the main one being that Playpulse combines the cycling input with buttons on the steering wheel, making the cycle a fully working controller. This lets the user play more advanced games such as Pedal tanks (see Section 6.9), with several in-game abilities and actions. A cycling trainer, on the other hand, does only take the cycling input, limiting the opportunity to play more advanced games (see Figure 7.6a). Zwift (see Section 6.8) uses the cycling trainer in its game. A difference between the Playpulse platform and the Zwift platform is that the Playpulse platform is comprised of a stationary exercise bike, while the Zwift platform is compatible with a regular outdoor cycle.

A cycling trainer by itself is not enough to play a game and requires an additional cycle and a screen. The pricing of the cycling trainer alone start at 499.99 US dollars for the cheapest and reaches up to 1,399.99 US dollars [103]. Moreover, together with a cycle and a screen, the equipment can be quite expensive for the regular consumer.

Playpulse delivers all the requires equipment, including a cycle with built-in controllers and a computer. However, Playpulse focuses on business to business sales, so there is no official pricing for private consumers. The technology is available on fitness centres and rehabilitation facilities.

7.7 Summary

This chapter showcase how different types of technologies can be used in exergames and other domains. The main difference between these technologies is mostly their availability. A smartphone is more accessible to most people than a stationary exercise bike or a VR headset, both because of price and the area of application. Since the project is defined with the use of the exercise bike from Playpulse, this will be the technology our exergame is based upon.

Chapter 8

Exercise

U. S. Department of Health and Human Services defines exercise as *"a form of physical activity that is planned, structured, repetitive, and performed with the goal of improving health or fitness"* [89]. This definition is quite similar to Y. Oh and S. Yangs proposed definition for exergaming which states that in order for a game to be known as exergaming, it should require physical exertion or movements that are more than sedentary activities. In addition, the exercise should include strength, balance, or flexibility activities [62]. Due to similar definitions, we consider it essential to introduce different types of exercises and how they benefit individuals.

8.1 Benefits of Exercise

Exercise is not only necessary to get stronger or being able to run a longer distance. It has also been found as an important factor in prevention of medical disorders. Among them are hypertention [66], diabetes [6], involutional osteorarthritis [92] [2], falling among elders [12] and coronary heart disease [47].

Exercise does not only have physical benefits, but also psychological benefits. Research has shown that exercise improves mood state and self-esteem [69], and enhances sleep quality and depression measures [79].

It is also an extensive cost associated with the lack of exercise, which is calculated in the US to be roughly 117 billion dollars in annual health care cost [89]. Exercise is, therefore, not only beneficial for the individual, but also the entire population.

8.2 Strength

In strength exercise, also known as resistance exercise, small rifts in the muscle fibre are made during training, and afterwards, fused creating new muscle strands [84]. This increases the width of the fibres, thus making the muscle stronger. Strength exercise does only affect the specific area of the body being exercised [67], so to get a full-body workout a handful of different exercise types have to be performed. Such exercises should focus on the major muscle groups, which includes hips, chest, shoulders, arms, back, abdomen and legs. Examples of strength exercises with a focus on major muscle groups are bench press, squats, dips, deadlift and pull-up. Research has indicated that focusing on the smaller muscle groups when starting to exercise as untrained might be particularly important [16]. For general exercise, 8-12 repetitions are recommended, but there are exceptions. To gain strength and power, 6-8 repetitions with heavier weights is recommended. For muscular endurance, the opposite with a higher amount of repetition with lower weight is recommended [67].

8.3 Endurance

Endurance exercise is divided into two main areas, aerobic and anaerobic. Aerobic exercise means ”with oxygen”, signifying the use of oxygen as an energy source, and are any type of cardiovascular conditioning [14]. Aerobic training can increase brain volume and spare the brain [15], and have beneficial short- and long-term effects on psychological outcomes [17]. Examples of aerobic exercises are swimming, walking, running and cycling. Anaerobic exercise is, on the other hand, without oxygen and is about using a large amount of energy in a short amount of time. When using such amount of energy, the oxygen demand excels the oxygen supply. This will break down glucose, which is available in the muscles, turning it into en-

ergy [43]. Examples of anaerobic exercises are high-intensity intervals, jumping, throwing and dynamic strength exercises.

The most valuable form of endurance exercise is *high-intensity interval training* (HIIT) because it is the most effective way to increase the amount of oxygen the body can take advantage of during exercise [36]. HIIT is an exercise approach where intervals are done with a heart rate at 85%-95% of the maximum heart rate (HR_{max}) [83]. There are several ways to do HIIT and one commonly used in research are the 4x4 (4 times 4 minute intervals with 1-3 minutes rest) [22] [55] [86] , thought 15/15 (15 times 15 seconds intervals with 15 seconds rest) have demonstrated to give an equal result [36]. HIIT is also considered as more enjoyable than moderate-intensity continuous exercise and may have an effect that increases exercise participation over longer terms [7].

8.4 Recommended Duration

The amount of exercise is also an important factor regarding the health benefits a person can obtain. U.S. Department of Health and Human Services, UK Department of Health and Social Care and the World Health Organization do all recommend at least 150 minutes of aerobic activity with moderate intensity or 75 minutes of aerobic activity with vigorous intensity over the duration of a week [89] [90] [99]. For further health benefits, it is recommended to increase the amount of aerobic moderate intensity activity to 300 minutes or 150 minutes with vigorous intensity. A combination of moderate and vigorous intensity is also possible with 2 minutes of moderate intensity corresponding to 1 minute of vigorous intensity. Figure 8.1 shows the intensity levels, described above, correlating to HR_{max} levels.

Intensity	**% of** HR_{max}
Very light	<50
Light	$50 - <64$
Moderate	$64 - <77$
Vigorous	$77 - <94$
Very Vigorous	$94 - <100$

Table 8.1: Heart rate zones [71]

8.5 Summary

This chapter highlights the importance of regular exercise and the consequences if not fulfilled. It further shows the amount of exercise necessary in order to gain benefit of exercise. Additionally, it features the recommended type and amount of exercise that provides the most value exchanged for the time used. Our project will use an exercise cycle to elicit exertion, and it is therefore, reasonable to consider endurance exercise as the most appropriate type for our exergame. Since high-intensity interval training is perceived as the most enjoyable and effective form of training, it is of significant interest to this project.

Chapter 9

Enjoyment and Captivation

For individuals to take part in activities, enjoyment plays a big factor in their commitment and interest. This chapter will look into concepts on enjoyment in general activities, and see how they can be applied to a more specific activity, such as exergames.

9.1 Flow

Flow is a state of mind in which a person is so engaged/consumed in an activity that it attracts all focus of awareness. Csikszentmihalyi defines flow as an experience *"so gratifying that people are willing to do it for its own sake, with little concern for what they will get out of it, even when it is difficult or dangerous"* [85]. He researched what characteristics made up an experience enjoyable among a wide variety of individuals with different interest, cultural background and professions. The answers turned out to be similar for everyone involved, and resulted in a list of eight characteristics for the experiences of flow:

- A task that is possible to complete.
- Must be able to concentration on the task.
- The task has clear goals.
- The task gives immediate feedback.

- Effortless involvement to the task without awareness of problems in daily life.
- Sense a control over actions.
- Losing the feeling of self-consciousness during the task, though appears stronger after the sense of flow has passed.
- The sense of time is changed.

In order for the flow experience to emerge, people have to perceive their capability to match with the skill needed to perform an activity. If it is a mismatch people may not feel joy. Players lack of skill could induce tension, while too skilled could induce disinterest. Figure 9.1 presents how skill and difficulty influence the state of flow. An activity can neither be to easy nor to difficult and has to align with a persons skill, thus at the borderline between anxiety and boredom.

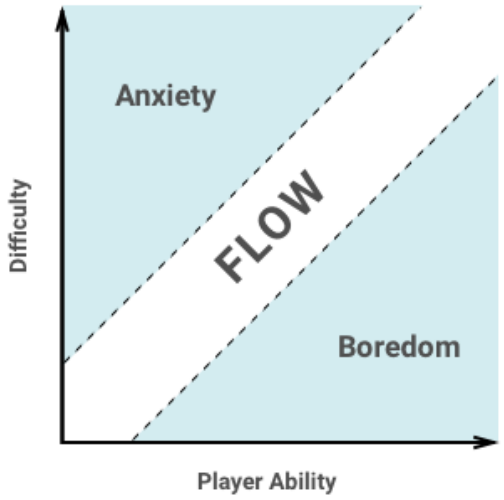


Figure 9.1: Figure of flow

The flow concept has also been used in more specific domains, such as games, and mapped how elements in video games can contribute to the state of flow. The model is called GameFlow and are comprised of eight relevant

elements to promote flow: concentration, challenge, player skill, control, clear goals, feedback, immersion, and social interaction [85]. Each element is associated with several key factors that align with Csikszentmihalyi's concept of flow.

1. **Concentration**

    - In order for a game to be enjoyable, players have to be able to concentrate on the gameplay. The game should absorb players attention early on and preserve it by acquiring all relevant skills needed from the player to mitigate distractions other than the challenge itself. Furthermore, all tasks should be relevant, leaving out tasks perceived by players as unnecessary. To maintain the concentration over time, the workload should increase concurrently with the player's ability to concentrate.

2. **Challenge**

    - Challenge is considered to be the most important aspect of game design. The challenge should match players skill at a suitable pace, enriching enjoyment, rather than boredom or suspense. Also, the challenge should vary in difficulty, manageable by players with different skill level. Players that accomplish challenges that meet their upper skill level will give them satisfaction and confidence to carry on with the game.

3. **Player skill**

    - The feeling of skill mastery and progression by players is important for an enjoyable gaming experience. It can be accomplished when perceived skill matches the game challenge. In such a case, it is a necessity that players skill advances in order to meet the challenges ahead while having fun. At first, a game should facilitate instructions on how to play the game. Tutorials that are intriguing and makes players immediately involved are favourable for ensuring fast progression and understanding. Tutorials can follow the actual gameplay, thus ensuring practice in a precise context, rather than a lengthy manual with unnecessary information.

4. **Control**

    - To experience flow in games, players must have a feeling of control over their actions. The actual in-game actions must correspond with players intentions. For players to learn quickly, core game controls should be accessible and basic. More advanced controls should be available for players at intermediate levels. While errors may happen in games, they should be minimized so that players do not feel they are losing control. Warning messages can help players recognize and recover from errors.

      A game should give players the feeling that their actions truly matter in the game and makes an impact. A choice of action may result in different scenarios each time, thus wanting players to repeat playing. It is also stated that for players to be deeply involved in the world they should have the choice for what they can be, do and have, and therefore not restrict actions towards one single strategy or path.

5. **Clear goals**

    - A game must have a clear goal or objective and present it to players early on in the game. It should be easy for players to understand their mission at hand. It is usually done during a cinematic introduction at the beginning of the gameplay.

6. **Feedback**

    - Feedback must be given to players at a proper time; precise and appropriate to the imminent situation. It must be frequent and give players information about their progress. Displaying score or player actions is a way to give frequent feedback and can be accompanied by sound to get their attention.

7. **Immersion**

    - Another part of GameFlow is how the player should feel totally absorbed in the gameplay, and forget about time, everyday life and concern for self. Audio and narrative can help players take

a conscious part in the game, by stimulating the sensory system, hearing.

8. **Social interaction**

   - Although social interaction is not part of the concept of flow, it can transmit enjoyment. Many players join games just to experience the social aspects it entails, either it is competition or cooperation between others. Games should support structured interactions between players, without ruining the immersion in the gameplay itself.

In addition, the elements can be categorized between those the game designer can categorically control such as challenge, control, clear goals, feedback, and those that must be adjusted to the players level and skill. From *Considerations for the design of exergames* it is advised to consider both when making an exergame [78]. (Game)Flow can be regarded as an important key in exergames, especially since exercise is often regarded as the one thing to be distracted from by being emerged into video games. With exergames, another important aspect to consider is the effectiveness as players fitness level progresses. The exercise level of gameplay has to continuously match the players increasing fitness condition in order to achieve the proper heart rate mark. Considering this, the concept of dual flow is convenient for the development of exergame dynamics.

Dual flow is comprised of the interaction between both attractiveness and effectiveness, where attractiveness corresponds to the regular description of flow, and effectiveness covers the balance between players' fitness and intensity relating to the exercise [78]. The right part of Figure 9.2 illustrates how fitness and intensity affect the benefit of exercise improvements. If players' fitness outweighs the exercise intensity, deterioration of players' fitness state may occur. Contrary, intensity exceeding players' fitness, may result in failure to complete the exercise. Lastly, if both players' fitness level and exercise intensity are low, no benefit or improvement is gained. This implies that dual flow involves the balance between players ability and challenge, and between the exercise intensity and players' fitness, to achieve an enjoyable and effective experience.

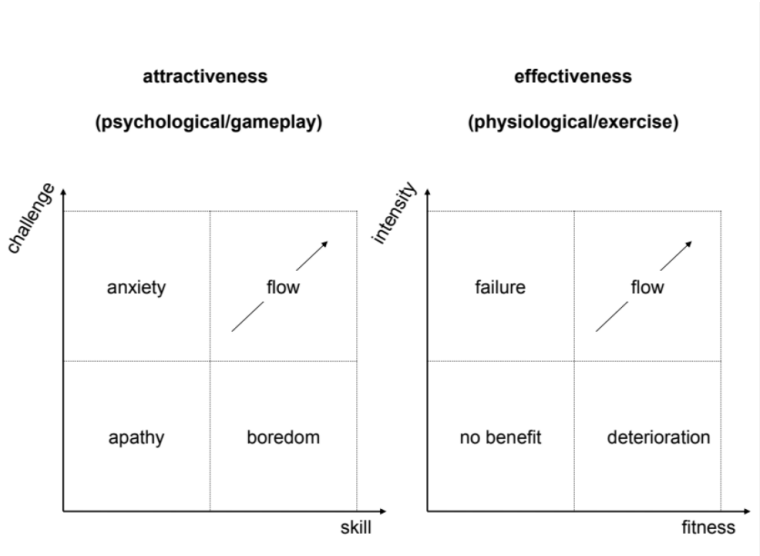


Figure 9.2: Figure of dual flow [78]

9.2 Challenge, fantasy and curiosity

Malone has established a concept of what defines a satisfying video game [51]. Although it is targeted toward educational games, the concept can be used for games in general, such as exergames. The concept is divided into three sections; Challenge, fantasy and curiosity.

9.2.1 Challenge

Just as challenge plays an important role in the concept of GameFlow, the same applies to Malone's theory. Malone suggested that for a game to be challenging it must provide goals that make players uncertain they will manage to complete, to maintain interest from player. Goals need to be appropriate to the game and therefore, carefully selected. Four key characteristics accommodate a good goal: A goal should be simple and understandable. It should be practical or fantasy-oriented, rather than directed towards a specific skill. Lastly, players must be able to track their progress towards the goal. For a challenge to be of interest, players must be uncertain whether they will win or lose. Malone presents four approaches to make the game more unpredictable.

1. **Variable difficulty level**: A game should have distinct difficulty levels. The difficulty can be either chosen automatically by a program that chooses difficulty in regards to players skill, by the players themselves or by the opponent's skill level, such as in a multiplayer game where players are matched with others at similar skill level.

2. **Multiple level goals**: A game should have goals with different levels of difficulty. A player may achieve the easiest goals, but struggle when the difficulty increases. Meta goals can be seen as a benefit to this, where achieving an objective is not enough, but also doing it efficiently.

3. **Hidden information**: Another way to add uncertainty is to hide information that influences the outcome, and carefully disclose some of it gradually.

4. **Randomness**: The last approach is to use randomness to make the outcome uncertain.

According to Malone, challenges with goals players can archive, may boost their self-esteem. If players are uncertain they will succeed, completing the challenge will feel more like a triumph of great importance. On the other hand, if a player does not succeed, it may lower the self-esteem and lose interest in the game. It is, therefore, wise to balance the uncertainty of challenges and the likelihood of succeeding based on skill.

9.2.2 Fantasy

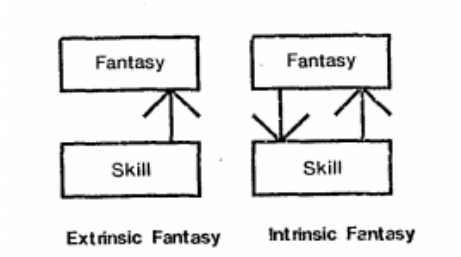


Figure 9.3: Models of extrinsic and intrinsic fantasy [51]

Fantasy encompass behaviour and circumstances not present in the real world, but possible to generate in a digital game environment. Malone divides fantasy into two types; Extrinsic fantasies and Intrinsic fantasies. *Extrinsic fantasies* are those types where the fantasy is determined by a players' skill, but no affiliation the other way around (see the left model in Figure 9.3). In *intrinsic fantasies*, both fantasy and players' skill is dependent on each other (see the right model in Figure 9.3). Fantasy in games can bring emotional needs and joy for a vast amount of players. Players are attracted to different types of fantasies, and when developing a game, it is, therefore, necessary to consider if the targeted user group corresponds with selected fantasy type.

9.2.3 Curiosity

The last part of Malones theory on enjoyment is curiosity, the motivation to carry on and spark interest. For a game to cause curiosity, the game environment should have a complexity corresponding with players prior knowledge and experience, thus at a level in which not everything is either known or unknown, but at a borderline in-between. The player should, therefore, have some understanding of the environment, but also be met with surprising situations not previously encountered. Curiosity is divided into two categories; Sensory curiosity and cognitive curiosity. *Sensory curiosity* is a type that is produced by sensory systems, such as vision and hearing. These aids can evoke interest and convey information more easily, as long as they are not seen as overwhelming. *Cognitive curiosity* is interest captivated as a mental process in order to understand the environment and its complexity. A game should always give players room to learn something new and to master a new skill.

9.3 Summary

This chapter presented theory on game principles found in enjoyable games. Challenge, Fantasy and Curiosity presented by Malone highlights relevant aspects to consider when making a game. Theory on flow describes how players can be immersed into activities, further illustrated for games with guidance found in GameFlow. Dual flow presents how the state of flow happens when exercise intensity and skill level aligns, and is of particular relevance to the concept of exergame. The content of this chapter will be used as a guideline when creating our exergame.

Chapter 10

Game Genre

The most important aspect in exergames, apart from exercise, is the incorporation of gameplay. Most video games differ in style and characteristics and can be categorized into genres. This chapter covers genres considered as the most common. Nearly all of the game genres introduced derives from Marc Prensky's article *Fun Play and Games - What Makes Games Engaging* [68].

10.1 Action Games

The action genre covers games with challenges that require a high state of continues attention and motor skills in order to progress. A player typically controls a character in an intensive environment requiring quick responses, avoiding obstacles and battling enemies. These type of games also provides some level of competition, hence adding to the intensity of the gameplay. Action games can be decomposed into several sub-genres such as shooter games, fighting games, survival game and platform games.

Figure 10.1: Counter-Strike

Counter-Strike is an example to the **shooter game genre** [26], shown in Figure 10.1. The main game mechanics focus on the use of weapons to shoot enemies, either being non-player characters (NPC) or other online players in a player vs player (PVP) environment. Players are divided into two teams, either terrorist with the objective to plant and defend a bomb, or counter-terrorists with the objective to attack and defuse the bomb. Main objectives in other shooting games may vary depending on different game modes such as capture the flag, team deathmatch, free for all and battle-royale.

Fighting games, such as Mortal Combat relies on swift reactions and manoeuvring [25]. Two players fight each other using martial arts, where the timing of attacks, counter-attacks, and blocking is essential for success. Fighting games usually support a series of attacks right after each other, resulting in a *Combo*, dealing extra damage to the opponent. Although it is not always the case, fighting games, such as Mortal Combat show players from a side view, presented in a two-dimensional style, even though the game is in 3D. Consequently, movement is restricted to left and right, or up when jumping.

Rust, is an example of a popular **survival game** [97]. The gameplay is situated in an open world environment populated with several other players. In order to survive as long as possible players must collect resources, craft tools, weapons and construct shelters. To increase chances of survival,

players can form alliances mitigating the possibility to be raided by others.

Figure 10.2: Super Mario

Super Mario is a **platform game** from the Nintendo franchise dating back to the 1980s [58]. The game has been remade since then with new updates both in 2D and 3D. In 2D versions, players move a character to the right in an environment filled with obstacles and enemies, as shown in Figure 10.2. A player progresses by avoiding obstacles and enemies by jumping and using power-ups. The 3D version follows the same principle, but with one more dimension. Super Mario is level-based with changing environment and difficulty for each level.

10.2 Strategy Games

The strategy genre focuses on players rational judgement and tactics, and actions taken strongly impacts the outcome. In strategy games, players usually control an army or society, which is evolves based on players preferences. The genre is often split into either real-time or turn-based strategy. In *turn-based strategy*, players take turns playing, while in *real-time strategy*, players can take action simultaneously.

Civilization is regarded as a popular **turn-based strategy** game [24]. The objective is to achieve victory against the opponent, which can be another

player or an NPC, by expanding and evolving a civilization to domination. Politics, trade, religion and culture are planned and overseen by players, thus requiring a complex system of parameters players can control. In Civilization, players have a bird's eye view of the map overseeing the environment and its intractable instances, providing situational awareness.

Figure 10.3: Age Of Empires

An example of a **real time strategy** game is Age of Empires [23], shown in Figure 10.3. In this game, players compete to conquer each others area by evolving the society and developing an army strong enough to attack and defend. In real-time strategy games such as Age of Empires players actions can take place simultaneously, therefor players must be ready to respond quickly.

10.3 Adventure Games

The adventure genre goes back to some of the first computer games developed. In this game genre players usually explores an unknown world through puzzle and riddle-solving. Games of this type also have a story embedded that players follow throughout the gameplay. Myst is an example from the adventure genre [41]. In Myst, the player moves around in a world full of interactive objects. Across the map lies clues and puzzles player must solve. For instance, one puzzle is to find the combination to a

safe, with the numbers hidden in the surroundings.

Figure 10.4: The Legend of Zelda

Adventure games are considered to be low pace games with emphasize on puzzle solving, yet with the combination of the action genre. Games such as The Legend of Zelda has emerged with more high pace gameplay [27]. In The Legend of Zelda, players control a character in a world filled with puzzles and enemies that must be dealt with in order to finish the game. Items and abilities are rewarded after exploring hidden areas and solving puzzles, and are beneficial for the progression. Figure 10.4 shows the game environment from one of the newest versions of the franchise, The Legend of Zelda: Breath of the Wild.

10.4 Party Games

Although the party game genre may not be recognized as a traditional game genre, it is a notable mention. Party games are often a collection of mini-games in which many players compete with each other at social gatherings. The games can be both cooperative and competitive to encourage social interaction. An example of a popular party game is Mario Party [59]. Mario Party is a digital board game where players throw dices to move across the board, trying to get the most stars. After each round, a random mini-game

initiates where players either are paired together battling the remaining opponents or all against all. Mini-games include for instance: Tennis, quiz, boat racing, cycle racing, or bumping brawl (players trying to bump the opponents off the platform).

10.5 Sport Games

Sport games are games that often simulate traditional sports characterized by speed, strength, tactics and competition. Such as in many traditional sports, sport games are usually high pace requiring precision and accuracy. Sport games can be everything from slalom to basketball. A typical sport game is the football game, FIFA [19], where players take control over football team, trying to win matches against other teams. FIFA requires precision, tactics and fast reactions in order to score goals and consequently win.

Figure 10.5: Need for Speed

A popular game type in the sport game genre is **racing games**, a competition between players to be the first to the finish line. Racing games also have a high pace and requires accuracy. An example of a racing game is Need for Speed (shown in Figure 10.5), a street racing game with fast customized cars, racing against other players or the computer to the finish line

[20]. By winning tournaments, players can unlock new tracks, cars and money to customize the cars.

10.6 Simulation Games

The simulation genre refers to games that are mimicking situations and features in real life, enacted to be as realistic as possible. Games from this genre may simulate the management of cities, theme parks, farms or football clubs. It may also focus on smaller aspects such as controlling a characters life in a simulated world and driving cars or planes with realistic physics. Simulation games do not necessarily have a rigorous goal for players to achieve, but rather let players roam freely within the simulated environment. Milestones or rewards may instead be given to players as they perform their chosen strategies in the simulated world.

Figure 10.6: City Skyline

City Skyline is a simulation game that embraces the planning and management of a city [64], as shown in Figure 10.6. Players can choose how to build and run a city, constructing roads, public services and residential-, business- and industry areas. As the population in cities increases, milestones are achieved, enabling new services and buildings. For a city to prosper, players must plan and tackle challenges that also are encountered in real-life cities. Examples of challenges can be designing road systems

that do not cause traffic jams, sufficient taxation to maintain public services, and educating the population to avoid unemployment and poverty.

Another example of a simulation game is Microsoft Flight Simulator [44]. In this game, players can control different types of planes in a realistic environment with real-life weather conditions. All planes available has authentic flight controllers, making the game controllers complicated and extensive. In order for a player to accurately fly a plane, they must grasp all features and mechanics available, understand the communication with air traffic control, and plan and adapt based on changing weather condition.

10.7 Role Playing Game (RPG)

The role playing game genre often involves a player controlling one or several characters in an eventful game world. These games usually contain a story-line players partake in through quests and puzzles. The quest to perform may differ, but usually involves combat and battle tactics. As a player completes quests, their character evolves in power and abilities, often customizable to the players liking.

Figure 10.7: World of Warcraft

World of Warcraft is an example of a popular role playing game [38], shown in Figure 10.7. In this game, a player creates a character with custom abil-

ities used to explore an immense game world with other online players. In the game world, players can team up with other players performing quests and battling enemies. As a player achieve victories from quests, their game character gains new skills and powers, thus becoming more powerful and influential. A team of different players is called a *Guild* and is often arranged with characters that compliment each other based on abilities and skill.

10.8 Summary

In this chapter, some of the most common game genres have been presented, demonstrated by games featuring characteristics found in each genre. Although all the games presented were categorized in terms of their main genre, they also have characteristics found in other genres. The genres mentioned will be used with the exergames from Chapter 6 to discuss feasible genres to the field of exergames.

Chapter 11

Social Interaction in Video Games

The game experience is not only defined by game genre but also the game mode it entails. Multiplayer is a mode that enables social interaction to the gameplay, and as a result, has become an increasingly popular game mode to play [18]. This chapter presents the social aspects of multiplayer and how it can support an enjoyable gaming experience.

11.1 Multiplayer

Multiplayer is a game mode where at least two individuals are playing with each other at the same time [76]. Since multiplayer involves several other persons, it often facilitates an extra layer to the gaming experience with social interaction. Research has shown that many people are more motivated to play games with multiplayer because of the social elements it expedites [76]. It is also indicated that the social elements it facilitates can spark further player enjoyment. The social aspects often found in multiplayer involves players being in the same game environment and taking actions that impacts other players. Verbal communication are also often supported via text-chat, voice-chat, or directly co-present. Multiplayer games can be played remote over the internet or with other individuals in the same room.

Playing with other players present in the same room features some key benefits. Having an audience has shown to make individuals perform better [76], thus possibly increase their sense of achievement. However, in

some cases, being watched can also cause anxiety and in the worst case, ruin the performance. Another positive effect of having someone present is that the social interaction is more intimate and relatable than from playing distributed over the internet. Co-present multiplayer games have shown to bring more enjoyment than remote multiplayer, indeed because of the relatedness caused by co-present communication and interaction. Multiplayer games played over the internet still have some benefits since they are more available, not requiring players to be in the same room, and can, to a greater extent be played with strangers. Also, if the game has many active players, it is easier to match skill level more accurately, than only choosing between a few friends. The multiplayer mode is further comprised of two types of modes, cooperation and competition, which are described below.

11.1.1 Cooperation

Cooperative multiplayer is a type in which people collaborate in order to achieve an objective [76]. The scale of interdependence needed to complete an objective may vary, but the higher it is, the more coordination and communication is necessary. This makes cooperation games highly dependent on team work thus complying to the social interaction, in GameFlow theory. The communication often necessary makes this game type suitable for close friends with interpersonal skills and experience. However, the high degree of relying on a partner can also cause frustration and conflict, resulting in less enjoyment for the game experience. Pedal Tanks, presented in Chapter 6, has cooperation implemented in the gameplay since a team consisting of two players have to work together in order to win.

11.1.2 Competition

In competitive multiplayer individuals play against each other to achieve an objective. Research has shown that competition can increase engagement, flow and enjoyment, when playing against a person rather than a non-player character [76]. In competition games, the player difficulty is a significant factor in terms of perceived enjoyment. Losing challenges because of uneven skills between players can become frustrating, thus matching players with similar skill is imperative. The majority of competitive multiplayer games, matches players based on skill level, such as in FIFA and Counter-Strike. Depending on gameplay, skill matching should be based on players

overall score in the game. Matchmaking is arguably extra critical for new players since research indicates that competition games have more experienced gamers, driven by the chance to beat others.

Most of the multiplayer exergames presented in Chapter 6 has competition embedded into the gameplay. This counts for Location Invaders, Pedal Kart and Pedal Tanks. As mentioned above, Pedal Tanks also have cooperation, thus utilizing the social potential from both multiplayer types.

11.2 Summary

In this chapter, we have discovered how multiplayer with its social interaction impacts players perception. From this chapter, co-present interaction has shown a potential to bring an extra layer to the total experience, and possibly motivate players to a better performance. This could be favourable in terms of players exercise performance.

Part III

Exergame Suggestions

The third part examines suitable game genres, presenting different exergame ideas and our initial concept, which was discontinued.

Chapter 12

Ideas for Exergame Genres

With the combination of both exertion and gameplay, it is convenient that the game itself supports the exercise technique and intensity found in an exergame. In order to achieve this, a proper game genre is worth considering. This section will use genres introduced in Chapter 10 to explore if, and eventually, how they correspond with the integration of different types of physical exercise. The genres will be demonstrated with previously introduced exergames from Chapter 6.

12.1 Action Games

Action games could be a suitable genre for exergames. With its fast-paced characteristic gameplay, it can compliment high-intensity exercise and player involvement needed to be distracted from the exhaustion caused by exercise. With the competition often found in action games, it could help players motivation while exercising. Pedal Tanks is an exergame that illustrates the suiting aspects from the action genre. Pedal Tanks requires quick responses while battling the enemies in a capture the flag competition. The intensity from both shooting enemies and competing to capture the flag makes for intriguing and captivating gameplay. One limitation the action genre can have on an exergame is the accuracy often required to perform objectives. Being accurate while the player is physically moving as a result of exercising, can be a complicating task, such as aiming at an enemy or moving to the correct spot. While it can be seen as a limitation, it all

depends on the type of technology and exercise form being used.

12.2 Strategy Games

With all tactics and development usually required in strategy games, it can be regarded as a game type with a magnitude of complexity. The amount of strategy and planning involved can have an impact on an exergame experience. Too much thinking and planning required may be too demanding while exercising, especially with an abundance of controllers a player must get the hang of in order to perform objectives. With the right amount of strategic depth involved, strategy games can contribute enjoyment and interest suitable for a long-term exergame experience. In turn-based strategy games, players have to wait between rounds, which could correspond with interval and set exercises since it already includes rest periods between workouts. Location Invaders is an exergame that has incorporated elements from the strategy genre. It uses real-time strategy to strive for high-intensity training. The risk of having too complicated game controllers is reduced in Location Invaders, by only providing simple and easy to use controllers while playing.

12.3 Adventure Games

The adventure genre is considered to be low paced because of its focus on riddles, puzzles and exploration. The genre in itself may lack the intensity often associated with sufficient exercise, thus separating the concepts of exercise and game in an exergame. With the inclusion of other genres such as action, adventure could be more applicable to the exercise aspect and perhaps enhance the gameplay experience with the curiosity and logic it conveys.

12.4 Party Games

Party games have a big focus on the social interaction between players and can, therefore, provide an extra incentive for players to focus on everything but the exercise. Besides, party games are not limited to only one game

concept, but a collection of smaller games to explore. The variation offered might maintain players long-term interest. With the variety of games, different types of exercises can also be adopted. Since the party genres characteristics are reasonably ambiguous when it comes to gameplay, the simplicity of implementing exercise highly depends on the mini-games created and the technology being used.

12.5 Sport Games

Games in the sport genre, fit quite well as exergames mainly because sports, in general, involves exercise. Since sport games often imitate real-life sports, it should be familiar to most people, and easy to transform into games since rules are already defined. Most sports have a predefined distance to travel or a time limit to consider, making it easy to control the amount of exercise to perform. Sport games are also comprised of competition. Competing against other players can have the positive effect of stimulating social interaction and be a motivational trigger for players to do their best. One pitfall that may occur with the sport genre is that the sport incorporated becomes a realistic simulation of the physical sport, leading to a minimal focus on the video game aspects, yet more focus on the exercise. Another issue can be found in the sub-genre, racing, where players with the highest speed often are rewarded. It does not convert easily to an exergame according to the study *Gameplay as Exercise*, since the activity can be too intensive, with uneven balance between activity and rest [34]. Racing can also cause unevenness when players with different fitness level compete since their fitness level converts to in-game speed and persistence.

Wii Fit, DDR and Pedal Kart are all exergames that incorporate the sport genre in different ways. They all use different technologies and platforms to utilize exercise types embedded in the sport genre. The exercises available in these exergames demonstrates the diversity in exercise forms the sport genre offers. Some of these exergames also illustrate how competition with the use of highscore and multiplayer can intrigue players interest and motivation.

12.6 Simulation Games

Simulation games offer an easy way of implementing exercise into games. Real-life exercise can be simulated into a realistic game environment. The exergame Zwift provides players with a realistic cycling experience using technology compatible with an ordinary bicycle. Although simulation games, such as Zwift, have the advantage of closely knitting exercise into a game environment, the resemblance to ordinary exercise can also be too excessive, resulting in an exergame lacking video game aspects and practically identical to ordinary exercise. The interest for such realistic exergames might depend on the user group. Individuals already exercising regularly may enjoy the realistic exergame experience, while individuals, not that accustomed to exercise and with a keen interest to video games, might consider it inadequate. The simulation exergame, Holopoint, illustrates how simulation can be used in a more video game relevant way, not imitating an ordinary exercise session, yet provide players with intriguing and fast-paced gameplay.

12.7 Role Playing Game

The role playing genre can also benefit an exergame. The exergame, Exermon, has incorporated character progression, offering players to evolve their characters by increasing stats, such as health and strength. The continuous development of character may support long-term player enjoyment, thus increasing the replayability of an exergame. The exploration aspect from role playing games can also be favourable in an exergame, such as in Pokemon Go. A big and eventful world open to explore, might spark players curiosity and interest to carry on. Exercise types are not necessarily limited by the genre and are illustrated trough Pokemon GO, that requires walking, and Exermon, that uses strength exercises. It is further illustrated with Ring Fit Adventure that combines several physical activities into one exergame.

12.8 Summary

All of the genres discussed above have individual characteristics that could be applicable to an exergame. Some might be more effortless to use than others. The genres we consider suitable to exergames are the action, party and sport genre. It does not mean that the remaining genres are unacceptable, but should preferably be combined with other genres to fulfil their potential to an exergame.

Chapter 13

Game Ideas

All game ideas described below were created during brainstorming sessions after the pre-study. Although the ideas presented did not end up as the final game concept, we included them to reflect what kinds of game genres we recognize as suiting for exergames, hence grouped based on genre. A recurring element in the presented game ideas is, multiplayer, which we consider as an essential factor for motivation and interest to play exergame. For this project we were constrained by the Playpulse platform and its apparatus, and for this reason all ideas are based on the use of an exercise bike.

13.1 Action Games

We regard action games as suitable for exergames because of the fast paced characteristics found in video games, as mentioned in Section 12.1. This section demonstrates two ideas from one of action games sub-genre platform games.

13.1.1 Sphere Evolver

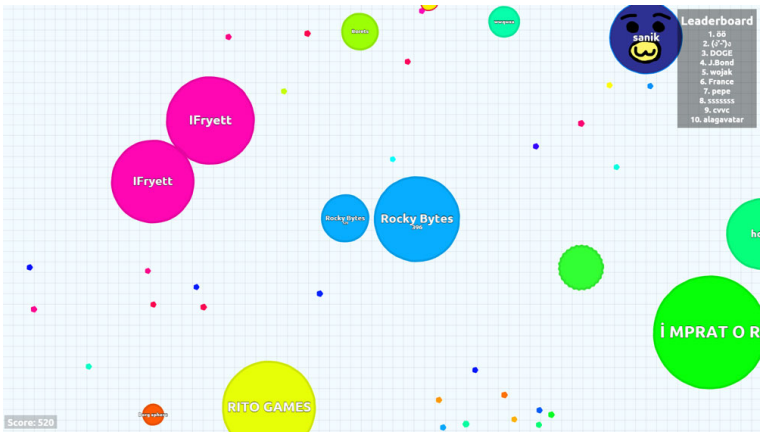


Figure 13.1: Screenshot of Agar.io gameplay

Agar.io is a popular online multiplayer game (see Figure 13.1) where players control small cells that get bigger by consuming cells smaller than them self [96]. Players can consume other players moving around, which gives the largest increase in size. There are also small static cells which are spread across the map. It is simple to learn for everyone due to its simple game mechanics and controls, moving around in a 2D environment.

Our idea is based on Agar.io, but with some modifications. A player moves forward by cycling and uses the handlebar buttons to steer left and right. Cycling also causes the players cell to increase in size. A challenge with this game is to facilitate a sufficient exercise duration, since players can be consumed by the opponent shortly after starting the game. Also, the game does not have an achievable goal, with only to become the biggest cell. To set a clear game duration a match will last for 5 to 10 minutes, where players will spawn back inn after being consumed. Intensity depends on the size of the map, whereas a small map will congregate players closer together, while a bigger map will give more available distance between players. The game can for that reason contribute to a low or high amount of exercise intensity.

13.1.2 Wall Trail

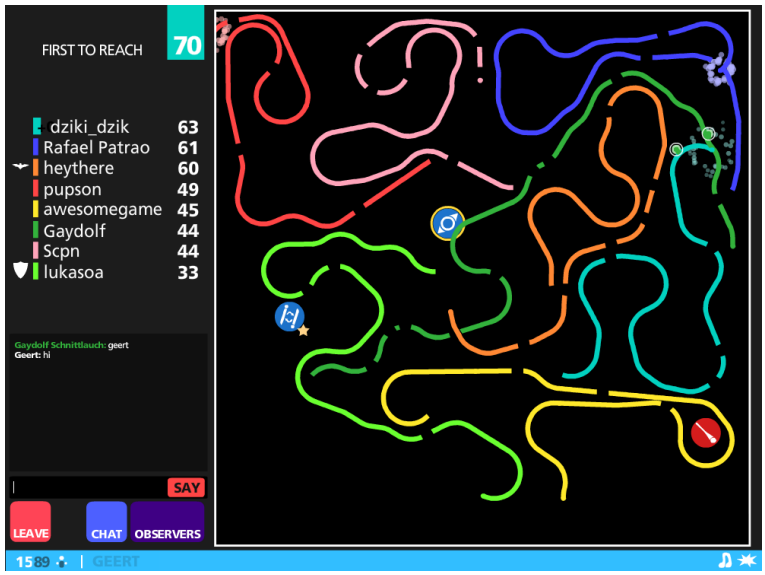


Figure 13.2: Screenshot of Curve Fever gameplay

Curve Fever is an online game where 2 to 6 players are competing against each other (see Figure 13.2) [95]. Each player control a colored dot than draws a line behind them which functions as a wall. If a player hits any of the colored lines it dies and the round is over. They will get points based on when they died and the game is finished when one player reaches a predefined total score. The players will have 2 items they can use for their advantage in order to add some uncertainty. A few examples of such items are jumping, slow-motion and make the player smaller.

Our idea differs some from the original game Curve Fever. In the original game players have a constant speed. In the exergame version the speed should be so high that the player will have problems steering. In order to gain control over the speed the player has to cycle accordingly to lower the speed. This will force the player to cycle throughout the game. Players are only controlling left and right turn with the thumb buttons and items with the index triggers. The easy controllers scheme would therefore fit perfectly to the cycle.

Because of the minimalistic gameplay, we consider both Curve Fever's and Agar.io's game mechanics to be simple to implement.

13.2 Sport Games

This section will present three ideas within the sport genre. They are all based on well known sports and, as mentioned in Section 12.5, should therefore be familiar to most people.

13.2.1 Ski Racing

Figure 13.3: Screenshot of ski racing gameplay

One idea proposed, was an alpine ski racing game. Players would ski down a slope maneuvering between gates (see Figure 13.3), where higher pedalling intensity on the bike would make the player lean down, thus gaining speed. As in regular skiing, players can not maintain full speed if they want to manage every turn. This will ensure that the player will change their pace throughout the run. Along the slope, bonus items could be acquired, such as slow motion abilities or better turn handling. The game would support both single-player where you play against the time or against a non-player character, and multiplayer where you compete against other players. The opponents would be transparent, thus possible to go through.

13.2.2 Pedal Plane

Figure 13.4: Screenshot of Google Earth plane simulator

In this idea the player have to cycle to get enough upward drift to keep the pedal plane in the air. For a game perspective the player has to avoid bad weather conditions and reach certain checkpoints visualized as circles, in order to not lose the game. Additionally there could be an open world feature where they can fly trough the landscape and just enjoy the view. If possible combined with technologies like Google Earth (see Figure 13.4) where the player could have a real world experience with popular sightings as the Grand Canyon, Niagara Falls and Eiffel Tower [30]. This will make it more interesting and appealing, and potentially result in the players wish to exercise longer. Although this game can be regarded as a simulation game, the idea is to combine this with the sport game perspectives, more accurately, racing. A possible issue of combining racing and simulation is, as mentioned in Chapter 12, that the game becomes to exercise oriented, not focusing on a constant game experience.

13.3 Party-Games

As mentioned in Section 12.4, party games focus on social interaction with various mini-games. This section presents two ideas fitting into this genre.

13.3.1 Mini-Games

Figure 13.5: Screenshot of Mario Party gameplay

Mario Party is a digital board game where the players compete in different mini-games (see Figure 13.5). This is the inspiration for this idea, where the players would compete in different high intensity mini-games to gain points visualized on a scoreboard. An idea like this would potentially be fun for a variety of players since there would be a good assortment of games to play. It might function as an interval exercise if the games are time based and with a short pauses in-between. Since party games often requires co-presence of several people, it can benefit from the social interaction described in Chapter 11. The game can have ten different games that would last 30-60 seconds with a 30 seconds pause in between. Mini-games implemented in this game would preferably be similar to those found in Mario Party and mentioned in Section 10.4.

13.3.2 Playpulse Bundle

A variation of mini-games described above, could be to bundle other existing exergames made for the Playpulse platform. With this bundle, players could have a tournament competing in all the games and gain points shown on a overall scoreboard. It will give the players a good variety of games to try, and may also introduce the players into games they have not tried before. Games made on the Playpulse platform includes already mentioned games such as Pedal Tanks and Pedal Kart, but also games such as Exer

Dungeon and CyberSteamPunkHoverWar 2088. The last two games are competition games also made specifically to the platform [52][53].

On the downside, party games requires many mini-games and would need comprehensive work; to much for only two developers during such short time period.

13.4 Summary

Although the games presented were discarded when choosing the final game idea, some of them are still relevant. These ideas can be used as inspiration and foundation for other developer wanting to make an exergame. We would like to point out Wall Trail as an exciting idea to further explore. Although sport games could be an interesting genre to explore, we consider our game ideas for this genre to be significantly orientated towards exercise as is, and should therefore be more refined with a stronger focus on game sensation.

Chapter 14

Our Initial Idea: Rocket league

Our initial game proposal was to make a multiplayer sport game, inspired by the successful video game, Rocket League. Rocket League is a football game, but with rocket cars instead of traditional football players [73]. The game consists of four players divided into two teams, trying to score on the opponent's goal. The first team to score five goals wins the match. Across the football field boost items spawns, increasing players speed. Such as in Pedal Tanks, we hoped that utilizing both cooperation by being on a team and competition by battling the opposing team would encourage and motivate for exciting social gameplay. The game concept also supported various player cars with different characteristics.

14.1 Implementation Implication

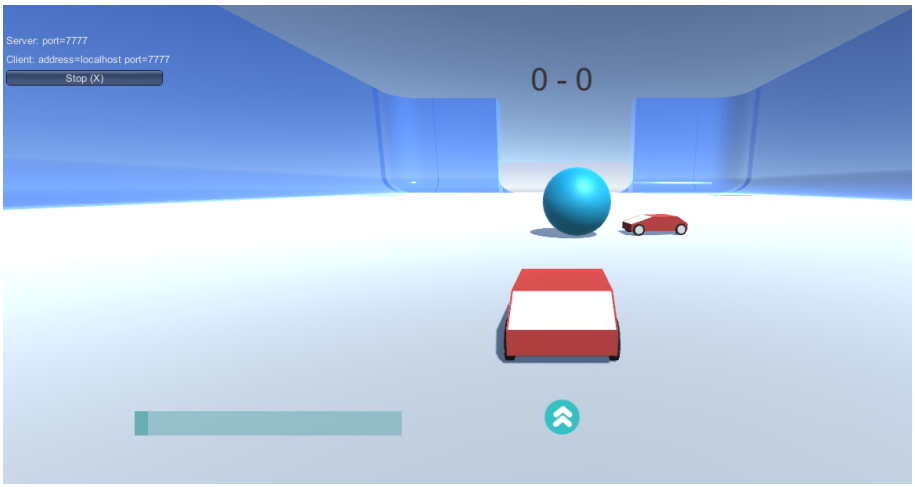


Figure 14.1: Rocket League prototype

We started developing the game idea in October but came to an abrupt halt at the beginning of January. Prior to January, we had finished designing the football field and all associated game objects (see Figure 14.1), programmed the core game dynamics including boost items and player controllers, and built the network infrastructure transmitting players position between clients and server. The next big step was to implement the football movement onto the network, transmitting its movement between client and server, which previously only happened locally. It proved to be a big undertaking, mainly because of one reason: Only the server or a local player has authority over the movement of the football. If the server has authority over the football, a clients impact onto the ball will not have authority to emit physical changes to the ball's movement. If a local client has ball authority, other clients impact onto the ball do not have permission to emit physical changes to the football. Moving authority to other clients is possible, but not instantaneous, resulting in faulting football movement when players simultaneously collide with the ball.

While researching for solutions, we found out how the original game, Rocket League, addressed this problem by developing an authoritative server handling both players and football. By receiving client input, the server would

calculate a players movement and transmit this back to all clients. Collision impact would be calculated on the server. After consulting with our supervisor, we concluded that changing the network system design would be too time-consuming and divert us from the initial project at hand.

14.2 Summary

Rocket League is still an interesting idea for an exergame, but with the required server and network implementation, it was not feasible and too time-consuming to develop. We used a little less than three months one the planning and development of this game, hence delaying our project timeline. Although we had less time developing the end result, we consider the time spent on Rocket League to have been educational, making it easier developing the final result.

Part IV

The Game: Lane Rider

After ending the work on Rocket League, we returned to our list of game ideas. In the middle of January we chose a new idea to develop. The third part presents the game concept, and the game and exercise mechanics of our game, titled: Lane Rider.

Chapter 15

Concept and Genre

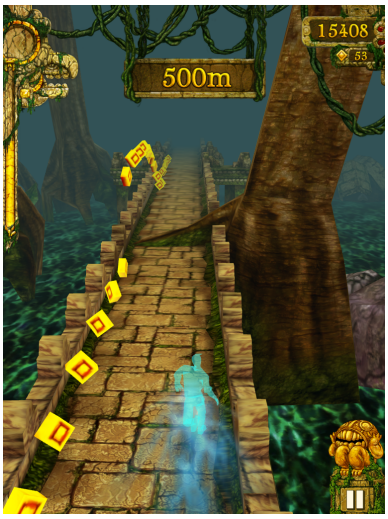
This chapter covers the concept of Lane Rider, focusing on chosen game genres and inspirations from other games.

15.1 The Essential Concept

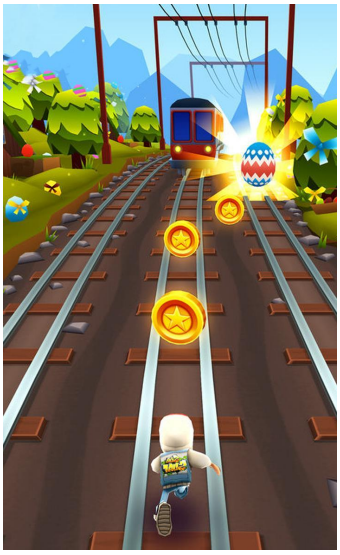
Lane Rider is a multiplayer racing game where two players compete against each other to get the lowest race time. The player with the lowest total race time after three consecutive levels win. On each level, players must move between three lanes in order to avoid hitting obstacles that slows them down. Along the tracks, players can improve their race time by picking up time bonus items, subtracting seconds from their race time. The game also contains four other items players can use on either themselves to improve the racing position or the opponent to prevent gaining a leading position. The exercise is performed on the Playpulse exercise bike presented in Chapter 7.

15.2 Genre and Inspiration

When brainstorming ideas, we wanted a game with a game genre closely associated with high intensity, making it easier to integrate the exercise dynamics. As discussed in Section 12.5, racing games from the sport genre could correspond with the exercise activity, competing at a fast pace to be the first to the finish line. Racing also facilitates easy implementation of



(a) Temple Run



(b) Subway Surfers

Figure 15.1: Screenshot of two Endless Runner games

exercise with the cycle, since it correlates with vehicle driven movement. In addition to racing, we wanted a game genre that embraced players concentration to the gameplay experience. The action genre, with its focus on quick responses and continues attention made a compelling argument for the use in Lane Rider. Consequently, the sub-genre of action, platform was chosen as the game genre. The platform genre offered the attention gripping gameplay with obstacle avoidance and multilevel design. Our intention is that the high-intensity gameplay made possible by the racing, and avoiding obstacles along changing terrain as in the platform genre, would make for an engaging experience for players and correspond to both aspects in exergames, that is exercise and gameplay.

Lane Rider is inspired in part by endless runner games, such as Temple Run and Subway Surfers (see Figure 15.1). In these games, a player moves nonstop along a track indefinitely. The goal is to get as far as possible without hitting any obstacles. If an obstacle is hit, the player must start all over. Obstacles can be avoided by moving between predefined lanes. To improve the score, players can also pick up coins. From the concepts of endless

runner, we have adopted the lane shift mechanics, obstacles along the track and score increase with pickups. Endless runner games usually has non-stop forward movement, which we did not implement for Lane Rider. For the gameplay to correspond with the exercise, players should have to cycle in order to move forward. To restrict the exercise duration we chose not to implement endless tracks.

Lastly, we have been inspired by the Nintendo's, Mario Kart game. Mario Kart is a racing game where players compete to get to the finish line. Players can choose between a selection of vehicles and characters, differing in driving capabilities and in-game items. Along the tracks, players can pick up items which can be used to advance race positions. What separates Mario Kart from other racing games are the power-up items, and this fantasy aspect is what we integrated into Lane Rider.

15.3 Summary

This chapter described the genres and inspiration used in Lane Rider. Both the main genres that are chosen, action and sport, embrace the characteristics of intense gameplay used to maintain players concentration and interest. We considered players concentration to the gameplay to be vital in order to mitigate players awareness of the exertion. Additionally, we considered the genres to correspond desirably with exercise, because of the intensity levels both emit.

Chapter 16

Gameplay

This section covers an in-depth description of the gameplay in Lane Rider. It includes the game controls, user interfaces, camera, level design, obstacles, goal, items and competition.

16.1 Objective

(a) Regular time bonus **(b)** Super time bonus **(c)** Negative time bonus

Figure 16.1: Types of time bonuses

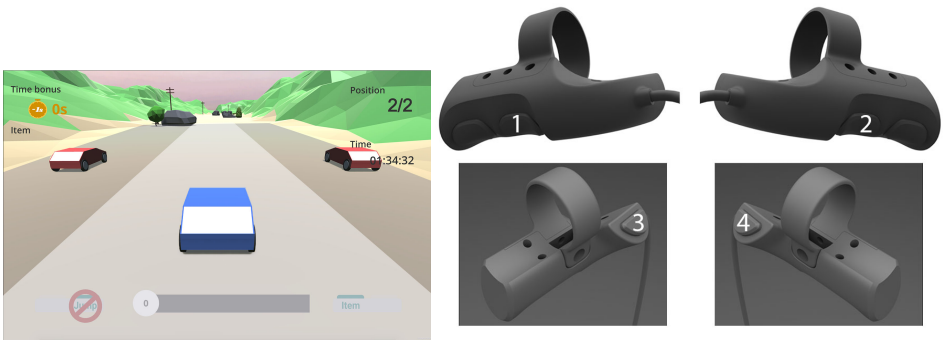
The Goal of the game is to have the lowest total time at the end of each level. It is accomplished by being the fastest to complete each level, combined with collecting time bonus items. There are two different types of time bonuses: A regular time bonus (see Figure 16.1a) which subtracts one

second from race time, and a super time bonus (see Figure 16.1b) which subtracts five seconds from the race time. The regular time bonuses are placed on levels in such a way that both players will have the possibility of obtaining an almost equal amount. A player in the lead will still have the benefit of choosing a path with time bonuses first. The super time bonus is extraordinary and therefore only three exist in each level. These bonuses are located in areas that demand player skill and some luck to get.

16.2 Competition

Lane Rider evolves heavily around competition by supporting a co-present multiplayer gameplay with two players. The competition is comprised of both being the first one to the finish line and gathering the highest amount of time bonuses. Since game skill and activity level can vary between players, game difficulty is influenced by the opponent's experience. In order to balance players skill and activity levels, rubberbanding is implemented. During gameplay, the last player receives a constant speed boost. It is implemented so that the loosing player can catch up with the leading player. The rubberbanding effect activates when a player is 50 meters behind the leader. The speed will gradually increase the further behind the player gets with a set maximum speed boost, so that it is possible to navigate between the obstacles. The effect is deactivated again when the player gets within a range of 50 meters of the leading player.

16.3 Game Controllers



(a) Illustration of the lanes **(b)** Controller schema

Figure 16.2: Player controls

To move the player character forward, players must use the pedals on the cycle. The speed depends on the pedaling intensity. Only four out of six buttons located on the handlebar are used in Lane Rider. The reason for this is to minimize attention to the controllers and let players be more focused on the gameplay. There are three lanes (illustrated in Figure 16.2a) the players can change between, using the left and right thumb buttons (number 3 and 4 in Figure 16.2b). Lane changes are necessary throughout the race in order to avoid obstacles or pick up items and time bonuses. An item will be available after pick up, and the player can trigger it with the right index finger button (number 1 in Figure 16.2b). The last player controller used is the jumping button. It is only available in particular areas of the map. When entering such an area the button at the left index (number 2 in Figure 16.2b) is enabled, which gives players the opportunity to jump over obstacles.

16.4 Level Design

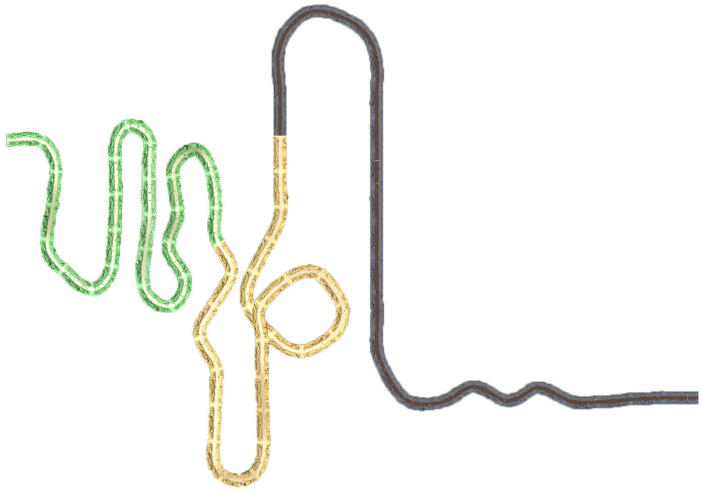


Figure 16.3: Overview over the levels

There are three levels in Lane Rider, increasing in difficulty from easy to hard. It can be seen in Figure 16.3 where the green part is the easy level, yellow is medium level and dark grey is the hard level. Each level is put together by 25 segments making them similar in length with some differences, due to turns shortening segments. The segments are divided into three categories: regular segments, jumping segments, and hill segments, and presented below:

Regular Segments

Regular segments are the most common segments and are located on the flat parts of each level. It contains both static and dynamic obstacles, which are further described in Section 16.5.

Jumping Segments

Jumping segments are located in level one and three. In these segments, the jumping button is enabled, and comprised of obstacles that can only be passed by jumping.

Hill Segment

There are two types of hills, uphill and downhill, utilized to simulate real-world hills. In uphills, a player has to increase its pedaling intensity in order to reach max speed. Ceasing the pedaling will cause the player character to roll backwards. Uphills contains barrel obstacles that spawn on top of the hill, rolling down a random lane. In downhills, the player will get a small increase in speed, even if a player do not pedal. Downhills contain both static and dynamic obstacles such as in regular segments.

16.5 Obstacles

There are two main types of obstacles the player can encounter throughout the levels, static and dynamic obstacles. *Static obstacles* are obstacles that do not move, while a *dynamic obstacles* are obstacles that move between fixed positions. When colliding with a static or dynamic obstacle, the player character will be moved backwards for one second in which the controllers also are disabled.

16.5.1 Static

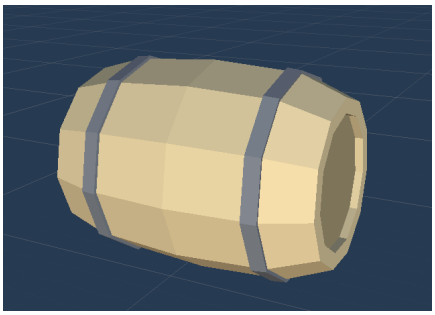
(a) Regular obstacle **(b)** Jump obstacle

Figure 16.4: Example of static items

There are two types of static obstacles, one that the player will have to avoid by changing lane (as seen in Figure 16.4a) and one that the player can jump over (as seen in Figure 16.4b). The first is the most common and is represented by a larger object, such as a rock, fence or a wall. The second

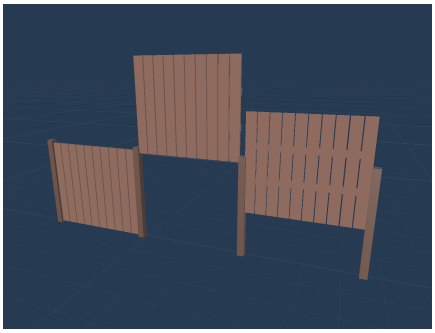
is only present in the jumping areas and is represented by a lower and wider object, such as a small and wide rock or a coffin.

16.5.2 Dynamic

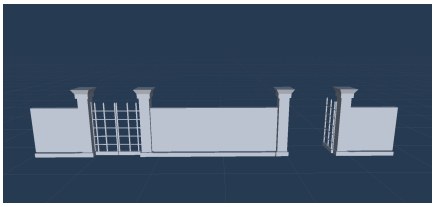


(a) Barrel

(b) Food truck



(c) Moving fence



(d) Moving gates

Figure 16.5: The different dynamic obstacles

There are four different types of dynamic obstacles the player will encounter: barrels, food trucks, moving fences and moving gates. Barrels (as seen in Figure 16.5a) are obstacles located in uphill terrain in every level and rolls downhill towards the player on random lanes. For each level, the speed of the barrels will increase. Additionally, there are three obstacles specifically designed for each level. The first level contains moving food trucks (as seen in Figure 16.5b). Food Trucks move in and out of a garage, blocking the left and middle lane. The second level has moving fences (as

seen in Figure 16.5d) that cover each of the three lanes, and moves up and down in a pattern that ensures that there is always one lane open to move trough. The third level has moving gates (as seen in Figure 16.5c). The gates are present on the left and right lanes that opens and close accordingly. Moving gates have a pattern similar to moving fences on level 2, in which one of the gates are open when the other one is closed.

In addition to colliding with obstacles, the player must also avoid colliding with the opponent's character. Character collision is done to ensure that a player can not drive straight trough the opponent, thus instead collide and get the same penalty as a collision with any other obstacle.

16.6 Items

(a) Speed Bonus **(b)** Time Multiplier **(c)** Speed Decrease **(d)** Time Penalty

Figure 16.6: The different items

Items are game objects with extra powers, that can be picked up by players and used to gain a leading position. Items are placed on each level with five to eight segments in between, such that players will get one regularly throughout each level. Items picked up are randomly selected and a player can use it whenever desired. When activated, it will last for 5 seconds. The list bellow describe each item's ability. The first two are items that a are used on the player themselves, while the last two are items used on the opponent.

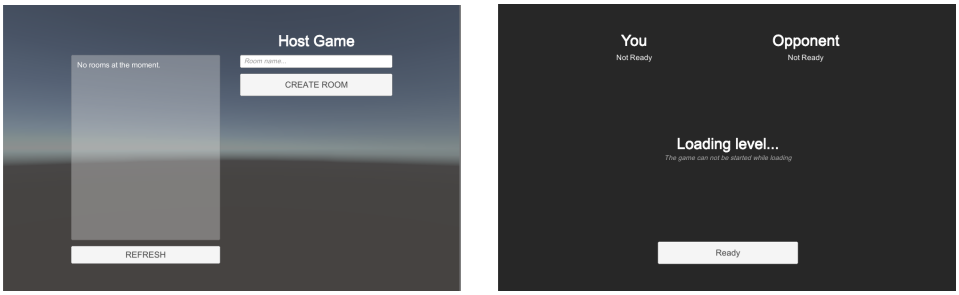
- Speed boost (see Figure 16.6a) gives the player a 50% speed increase with the possibility to reach 150 in speed.

- Time multiplier (see Figure 16.6b) doubles the time bonuses picked up while it is activated. 1-second time bonus will give 2 seconds and a 5-second time bonus will give 10 seconds.
- Speed decrease (see Figure 16.6c) gives the opponent a 30% speed decrease, thus restricting their max speed to 70.
- Time penalty (see Figure 16.6d) gives the opponent a negative time bonus by subtracting time bonuses picked up by the opponent. When a player receives a time penalty from the opponent time bonuses changes colour to red, indicating a time penalty if picked up. The time penalty item applies to both 1-second and 5-second time bonuses.

16.7 User Interface

User interfaces in Lane Rider conveys necessary information about players' stats and used for administering game matches. This section describes the most relevant interfaces available.

16.7.1 Matchmaking Interface



(a) Matchmaking **(b)** Ready screen

Figure 16.7: Pregame interfaces

In order to play Lane Rider, a player has to enter the matchmaking lobby (see Figure 16.7a), where it is possible to create a room or join an existing one. After joining or creating a room, the game proceeds to a ready screen (see Figure 16.7b). In this interface a player can declare them self as ready

to start. The game will start when both players are ready, and the level has finished loading.

16.7.2 Gameplay Interface

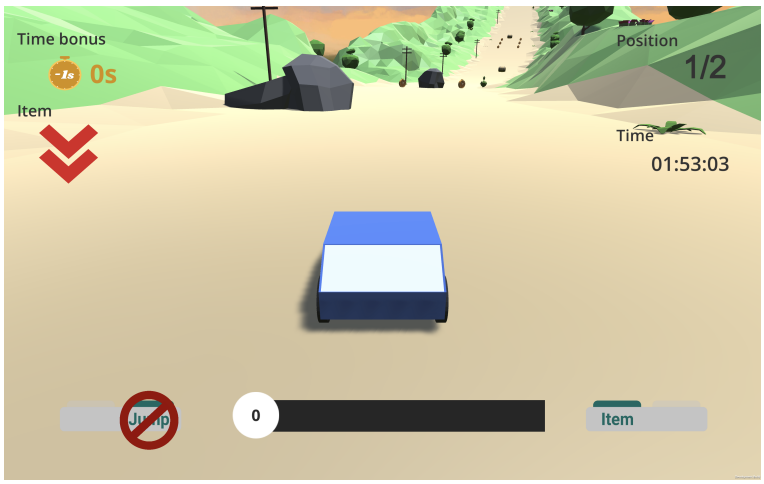


Figure 16.8: User interface

The user interface (as shown in Figure 16.8) presents all necessary information a player will need throughout the race. In the top left corner the time bonus counter is displayed with the amount of seconds the player has collected so far on that level. Below the time bonus counter is the item in possession displayed. If an item is picked up, the item's icon (shown in Figure 16.6) is shown, which is otherwise empty. In the upper right corner is the player's position and time spent displayed. In the bottom of the screen is a visualisation of the jump button's state, with a slash sign indicating whether or not the jump button is activated. On the right side, the item button is displayed and is only used to remind players on which side the item button is located. In the middle is the speedometer, showing player's speed as a numerical value and as an horizontal sliding bar.

Additionally, messages are displayed in the middle of the screen when necessary. It includes the countdown on each level, information if the other player is already using an item and alert when the jumping segments begins or ends.

16.7.3 Round Summary

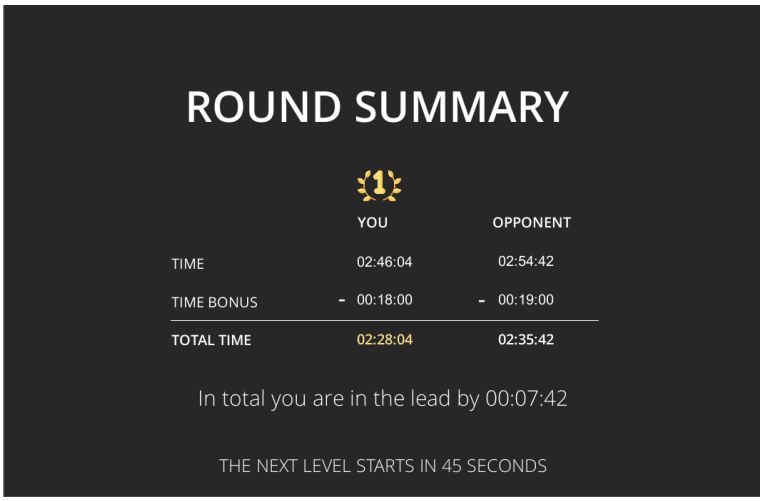


Figure 16.9: Round summary

In between each round a scoreboard (see Figure 16.9) is displayed giving players an overview round score compared to the opponent. It shows much time was spent from start to finish, the number of time bonuses picked up and the total round time after the time bonuses are subtracted. In addition, the winner of the round is displayed. A counter on the bottom indicates time until next level commences.

16.7.4 Final Scoreboard

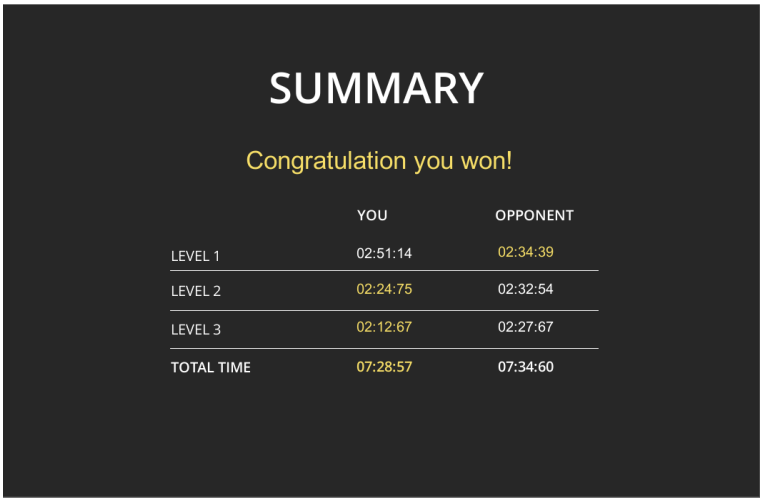


Figure 16.10: Final Summary

The final summary (see Figure 16.10) displays the total time for each level with a total time for the whole game. The player with the lowest total time is shown as the winner.

16.7.5 Additional Statistics

Figure 16.11: Additional statistics

The additional statistics (see Figure 16.11) displays extra information gathered throughout the game. Intensity describes the percentage of maximum cycling intensity the player performed. Lane changes shows the number of lane changes performed and obstacles hit shows the number of obstacles hit.

16.8 Camera Movement

The camera follows the movement of the car. In hills, the camera moves up and down based on the rotation of the car. This is done to make an additional effect of the steepness. To give players a sensation of higher speed the camera is moving closer to the character when accelerating. This also makes game objects feel larger and a sensation of travelling over a longer distance.

16.9 Summary

This chapter has described the general game design for Lane Rider and can be used as an introduction if doing further implementations in the future. This chapter can also assist in understanding the context of possible in-game situations described in the results and discussion chapter.

Chapter 17

Game Mechanics

The following section covers how we aimed to adopt game mechanics discussed in Chapter 9 to Lane Rider. This includes theory on Flow and Challenge, Fantasy and Curiosity.

17.1 GameFlow

To illustrate game mechanics in regards to flow, we will use the guidelines described in GameFlow.

17.1.1 Concentration

Maintaining players' concentration to the gameplay in an exergame can be challenging if players feel exhausted while exercising. Lane Rider tries to mitigate this and distractions from the surroundings by continuously provide different types of hinders and power-ups along each level. In order for players to succeed, they must keep the focus on avoiding obstacles, collecting time bonuses and outmaneuver the opponents. It requires fast reaction time and strategy skills, maintaining their attention to the gameplay.

17.1.2 Challenge

Each level in Lane Rider differs in difficulty. The difficulty is based on how tight and often different types of obstacles and time bonuses occur. Level

one is easy, level two is medium, while level three is considered hard. We have attempted to make each level slightly more challenging, not too demanding, yet provide challenges according to a player's upper skill level. Since this game is a multiplayer game, game skills among players may differ. To counterbalance any unevenness between players, we use rubberbanding to assist players falling behind a chance of winning, consequently also raising the challenge for the leading player. The losing player also has the advantage of better knowledge of the leading player's position.

17.1.3 Player Skill

To facilitate the development of players skill the first level in Lane Rider is regarded as a tutorial level, because of its light difficulty. It gives the player a hands-on and realistic introduction to the gameplay and its controllers. We anticipate a steep learning curve by completing the first level.

At first, players will become familiar with the gameplay, focusing on avoiding obstacles and getting first to the finish line. However, as players skill progresses, they can ascertain a firmer grasp of strategies possible, thus a new layer of difficulty to master. Some of the strategies can for instance be which time bonuses to collect or when to use items skillfully.

17.1.4 Controls

Player controls are limited to four basic buttons (move left, move right, jump and use item), as well as pedals, making it rather easy for players to learn the controllers. One of the main limitations with the game controllers on the exercise bike was that it did not provide pressure-sensitive buttons. Moving a player object left or right by pressing a button did not feel accurate and sensitive enough, thus resulting in a slightly different direction than intended. As presented about the theory of GameFlow in Chapter 9 players must have the feeling of control over their actions in order to experience flow. This was a major reason to why we chose implementing predefined paths and lanes players could move between at the press of a button.

17.1.5 Clear Goal

In Lane Rider the core goal is introduced before the game has started in an explanatory fashion; ”The goal in Lane Rider is to get the lowest total time after three levels”, followed by an explanation on how this is achieved; ”Get first to the finish line.” and ”Collect time-bonuses, subtracted from your time at the finish line”.

17.1.6 Feedback

The in-game interface supports immediate feedback on players status. Player position, time spent, speed, power-ups in possession and time bonus count are constantly updated and constantly available. A summary of players score is shown after each level assuring awareness on who is leading and who is behind. Actions taken by a player is conveyed with a designated sound making it easier for players to react appropriately.

17.1.7 Immersion

Apart from the conventional sensory systems touch and vision used in exergame, Lane Rider has included hearing. As mentioned above, sounds implemented are primarily used for feedback, but may also stimulate player immersion since sounds appear regularly.

17.1.8 Social interaction

Social interaction is made possible by multiplayer competition and can be present both physically and digitally. The game is developed with the intention of players being co-present, sitting beside each other on the exercise bike, and thus enabling direct social interaction. Digital interaction is performed when players perform in-game actions affecting the opponent. It includes colliding with or blocking the opponent’s car and using power-ups on the opponent. The digital interaction is also present when comparing score or stats, and when Lane Rider announce a winner. The digital interaction can also serve as a facilitator for direct social interaction, which in turn might increase the competitive spirit.

17.2 Dual-Flow

The balance in *attractiveness* from the dual flow theory was covered in Section 17.1 above. In terms of *effectiveness*, Lane Rider has a high exercise-intensity with similar benefit as from high-intensity interval training (see Chapter 18). A potential consequence is that the intensity will be higher, than the fitness level of a player, which can, in turn, result in failure to complete the exercise. The most effective way to counterbalance personal fitness and intensity is to adjust wheel resistance on the exercise cycle. We have tried to calibrate the resistance to a level that is achievable for individuals with a normal fitness level. Since the game might be regarded as intense by players, we have tried not to overburden them by creating levels with a play-duration limited to 3 minutes. The rubberbanding mentioned above might also support players with a low fitness level, decreasing the potential time spent on completing a level by increasing the speed.

17.3 Challenge, Fantasy, and Curiosity

This section covers game mechanics corresponding to Malone's theory on Challenge, Fantasy and Curiosity.

17.3.1 Challenge

In Lane Rider the *variable difficulty level* is decided by both level difficulty and the opponents skill level. Level difficulty varies from each level, starting easy, followed by levels with increasing difficulty. A way to facilitate additional variable difficulty levels would be to let players choose from a substantial collection of levels with various difficulties. However, since Lane Rider is a proof of concept, we only offer three levels in subsequent order. In Lane Rider, players can join a game from a lobby. There are no tracked records of players game and fitness skills, so players are paired arbitrarily. If players score and in-game stats were saved and displayed for other players, it would be easier to choose an opponent with the desired skill level. A program could also be made that automatically picked players with matching skill level. For this solution to work, the game would need a big user base, having enough players available to play and match skill levels.

Getting the lowest time score in a level counts as a sub-goal where the lowest total time after three levels is the main goal. To make the game more challenging and alluring, we introduced *multiple level goals* via meta-goals that are active during all three levels. These are fewest total lane shifts, highest total intensity and fewest total obstacle collisions. The meta-goals will not influence the final score but serve as a bonus challenge for players. Although a player may not win the total goal, it is still possible to achieve a meta-goal and acquire some self-esteem.

In order to get a players outcome more uncertain, Lane Rider has incorporated *random behaviour* to different game mechanics. Types of power-ups are randomly chosen when picked up, making it harder for players to take tactical decisions on which item to use. Random behaviour is also incorporated to barrel obstacles. On top of hills, barrels spawn randomly onto different lanes, making it complicated for players to obtain time bonuses in the hill without hitting rolling barrels.

A players field of view is limited and gradually exposed when moving forward, *hiding information* of what challenges lies ahead on the track. Also, jumping areas are not disclosed before a player gets close to them. A player can first notice a sign on the side of the track alerting the player. When the jumping area begins a notice are displayed on the screen. Players noticing the sign will have more time to react, thus higher possibility of avoiding the jumping obstacles. Lastly, power-ups do not disclose its ability before being picked up.

17.3.2 Fantasy

To affect players emotion and interest, Lane Rider has integrated fantasy. A player takes on the role as a car in a poly themed universe, gathering supernatural elements and avoiding obstacles by shifting lanes and jumping. A low-poly theme was chosen for the game universe, since it is a usual theme in popular mobile games, thus making it more familiar for new players. The game uses both extrinsic and intrinsic fantasy. Extrinsic fantasy appears when a player is driving a car, which does not depend on the player's character. In doing so, fantasy depends on skill but not vice versa. Intrinsic fantasy appears when a player interacts with items, time-bonuses and

obstacles where the interaction influence the player's skill; In other words, skill and fantasy are dependent on each other.

17.3.3 Curiosity

To maintain and spark curiosity Lane Rider varies scenery and obstacles during tracks, with new game elements and themes for each level. Although a player may understand the underlying environment of the game, the track takes different directions, and obstacles differ in appearance, behaviour and position. Ideally, levels should be procedurally generated, making the tracks more unique and unexpected. Furthermore, Lane Rider should have an extensive collection of levels, each with new obstacles and features, stimulating players curiosity and replayability. Although we have only developed three levels with custom positioning of game elements for each level, we consider the prototype illustrating a potential for this type of game design.

17.4 Summary

This chapter covered all game mechanics incorporated to elicit a desired player sensation. We consider the most substantial game mechanics to be lanes with corresponding controllers and levels with various difficulty. The movement controllers on the handlebar could have been a disturbance for players if not working as anticipate. We consider that the lane changing movement makes for easier controlling, suitable in a fast pace environment, even for individuals not familiar with video games in particular. The difficulty variation supported in our level design might assist challenging players skill progression, while giving an incentive to continue the activity, upholding the long-term interest.

Chapter 18

Exercise Mechanics

The exercise type chosen for Lane Rider is high-intensity interval training (HIIT), and will, as previously stated, be performed on an exercise bike. HIIT is a recommended type of exercise because it is the most effective way to increase the amount of oxygen the body can take advantage of during exercise.

18.1 The General Exercise Structure

The level design is arranged to facilitate the recommended HIIT, as mentioned in Section 8.3. There are three levels that each takes approximately three minutes to cycle, with 45 seconds pause in between. The pause is implemented to give players time to recover. Although we desired to support a 4X4 method, we had to compromise because of the time constraints, reducing levels available down to three with three minutes duration each, hence a 3X3. It is still close to the preferred 4X4 and could potentially show a similar benefit.

18.2 Elevation

Each level has elevation in the track for the purpose of simulating actual pressure from uphill cycling. Based on track uphill steepness, the maximum intensity required increases, resulting in players having to pedal faster. When ascending uphill, the intensity required to reach maximum

speed increases with up to 40%. During high-intensity training a persons heart rate should be close to 85-95% of HR_{max} for as long as possible. Ensuring that players rapidly gains a higher heart rate, an uphill is placed close to the start of each level. To counterbalance the focus on ascending exertion, distractions are present uphill in the form of barrels and time bonus items. It is reasonable to consider decreasing intensity during downhill terrain, since it can simulate cycling downhills in real life. However, since the heart rate should be consistently high during high-intensity training, we did not want to decrease the intensity downhill. Instead, we increased the speed by 30% so the player could get a feeling of descending. After each uphill a downhill takes place. It is done to give the player the excitement from speed gained, and uphold players concentration to game, since the speed increase makes it harder to avoid obstacles.

18.3 Alteration to the Cycle

(a) Old indicator **(b)** New indicator

Figure 18.1: Types of indicators

As stated in Section 12.5, one of the pitfalls with racing games is that players with the highest speed often wins. This can give the player with the best endurance a great advantage and at the same time cause the opponent to be exhausted. To counteract this, we chose to change the indicator for the speed sensor located on the bicycle wheel, gaining a higher range of pedal power available in the game. The old indicator (see Figure 18.1a) has more black and white sectors, resulting in reaching maximum speed faster than

the new indicator (see Figure 18.1b). This allowed us to decrease the intensity required to gain maximum speed. The remaining excess of intensity available is then used to maintain a high intensity in hills, without draining the players to fast.

18.4 Summary

Lane Rider is based upon high-intensity interval training with intervals lasting around 3 minutes each and a rest period of 45 seconds in between. Varying available intensity is done to uphold the heart rate zone close to peak, maintained with uphill terrain arranged throughout each level. The challenge when designing a game to support HIIT is to balance the exercise intensity and players with different fitness level. Although we have tried to make the activity endurable for most individuals, some might find the exercise a bit heavy, but not still possible to complete.

Chapter 19

Development

This chapter outlines the development of Lane Rider. It contains a brief presentation of the development process, the multiplayer system, the architecture and testing. As stated in Section 3.2, the development process was prototype oriented and is, therefore, more broadly discussed.

19.1 The Process

We used three months on the development of Lane Rider, from January to March. The process started with conceptualizing the idea, creating design sketches and identifying main features. Figure 19.1 shows some of the sketches made, including the features: lanes, time-bonus items and obstacle.

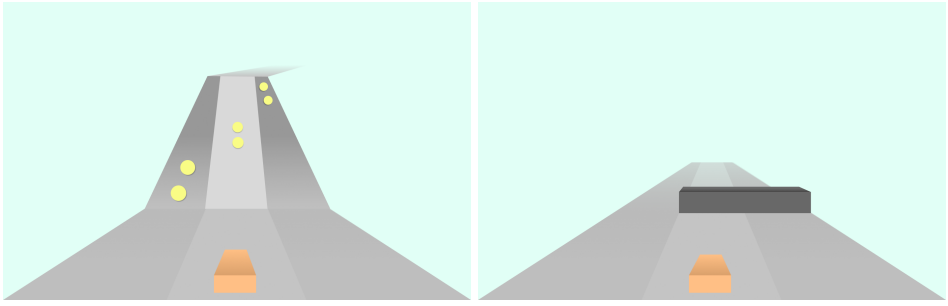


Figure 19.1: Illustrations of the conceptual design

Before starting the development process, we also made a proposal for level

design correlating with exercise intensity. Figure 19.2 illustrates the idea of level design with uphills with high intensity, and flat and downhill areas with normal intensity.

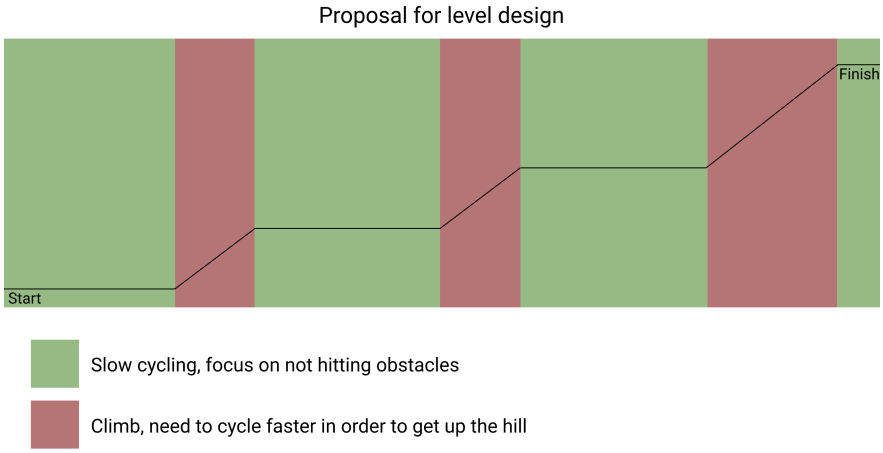


Figure 19.2: Illustration of the exercise intensity in the level design

Unity, a development platform for making 2D/3D games, was used when creating Lane Rider. Since we already had experience with Unity from working on the previous game idea, Rocket league, implementation of features took less time with Lane Rider. We began by connecting the exercise bike input to a game character, implementing player movement into the game. After that, we started on implementing lanes to move between. This was done using the external asset, Forever made by Dreamteck, which generated pre-made lanes onto road-segments. After adjusting the movement controllers to feel responsive and intuitive, we started on implementing the track for all three levels. This was done by placing numerous vector points in the scene, which together formed a path. With Forever, road-segments were then generated along the path, making the track for all three levels (see Figure 16.3). So far, we had only made a plain road-segment when working on player movement. The next step was to create various segments containing obstacles, that would be generated onto the path. We made 25 custom segments for each level with different types of static and moving obstacles.

When all levels were made, we began implementing the multiplayer system. Much of the Unity Multiplayer system was already arranged in the previous idea, Rocket League, and could, therefore, be reused in Lane Rider. When we had the multiplayer up and working, we began working on the item pickup. It consisted of implementing a network spawn for items, abilities, and inventory system for picking up and using an item. Time-bonuses were also implemented at the same time as items, because of their similarities.

In the end of the development process, we created a system controlling ranking, level changes and generation of it-game objects throughout the gameplay. At last, we implemented all user interfaces needed.

19.1.1 Network

Multiplayer was made possible using Unity Networking (UNET). Although the system is deprecated, it works well for prototypes with few clients and minimal transmissions between them. Figure 19.3 illustrates how the network is arranged in Lane Rider. One client acts as a host and connects to the server run on the same computer. The remote client is on another computer and connects to the host's server via the network lobby.

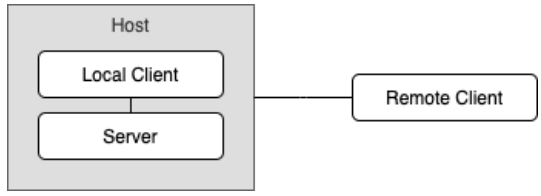


Figure 19.3: Server Host

Figure 19.4 illustrates the player instances projected via the server to all clients. Players with shadow effect represent the local player for each client. When a player connects to the server, their game object becomes a local instance on the client, directly associated with the instance connected to the server. When a player moves forward one frame, the new position is transmitted from the local client to the server. It is then updated and transmitted to all other clients.

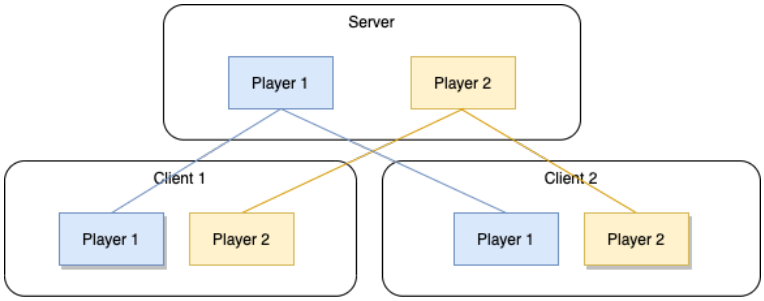


Figure 19.4: Client server

Figure 19.5 shows the direction of action in the network system. The client transmits input data from their computer and on to the host servers instance of the client player. The action is then sent to the object which takes the necessary action, transmitting the change to all other client objects. For instance, when a player uses an item with the press of a button, it triggers a command to the server about the update for the designated player instance. It is then forwarded to the game object which activates the correct item power and updates this to all clients. The clients receive the change and checks if it is the correct receiver, in which the change is activated locally.

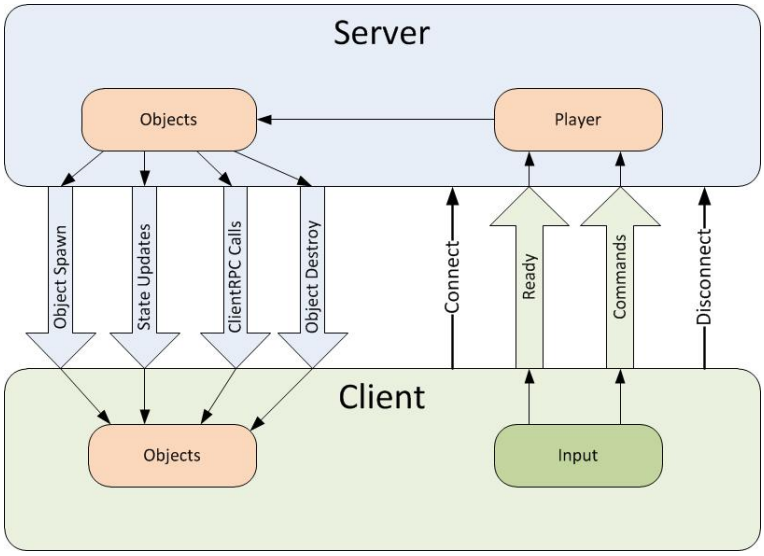


Figure 19.5: UNets directions of actions [91]

19.2 Architecture

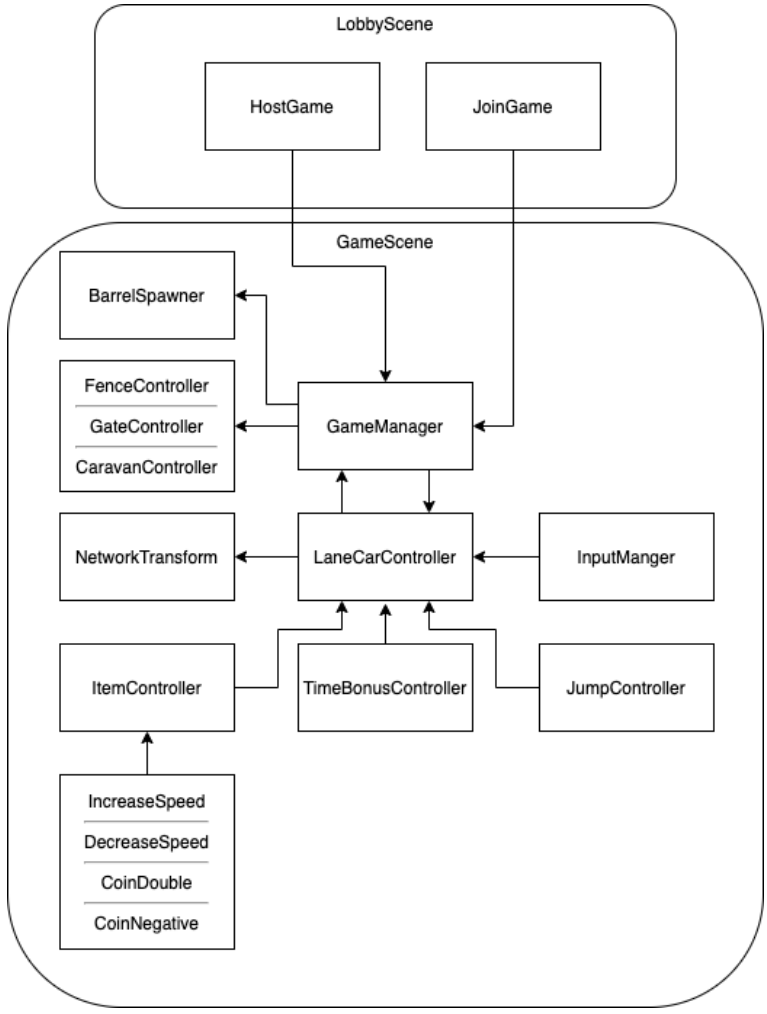


Figure 19.6: Overall class structure with scenes

Figure 19.6 illustrates a simplified version of the classes and how the information is sent between them. In the LobbyScene, players either host a game or join a game. HostGame will initiate a GameManager instance in GameScene, while JoinGame will use an already initiated GameManager instance. GameManager is in control of the game, which includes the rounds, scores, spawning of barrels, syncing of dynamic obstacles and

spawning the players. LaneCarController takes input from the InputManager in order to control the car with the cycle. Car positions are sent to the NetworkTransform transmitting the position data to the server, which again sends it over to the other client. When the player interacts with a game object, this object will tell the LaneCarController what to do. This includes when entering/leaving a jumping area, and picking up time bonuses and items. The item objects have a basic ItemController which is connected to a script which controls item types and abilities.

19.3 User testing

Testing was done after each new feature was implemented by us, the authors, and occasionally some friends. These tests uncovered bugs and inconsistencies that had to be fixed before the final experiment. One week before the initial date for the experiment, we invited two fellow students to test for irregularities in the game. Feedback and observations from the test gave us some indications on necessary improvements. The list below describes the most urgent changes made before we conducted the experiment.

- Occasionally, The game would disconnect from the server because of buffer overflow. To fix it, we reduced the send rate of car position updates between client and server.

- Some of the dynamic obstacles moved too quickly, making it difficult to pass. To fix it, we decreased the animation speed of obstacles movement.

- Hard to see when the jump button was enabled and disabled. To fix it, we added a UI illustration that indicates when the jump button is enabled and disabled.

- The UI showing active items was concealing the track. To fix it, we moved the active items to the bottom of the screen and decreasing its size.

19.4 Summary

This chapter covered the main aspects of the development of Lane Rider. This chapter does not describe all aspects in full detail, yet depicts an overview of the most relevant parts of both the process and system. Unet, being deprecated, made it harder to find helpful information that was not out-dated. However, we made it work for two clients in the game. For further work, it would be appropriate to substitute Unet with another multiplayer service.

Part V

The Study

The fifth part presents the methodological aspects of the experiment conducted and the results gathered from the experiment.

Chapter 20

Methodology and Data Generation

This chapter presents the foundation of the experiment, describing the sample, the data generation methods and the data analysis used. Covid-19 had a direct impact on our experiment, so the first part of this chapter will establish the repercussions.

20.1 Covid-19 repercussions

From March 12th, NTNU closed down all campuses following the Covid-19 outbreak. As a result, our scheduled testing from 16th of March became postponed indefinitely, and most of our selected test subjects went back home. We were dependent on a testing facility on campus, since all our equipment were stationary, e.g., exercise bike and associated computers. It was not before April the 16th we got permission to start testing on campus, and the permission relied on arranging preventative measures against Covid-19 infection. In order to have enough distance between test subjects and a steady stream of fresh air, we used the facilities at NTNUs UX-lab. The measures planned and implemented are listed below.

- The test will be performed in a room with appropriate space, e.g., hallway or auditorium.
- The exercise bikes will be distanced minimum two meters apart, with a light interior wall in between.

- The exercise bikes will be cleaned and disinfected before and after use.
- Observations will be performed two meters apart from the test subjects.
- The computer used by test subjects to answer a questionnaire will be disinfected before and after use. Test subjects are recommended bringing their own smartphone to answer the questionnaire.
- The heart rate monitor used by test subjects will be disinfected before and after use.
- Participants are paired if living together or already been in close contact.

20.2 Execution

Figure 20.1: Picture from the experiment. Faces are hidden for privacy concerns

The experiment served two main purposes:

1. Identify the exercise outcome, mapping test subjects exercise effects.
2. Identify the players game experience, mapping test subjects enjoyment, motivation and social interaction.

The experiment (see Figure 20.1) was distributed throughout five days, in which participants attended three sessions, one each day. Making players attend three sessions were done to examine the long-term effects of the exercise and enjoyment outcome. Each session lasted approximately 30 minutes, apart from the participants' first session since an introduction was necessary. The introduction consisted of a presentation of the game and its game controllers. We handed out a short manual containing the most necessary information, as presented in Appendix B. In accordance with the theory on player skill from GameFlow in Chapter 9, we let the participants practice on the first level before starting the experiment. After the test subjects finished the game, the questionnaire was handed out. The heart rate monitor, Fitbit Charge 3, was used by all participants.

20.3 Norsk Senter For Forskningsdata (NSD)

Before starting the experiment, we filed a request to *Norsk Senter For Forskningsdata* (NSD) for the approval of processing personal data collected from the experiment. This had to be done regarding the data protection legislation. A document describing the processing of personal data was delivered to NSD, containing the following:

- The data collected from participants is heart rate data; Personal data (age, height, weight and gender); and data about perceived exercise and gameplay experience.
- It is voluntary to take part in the experiment. Participants can, at any time, withdraw their consent.
- All data will be anonymized, not identifying the participants in our publication.
- All data processed is based on the participants' consent. NSD has considered the experiment to be in accordance with the privacy regulations.

The document was also provided to potential test subjects, including a description of potential risks involved by participating, due to Covid-19. When participants arrived at their first session, they had to sign the document, consenting to take part in the experiment. A copy of the NSD document is embedded in Appendix A.

20.4 Sample

When gathering participants, we used non-probabilistic sampling [61]. Non-probabilistic sampling is used when it is not beneficial or necessary to have a sample that is representative of a wider population and does not need to be generalized. In this case, our aim was to investigate whether the prototype shows potential as an exergame and thus worth further improving. It was therefore regarded as adequate with a low applicable sample.

The target population for this project were mainly the younger generation, which is usually more familiar to the concept of gaming and regarded as the population at risk of inactivity. Since the demographic chosen was far-ranging, we reduced it to the age between 20 and 35, hence young adults. This age group correlated with most students at NTNU and were therefore chosen as population frame. Because of Covid-19 regulations, many students, including most of our pre-selected participants, had gone back home. This made the non-probabilistic sampling relevant, since it was, at this point, hard to obtain any participants at all. To ease the sampling process, we turned to convenience sampling, finding test subjects available, with no underlying medical conditions vulnerable to Covid-19. A sample size of at least 30 participants is recommended for statistical analysis to be reliable. Due to the university being closed, it was a challenge to find an adequate amount of participants.

20.5 Questionnaire

After each three sessions, an online questionnaire was given to the test subjects. It was a self-administered questionnaire and used to collect standardized data from the participants. The questions were identical for all participants and repeated for each session. As recommended in *Researching*

Information Systems and Computing, consideration around *content validity*, *construct validity* and *reliability* was done during creation of the questionnaire [61]. *Content validity* is about well-balanced questions and if they cover the domain. In order to insure Content Validity, we took inspiration from the previously used questionnaire in the Pedal Kart experiment [81], and an inspection by our supervisor. *Construct validity* is about whether the questionnaire is measuring what it is supposed to measure or not. To ensure that the questionnaire has construct validity, some of the questions had to be verified by observations or other information. An example of this was to check if the answers to the statement: "I felt like I was exercising", corresponded with the observation of the test subjects. *Reliability* is about whether the questionnaire would give the same outcome if given to the same test subjects several times. It would have been appropriate to have a control group in terms of validating the reliability, but because of time constraints and Covid-19, it was not achievable.

The questionnaire was split into four parts. The first part considered demographics, asking open questions about age, height, weight and sex. The second part used open questions and closed questions with the use of a Likert scale (strongly disagree, disagree, neutral, agree and strongly agree). It asked how much they enjoyed exercise and computer games, and how much time they used on average over a week. The third part, was the main part with only closed questions, also using the Likert scale, and covered *Enjoyment*, *Motivation*, *Perceived Exercise* and *Social Interaction*. The fourth and last part consisted of open questions where the subjects could answer what they liked/did not like about the game and give optional feedback.

Since the third part of the questionnaire, is the main part, it will be further described in the following sub-sections. The entire questionnaire form is presented in C.

20.5.1 Enjoyment

Research question RQ4 and its sub-question RQ4.1 investigates players' enjoyment to Lane Rider. The questionnaire contained 17 statements in total concerning enjoyment. Six of these were general statements about enjoying the game. The remaining statements covered concepts from the theory on flow, since, as discussed in Chapter 9, it promotes an enjoyable

game experience. The following two lists show the general and specialized statements regarding enjoyment:

General statements

- I had had fun while playing
- I enjoyed the game
- I enjoyed this game genre
- The game got more enjoyable over time
- I was so engaged in the game that I lost the sense of being in physical activity

Specialized statements

- I was fully focused on the game
- I lost the feeling of time and space
- I was engaged while playing the game
- My engagement increased during the game
- I understood what I was supposed to do in the game
- I had control over the situation/the player
- It was easy to learn the controllers for the game
- Items led to some uncertainty about the end result
- It was hard to avoid the barrels in the uphill
- Moving obstacles made the game more uncertain
- The game became more challenging for each round
- I felt I was getting better for each round
- I felt I had a good chance of winning

20.5.2 Motivation

Research question RQ5 investigate players' motivation to Lane Rider. The questionnaire contained five statements on participants motivation towards playing the game and doing exercise. Some of the statements looked at how motivating the exergame was compared to doing traditional exercise.

- I were motivated before each round
- I would like to play again
- I am more motivated to exercise with the help of this game, rather than cycle outside
- I would rather play this game than practice regular exercise
- This game has motivated me to be more active/exercise more

20.5.3 Perceived exercise effect

Research question RQ6, RQ3 and its sub-question RQ3.1 investigates the exercise effect from Lane Rider. The questionnaire contained six statements regarding participants perceived exercise effect. Four of these were general statements, while the last two statements focused on exercise mechanics implemented and how they were perceived.

- I noticed a difference in heart rate before I played and during the most intense
- The game had a high-intensity level
- I felt I got a good workout
- I felt like I was exercising
- The uphill terrain required more of me physically
- The downhill terrain required less of me physically

20.5.4 Social Interaction

Research question RQ2 investigate the social interaction from Lane Rider. The questionnaire contained four statements regarding social interaction in the exergame, focusing on competition.

- To play against other people made me give more
- It was engaging to play against others
- To play against others made the game fun
- Knowing my position based on the opponent affects the motivation for the next round

20.6 Observation

For this experiment we did observations in order to gather contextual data complementing the questionnaire and heart rate data. The observation method we used is called *Overt research*, referring to participants knowing they will be observed [61]. As discussed in *Researching Information Systems and Computing*, overt observations makes the research more ethical and trustworthy [61]. However, doing it overt can also cause the trouble of making participants stressed, knowing they are being watched, which in turn can cause unusual and false behaviour. During sessions, we adopted *participant observation*, standing behind the test subjects and writing down all observations that were relevant, such as emotions, verbal interactions, how they played and how tired they looked when exercising. After sessions, we would ask test subjects questions general to the game or situations that test subjects encountered while playing.

20.7 Fitbit

During each session, participants used a Fitbit Charge 3 (FC3) to monitor the heart rate. FC3 was released in October 2018. Although the Fitbit has been on the market since 2018, research on its accuracy is limited. Fitbit Charge 2 (FC2) on the other hand, has been studied and is the closest product comparable to the FC3. The FC2 has by a study been evaluated

as inaccurate and not suited as a medical device [10]. Chest-worn heart rate monitors usually offer better accuracy than with wrist-worn devices, such as FC2 [39]. A study evaluating the accuracy for FC2 while indoor cycling, showed that the data were only valid for heart rate at rest and a few infrequent times when cycling [11]. Another study has shown that the FC2 pose a moderate bias on average, but for individual measures, can be underestimated by up to 30 BPM compared to Electrocardiography (ECG) [8].

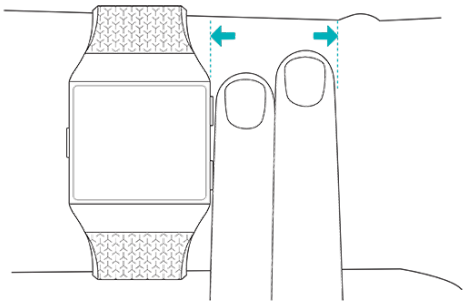


Figure 20.2: How to wear Fitbit Charge 2.

Fitbit has stated that while bike riding, the wrist frequently bends [1]. This can interfere with the heart rate signal and cause an inaccurate result. Fitbit suggests users not to wear the device too tight, but in solid contact with the skin. For increased accuracy, the device should be placed two finger's width above the wrist bone, as illustrated in Figure 20.2. The FH3 might not give us a conclusive result because of its inaccuracy but offers some indications on Lane Rider's exercise intensity and potential benefit.

20.8 Data Analysis

For this experiment, the data gathered from the questionnaire and heart rate sensors were used for quantitative data analysis. The Likert scale-based answers from the questionnaire provide numbers assigned between a set scale and defined as *ordinal data* [61]. The numerical values collected by the heart rate sensor, have units of the same size and ranked based on a scale with a true zero, defined as *ration data*. To illustrate the central tendency

of the data, *mean* and *median* were calculated, in which mean is the average numerical value of the results and median is the midpoint of the scaled results. Standard deviation was calculated, with the Google Sheet formula STDEVPA [31], on the heart rate data, in order to display the amount of variation to the average score. Participants HR_{max} was calculated using the the formula, $211 - 0.64 \times age$ [57].

To investigate the relationship of two independent groups, we used the non-parametric Mann-Whitney test [48]. To use the Mann-Whitney test, four assumptions have to be satisfied [45]. First, the dependant variable should be ordinal data, which we got using the Likert scale for the questionnaire. Second, the independent variable should be of two independent groups, which we obtained by dividing into gamers and non-gamers, and active and non-active. Third, the groups should be independent of each other, which we got by having individual participant in each group, and not both. The fourth, and last, is that the two groups do not need to be normally distributed, which suited our groups of different sizes. The average score from day one, two and three were used to perform the Mann-Whitney test.

The last part of the questionnaire and the observations covers a more qualitative data sample and was used in combination with the quantitative data in order to give further meaning to the results.

20.9 Summary

This chapter has presented the most relevant topics for the experiment. Although the Covid-19 outbreak did affect our experiment in certain ways, we still managed to perform it without to many complications. The measures implemented might have had an impact on the end results. For instance, the distance and interior wall needed, might have created some social barriers for interaction to take place.

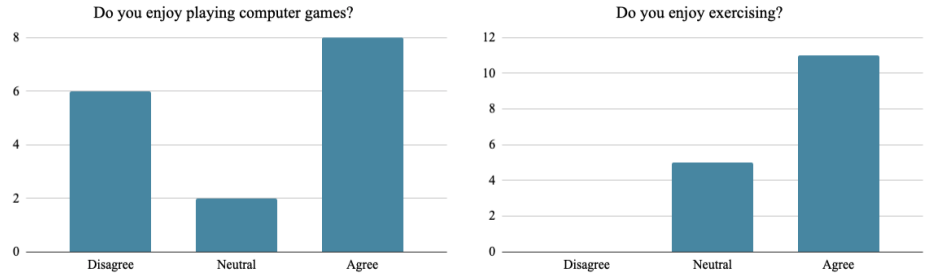
Chapter 21

Results

This chapter presents the data we collected from the experiment with Lane Rider and is categorized into sections based on the data collection method. The chapter begins by presenting the test subjects participating in the experiment, followed by results from the questionnaire, heart rate monitor and observations.

21.1 Test Population

In total, we had 16 test subjects, consisting of friends and fellow students. The collection consisted of 4 women and 12 men in the age range 22-29. To make the figures in this section more tangible, strongly disagree has been merged with disagree and strongly agree with agree. Figure 21.1b shows that 69% of the participants stated that they enjoy exercising while the rest were neutral. Figure 21.1a shows that 50% of the participants stated to enjoy playing computer games, 12.5% were neutral while 37.5% disagreed.



(a) Enjoy gaming

(b) Enjoy exercise

Figure 21.1: Participants enjoyment on gaming and exercise.

Table 21.1 shows the average and median amount of hours of exercise and gaming for the participants. The hours of exercise has an insignificant difference between the average and median, but do have a standard deviation of 4. The hours of gaming, on the other hand, do have a significant difference between the average on 8.6 hours with a standard deviation of 15 and the median on 2.5 hours. This is due to some participants playing 0 hours a week, while some playing up to 50 hours a week.

Avg. Hours of exercise	**Median Hours of exercise**	**Avg. Hours of gaming**	**Median Hours of gaming**
4.2	3	8.6	2.5

Table 21.1: Average and median hours of exercise and gaming.

The participants can be grouped into two different sets of counterparts. The first set splits the participants into two groups: participants exercising less than 150 minutes weekly, and participants exercising 150 minutes weekly or more. 150 minutes are the recommended amount of a week exercise, as mentioned in Chapter 8. 37.5% of the participants exercised less than the recommended amount, and 62.5% exercised equal to or greater than the recommended amount. The second set splits the participants into two groups: participants playing video games less than 150 minutes weekly, and participants playing video games 150 minutes weekly ore more. It resulted in an even split with 50% of the participants in each group.

21.2 Questionnaire

This section covers answers from the questionnaire and are sectioned into the key points: social interaction, enjoyment, motivation and perceived exercise effect. Statements were answered with a Likert scale from 1 to 5, where 1 is strongly disagree, 2 is disagree, 3 is neutral, 4 is agree, and 5 is strongly agree. To clarify answers from all three sessions, they are aggregated into Mean and Median for each day. In the tables presented below, day two is not represented, even though it was performed. We chose not to represent day two for readability purposes and because day one and day three conveys the information, necessary. Day one is relevant since it was the day participants tried the game for the very first time. Day three is relevant since the participants tried the game for the third and last time. All answers from the participants can be seen in Appendix D.

21.2.1 Enjoyment

The questionnaire contained questions related to perceived enjoyment. The participants' enjoyment was recorded based on general statements on how players perceived the experience, as seen in Table 21.2. To further investigate participants enjoyment, statements concerning the theory on flow and challenge, fantasy and curiosity were used, as seen in table 21.3.

Table 21.2 shows that the scores on enjoyment are high for each day. Q1 was noticeable high for day one with a score at 4.6 but had a minor decrease to 4.3 on day three. While Q1-Q4 had a score above 4, Q5 was the only statement below 4.

ID	Statements	Session					
		Mean			Median		
		Day 1	Day 3	Change	Day 1	Day 3	Change
Q1	I had had fun while playing	4.6	4.3	-0.3	5.0	4.0	-1.0
Q2	I enjoyed the game	4.5	4.5	0.0	4.5	5.0	0.5
Q3	I enjoyed this type of game	4.4	4.5	0.1	4.5	5.0	0.5
Q4	The game got more enjoyable over time	4.3	4.1	-0.2	4.0	4.0	0.0
Q5	I was so engaged in the game that I lost the sense of being in physical activity	3.8	3.8	0.0	4.0	4.0	0.0

Table 21.2: Results on perceived enjoyment

Table 21.3 shows that the scores were high for most statements. Q8 was considerably high on the first day with an average score of 4.8. It decreased to 4.4 on day three, showing a minimal drop in engagement while playing for some participants, with a median reduced from 5 to 4 on the last day. Q12 showed that most of the participants agreed to the controllers being easy to learn. This score increased on day three by 0.5, indicating it became easier the more they played. Q13 had an average score at 3.4 the first day and increased to an average of 4.1 the last day, showing in-game items influenced participants to a higher degree after each session. Q16 were high at day one but decreased by 0.5 on day three showing that the game became less challenging over time.

ID	Statements	Session					
		Mean			Median		
		Day 1	Day 3	Change	Day 1	Day 3	Change
Q6	I was fully focused on the game	4.7	4.6	-0.1	5.0	5.0	0.0
Q7	I lost feeling of time and space	3.6	3.7	0.1	3.0	4.0	1.0
Q8	I was engaged while playing the game	4.8	4.4	-0.4	5.0	4.0	-1.0
Q9	My engagement increased during the game	4.6	4.3	-0.3	5.0	4.0	-1.0
Q10	I understood what I was supposed to do in the game	4.6	4.7	0.1	5.0	5.0	0.0
Q11	I had control over the situation/the player	3.9	4.0	0.1	4.0	4.0	0.0
Q12	It was easy to learn the controllers for the game	3.9	4.4	0.5	4.0	4.0	0.0
Q13	Items led to some uncertainty about the end result	3.4	4.1	0.7	3.5	4.0	0.5
Q14	It was hard to avoid the barrels in the uphill	2.8	2.3	-0.4	2.5	2.0	-0.5
Q15	Moving obstacles made the game more uncertain	4.1	4.2	0.1	4.0	4.0	0.0
Q16	The game became more challenging for each round	4.4	3.9	-0.5	4.0	4.0	0.0
Q17	I felt I was getting better for each round	4.0	3.7	-0.3	4.0	4.0	0.0
Q18	I felt I had a good chance of winning	4.1	4.3	0.2	4.0	5.0	1.0

Table 21.3: Results on precised enjoyment aspects

21.2.2 Motivation

The questionnaire contained statements related to motivation, seen in Table 21.4. Q19 and Q20 asked about participants motivation in terms of the game, and the scores show that participants felt highly motivated. Q21 and Q22 asked how the game compared to other types of exercise. Most participants showed a higher interest in playing the exergame than cycling outside, but impartial when compared to regular exercise. Q23 asked if the

game motivated participants to be more active. On day one, participants were neutral, with a score at 2.9. The score increased on day three to 3.6, indicating a greater motivation.

ID	Statement	Session					
		Mean			Median		
		Day 1	Day 3	Change	Day 1	Day 3	Change
Q19	I were motivated before each round	4.4	4.5	0.1	5.0	5.0	0.0
Q20	I would like to play again	4.6	4.6	0.0	5.0	5.0	0.0
Q21	I am more motivated to exercise with help of this game, rather than cycle outside	3.6	3.5	-0.1	4.0	4.0	0.0
Q22	I would rather play this game than practice regular exercise	2.9	3.0	0.1	3.0	3.0	0.0
Q23	This game has motivated me to be more active/exercise more	2.9	3.6	0.7	3.0	4.0	1.0

Table 21.4: Results on motivation

21.2.3 Perceived Exercise Effect

The questionnaire consisted of statements about participants perceived exercise effect, shown in Table 21.5. Statement Q24 to Q27 asked about participants perceived exercise experience, while Q28 and Q29 asked about participants perception of the game's embedded exercise mechanics. On statement Q24 to Q27 participants answered with an average above 4 for each day. The only statement with a noticeable change was Q27 with the score decreasing from 4.7 to 4.3. The decrease of 0.4, seen in relation to the median for each session, 5.0 and 5.0 respectively, shows that a minority of participants did not get the feeling of exercising. Q28 and Q29 show that participants were and became, more aware of the intensity regarding uphill terrain compared to downhill terrain.

ID	Statements	Session					
		Mean			Median		
		Day 1	Day 3	Change	Day 1	Day 3	Change
Q24	I noticed difference in heart rate before I played and during the most intense	4.9	4.8	-0.1	5.0	5.0	0.0
Q25	The game had a high intensity level	4.5	4.5	0.0	5.0	5.0	0.0
Q26	I felt I got a good workout	4.2	4.2	0.0	4.0	4.0	0.0
Q27	I felt like I was exercising	4.7	4.3	-0.4	5.0	5.0	0.0
Q28	The uphill terrain required more of me physically	3.7	4.1	0.4	4.0	4.0	0.0
Q29	The downhill terrain required less of me physically	3.4	3.3	-0.1	3.5	3.0	-0.5

Table 21.5: Results on perceived exercise outcome

21.2.4 Social Interaction

The statements in Table 21.6 do all have an average of 4.5 or more, indicating that all participants found the social interactions available a highly positive factor to the game experience. There was no notable changes in score from day one to day three, staying highly positive throughout the experiment.

ID	Statements	Session					
		Mean			Median		
		Day 1	Day 3	Change	Day 1	Day 3	Change
Q30	To play against other people made me give more	4.6	4.6	0.0	5.0	5.0	0.0
Q31	It was engaging to play against others	4.6	4.7	0.1	5.0	5.0	0.0
Q32	To play against others made the game fun	4.6	4.6	0.0	5.0	5.0	0.0
Q33	Knowing my position based on the opponent affects the motivation for the next round	4.5	4.5	0.0	5.0	5.0	0.0

Table 21.6: Results on social interaction.

21.2.5 General Feedback

The last part of the questionnaire contained the questions: ”What did you like the best about the game?”, ”What did you like the least about the game?” and ”Any further comments?”. The questions were answered textually, where the most reacquiring and interesting feedback is presented in the tables below.

What did you like the best about the game?
Being pushed to cycle in order to win, good motivation to give a little extra.
Fun with competition! Enjoyed it when it was challenging so you didn't have to think about being tired, but more focused on the tasks.
That I forgot that I was cycling while playing
That it was intense, I felt that I got a good workout. Playing with someone made me want to win and perform better.
The best part was that you can compete against others. Items made it a little more exciting. In addition, it was easy to learn!
That you have to pedal harder in the uphill slopes, and that you play against someone, which made me perform more.

Table 21.7: Answers about positive aspects of the game

Table 21.7 shows positive feedback about the game. A recurring answer was that the competition aspect made the game appealing, stating that it helped to push players to perform better. The answers indicate that players were so focused on the game that they forgot that they were exercising. The answers also showed that the participants enjoyed the intensity from the uphill terrain.

What did you like the least about the game?
The doors that opened and closed were very annoying and made it a little demotivating when you have hit them many times in a row without moving on.
Had problems knowing when I could turn, and to separate left and jumping button. Pressed wrong very often.
It was a bit boring when you were leading that you had no indication of where the opponent was. Just had to listen for bouncy sounds etc. to try to find out. Maybe have an ”opponent x meters behind”? So that you get the motivation to pedal a little extra.
Not motivating that it's hard to drive past someone without being pushed back and losing like 10 seconds.
Felt a bit unfair if your behind
The same levels. Would be cool with changes between each session

Table 21.8: Answers about negative aspects of the game

Table 21.8 shows that players found it annoying hitting obstacles to many times. The participants also answered having trouble separating the jump and item button. Some participants also felt that it was hard to take the first place if falling behind.

Other comments?
A map that shows the difference between the players, the leader does not know where the second place is.
A bit boring that the leader can't see the other player. A mirror to see the opponent?
Can't wait to try again. I will beat the record.
Very fun, would be fun with a full release with smoother controls and graphics etc. And had it at the fitness centre.

Table 21.9: Answers about other comment

Table 21.9 shows that participants found it challenging not knowing the position of the opponent when in the lead. Many suggested implementing a map or a mirror to get some overview of the player positions. Finally, we got comments on how participants enjoyed the game and looked forward to the next session.

21.3 Gamers and Non-Gamers

This section covers the differences between participants playing video games less than 150 minutes weekly, and participants playing video games 150 minutes weekly or more. These groups are, from now on, described as non-gamers and gamers, respectively.

Table 21.10 shows the statements that had the most substantial differences in score between gamers and non-gamers. Q2 shows that gamers felt it was easier to learn the controllers than non-gamers on the first day, but evened out on the last day. The same tendency can be found in Q3 and Q7, with an even greater change from day one to day three for non-gamers. Q7 shows that gamers felt the intensity from the uphill terrain to a higher degree than the non-gamers, which also evened out on the last day. Q8 showed that both non-gamers and gamers were neutral to the game motivating them to be more active on day one. However, this increased for both groups, with as much as 0.9 for the gamers.

ID	Statements	Groups					
		Non-gamers			Gamers		
		Day 1	Day 3	Change	Day 1	Day 3	Change
Q1	I was engaged while playing the game	4.8	4.6	-0.2	4.8	4.3	-0.5
Q2	It was easy to learn the controllers for the game	3.6	4.3	0.7	4.1	4.5	0.4
Q3	Items led to some uncertainty about the end result	2.9	4.0	1.3	4.0	4.1	0.1
Q4	It was hard to avoid the barrels in the uphill	2.8	2.3	-0.5	2.8	2.4	-0.4
Q5	The game became more challenging for each round	4.4	3.7	-0.7	4.4	4.0	-0.4
Q6	Knowing my position based on the opponent affects the motivation for the next round	4.4	4.4	0.0	5.0	4.5	-0.5
Q7	The uphill terrain required more of me physically	3.0	4.0	1.0	4.0	4.1	0.1
Q8	This game has motivated me to be more active/exercise more	3.0	3.4	0.4	2.9	3.8	0.9

Table 21.10: Differences between non-gamers and gamers

Table 21.11 shows the results of statistical significance with the two groups using the Mann-Whitney test. It contains statements from the questionnaire that had a difference in score of minimum 0.5 between the two groups. P-values are colourized based on its significance. Yellow indicates borderline cases in which values are close to 0.05, while red indicates cases that indicate statistical significance in which values are below 0.05. Two statements showed statistically significant differences: ”I was so engaged in the game that I lost the sense of being in physical activity” and ”The downhill terrain required less of me physically”.

Statement	Group	Disagree	Neutral	Agree	Z	P
I was so engaged in the game that I lost the sense of being in physical activity	Non-gamers	0.0%	37.5%	62.5%		
	Gamers	0.0%	62.5%	37.5%	1.7900	**0.0367**
Items led to some uncertainty about the end result	Non-gamers	12.5%	50.0%	37.5%		
	Gamers	0.0%	12.5%	87.5%	-1.63	**0.0516**
The uphill terrain required more of me physically	Non-gamers	12.5%	25.0%	62.5%		
	Gamers	0.0%	25.0%	75.0%	-1.1	0.1357
The downhill terrain required less of me physically	Non-gamers	37.5%	50.0%	12.5%		
	Gamers	12.5%	37.5%	50.0%	-1.89	**0.0294**

Table 21.11: Results from Mann-Whitney Test

21.4 Active and Non-active

This section covers the differences between participants exercising less than 150 minutes weekly, and participants exercising 150 minutes weekly or more. The groups are, from now on, described as non-active and active, respectively.

Table 21.12 shows the statements that had the most substantial difference in score between active and non-active participants. Q1 shows that non-actives were less engaged compared to actives on the first day, but evened out on the third day. Q5 shows that non-actives were neutral to how easy it was to learn the controllers, while actives felt it was easy. This score increased significantly for non-actives on the last day. Q10 shows that both actives and non-actives felt that they were exercising to a high degree, with non-actives scoring the highest. For Q13 both groups had a high average score and increased for the non-actives from 4.3 the first day to 4.8 the last day. The actives had a decrease from 4.8 on the first day to 4.5 on the last day. Q14 shows that non-actives did not agree on playing the game rather than practising regular exercise on the first day. However, the score increased to neutral on the last day. Actives were more or less neutral to the statement for both day one, with a score at 3.3, and day three, with a score at 3. Q15 shows that the non-active were more motivated to exercise after playing this game with an increase from 3.0 to 4.2. The active did only have a minor increase in comparison.

ID	Statements	Groups					
		Non-active			Active		
		Day 1	Day 3	Change	Day 1	Day 3	Change
Q1	My engagement increased during the game	4.0	4.2	0.2	4.9	4.3	-0.6
Q2	I had had fun while playing	4.3	4.2	-0.1	4.9	4.4	-0.5
Q3	I had control over the situation/the player	3.7	4.4	0.7	4.1	3.8	-0.3
Q4	I lost feeling of time and space	3.8	3.2	-0.6	3.4	3.9	0.5
Q5	It was easy to learn the controllers for the game	3.0	4.6	1.6	4.4	4.3	-0.1
Q6	Items led to some uncertainty about the end result	3.2	4.2	1.0	3.6	4.2	0.5
Q7	It was hard to avoid the barrels in the uphill	2.5	2.8	0.3	2.9	2.1	-0.8
Q8	The game became more challenging for each round	4.7	3.8	-0.9	4.2	3.9	-0.3
Q9	I felt I was getting better for each round	3.5	3.8	0.3	4.3	3.6	-0.7
Q10	I felt like I was exercising	5.0	4.4	-0.6	4.5	4.3	-0.2
Q11	The uphill terrain required more of me physically	4.0	4.0	0.0	3.5	4.1	0.6
Q12	The downhill terrain required less of me physically	3.8	3.2	-0.6	3.1	3.3	0.2
Q13	I would like to play again	4.3	4.8	0.5	4.8	4.5	-0.3
Q14	I would rather play this game than practice regular exercise	2.3	3.0	0.7	3.3	3.0	-0.3
Q15	This game has motivated me to be more active/exercise more	3.0	4.2	1.2	2.9	3.3	0.4

Table 21.12: Differences between non-active and active

Table 21.13 shows the results from indicating significance with the two groups using the Mann-Whitney test. It contains statements from the questionnaire that had a difference in score of minimum 0.5 between active and non-active. P-values are colourized based on its significance. Yellow indicates borderline cases in which values are close to the 0.05, while red indicates cases that indicate statistical significance in which values are below 0.05. Four statements showed statistically significant differences: ”Moving obstacles made the game more uncertain”, ”To play against other people made me give more”, ”To play against others made the game fun” and ”Knowing my position based on the opponent affects the motivation for the next round”.

Statement	Group	Disagree	Neutral	Agree	Z	P
Moving obstacles made the game more uncertain	Non-active	0.0%	16.7%	83.3%		
	Active	0.0%	0.0%	100.0%	1.9	**0.0287**
To play against other people made me give more	Non-active	0.0%	16.7%	83.3%		
	Active	0.0%	0.0%	100.0%	1.95	**0.0256**
It was engaging to play against others	Non-active	0.0%	16.7%	83.3%		
	Active	0.0%	0.0%	100.0%	1.63	**0.0516**
To play against others made the game fun	Non-active	0.0%	16.7%	83.3%		
	Active	0.0%	0.0%	100.0%	1.9	**0.0287**
Knowing my position based on the opponent affects the motivation for the next round	Non-active	0.0%	60.0%	40.0%		
	Active	0.0%	0.0%	100.0%	2.2	**0.0116**
I am more motivated to exercise with help of this game, rather than cycle outside	Non-active	33.3%	16.7%	50.0%		
	Active	10.0%	20.0%	70.0%	0.92	0.1788

Table 21.13: Results from Mann-Whitney Test

21.5 Heart Rate

This section covers the heart rate data collected from the experiment. The results are presented with the average and maximum heart rate for each participant. The HR_{max} of all participants were on average at $194.8 \pm 1.3BPM$. After finding the average heart rate for the three sessions of each participant, the percentage of their HR_{max} was found. The average

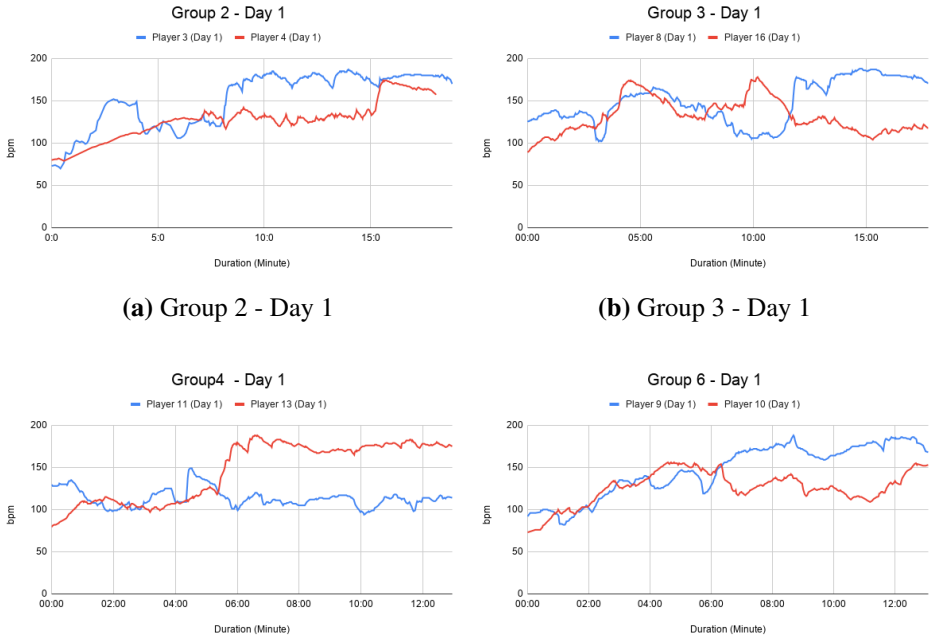
for all participants were $66.7\% \pm 7.7\%$. The same procedure was done to the maximum HR reached for all three sessions, and the average percentage was $83.8\% \pm 9.5\%$. The calculations of average and maximum heart rate includes data from the restitution periods in between levels.

	Average			Max. reached		
Participant	**Day 1**	**Day 2**	**Day 3**	**Day 1**	**Day 2**	**Day 3**
1	115.4	114.8	-*	143.0	134.0	-*
2	126.8	109.3	154.6	168.0	129.0	185.0
3	160.7	151.5	154.7	187.0	185.0	185.0
4	131.9	140.7	160.4	174.0	188.0	186.0
5	123.4	111.9	108.4	153.0	149.0	129.0
6	120.8	108.9	109.1	146.0	130.0	128.0
7	101.9	108.4	134.9	124.0	168.0	156.0
8	144.4	151.0	141.1	188.0	188.0	174.0
9	146.0	126.7	128.7	188.0	197.0	157.0
10	131.0	118.8	128.4	165.0	141.0	163.0
11	113.5	133.0	130.2	149.0	179.0	182.0
12	113.6	113.1	108.7	146.0	134.0	146.0
13	145.1	154.2	161.9	188.0	189.0	193.0
14	134.8	136.4	172.2	179.0	166.0	192.0
15	109.1	165.2	116.6	161.0	186.0	150.0
16	131.7	109.8	111.0	178.0	137.0	130.0
Average	128.1	128.4	134.7	164.8	162.5	163.7

Table 21.14: Average and maximum reached heart rate.**Participant 1 were not present on day 3, due to illness*

Table 21.14 shows all average heart rates and maximum heart rates reached for each participant on day 1, 2 and 3. The average heart rate for each day is relative similar ranging from 128.1 BPM to 134.7 BPM. The average heart rate was 66.7% of the average HR_{max}. The average maximum heart rate did also show small differences, ranging from 162.5 BPM to 164.8 BPM. The maximum heart rate was on average 83.8% of the average HR_{max}. The highest recorded average heart rate was at 172.2 BPM, while the highest recorded maximum heart rate was at 197 BPM.

Figure 21.2, Figure 21.3 and Figure 21.4 shows heart rates from sessions on day one, two and three. All remaining heart rate sessions are presented in Appendix E.



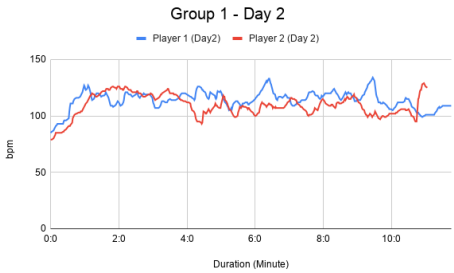
(a) Group 2 - Day 1

(b) Group 3 - Day 1

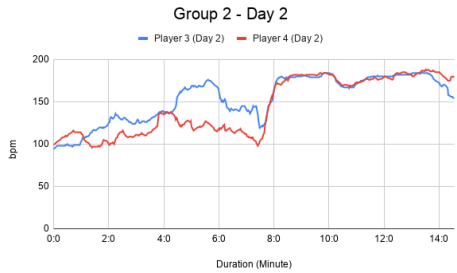
(c) Group 4 - Day 1

(d) Group 6 - Day 1

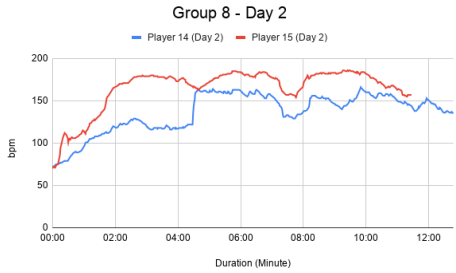
Figure 21.2: Selection of heart rates from day 1



(a) Group 1 - Day 2

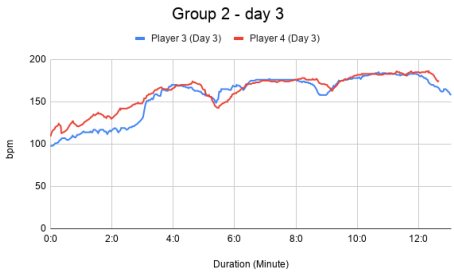


(b) Group 2 - Day 2

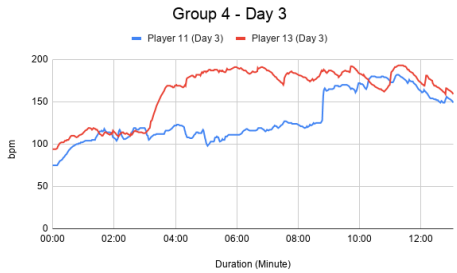


(c) Group 8 - Day 2

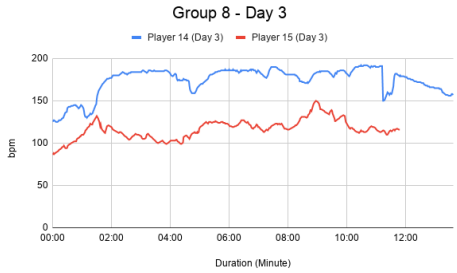
Figure 21.3: Selection of heart rates from day 2



(a) Group 2 - Day 3



(b) Group 4 - Day 3

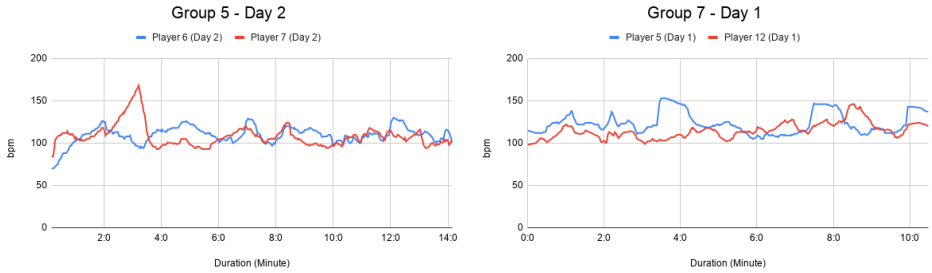


(c) Group 8 - Day 3

Figure 21.4: Selection of heart rates from day 3

21.5.1 Underestimated Heart Rate Data

Figure 21.5 shows examples of heart rates we considered to be underestimated. The claim was strengthened by our observation on participants exhaustion, and by the use of a chest-worn heart rate monitor, Garmin Forerunner 645 (GF645), as a control device. The chest-worn heart rate monitor was used by one participant during each of the three sessions. Table 21.15 shows the difference between the average and max heart rate data from the FC3 and GF645. The comparison shows that the FC3 underestimated with an average difference at $37.3BPM$ for the average heart rate, and an average difference at $21.7BPM$ for the maximum reached heart rate.



(a) Group 5 - Day 2 **(b)** Group 7 - Day 1

Figure 21.5: Example of corrupt data

	FitBit Charge 3	Garmin Forerunner 645	Difference
Day 1 - Average	101.9	148.0	46.1
Day 1 - Max	124.0	168.0	44.0
Day 2 - Average	108.4	158.0	49.6
Day 2 - Max	168.0	179.0	11.0
Day 3 - Average	134.9	151.0	16.1
Day 3 - Max	156.0	166.0	10.0

Table 21.15: Differences between FC3 and GF645

21.6 Observation

This section covers all the observations made. The observations are categorized into: Exercise effect, enjoyment, motivation and social interaction.

21.6.1 Exercise Effect

During the first sessions, we had some problems adjusting the pedal-resistance to align with participants fitness level. This lead to some participants having too low intensity with little exhaustion, and some having too high intensity with too much exhaustion, thus having to step in during gameplay to ease the resistance. After two sessions, we found the right resistance aligning with the fitness levels of the majority. From the experiment, we observed that all participants showed signs of physical exhaustion by being short of breath and by sweating a lot. The first time participants tried the game their cycle intensity was higher than needed to archive top speed. Up to six participants were sweating so much that a puddle was formed on the ground beneath them. In between levels, some participants expressed dehydration and had to run to the sink to refill their water bottles. When participants went uphill, we noticed a higher pace accompanied by heavier breathing. When asking how they felt in regards to the exercise, the majority expressed being exhausted. One participant stated: ”(...)[The gameplay] feels like an interval session”.

21.6.2 Enjoyment

Many participants had a smile on their face after sessions, although showing signs of exhaustion from the exercise experienced. The participants expressed joy about playing the game. One participant stated: ”For someone who hates spinning, this is fucking fun”. When observing a player during uphill terrain, we noticed the player slowing down the pace. When asking about the situation after the session, the participant stated: ”I totally forget to cycle, too focused on the track”. A similar feeling was expressed from another participant after a technical issue caused the game to shut down. One participant responded by saying: ”No, I was so into the flow”, seemingly frustrated.

A recurring trend was frustration towards level three during participants

first session. We noticed many irritated sighs after colliding with several obstacles in a row. Some preceded to yell profanities when they felt stuck. We observed that the frustration calmed down on day 2 and 3. The movement controllers seemed intuitive for participants, conveniently moving between lanes. However, some participants expressed and showed problems with remembering jumping and items button, resulting in frantically pressing all buttons available. We also observed that it was often even between participants, resulting in all, apart from one participant, winning a level during all sessions. In addition, all, apart from three participants, got the total victory from a session.

21.6.3 Motivation

We noticed that the player behind would often be more motivated when observing the leading player. If the leading player was out of sight, the pace declined. Similar situations were seen for the leading players. Some of the participants leading the race would eventually move slower but accelerate if they were overtaken. Three of the participants expressed some lack of motivation because they did not have a competitive spirit.

21.6.4 Social Interaction

Participants showed some direct social interaction when competing. Some participants shouted out in victory when they won the match, and some would express their desire to win the next level to the opponent. When a participant interacted in-game by sending a negative item to the opponent, the opponent would often get frustrated. One answered sarcastically: ”Thank you”. On another occasion, a player yelled about getting a lousy start in which the opponent answered: ”That’s just what I like to hear”. The majority of players were quiet during most of the sessions, looking focused with not much verbal communication. Participants also mentioned they had not been in contact with others in a long time and thought it was nice to finally meet others.

21.7 Summary

This chapter has described the most relevant results from the experiment. In order to present most of the results in a readable and concise manner, they were presented collectively, rather than individually.

Part VI

Discussion, Conclusion And Further Work

The final part presents discussion of results, followed by its validity. Lastly, a conclusion will be suggested, ending with an outline of the way forward.

Chapter 22

Discussion

This chapter discusses the results of the experiment relating to our research questions. The discussion is categorized into topics corresponding to these.

22.1 Exergame genre

RQ1: What kind of game genres are suitable in exergames?

When discussing suitable genres for exergames, it is appropriate to recognize that a game genre only establishes a foundation to a game concept, rather than determining the whole game concept itself. A game genre can have characteristics that make it easier to incorporate exercise into the game and maintain the balance between exercise and game in an exergame. From Chapter 12, we discussed the potential up- and down-sides of some of the most recognized game genres when applied to an exergame. The discussion revealed two key factors for a suiting genre. The first factor is that the genre should support and maintain the required intensity necessary for the exercise type. For instance, our game, which has endurance with HIIT as exercise type, would benefit from a game genre that elicits high-intensity gameplay, rather than a low one. The second factor is that the genre should uphold players focus, mitigating the attention to the exercise performed. If the game is to closely related to the exercise, the game sensation with its positive effects might be reduced.

Taking these factors into account, genres such as sport and simulation can be considered to facilitate a simple implementation of exercise with the right intensity. However, with the ease of implementing exercise, these genres can become too exercise specific and not provide the game sensation that players often desire. Strategy, RPG and adventure genre usually entails a more in-depth game experience but might struggle to implement exercise with its intensity in a meaningful and coherent way. Party games also lack an easy way to implement exercise. However, party games offer a variation in gameplay and a social aspect, which has shown to be an essential factor, as seen in Section 22.4. Based on this, all genres can be considered to involve elements suitable for an exergame. However, a combination of genres can prove to be even more beneficial and elicit a coherent experience between exercise and gaming. Our exergame consisted of the core genres, action and sport, which we regard as a cohesive solution in terms of the two factors. Lane Riders implementation of the platform (sub-genre of action) and racing (sub-genre of sport) genre showed promise when asking participants how they enjoyed the type of game, receiving an average score of 4.5 out of 5. However, we did not ask which characteristics they enjoyed, relatable to a specific genre, so it is uncertain if they liked both or only one. When asking participants what they liked most from Lane Rider, a recurring answer was to compete against others. It might imply a positive attitude towards racing since it strongly relates to competition, but is not enough to ascertain whether that is the case .

22.2 Exercise

The experiment gathered data from three different arrangements concerning the exercise effect. These were subjective observations on participants exertions, subjective answers from participants perceived exercise effect and objective heart rate data.

The heart rate data gathered in this project may not be as precise as needed to achieve any conclusions. Two main factors are indicating that it might be underestimated. The first factor, the heart rate data do also include the restitution phases in between levels, which in total were 2 minutes. The average for each player would most likely increase if these were removed from the heart rate calculations. The second factor, as mentioned in Section 20.7, the predecessor to the Fitbit Charge 3, the Fitbit Charge 2, has shown to underestimate heart rate data by up to $30BPM$. It was supported by the comparison done in Section 21.5.1, where the FC3 had an average underestimation of $37.3BPM$ compared to the Garmin Forerunner 645 with a chest-worn monitor. On the other hand, the heart rate data might be overestimated for some participants. This assumption is based on one participant getting a maximum heart rate score of $197BPM$, which is above the HR_{max}.

RQ3: How does our exergame influence players' physical activity?

The results from the questionnaire show that most participants felt they were exercising and that it was a good workout. One of the participants did answer *"That it was intense, I felt that I got a good workout."* on the feedback question *What did you like the best about the game?*. The positive exercise effect was also seen during observation, in which participants showed signs of physical exhaustion by being short of breath. The heart rate data can confirm the answers from the questionnaire and the observation by having an average for all sessions at $130.0 \pm 14.8BPM$. The difference between the highest average, $172.2BPM$, and the lowest, $101.9BPM$, is substantial and could have been affected by the adjustment to the resistance. As described in dual flow, it is important to balance the fitness level with intensity. This came down to adjusting the resistance, which we struggled with in the beginning. The first sessions, on the first day, some participants experienced too high intensity compared to fitness skill, which almost made

them give up. However, we managed to adjust the resistance to an acceptable level for all participants after some trial and error. It indicates that the cycle resistance plays a crucial role in terms of dual flow.

RQ3.1: How does our exergame influence players' physical activity over time?

Based on the questionnaire, most of the participant agreed that our game gave them an exercise throughout all three sessions, and the results did not indicate discord worthy of note, except for one case. The statement about whether the participants felt they were exercising had a negative trend from day one to three declined from 4.7 to 4.3. which is a decrease of 0.4. It might be due to the resistance on the bike being higher at day one than day three, making it easier for the participants on the last day. Another possibility could be that the participants learned that they did not need to cycle as hard as they did on day one to maintain max speed.

Even though some players' implied through the questionnaire that they felt less exertion from day one to day three, the heart rate data says otherwise. The average heart rate was almost the same across all three sessions, with $128.1BPM$, $128,4BPM$ and $134.7BPM$ on day one, two and three. The same can be noticed for the maximum reached HR, which were $164.8BPM$ on day one, $162.5BPM$ on day two and $163.7BPM$ on day three. Such results suggest that our exergame may influence players' physical performance over time. However, the experiment lasted only for three days, and might not be sufficient to conclude on the long-term effect of the play. Nevertheless this, it indicates the potential of a short to mid-term exercise benefit.

RQ6: How well does our exergame with its game mechanics, support high-intensity interval training?

From the questionnaire, it was established that players' felt the exercise had a high intensity. However, for an exercise to be classified as a high-intensity interval training (HIIT), the average heart rate (HR) when doing the intervals, must lie between 85-95 percent of the players HR_{max}.

The level design was inspired by the 4x4 interval and configured into a 3x3 interval. The game consisted of 3 levels, which took around 3 minutes each to complete with a restitution phase of 45 seconds in between. The restitution phase was maybe too short, in the sense of not letting the players rest long enough before the next round. This was also indicated by the heart rate data where it was hard to spot players' rest periods. A longer restitution phase of 1.5-2 minutes in between levels, should have been sufficient.

As mentioned in Chapter 18, the participants had to increase the intensity to keep max speed in the uphills. In the game the possibility of letting the participants cycle faster was implemented, thus making it possible for them to increase their work load. Based on the results on Q28, most of the participants noticed the need for increasing the amount of intensity in the uphills, and was also noted during observations. *"That you have to pedal harder in the uphill slopes"* was also answered when they were asked about what they liked about the game, indicating that this game mechanic might increase their heart rate.

As declared above in this section, the average heart rate for all sessions were $130.0 \pm 14.8 BPM$, which is 66.7% of the average HR_{max} and 18.3% below the 85% threshold. However, one player had one session with an average heart rate of 88.6% of their HR_{max}, which corresponds with HIIT. There were additionally four different players' who had one session each with an average heart rate above 82% of their HR_{max}. This indicates a potential for our exergame to achieve the necessary 85% of HR_{max} needed for being classified as a HIIT workout. The maximum HR reached also showed similar potential. On average it was recorded at $83.8\% \pm 9.5\%$, which is 1.7% under the 85% of HR_{max} threshold. However, when removing the data we considered underestimated, the average maximum HR reached increased to $87.4\% \pm 8.1\%$. Even if the total average were below the necessary threshold for being characterized as HIIT, the average maximum HR reached, showed that most of the players reached 85% of HR_{max} during the sessions.

22.3 Enjoyment

The experiment gathered data from two arrangements concerning players enjoyment. These were subjective observations of participants and subjective answers of participants perceived enjoyment.

RQ4: How does our exergame affect players' enjoyment?

The results from the questionnaire indicate that all participants enjoyed the exergame. Overall, participants agreed on enjoying the game and having fun while playing. Players also thought that the game became more enjoyable over time. Quite a few felt that they lost the sense of exercising while playing, although the total average score was not as high as the other statements, but still a considerable score at 3.8.

To gain further insight into the evaluation of enjoyment, we used statements that are related to the theory on Gameflow and Malones concept of satisfaction in games. The results suggest that some participants could potentially have experienced flow when using the exergame, since the average scores for statements concerning the state of flow were high. It is possible that the participants we observed being deeply concentrated, were in fact in a state of flow. One participant even expressed being in the flow, while another mentioned being so focused that they forgot to cycle. A statement that might summarize the participants' experience of immersion is: "I lost the feeling of time and space". The total average score was at 3.7 out of 5, indicating that many participants agree to having experienced a feeling of flow. One particular aspect we observed as a potential hinder for flow was understanding the player controllers. Most participants learned how to accelerate and turn left and right quickly, yet some had problems with remembering the jump and item buttons. The problems with the controllers led to some confusion and seemed to ruine their focus. However, these problems were not shown in the questionnaire, where the statements concerning the easiness of learning the controllers had a total average score of 4.2 out of 5.

RQ4.1: How does our exergame affect players' enjoyment over time?

The long-term effects on enjoyment of the exergame were overall positive. We noticed some minor positive adjustments in scores from day one to day three that most likely relate to participants getting a better understanding of how the game works. We also observed that participants went through a learning curve, for instance, uncovering the advantage of using items and thus utilizing them more for each day. Likewise, there were some minor negative adjustments to the score. This might have had something to do with the participants feling the challenge became easier after playing more than one time. Participants had, after all, tried the same three levels in each session, so it is possible that they thought the levels were becoming increasingly uninteresting and effortless. One participant even stated in the feedback section of the questionnaire that it would be nice with new levels for each session. The minor negative decline can also have been due to the novelty effect to wear off, since many participants had not tried an exergame before, making it temporarily different and exciting the first time trying it. Social interaction is listed as an element in Gameflow that promotes joy. It has most likely had a positive influence on participants long-term enjoyment for this exergame and is further described in Section 22.4, below.

22.4 Social Interaction

RQ2: How does social interaction affect players' experience in our exergame?

The experiment gathered data from two arrangements concerning social interaction in our exergame. The data was subjective observations on participants interaction with the opponent and subjective answers from participants' perceived affection from social interaction.

As discussed in Chapter 11, social interaction in video games occurs in multiplayer mode. Previous studies have indicated that the social aspects in multiplayer modus can stimulate players enjoyment, motivation and engagement for games. Theory on Gameflow, discussed in Chapter 9, also demonstrates the importance of social interaction in video games. The results from this questionnaire seem to correspond with these assessments. All statements concerning social interaction were overall positive. The results indicates that participants got highly motivated by playing against an opponent. Competing with another participant made the game highly more engaging to play, with the lowest score from all session at 4.6. Participants also felt that playing against others made the experience more enjoyable, with a score of 4.6. The significance of social interaction was further demonstrated by the feedback questions from the last part of the questionnaire. From asking participants what they liked the most about the game, the most recurring answer was to compete against an opponent. Our observations can confirm some of the excitement elicited from the multiplayer competition. The in-game interactions caused some participants to express their emotions verbally to the opponent. However, the majority of social interaction happened in-game facilitated by items and collisions. Direct communication was absent for most sessions, which could have something to do with the preventative measure implemented. The walls set up in between might have caused the participants to lose the perception of being co-present.

The overall results on social interaction show a considerable positive score compared to all other topics covered in the questionnaire. It could have something to do with the Covid-19 outbreak. All participants had presumably, like everyone else, been home for several weeks maintaining social

distancing and minimal interaction with others. It is, therefore, possible that the participants were extra eager and positive towards all social aspects of the experiment. This can be supported by the observation in which many participants expressed joy to finally meet others. Even though the Covid-19 situation might have had an impact on the results, the consistently high ratings from everyone demonstrates some legitimacy to the answers. This shows that the social aspects of our exergame yield great benefit to the experience by facilitating players motivation, enjoyment and engagement.

22.5 Motivation

RQ5: How does our exergame affect players' motivation?

The experiment gathered data from two arrangements concerning participants motivation. These were subjective observations on participants motivation and subjective answers from participants perceived motivation.

The results of the questionnaire show that motivation was high when playing the exergame. Motivation stayed high before each new level, and all participants wanted to play the game again, with an average score preserved at 4.6 both the first and the last day. Although the questionnaire did not cover all areas of what participants found motivating, one aspect is worth mentioning. From Section 22.4 above, competition was stated as a motivational factor of this exergame. Which was also indirectly noticed during observations. When a participant stayed in second place and detected the opponent being near, the pedalling would intensify, even though being noticeably exhausted. A similar motivational boost was also noticed for leading players. When in the lead, some participants were observed slowing down, but to immediately increase the intensity when overtaken by the opponent. One aspect which might have had a negative impact on motivation in-game, was when the levels were too challenging, causing participants to constantly collide with obstacles and not progressing. From the questionnaires feedback section, some participants mentioned this had a negative impact on their motivation. It was also noticed during observations. Participants that got stuck, colliding with obstacles, were so frustrated that it looked like they almost gave up. It indicates that not only did the unbalance between skill and challenge have a negative impact on participants enjoyment, but also on their motivation since the two sensations are closely related.

In terms of the exergame being a motivator for doing more exercise, the participants felt more neutral after the first day, with an average score of 2.9. The motivation for exercise increased after the last day, with an average score of 3.6. The results also showed that participants were to some extent more motivated to use the exergame for exercise, than to embark on outdoor cycling. When comparing the exergame with regular exercise, the answers indicate that participants would most likely not replace their

ordinary exercise practice with playing the exergame. However, we did not investigate what type of exercises participants usually practice, so it is possible they would not replace their exercise because the exergame is not applicable to, for instance, a preference to strength training.

22.6 Active and Non-active

RQ7: How does physical active players' enjoy the exergame compared to non-active players?

When asked if *this game has motivated me to be more active/exercise more*, both groups were neutral on the first day. On the last day, the actives observed a minor increase in motivation, while the non-actives had a substantial increase. The reason why actives were not as motivated as the non-actives can possibly be explained by the actives already being active and thus not experiencing a preconceived lack of motivation pertaining to training. The non-actives, on the other hand, by not being physical active and thus not exercising to the same extent as the actives, might have a preconceived reluctance to training. Another possible reason for the non-actives' increase in motivation might be since they felt they exercised less on day three compared to day one, which is substantiated from the observations. The cycle resistance was not set correctly on the first day, making it harder to cycle for those who were not used to exercising. Also, the players were new to the game and did not know the intensity necessary to keep max speed, which made most of the players cycle faster than needed.

Looking at the Mann-Whitney test in Table 21.13, 4 out of 6 statements were related to social interaction. 3 out of 4 of these statements were considered statistically significant, indicating that there were differences between the two groups. The fourth social interaction statement had a score of 0.0516, which is relatively close to the 0.05 and should be taken into consideration. Further on, all of the actives agreed on all the statements related to social interaction which demonstrates that it is a substantial factor. The non-actives, on the other hand, did mostly agree on the statements, but with one exception. On the statement, *knowing my position based on the*

opponent affects the motivation for the next round, 60% of the non-actives answered neutral, indicating that it did not affect them in the same way as for the actives. Why the social interaction affected the actives more, might be because they are used to compete against others and compare performances more regularly since it is a standard procedure in traditional sports and exercise. The actives might also be more used to exercising with others, e.g. in gyms, playing football or other social activities. Since they might be more used to exercising around and with others, they would possibly be more comfortable in such a situation when playing our exergame.

22.7 Gamers and Non-Gamers

RQ8: How do gamers enjoy the exergame compared to non-gamers?

Gamers seemed to learn the game quicker compared to non-gamers. This assumption is based on gamers felt it was easier to learn the controllers, and already from day one noticed how the items and uphills acted. For the non-gamers, items and uphills might have been overlooked on day one in order to focus on the controllers and getting an understanding of the fundamentals of the game. Gamers were also more critical to the game, which was noticed during the observations were they often would give feedback on what was wrong with the game, what felt weird with the controllers and points of improvements. Some participants referred to how popular games solved a particular problem in our game. This can be supported by most of the gamers answered neutral when being asked if they were so engaged in the game that they lost the sense of being in physical activity. In comparison to non-gamers, most of them answered agree. It is hard to say if this could be because non-gamers were in better shape than the gamers, and therefore would not feel the physical activity remarkably. It could be that gamers has a higher focus on the game design and mechanic compared to non-gamers. Even though the gamers were not as engaged and felt the physical activity more than non-gamers, they got more motivated to be in physical activity from day one to day three. They had an increase that went from neutral to mostly agree.

22.8 Summary

The discussion has revealed that Lane Rider shows potential as an exergame, but still has room for improvements. The discussion also showed how social interaction seems to play an essential part in many of the discussed topics.

Chapter 23

Validity & Reliability

This chapter covers the potential shortcomings of the data collected. Due to Covid-19, we had to take several measures that influenced how we executed the experiment.

23.1 Limitations by Preventative Measures

It is possible that the preventative measures we had to enforce influenced the experiment to some degree. Installing a wall and having distance between participants can have affected the direct social interaction we investigated. The measures also made it hard to pair participants together based on fitness and player skill, since we had to match participants that already had been in close contact.

23.2 Adjustments to the Resistance

In the theory on how to perform an experiment, it is stated: ”The aim of a research strategy based on experiments is to show that one factor only causes an observed change.”. It means that the experiment should have control of all variables, such that one factor is the visible and viable cause of a change, and if an element can not be eliminated, hold it constant [61]. In our case, we had a variable that could change the exercise intensity of the exergame, the cycle resistance. Even though we tried to adjust it to suit the majority of the participants' fitness level, we had to re-adjust on

sessions at day one. The adjustment can have caused the heart rate data to differ from the remaining days, thus not give an accurate representation of the long term exercise effect.

23.3 Inaccurate Heart Rate Monitoring

As discussed in Section 20.7, the Fitbit heart rate monitor has been discovered to underestimate the heart rate values. Several of our participants were observed being visibly exhausted with heavy breathing, yet the heart rate data only showed a moderate exercise outcome. The chest-worn monitor, Garmin Forerunner 645, also supported these claims with an average difference at 37.3 BPM. Because of the possibility of Fitbit underestimating the heart rate, our related results can not give a reliable conclusion on the exercise effect, but rather serve as an indication along with observations and results from the questionnaire.

23.4 Sample

Our sample was gathered based on convenience since it was hard to find potential participants due to the university being closed. The convenience sample limits the possibility to generalize for a wider population. The sample size for this project was also less than the recommended amount of 30 participants, for a reliable statistical analysis [61]. Also, all of the participants were friends and fellow students. Although we explained that participants had to be as honest as possible, it is possible that our association with the participants made them inclined to answer kindly and sympathetically to our exergame.

23.5 Summary

The main concern for this experiment was the Covid-19, both because of the limitations it induced and the influence it might have had on participants that had been staying isolated for a while. We also consider the heart rate data to be of greater concern since the chest-worn monitor data differed to a greater extent from our Fitbit Charge 3 data.

Chapter 24

Conclusion

The goal of this thesis was to create an exergame that promotes physical activity in an enjoyable game setting. Research questions were created to focus our attention and assist in measuring our results. We began by examining the realm of exergames, looking at existing exergames, viable technologies, suitable game mechanics and genres. The pre-study resulted in conceptualizing appropriate genres and exergame ideas, in which we selected the game idea called Lane Rider. Lane Rider encompasses the use of racing and platform-based action into a competitive multiplayer game. The designated level design, with its set length and uphill exercise mechanics, aspires to high-intensity interval training, on an exercise bike. Obstacles, items and time-bonuses requires players swift reaction and concentration, maintaining an enjoyable and engaging experience. To ascertain the effect on players exercise and enjoyment, an experiment was conducted. It lasted over three days to look for benefits over time. The results provided answers to our research questions, which are presented below.

RQ1: What kind of game genres are suitable in exergames?

From our discussion of exergame genres, we discovered two purposeful factors when combining exercise and games. Firstly, the genre should embrace an intensity correlating to the type of exercise. Secondly, the genre should maintain players concentration reducing focus on the exercise performed. These factors reveal that video game genres entails different characteristics, that in combination with other genres can prove beneficial to an

exergame. We considered action and sport to be appropriate genres, and demonstrated their potential by using a variation of these genres in Lane Rider. The results show that the participants reviewed with approval the type of gameplay. However, the results serve more as an indicative conclusion rather than a factual conclusion for this research question due to insufficient inquiry and cross-examination for this topic.

RQ2: How does social interaction affect players' experience in our exergame?

Based on the results we have found that the social interaction incorporated into Lane Rider had a considerable beneficial effect on players. The results show that the social aspects have had a positive impact on participants motivation, enjoyment and engagement to the exergame experience. Competing against another player were perceived, by a majority of the participants, as the greatest quality in Lane Rider. Direct social interaction between participants playing was marginal and thereby not giving a notable result for participants sensation. The Covid-19 outbreak might have had an impact on the social aspects; however, the results are exceptionally positive, thus demonstrating a reasonably credible indication.

RQ3: How does our exergame influence players' physical activity?

We chose to incorporate endurance with HIIT as exercise type in Lane Rider. Based on the results, we found the exergame to promote intense physical activity. Both observations and the questionnaire showed that participants received a highly intensive workout. The heart rate data provided more mixed results, with an average heart rate corresponding to moderate intensity. Considering the recorded inaccuracy of the Fitbit Charge 3 and that our recorded heart rate data includes restitution periods, the exercise outcome is most likely higher than what the heart rate results are indicating.

RQ3.1: How does our exergame influence players' physical activity over time?

The experiment lasted over three days to investigate physical activity over time. There were no prominent differences from the first to the last day on either the heart rate data or the questionnaire. Overall, the results showed a

consistent exercise intensity with a positive impact on participants fitness. The duration of the experiment is not sufficient to assert the long term effects of the exercise. However, the results show that the exergame supports a persistent exercise intensity for a short to mid-term period.

RQ4: How does our exergame affect players' enjoyment?

The results from the experiment showed that the participants enjoyed playing Lane Rider and suggest that participants experienced a state of flow while playing the game. Even though we observed some frustration that could have had a negative effect on enjoyment, it was not detected in the results of the questionnaire.

RQ4.1: How does our exergame affect players' enjoyment over time?

The results from the experiment show that participants enjoyment persisted from the first to the last day, with modest changes in scores. The results also indicate that competition has facilitated the level of enjoyment to be considerably high during all three days. A minor decline in enjoyment was noticed, which can have been caused by the novelty effect and/or the lack of new challenges. Regardless, implementations of new levels are considered essential to sustain the challenge and therefore, the enjoyment over time.

RQ5: How does our exergame affect players' motivation?

The results show that participants felt highly motivated when playing the game throughout all sessions and that competing against others serves as a motivational boost, pushing towards a better exercise outcome. Based on observations and feedback we discovered that not knowing the opponents' position in the game also had an impact on participants motivation to preserve a high intensity throughout the whole game, and should be improved in future implementations. The exergame did have some positive impact on participants motivation to do more exercise, but they would not necessarily replace ordinary exercise with the exergame.

RQ6: How well does our exergame with its game mechanics, support high-intensity interval training?

From the theory on exercise in Chapter 8 it was stated that for exercise to be classified as a HIIT, the average heart rate should be within 85%-95% of the player's HR_{max}. The results show that our game did not reach the necessary amount of average heart rate to be classified as a HIIT, with an average of 66.7% of the average HR_{max}. However, two players had one session each where they met the required heart rate. Additionally, most players had a maximum reached heart rate over the necessary amount, demonstrating that the game has potential to support HIIT.

RQ7: How does physical active players' enjoy the exergame compared to non-active players?

The results show that the active group had a higher enjoyment towards Lane Riders' social interaction compared to the non-active. It is difficult to draw a conclusion on why this is the case, yet one suggestion indicates that actives might enjoy the competitive aspects, as it closely relates to traditional sports and training. The results also showed that the non-actives were considerably more motivated to begin exercising more after testing our exergame.

RQ8: How do gamers enjoy the exergame compared to non-gamers?

When comparing the results between gamers and non-gamer, it was a clear difference in how they understood the game. The gamers learned how to play the game and got an understanding of the game mechanics earlier than the non-gamers. At the same time, gamers were also more critical to the game and noticed points of improvements more often. It is reasonable to consider that gamers have more knowledge to the realm of video games, after many hours invested, and therefore would also expect more from a game, comparing it to a collection of previously played games.

24.1 Summary

Based on these conclusions, we can summarise the project as considerably successful. We have created an exergame that shows great potential to players enjoyment, motivation and exertion, possibly enhanced by the social interaction embedded. Still, the exergame intensity has not reached its full potential in accordance with HIIT. Social interaction has shown to stimulate the physically active participants, more than less active participants. The comparison between gamers and non-gamers has shown that gamers expects more from the game, but also learns how to play faster.

Chapter 25

Further Work

This chapter covers potential further work. It describes improvements we would like to implement, a new concept to discover, and further experiments.

25.1 Improvements

Cycle resistance was perhaps the factor that had the most impact on players' exhaustion. The resistance could either be to low, making the exercise to easy or to high, making the exercise to hard. An improvement would be to research a method that adjusts the cycle resistance based on the players' fitness level. This could make the game more accessible to a wider audience with different fitness levels. One idea is to investigate the possibility of steering the resistance automatically based on heart rate.

Lane Rider is a multiplayer game inspired by the popular *single-player* genre endless runner. It would, therefore, be interesting to see how the game would perform if it was refactored as a single-player version. Especially to see how much social interaction influences the experience. However, there is a need for some changes to the game in order for this to work. This includes changing the items to be power-ups only for the player.

For this prototype, there were only three levels corresponding to three different difficulties. To keep the game exciting, *more levels* need to be cre-

ated. This was also mentioned by one of the players, wanting a new levels after the third session. A potential solution is to automatically generate levels with a random pattern, creating a new experience for the players each time they play.

There are only four different items included in the prototype, which are relatively similar to each other. Adding *more items* to the game would enhance the player experience. Examples of items that could be implemented are invincibility (a player can drive through anything), invisibility (the opponent can not see the player), delusion (the opponent sees double), and time freeze (Everything will freeze for the opponent).

Experience points for unlocking new levels and cars could potentially increase the replayability for the game and should, therefore, be considered a key factor to research further.

A *high-score* presenting the best times were requested during the experiment. We noticed that many of the more experienced players would get increased motivation when knowing that someone in another group had a better time than them.

25.2 New Concepts

As mentioned in Chapter 13, we would like to point out our idea, Wall Trail, as an exciting idea to further explore. It is both a competitive and social game that, which could fit as an exergame. The game has characteristics of quick rounds with breaks in between, supporting the standard of a HIIT.

25.3 Further Experiment

As discussed in Chapter 23, the experiment had some deficiencies in terms of validity and reliability. The Covid-19 situation made the experiment somewhat pragmatic and ordeal than under more normal circumstances. Although the research on this exergame was made to indicate rather than prove potential effects regarding enjoyment and exercise benefit, further research on the game is optimal. A new experiment is recommended to fur-

ther strengthen and control our results. It should include a control group, more accurate monitoring, a more extended period, and a more randomized and various group of participants. The control group should perform outdoors cycling or jogging to map and assess differences in enjoyment and exercise outcomes from regular exercise. The hear rate monitor we used for this experiment, Fitbit Charge 3, showed signs of inconsistency in terms of exercise effect and should be replaced by more accurate monitoring such as with VO2 measurements. Our experiment also lasted over a shorter period, making it difficult to assess the long term experience of our game. The new experiment should last over three weeks with one session each week to further explore longstanding effects. Lastly, the experiment should have a bigger and more randomized sample. Almost all of our participants were students at NTNU, with high technical abilities and a similar understanding. A sample with people from different backgrounds and of different ages could be highly favoured to generalize the results.

25.4 Summary

We believe that Lane Rider should be further improved and studied after this project. Implementing single-player might enhance the availability of the game and be a good option in a gym or at home. Since the experiment was subject to some unfortunate restraints that might have affected the reliability, it is convenient to continue with more experiments related to Lane Rider.

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Appendix

Appendix A

User Consent Form

Forespørsel om deltakelse i forskningsprosjektet

Exergaming som en alternativ treningsmetode

Bakgrunn og formål

Dette er et spørsmål til deg om å delta i et forskningsprosjekt for å undersøke om regelmessig spilling av et såkalt exergame (aktivt dataspill) kan føre til bedring av fysisk form og motivasjon til trening. Forskningsprosjektet er en del av en masteroppgave ved Institutt for datateknologi og informatikk, NTNU. Du blir forespurt om å delta siden du er mellom 20 og 40 år.

For å delta må du ha mulighet til å komme for tre undersøkelser ved Gløshaugen, NTNU. Du må også være i stand til å sykle på en spinningsykkel i minimum 20 minutter med moderat og/eller høy intensitet.

Hva innebærer det for deg å delta?

Hvis du velger å delta i prosjektet innebærer det følgende:

- Du vil delta i tre fysiske tester der du bruker en spinningsykkel som kontroller til et spill. Dette vil la deg kombinere sykling og spilling. Hver fysiske test vil ta ca 30 minutter å gjennomføre.

- Du vil fylle ut et spørreskjema. Det vil ta deg ca. 15 minutter. Spørreskjemaet inneholder spørsmål om alder, kjønn, vekt, høyde, fysisk form, motivasjon. Det vil også be deg beskrive ulike følelser knyttet til spillingen (hvordan du opplevde spillingen) rett etter du har brukt spillet. Dine svar fra spørreskjemaet blir registrert elektronisk.

- Vi vil måle din pulsfrekvens underveis i testen ved hjelp av en Fitbit for å kartlegge effekten av treningsopplegget.

- Underveis i spillet vil vi observere din interaksjon med spillet.

Mulige fordeler og ulemper

Fordelene for deg som deltaker er at du vil få være med å prøve et helt nytt spill, møte andre og kanskje komme i bedre form gjennom spillingen. Ulempen ved å delta i prosjektet er risikoen for smitte som følge av Koronautbruddet. Dette blir ytterligere beskrevet under. Utenom smitterisikoen ser vi ikke at dette prosjektet innebærer noen ulemper for deg utover at du må avse litt tid til undersøkelsene. I løpet av studien vil du maksimalt måtte avse 3

timer, inkludert reisetid til Gløshaugen. En annen eventuell ulempe er den muskelsårhet som trening kan innebære.

Frivillig deltakelse og mulighet for å trekke sitt samtykke

Det er frivillig å delta i prosjektet. Dersom du ønsker å delta, undertegner du samtykkeerklæringen på siste side. Du kan når som helst og uten å oppgi noen grunn trekke ditt samtykke. Dersom du trekker deg fra prosjektet, kan du kreve å få slettet innsamlede prøver og opplysninger.

Hva skjer med opplysningene om deg?

Alle opplysningene vil bli behandlet uten navn og fødselsnummer eller andre direkte gjenkjennende opplysninger. En kode knytter deg til dine opplysninger gjennom en navneliste adskilt fra øvrig data.

Opplysningene om deg vil bli anonymisert og ikke gjenkjennbare i våre publikasjoner.

Prosjektet skal etter planen avsluttes 05.07.2020. Ved prosjektslutt vil datamaterialet bli anonymisert slik at du ikke kan gjenkjennes. Dette gjøres for etterprøvbarhet og eventuell senere forskning.

Dine rettigheter

Så lenge du kan identifiseres i datamaterialet, har du rett til:

- innsyn i hvilke personopplysninger som er registrert om deg, og å få utlevert en kopi av opplysningene,
- å få rettet personopplysninger om deg,
- å få slettet personopplysninger om deg, og
- å sende klage til Datatilsynet om behandlingen av dine personopplysninger.

Hva gir oss rett til å behandle personopplysninger om deg?

Vi behandler opplysninger om deg basert på ditt samtykke.

På oppdrag fra Institutt for Datateknologi og Informatikk har NSD – Norsk senter for forskningsdata AS vurdert at behandlingen av personopplysninger i dette prosjektet er i samsvar med personvernregelverket.

Hva slags smitteverntiltak blir iverksatt?

Grunnet Koronautbruddet(Covid-19) vil forskningsprosjektet iverksette anbefalte tiltak for å minimere risikoen for smitte. Vi følger råd og retningslinjer fra FHI(Folkehelseinsituttet), men det kan likevel medføre smitterisiko å delta i prosjektet. Du kan ikke delta i undersøkelsen dersom du er i en risikogruppe eller har symptomer relatert til Koronaviruset*. Alle tiltak er planlagt i samråd med fakultetet, og er som følger:

- Prosjektet vil bli gjennomført i et rom med tilstrekkelig plass og gjennomlufting.
- Spinningsyklene vil ha en avstand på minimum to meter, adskilt med en skillevegg.
- Spinningsyklene vil bli vasket med desinfiserende middel før og etter bruk.
- Pulsmåler vil bli vasket med desinfiserende middel før og etter bruk.
- Datamaskin brukt for å besvare spørreundersøkelsen vil bli vasket med desinfiserende middel før og etter bruk. Testpersoner er anbefalt å ta med seg egen smarttelefon til å besvare spørreundersøkelse .

**(Se Folkehelseinstitutte og Helsenore sine nettsider for mer informasjon om risikogrupper og symptomer.)*

- *https://www.fhi.no/nettpub/coronavirus/fakta/risikogrupper/*
- *https://helsenorge.no/koronavirus/smitte-og-inkubasjonstid*

Hvor kan jeg finne ut mer?

Hvis du har spørsmål til studien, eller ønsker å benytte deg av dine rettigheter, ta kontakt med:

- NTNU ved professor Alf Inge Wang ved Institutt for datateknologi og informatikk (alf.inge.wang@ntnu.no, mob.: 735 94 485)
- Ansvarlige for undersøkelsen Øystein Hammersland (mob: 97418333, oysteham@stud.ntnu.no) og Emil Petter Schrøder (mob: 95111185, emilps@stud.ntnu.no)
- Vårt personvernombud: Thomas Helgesen (thomas.helgesen@ntnu.no)

Hvis du har spørsmål knyttet til NSD sin vurdering av prosjektet, kan du ta kontakt med:

- NSD – Norsk senter for forskningsdata AS på epost (personverntjenester@nsd.no) eller på telefon: 55 58 21 17.

Samtykke til deltakelse i prosjektet

- Ved samtykke bekrefter du å delta i prosjektet.
- Ved samtykke bekrefter du å ikke være i en risikogruppe*.
- Ved samtykke bekrefter du å ikke ha symptomer relatert til koronaviruset**.
- Ved samtykke er du innforstått med smitterisikoen involvert.

**(Se Folkehelseinstitutte sine nettsider for mer informasjon om risikogrupper)*
https://www.fhi.no/nettpub/coronavirus/fakta/risikogrupper/

***(Se Helsenorge for mer informasjon om gjeldende symptomer)*
https://helsenorge.no/koronavirus/smitte-og-inkubasjonstid

Sted og dato: *Deltakers signatur:*

_____ _____

Appendix B

Game Manual

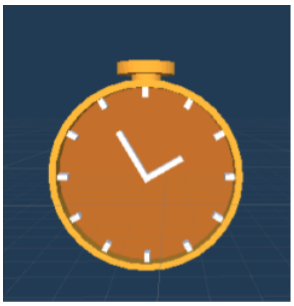
En introduksjon til Lane Runner

Spillets gang

Målet i Lane Runner er å få laveste totale tid sammenlagt etter tre runder. Det kan oppnås ved:

1. Komme først i mål.
2. Plukke opp tidsbonus(Se illustrasjon under). Bonusen trekkes fra din tid ved målgang.

Tidsbonus:



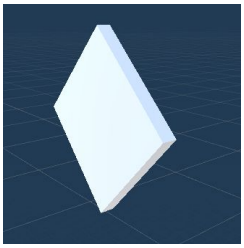
Tidsbonus. Trekker fra -1. sekund.

Super-tidsbonus. Trekker fra -5. sekunder.

Hvordan spille

- Beveg deg framover ved å sykle.
- Unngå hindringer/motstander ved å bytte kjørefelt med høyre og venstre knappene.
- Underveis i spillet kan hopp-knappen bli aktivert og må brukes for å komme seg over hindringer.
- Plukk opp items for å få fordeler eller gi bort ulemper til motspiller.

Items på banen:



Items som påvirker deg selv:

Fartstillegg

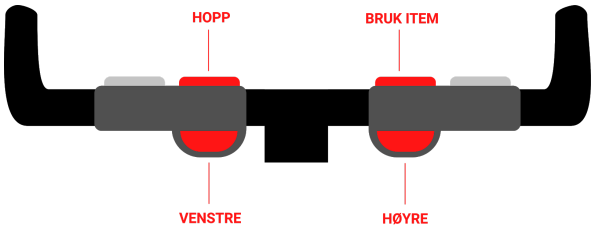
2X tidsbonus

Items som påvirker motstanderen:

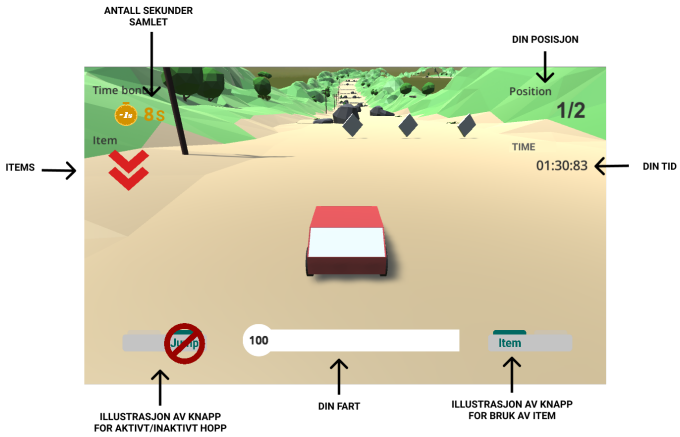
Fartsreduksjon

+1. sekund tidstillegg
på tidsbonuser som
plukkes opp

Spillkontroller



Brukergrensesnitt



Appendix C

Questionnaire

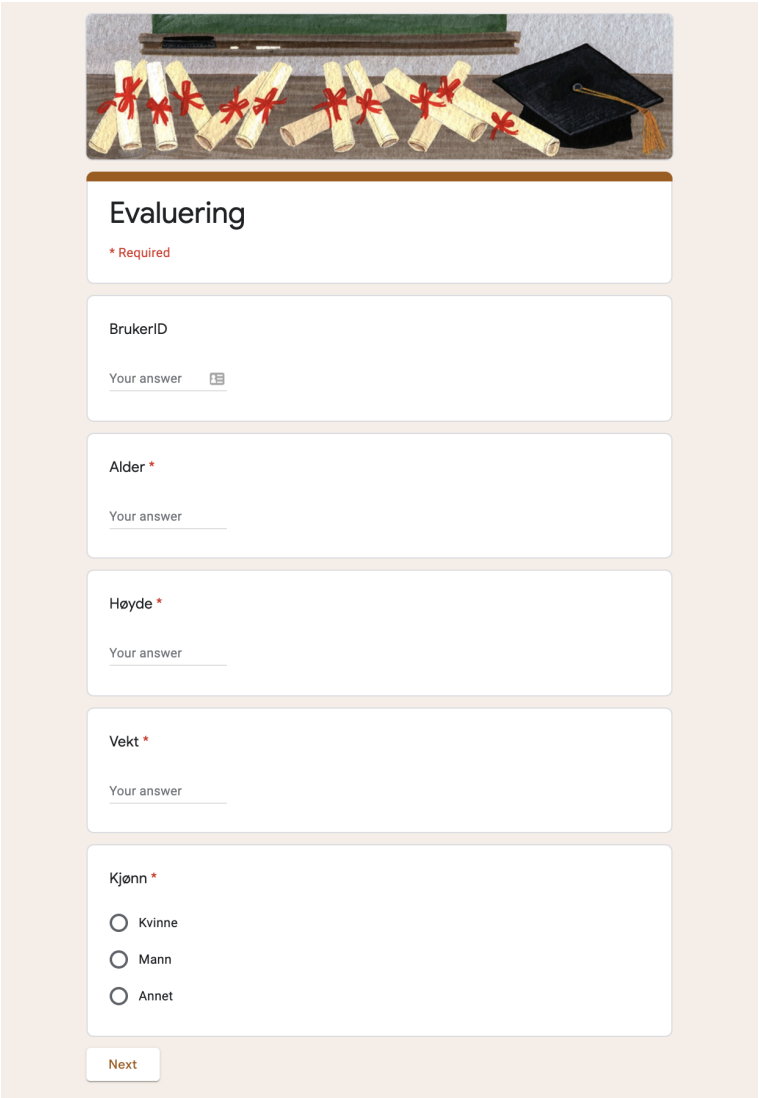


Figure C.1: Questionnaire - Part 1

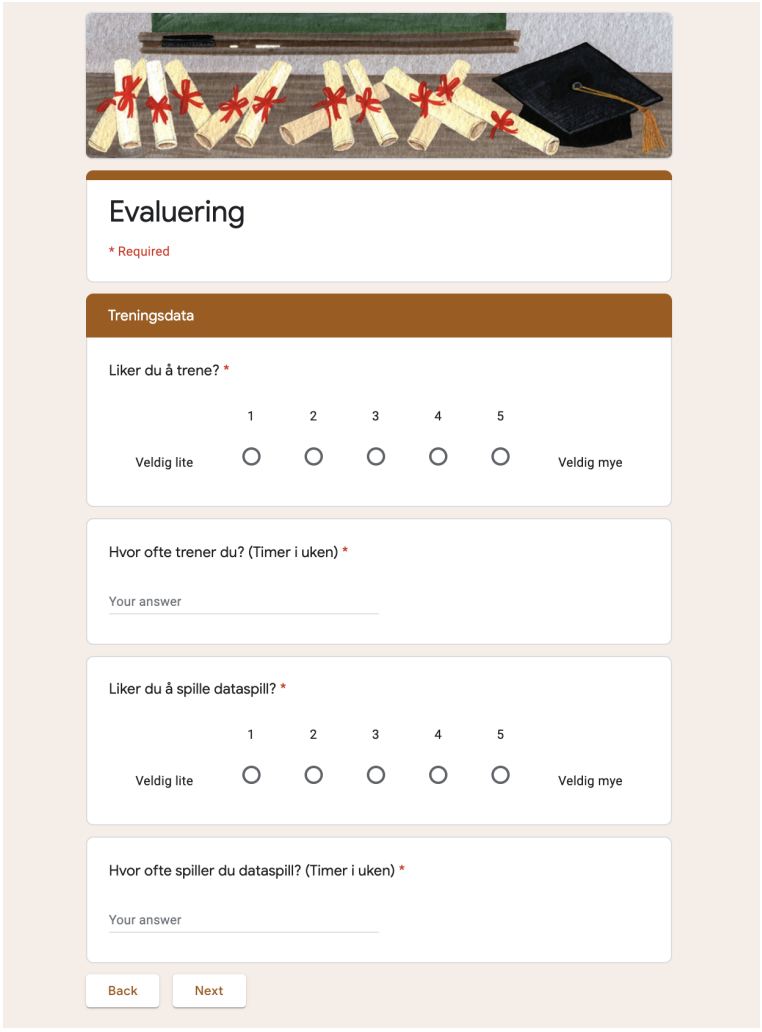


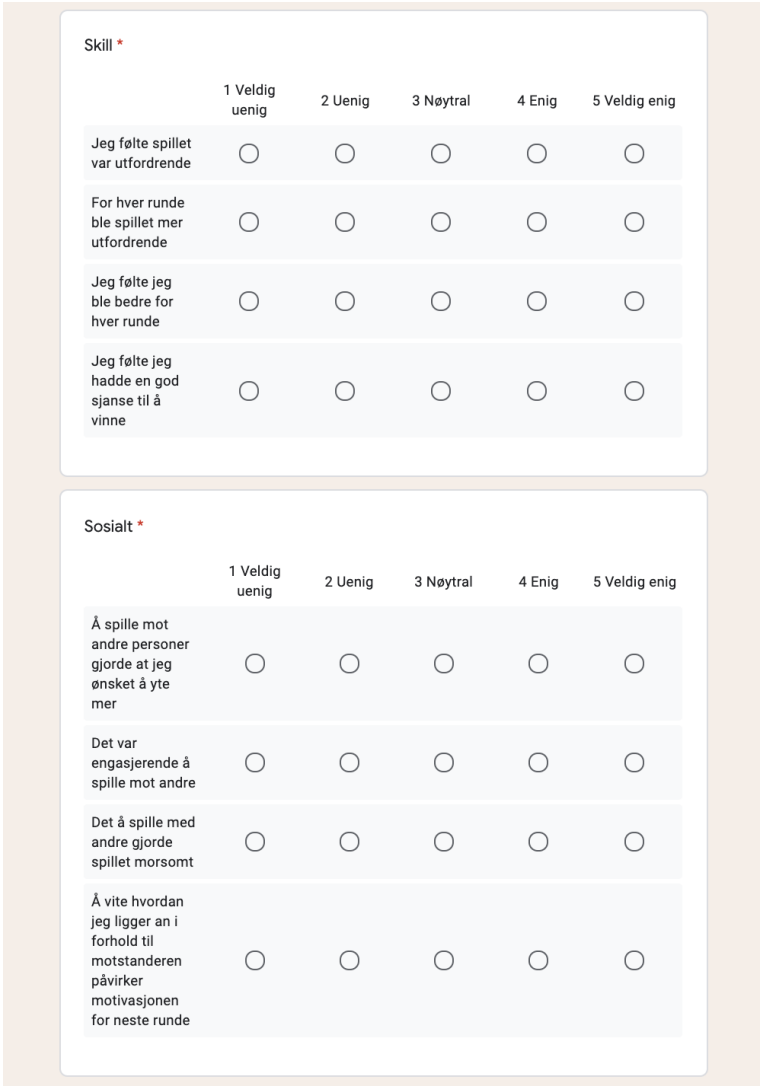
Figure C.2: Questionnaire - Part 2

Avkrysningsskjema

Tilfredstillhet *

	1 Veldig uenig	2 Uenig	3 Nøytral	4 Enig	5 Veldig enig
Jeg var engasjert mens jeg spilte	○	○	○	○	○
Engasjementet mitt økte underveis i spillet	○	○	○	○	○
Jeg forstod hva jeg skulle gjøre i spillet	○	○	○	○	○
Jeg hadde fullt fokus på spillet	○	○	○	○	○
Jeg hadde det gøy mens jeg spilte	○	○	○	○	○
Jeg hadde kontroll over situasjonen/spilleren	○	○	○	○	○
Jeg likte spillet	○	○	○	○	○
Jeg mistet følelsen av tid og rom	○	○	○	○	○
Jeg likte denne type spill	○	○	○	○	○
Spillet ble morsommere over tid	○	○	○	○	○
Jeg var så engasjert i spillet at jeg glemte jeg var i fysisk aktivitet	○	○	○	○	○
Det var lett lære seg kontrollene til spillet	○	○	○	○	○
Jeg var motivert før hver eneste runde	○	○	○	○	○
Items førte til en viss usikkerhet rundt sluttresultatet	○	○	○	○	○
Det var vanskelig å unngå tønnene i bakken	○	○	○	○	○
Bevegende hindringer gjorde spillet mer uforutsigbart	○	○	○	○	○

Figure C.3: Questionnaire - Part 3.1



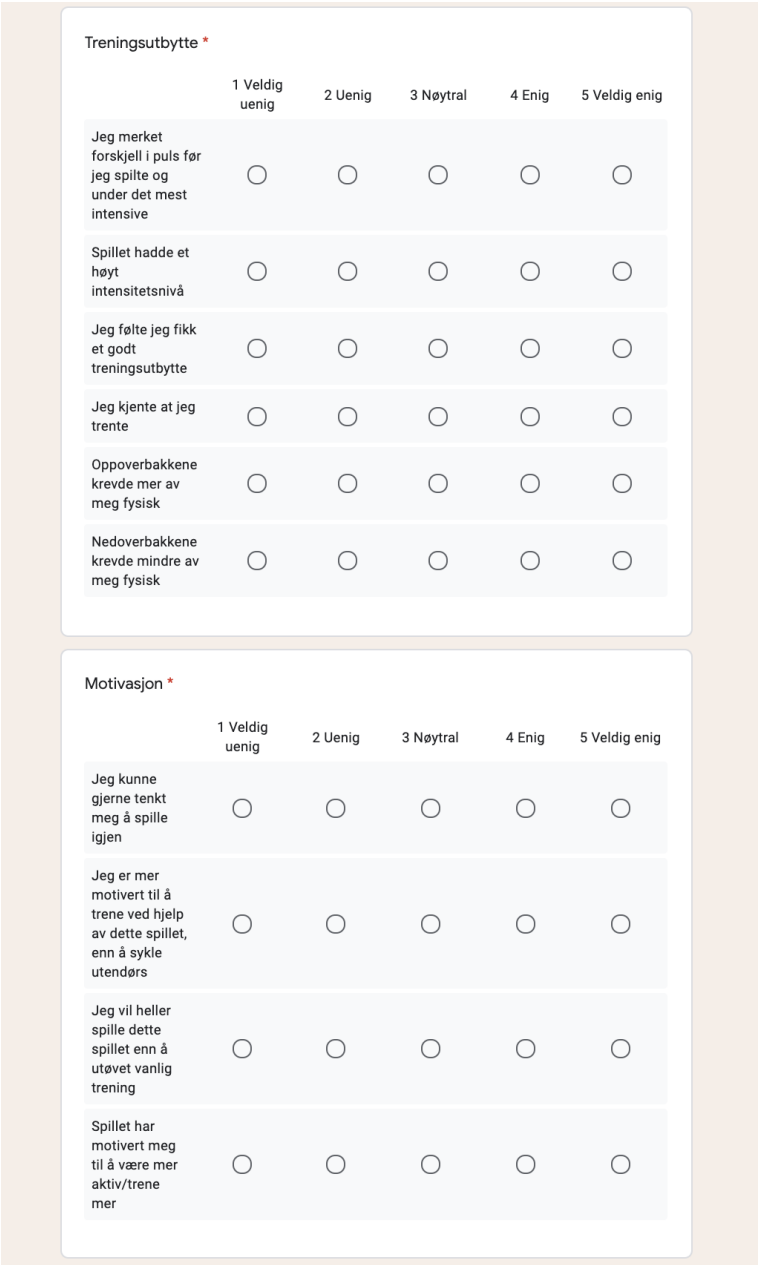
Skill *

	1 Veldig uenig	2 Uenig	3 Nøytral	4 Enig	5 Veldig enig
Jeg følte spillet var utfordrende	○	○	○	○	○
For hver runde ble spillet mer utfordrende	○	○	○	○	○
Jeg følte jeg ble bedre for hver runde	○	○	○	○	○
Jeg følte jeg hadde en god sjanse til å vinne	○	○	○	○	○

Sosialt *

	1 Veldig uenig	2 Uenig	3 Nøytral	4 Enig	5 Veldig enig
Å spille mot andre personer gjorde at jeg ønsket å yte mer	○	○	○	○	○
Det var engasjerende å spille mot andre	○	○	○	○	○
Det å spille med andre gjorde spillet morsomt	○	○	○	○	○
Å vite hvordan jeg ligger an i forhold til motstanderen påvirker motivasjonen for neste runde	○	○	○	○	○

Figure C.4: Questionnaire - Part 3.2



Treningsutbytte *

	1 Veldig uenig	2 Uenig	3 Nøytral	4 Enig	5 Veldig enig
Jeg merket forskjell i puls før jeg spilte og under det mest intensive	○	○	○	○	○
Spillet hadde et høyt intensitetsnivå	○	○	○	○	○
Jeg følte jeg fikk et godt treningsutbytte	○	○	○	○	○
Jeg kjente at jeg trente	○	○	○	○	○
Oppoverbakkene krevde mer av meg fysisk	○	○	○	○	○
Nedoverbakkene krevde mindre av meg fysisk	○	○	○	○	○

Motivasjon *

	1 Veldig uenig	2 Uenig	3 Nøytral	4 Enig	5 Veldig enig
Jeg kunne gjerne tenkt meg å spille igjen	○	○	○	○	○
Jeg er mer motivert til å trene ved hjelp av dette spillet, enn å sykle utendørs	○	○	○	○	○
Jeg vil heller spille dette spillet enn å utøvet vanlig trening	○	○	○	○	○
Spillet har motivert meg til å være mer aktiv/trene mer	○	○	○	○	○

Figure C.5: Questionnaire - Part 3.3

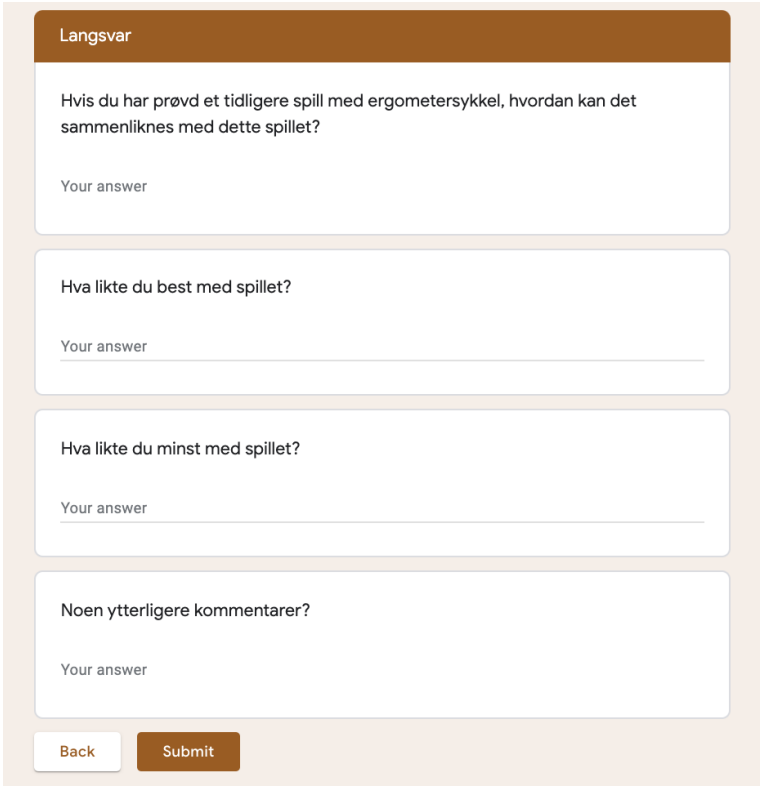


Figure C.6: Questionnaire - Part 4

Appendix D

Questionnaire Results

The tables contain the following abbreviations:

SD = Strongly Disagree
D = Disagree
N = Neutral
A = Agree
SA = Strongly Agree

D.1 Day one

Statement	SD	D	N	A	SA
I had had fun while playing	0	0	0	6	10
I enjoyed the game	0	0	0	8	8
I enjoyed this type of game	0	0	1	7	8
The game got more enjoyable over time	0	0	3	6	7
I was so engaged in the game that I lost the sense of being in physical activity	0	1	4	9	2
I was fully focused on the game	0	0	0	5	11
I lost feeling of time and space	0	2	7	3	4
I was engaged while playing the game	0	0	0	4	12
My engagement increased during the game	0	0	2	3	11
I understood what I was supposed to do in the game	0	0	1	4	11
I had control over the situation/the player	0	1	4	6	5
It was easy to learn the controllers for the game	0	3	1	7	5
Items led to some uncertainty about the end result	0	5	3	4	4
It was hard to avoid the barrels in the uphill	1	7	3	5	0
Moving obstacles made the game more uncertain	0	1	1	9	5
I felt the game was challenging	0	1	1	12	2
The game became more challenging for each round	0	0	0	10	6
I felt I was getting better for each round	0	0	4	8	4
I felt I had a good chance of winning	0	0	4	6	6
I were motivated before each round	0	0	3	4	9
I would like to play again	0	0	0	6	10
I am more motivated to exercise with help of this game, rather than cycle outside	0	4	3	5	4
I would rather play this game than practice regular exercise	1	5	6	2	2
This game has motivated me to be more active/exercise more	0	4	9	3	0
I noticed difference in heart rate before I played and during the most intense	0	0	0	2	14
The game had a high intensity level	0	0	1	6	9
I felt I got a good workout	0	0	3	7	6
I felt like I was exercising	0	0	0	5	11
The uphill terrain required more of me physically	1	3	2	4	6
The downhill terrain required less of me physically	1	4	3	4	4
To play against other people made me give more	0	0	0	6	10
It was engaging to play against others	0	0	2	3	11
To play against others made the game fun	0	0	1	4	11

Table D.1: Table of participants answers on Day 1.

Hva likte du best med spillet?
Konkurranseinstinkt
At man måtte tenke fort for unngå hindre
Fungerte intuitivt. Det var spennende. Fikk veldig konkurranseinstinkt
Konkurranseelementet!
Gøyeste var at man kan konkurrere mot andre. Ser for meg det hadde vrt skikkelig kult om man kunne vrt sånn 4-5 stk p spillet. Gøy at det var med items, gjorde det litt mer spennende. I tillegg var det greit at det var spass enkelt å lre seg!
å vinne
Konkurransen
Morsom kombinasjon av spill og trening. Konkurrere mot andre
Konkurranse
At jeg glemte at jeg syklet mens jeg spilte
Konkurranse
Morro med konkurranse! Likte når det var utfordrende sånn at du slapp å tenke på at du var sliten men mer fokusert p oppgavene.
Gøy med spill. Må tenke litt, glemmer litt bort treninga
Konkurranseaspektet
At det var intensivt, følte jeg fikk et godt treningsytbytte. Samtidig som at det å spille med noen gjorde at jeg ville vinne og yte mer.
Konkurransen mot noen andre

Table D.2: What did you like the best about the game? - Day 1

Hva likte du minst med spillet?
Bugs som demotiverte
Litt vanskelig å se hvor hardt jeg måtte sykle for å nå 100% fart. Og jeg skulle ønske at motstanden var helt lik for begge spillere.
At vi kunne passere hverandre når vi kolliderte i hverandre
Skulle vært litt vanskeligere å komme opp på top speed,
Krasjet mye
Hadde ikke fått med meg alle instruksjonene
Vanskelig å matche folk i forskjellig fysisk form, ref motstand i sykkel
Tønnene
Hitboksene
Fikk vondt i tomlene. Burde være mer forskjell tyngde om det var opp eller nedoverbakke.
Slet litt med når jeg kunne svinge, og å skille venstre og hoppeknappen. Trykka veldig ofte feil
Føltes til tider litt tilfeldig om man kom til treffe et objekt. Kan ha uflaks
De dørene som åpnet og lukket seg var veldig irriterende og gjorde det litt demotiverende når man har stanget i de mange ganger på rad uten å komme seg videre.
De jævla dørene

Table D.3: What did you like the least about the game? - Day 1

Noen ytterligere kommentarer?
Knapp på venstre tommel var litt treg
Veldig imponerende!
Gøy!
Gleder meg til neste gang:D
Gøy!
Tønnene virket litt unfair med at den spawnet rett i trynet mitt Litt kjipt at den som leder ikke kan se den andre spilleren Speil for å se motstanderen? Burde få beskjed at hopp forsvinner.
Veldig artig, hadde vært gøy med en full release med smoothere kontroller og graphics etc. Og hatt det på treningssenter.
Kart som viser forskjellen mellom spillere, førsteplass vet ikke hvor andre plass er
Bra jobba!
Mine kommentarer om det er motiverende å spille mot noen andre er basert på at jeg spilte mot **** som fikk en del bedre tid;-) men detta var bra<3
Bra spill som ga god motivasjon

Table D.4: Other comments? - Day 1

D.2 Day two

Statement	SD	D	N	A	SA
I was engaged while playing the game	0	0	1	5	10
My engagement increased during the game	0	1	2	8	5
I understood what I was supposed to do in the game	0	0	0	5	11
I was fully focused on the game	0	0	1	5	10
I had had fun while playing	0	0	0	7	9
I had control over the situation/the player	0	2	2	7	5
I enjoyed the game	0	0	2	6	8
I lost feeling of time and space	1	3	3	6	3
I enjoyed this type of game	0	0	2	7	7
The game got more enjoyable over time	0	0	5	7	4
I was so engaged in the game that I lost the sense of being in physical activity	0	2	4	8	2
It was easy to learn the controllers for the game	0	1	3	7	5
I were motivated before each round	0	0	3	5	8
Items led to some uncertainty about the end result	1	1	2	5	7
It was hard to avoid the barrels in the uphill	2	6	6	1	1
Moving obstacles made the game more uncertain	0	0	2	7	7
I felt the game was challenging	0	0	3	10	3
The game became more challenging for each round	0	1	1	11	3
I felt I was getting better for each round	0	1	5	7	3
I felt I had a good chance of winning	0	2	0	4	10
To play against other people made me give more	0	0	1	1	14
It was engaging to play against others	0	0	1	4	11
To play against others made the game fun	0	0	1	4	11
I noticed difference in heart rate before I played and during the most intense	0	0	0	5	11
The game had a high intensity level	0	0	3	4	9
I felt I got a good workout	0	0	3	6	7
I felt like I was exercising	0	0	0	8	8
The uphill terrain required more of me physically	0	2	2	4	8
The downhill terrain required less of me physically	1	3	6	3	3
I would like to play again	0	0	1	5	10
I am more motivated to exercise with help of this game, rather than cycle outside	0	2	3	6	5
I would rather play this game than practice regular exercise	3	3	5	2	3
This game has motivated me to be more active/exercise more	0	2	6	6	2

Table D.5: Table of participants answers on Day 2.

Hva likte du best med spillet?
å slå ****
Er veldig engasjerende
Konkurranse! Og spenningen når man ventet på å se hvem som vant
gøy å spille med andre. Denne gangen var det gøy at det var mer utfordrende i oppoverbakkene osv. Gjorde det mer slitsomt og ble litt mer konkurranse når man måtte flge med mer på farten
At jeg faktisk får trent og at man konkurrerer
Konkurransen
Fin motivasjon om man absolutt ikke ønsker å trene. Gøy å konkurrere mot andre så fremt man har mulighet til vinne. Konkurranse på tvers av fysisk form.
Konkurranse
At man kan spille mot andre og at man får treningsutbytte
Likte at det var tyngre i oppoberbakken og at det gikk fort nedover
Glemte at jeg ble like sliten
At man må tenke mens man spiller
Konkurranseaspektet. Man yter mer når man spiller mot andre
At man må tråkke hardere i oppoverbakkene, og at man spiller mot noen, som gjorde at jeg yter mer.
Konkuranseelementet i spillet

Table D.6: What did you like the best about the game? - Day 2

Hva likte du minst med spillet?
Lite motiverende at det er sykt vanskelig å kjøre forbi noen uten å selv bli slått tilbake og miste sånn 10 sekunder
Noen småbugs. Men det er greit
Tenkte ikke på noe negativt i dag
å krasje i ting
Litt treg reaksjon på kontrolleren noen ganger.
Bugs i fysikk/spill. Det mest naturlige i oppoverbakke hadde vrt at motstanden i selve sykkelen ble redusert. Slik det er nå er det litt unaturlig.
Føles litt unfair om man først ligger bak
Noen mangler ennå, kanskje litt balancing issues også som gjør at fremste spiller får fordel.
Burde vært jevnere
Slet fortsatt litt med å skille hopp fra sving til venstre, så ble litt prakk der.
Litt uforutsigbart med items. Vanskelig å ta igjen andre spillere når begge sykler på den maksimale hastigheten i spillet
Det var litt kjedelig når man lå fremst at man ikke hadde noen indikasjoner på hvor motstanderen lå an. Måtte bare høre etter hoppelyder etc for prøve å finne ut. Kanskje ha en ”opponent x meters behind”? Sånn at man får motivasjon til tråkke litt ekstra på.
Crashing i den andre spilleren

Table D.7: What did you like the least about the game? - Day 2

Noen ytterligere kommentarer?
Bilen svinger litt av seg selv i svinger?
Moro!
Kollisjondeteksjon er ikke helt onpoint om man ligger bak. Knappene er noe unaturlig plassert. Jeg catcher meg selv i å svinge når jeg nsker å hoppe og vice versa. Det kan være dette kommer grunnet vane fra tidligere spill El. Lign.
Gler meg til prøve igjen, skal slå rekorden.
Kart for å se hverandre
Jeg likte spillet : enig. Fikk vondt i tommeln pga høyre og venstreknappene. Måtte strekke litt. Kræsjer fortsatt inni ting selv om jeg føler at jeg har kjørt forbi dem.
Kunne kanskje økt makshastigheten litt for å øke intensitet og konkurranse
Gleder meg til imorgen!

Table D.8: Other comments? - Day 2

D.3 Day three

Statement	SD	D	N	A	SA
I was engaged while playing the game	0	0	1	7	7
My engagement increased during the game	0	0	2	5	7
I understood what I was supposed to do in the game	0	0	0	4	11
I was fully focused on the game	0	0	1	4	10
I had had fun while playing	0	0	1	8	6
I had control over the situation/the player	0	0	3	9	3
I enjoyed the game	0	0	1	6	8
I lost feeling of time and space	0	3	4	3	5
I enjoyed this type of game	0	0	1	6	8
The game got more enjoyable over time	0	1	2	6	6
I was so engaged in the game that I lost the sense of being in physical activity	1	0	5	4	5
It was easy to learn the controllers for the game	0	0	1	7	7
I were motivated before each round	0	0	2	4	9
Items led to some uncertainty about the end result	0	1	2	6	6
It was hard to avoid the barrels in the uphill	3	7	3	1	1
Moving obstacles made the game more uncertain	0	1	0	9	5
I felt the game was challenging	0	1	1	9	4
The game became more challenging for each round	1	0	1	9	3
I felt I was getting better for each round	0	0	6	8	1
I felt I had a good chance of winning	0	1	2	4	8
To play against other people made me give more	0	0	1	3	11
It was engaging to play against others	0	0	1	4	10
To play against others made the game fun	0	0	3	2	10
I noticed difference in heart rate before I played and during the most intense	0	0	1	1	13
The game had a high intensity level	0	1	0	5	9
I felt I got a good workout	0	1	2	5	7
I felt like I was exercising	0	1	1	5	8
The uphill terrain required more of me physically	0	2	1	4	7
The downhill terrain required less of me physically	0	5	3	3	3
I would like to play again	0	0	0	6	9
I am more motivated to exercise with help of this game, rather than cycle outside	0	4	3	4	4
I would rather play this game than practice regular exercise	1	5	4	3	2
This game has motivated me to be more active/exercise more	0	2	4	7	2

Table D.9: Table of participants answers on Day 3.

Hva likte du best med spillet?
Det er gøy!
Konkurranse. Uforutsigbarheten på slutten. At der er gøy å trene!
Sliten uten at man merker det
At jeg får trent og konkurrere
Konkurransen og framgangen
Likte treningsutbytte. Nok motstand til å bli skikkelig sliten er mer verdt enn å vinne.
Konkurranse
Trene og spille samtidig
De delene som samvarer med realiteten, nedoverbakke og oppover.
Morsomt å gjøre noe med noen andre
Konkurrere mot andre
At man blir pushet til å sykle for å vinne, god motivasjon for å gi litt ekstra
Konkurransen
Konkuranseelementet i spillet

Table D.10: What did you like the best about the game? - Day 3

Hva likte du minst med spillet?
At jeg tapte
Bugs
å tape
Av og til trege kontrollere
Like baner. Hadde vrt kult med endringer mellom hver økt
Kræsjing, ligge bak
Burde vært automatisk utjevning
Vondt i rumpa og gnagsår i tissen. Når jeg ikke fikk tatt items pgs motstander brukte de.
Litt uforutsigbart hvem som blir stoppet når man kræsjer med andre spillere
At man ikke kan plukke opp items om motstanderen bruker en item p deg:(
Når du kommer bak er du litt fucked

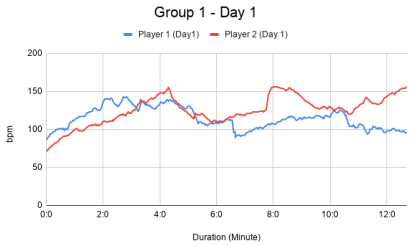
Table D.11: What did you like the least about the game? - Day 3

Noen ytterligere kommentarer?
Skikkelig bra prosjekt!
Vondt i rumpa og sår mellom beina:D
Moro!
Kart
Helheltvurdering, veldig morro!!
Bra spill. God motivasjon til trening

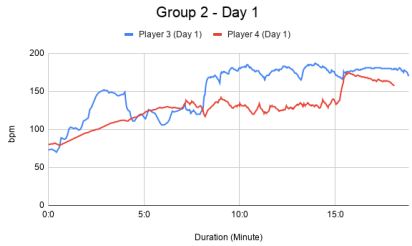
Table D.12: Other comments? - Day 3

Appendix E

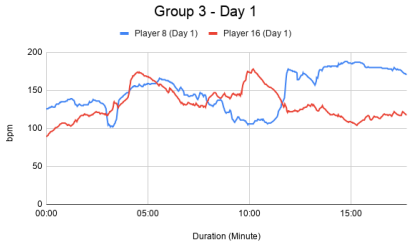
Heart rate



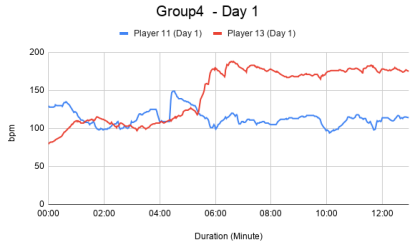
(a) Group 1 - Day 1



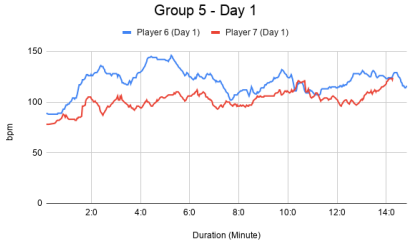
(b) Group 2 - Day 1



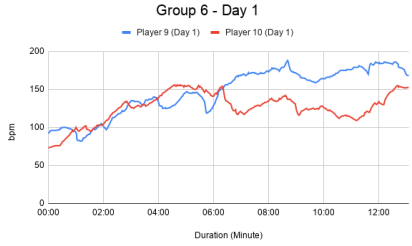
(c) Group 3 - Day 1



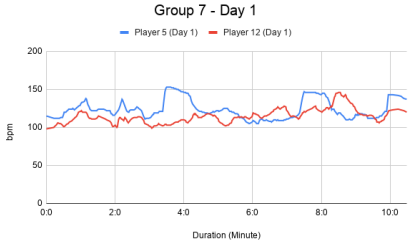
(d) Group 4 - Day 1



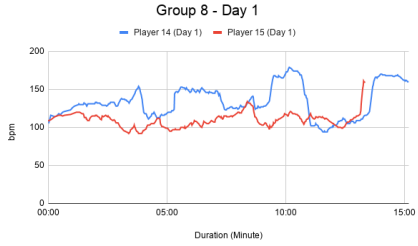
(e) Group 5 - Day 1



(f) Group 6 - Day 1

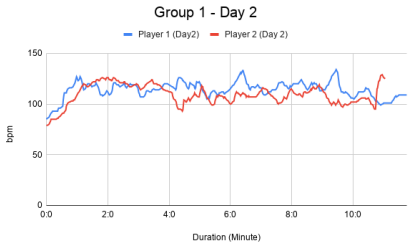


(g) Group 7 - Day 1

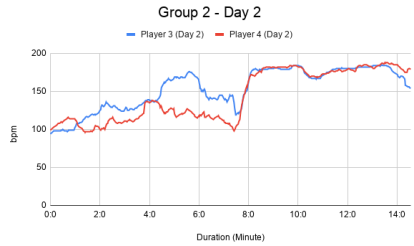


(h) Group 8 - Day 1

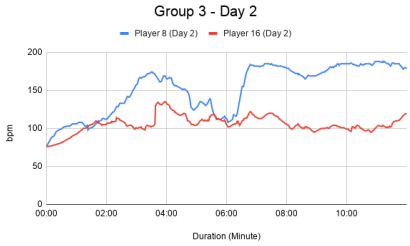
Figure E.1: Heart rate - Day 1



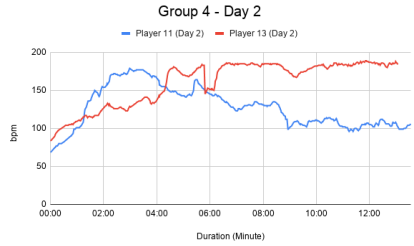
(a) Group 1 - Day 2



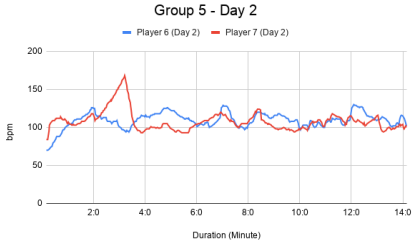
(b) Group 2 - Day 2



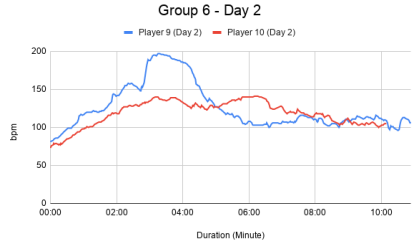
(c) Group 3 - Day 2



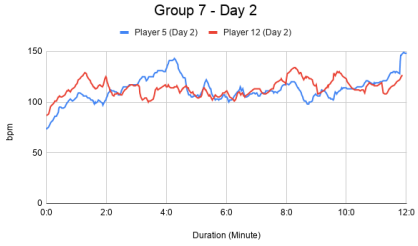
(d) Group 4 - Day 2



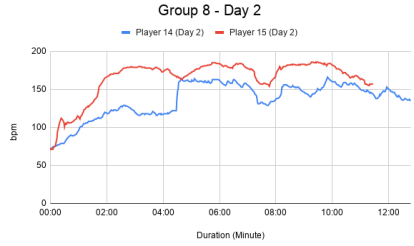
(e) Group 5 - Day 2



(f) Group 6 - Day 2

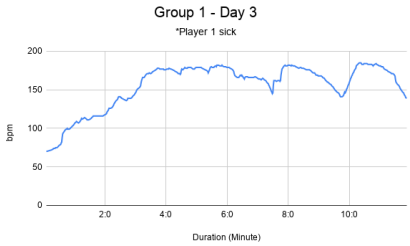


(g) Group 7 - Day 2

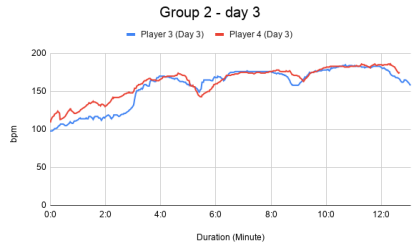


(h) Group 8 - Day 2

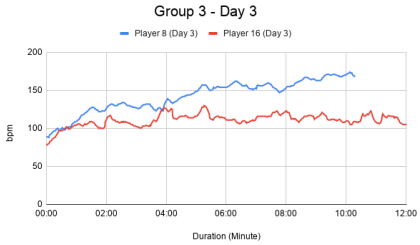
Figure E.2: Heart rate - Day 2



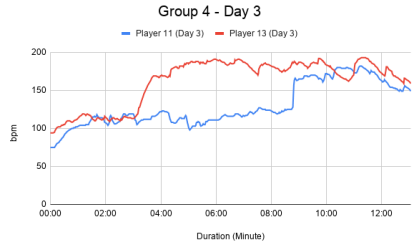
(a) Group 1 - Day 3



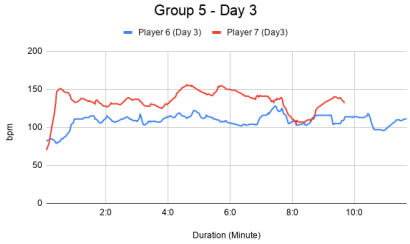
(b) Group 2 - Day 3



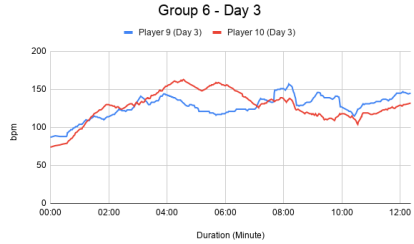
(c) Group 3 - Day 3



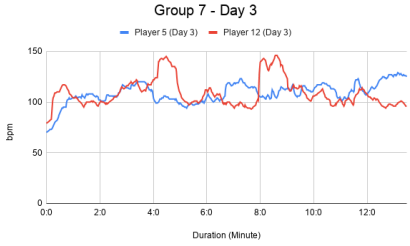
(d) Group 4 - Day 3



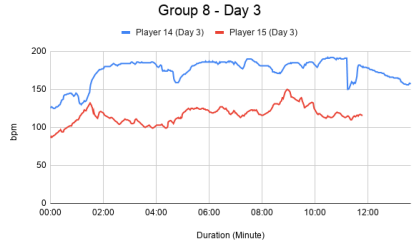
(e) Group 5 - Day 3



(f) Group 6 - Day 3



(g) Group 7 - Day 3



(h) Group 8 - Day 3

Figure E.3: Heart rate - Day 3