Master's thesis

NTNU
Norwegian University of Science and Technology
Faculty of Information Technology and Electrical Engineering
Department of Computer Science

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FlipBoard - Unexplored Genres in Exergames

Master's thesis in Computer Science
Supervisor: Alf Inge Wang
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Abstract

A growing trend of sedentary behaviour is causing several health risks. Exergames, video games with physical elements causing exertion, approach this problem by providing effective, enjoyable, and motivating exercise through a medium often associated with sedentary behaviour. Furthermore, players of exergames also gain other mental and physical benefits, in addition to spending time with exergames instead of playing sedentary video games. However, unlike video games, there is a lack of variety in exergames. Most existing exergames fall under the action genre and focus on the exercise method (like riding a bike in an exerbike game). This similarity might exclude people not interested in those genres or themes, who might otherwise have benefited from playing exergames.

The game concept of FlipBoard considers both game design theory and exercise theory to provide efficient, enjoyable, and motivating exercise. With the addition of puzzle elements, the concept aims to capture the player's attention and facilitate a flow state, leading to more enjoyment and increasing the likelihood of the player wanting to play the game again. Furthermore, the concept strives to divert focus from the exercise form to appeal to players who dislike exercising rather than emphasising it like other exergames.

A prototype was developed based on the game concept to test whether a puzzle exergame is feasible. An experiment determined that participants playing the game reached a state of flow and gained moderate- to high-intensity exercise. During the experiments, 10 participants went through three sessions each; one control session of exercising on an exercise bike with music and two sessions playing the game. Although the results were mostly positive, some improvements, like adding more reward systems and updating the equipment, might cause the game to better appeal to different player types, increase exercise intensity and make the game more engaging long term.

This master thesis discovered that the puzzle games genre was the most commonly enjoyed genre among the respondents to a general survey, with 65% enjoying them. The adventure games (story-focused games) genre, along with puzzle games, was the second most enjoyed by those not physically active. Neither genre is present in any of the exergames examined during this project. There were also some interesting findings about differences between genders discovered. Mainly, a significantly bigger percentage of women enjoy puzzle games than men, and significantly fewer enjoy strategy and action games. The latter being the most common genre in exergames means that a majority of women will not find the current exergame market interesting. A strong preference for singleplayer over multiplayer also emerged for women, which differed from the more neutral preferences of the male respondents.

Sammendrag

En økende trend av stillesittende adferd fører til en rekke ulike helseproblemer. Exergame-spill, videospill som forårsaker anstrengelse med fysiske elementer, prøver å løse dette problemet ved å tilby effektiv trening på en motiverende og morsom måte, ved hjelp av et medium som vanligvis assosieres med stillesittende adferd. Flere mentale og fysiske fordeler kan også oppnås fra exergame-spill, i tillegg til tiden som blir brukt på å bevege seg som ellers kunne ha vært brukt på stillesittende videospill. I motsetning til videospill er det imidlertid mangel på variasjon i exergame-spill. De fleste av de eksisterende exergame-spillene faller inn under actionsjangeren og omhandler den tilhørende treningsmetoden (som å sykle i et spill spilt på treningssykkel). Dette kan føre til ekskludering av personer som ikke er interessert i disse sjangrene eller temaene, som ellers kunne ha hatt nytte av å spille exergame-spill.

Spillkonseptet til FlipBoard ble laget med hensyn til både spilldesignteori og treningsteori, for å gi effektiv, morsom og motiverende trening. Ved å legge til puslespillelementer prøvde konseptet å fange oppmerksomheten til spilleren og tilrettelegge flow, noe som fører til mer glede og øker sannsynligheten for at spilleren ønsker å spille spillet igjen. Konseptet ble designet for å lede fokus bort fra treningsformen, i stedet for å fremheve den som andre exergame-spill gjør, for å appellere til spillere som ikke liker å trene.

En prototype ble laget basert på spillkonseptet, for å teste om et exergame i puzzle-sjangeren er gjennomførbart. Det ble vist eksperimentelt at deltakere som spilte spillet opplevde flow, og fikk trening av moderat til høy intensitet. I løpet av forsøkene gikk 10 deltakere gjennom tre økter hver; en kontrolløkt med trening på en treningssykkel med musikk, og to økter med å spille spillet. Selv om resultatene stort sett var positive, kan det gjøres noen forbedringer til spillet, som flere belønningssystem og oppdatert utstyr, for å appellere bedre til ulike spillertyper, øke intensiteten og gjøre spillet mer engasjerende på lang sikt.

Gjennom masteroppgaven ble det oppdaget at puzzle-spill var den mest populære sjangeren blant de som svarte på en generell undersøkelse, med 65% som liker den typen spill. Eventyrspill (historiefokuserte spill), i tillegg til puzzle-spill, var den nest mest likte sjangeren blant de som ikke er fysisk aktive. Ingen av disse sjangrene er til stede i noen av exergame-spillene som ble undersøkt under dette prosjektet. Det ble også oppdaget noen interessante funn om forskjeller mellom kjønn. Hovedsakelig at en betydelig større prosentandel av kvinner liker puzzle-spill enn menn, og at mange færre av dem liker strategispill og actionspill. At sistnevnte er den vanligste sjangeren i exergame-spillene undersøkt betyr at et flertall av kvinner ikke vil finne det nåværende exergame-markedet interessant. Det var også en sterk preferanse for singleplayer fremfor multiplayer for kvinner, som skiller seg fra de mer nøytrale preferansene til mennene som svarte på undersøkelsen.

Acknowledgement

First, we would like to thank our supervisor, Professor Alf Inge Wang, for all the help he has given us during this last year and for the opportunity to do this exciting project. The weekly meetings have been highly insightful and fun. We appreciate both the meetings packed full of feedback and improvements and those that devolved into excited discussions regarding video games and hobbies. Thank you for not kicking us out after we used almost double our allotted time, and thank you for being scarily quick with giving excellent and detailed feedback. You have been a source of light for us through this process and were always generous with motivation and optimism when we were stressing about deadlines and imperfections. Thank you.

We would also like to give our thanks to Terje Røsand for allowing us to use part of the Design Lab for the experiments and for all his help regarding the room and equipment. Thank you for your patience and helpful responses to our many emails.

A huge thanks must also be given to our experiment participants. Thank you for taking the time out of your days to be our loyal lab rats for a couple of hours over the course of two weeks. Without you, this project would not have been possible, and we would have way fewer results. We also appreciate everyone who replied to our general survey.

Additionally, we want to thank Niels Pálmi Skovsgård Jónsson, who took the time out of his limited time in Trondheim to test our game during development and give valuable feedback.

Finally, we sincerely thank our friends and family for keeping us sane these last few months. Especially those who read through this entire thesis and gave us invaluable feedback. We know this thesis is not exactly short, so thank you for taking time out of your day to help.

Abbreviations

AR Augmented Reality

AQ Questions from the Anonymous Questionnaire

ESA Entertainment Software Association

FHI Norwegian Institute of Public Health

GQ Questions from the General Questionnaire

HIIT High-intensity interval training

HR Heart Rate

IQ Questions from the Interview Guide

MMO Massively multiplayer online (part of the RPG genre)

MVC Model-view-controller pattern

MVP Minimal viable product

RPG Role-playing game (genre)

RQ Research Question

UI User Interface

VR Virtual Reality

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Part I

Introduction

"*Research is formalized curiosity. It is poking and prying with a purpose.*"
Zora Neale Hurston (1996)

This part will introduce the project by first explaining the societal and personal motivation behind the chosen field of study before describing the context and limitations of the project. Afterwards, the research questions will be defined, followed by a description of how the research will be structured to answer them. The introduction will end with an outline of the report. The *Motivation* and *Project and Context* chapters are based on the authors' previous specialisation project preceding this thesis (Elnan and Stabell, 2022), with some modifications and additions to suit the more extensive scope of this master thesis.

1 Motivation

There is a growing trend of sedentary behaviour in modern society (López-Valenciano et al., 2020). While 75% of Norwegians satisfy the minimum weekly recommendation for exercise, there is still 25% that does not (Hansen et al., 2023). In addition, only 30% meets the new recommendations that the Norwegian Institute of Public Health (Hansen et al., 2023) published in April of 2023, which doubles the old recommendation for adults who sit still more than 8 hours a day. Exergames, video games with physical elements causing exertion, have proven to considerably increase the enjoyment of exercise and reduce sedentary behaviour (Matallaoui et al., 2017). In addition, exergames can reduce anxiety, increase motivation, and provide social and academic benefits (Chtourou et al., 2020; Staiano and Calvert, 2011). Considering these benefits, exergames could be a way to help people reduce sedentary behaviour, given that they are accessible and engaging to as many people as possible.

The authors of this thesis have a background in Computer Science and have gained experience with game development, software development, user testing, and design of user experience through their studies and summer jobs. They also have a love and enthusiasm for video games, and both know the feeling of lacking motivation to exercise. Vilde spent a year studying game development at Namdals Folkehøyskole, and Sigrid has years of experience with cycling and spinning classes. With this project combining both, they are motivated and excited to combine their knowledge to add more insight into this field of study.

2 Project and Context

The project and this report serve as the authors' master's thesis. The project is a continuation of the specialisation project done in the fall of 2022, with Part I, Part II and Part III being based on that specialisation project (Elnan and Stabell, 2022). Both projects are a part of the Game Technology 4 Health Network (NTNU, 2022), which aims to collect and increase knowledge about the health benefits of gaming.

The project has some limitations regarding available equipment, time and resources. Firstly, two prototype PlayPulse exercise bikes are available during the project, which will be described more in-depth in Chapter 14. Due to the availability of these specific bikes, the resulting game concept will be an exercise bike game. Additionally, the max heart rate of the participants will be calculated rather than doing more accurate tests, as the time and resources of running these tests do not out-weight the value gained.

The original description for this project was:

> "**[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 multiple buttons. In addition to input from buttons, the player should control the game through using her/his feet 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 are:*
>
> *- 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.*
>
> *- Evaluate the game through user experiments"*

However, the focus shifted after some exciting findings during the literature review in the specialisation project (Part II). As will be further discussed in Chapter 12, most exergames fall under the same genres and themes. Additionally, a lot of research has already been done around the effect of multiplayer in exergames. This led to the multiplayer aspect being considered less critical and more emphasis being placed on the genres lacking in the exergame market.

3 Research Questions

Based on the original project description, the specialisation project, and discussions with the supervisor, a research goal was created:

> *Develop an exergame prototype that motivates sedentary young adults to reach the recommended amount of physical activity.*

This includes designing an exergame concept (based on the specialisation project) that is motivating and enjoyable but provides enough exercise to be beneficial. To ensure this, the prototype should be tested, which might also provide valuable insights into both exergames similar to the prototype and in general. Several research questions have been defined to achieve this:

- **RQ1:** *Are there commonly enjoyed game genres, or other gaming preferences, that are not sufficiently represented in the current exergame market?*

  Potential gaps in the current exergame market might exclude players who would have otherwise benefited from exergames. Specifically, exergames might share video games' tendency to target specific groups and leave other groups with different preferences, like women, out (Greenberg et al., 2010). Therefore, the project will look into commonalities between existing exergames and whether there is room for more variety to reach a larger target audience.

  This research question aims to discover what kinds of exergames exist in the current market, which genres people enjoy, and if any genres are commonly enjoyed but not present in the exergame market.

  - **RQ1.1:** *Does gender affect gaming preferences?*

    It is no secret that gaming used to be a heavily male-dominated pastime and that games mostly catered towards men and their preferences. However, times have changed, and more and more women have started playing video games, with the Entertainment Software Association (2022) reporting that 48% of video game players are female. This sub-question aims to look for possible differences and discuss how those differences should be taken into consideration to make gaming more accessible to women as well. Being a sedentary young adult is, after all, not restricted to men, and women would also benefit from exciting exergames.

- **RQ2:** *How can existing game design and exercise theory be combined with a new exergame genre into a unique game concept?*

  While a master's thesis is meant to provide a research field with more knowledge, it is not necessary to reinvent the wheel. Instead, existing theories and principles can be used as a foundation so that more effort can be spent on researching the new parts. In this way, the project might contribute unique insight into exergames, with a smaller chance of corrupting the data generated by testing a lousy game.

- **RQ3:** *Can such an exergame facilitate a state of flow?*

  A game must be motivating, interesting and fun for players to want to play it. After all, no exercise will be gained from the game if it is never played. Reaching a state of flow while playing indicates that the game is enjoyable. Among other factors, the level of concentration and immersion reached while playing contributes to whether or not flow is achieved. A sign of this is that the player is in their own little world and fails to notice the outside world and that time is passing.

- **RQ4:** *Can such an exergame contribute to more people reaching the recommended exercise amount?*

  The exergame must facilitate moderate to high-intensity exercise to help players reach the recommended amount of physical activity. It is also crucial that players are motivated to keep playing, as one of the key aspects of exercise is repetition, and reaching the recommended amount of physical activity is a lifestyle change rather than a temporary fix.

- **RQ5:** *Does the equipment needed for an exergame deter people from playing exergames?*

  A downside with many exergames is that they require expensive and bulky equipment to play. This research question therefore aims to investigate whether or not people are willing to invest in an exercise bike to play exergames.

4 Research Method

The research conducted in this thesis is structured after the research model of Oates et al. (2022) (Shown in Figure 1). Which strategies and data generation methods that will be used in this project are highlighted in dark blue. The figure also illustrates how the **research questions** described above were formulated based on the **experiences and motivations** of the authors as described above and the literature review seen in Part II. The literature review also motivated the **conceptual framework**, that is, how the research questions will be approached and investigated (as this chapter explains).

This chapter will describe the different elements of the chosen research method from a theoretical standpoint. For more in-depth details about how the research strategies and data generation methods were conducted, see Part V.

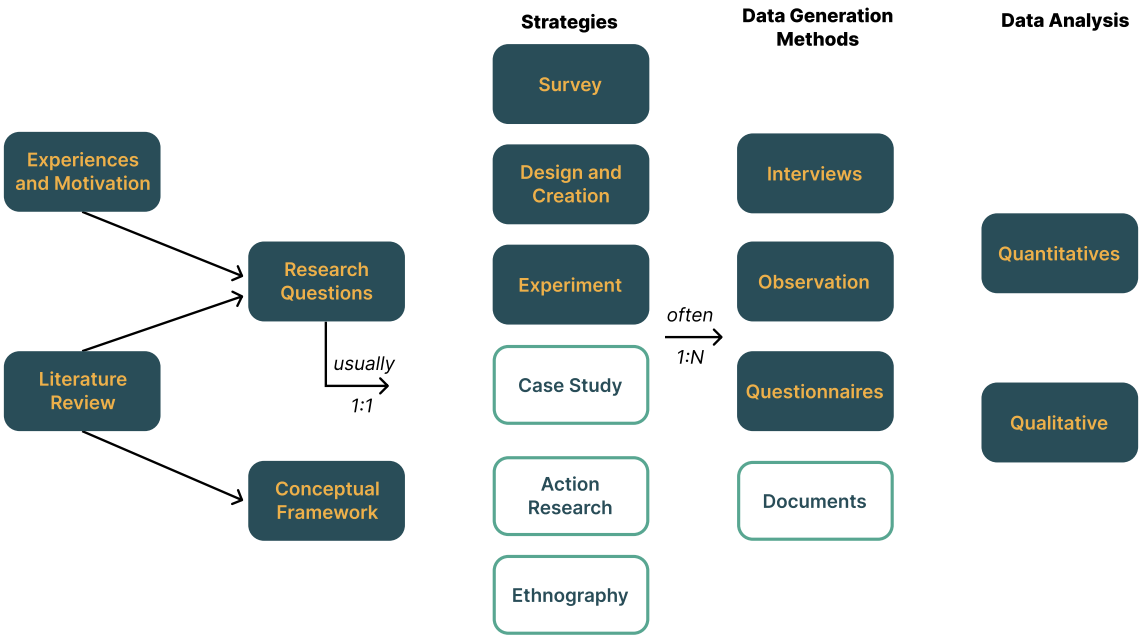


Figure 1: The chosen research path of this thesis, marked in dark blue. Based on the diagram from Oates et al. (2022).

4.1 Literature Review

As defined by Oates et al., a **literature review** consists of two parts. Initially, the researchers get more familiar with the relevant research done on the topic and identify areas that need more research. This foundation is used to form the research goal and questions. The second part lasts throughout the project, as new studies might be published closer to the end. The latter part mainly consists of gathering evidence through previous research to support the conclusion reached. This is done to show that new knowledge has been achieved, that this research is not just repeating what others have done before, and to argue that the chosen topic is worth studying. A literary review might also help other researchers understand the field of study and this project's part in it.

For the literature review in this project, the sources will be evaluated through the CRAAP Test (Meriam Library, California State University, Chico, 2010) before being used in this thesis. The criteria consist of Currency, Relevance, Authority, Accuracy, and Purpose. Firstly, *Currency* concerns how recently the information source was published, whether it has been updated and whether current information is required for the particular topic. Next, *Relevance* evaluates how vital the information is for the answer or topic being discussed. Evaluation criteria include who the intended audience is, whether the information is too advanced or simplified and whether other sources might be better. Thirdly, *Authority* concerns the authors (and publisher) and their qualifications

and trustworthiness. The fourth, *Accuracy*, questions the truthfulness and reliability of the information, including whether evidence is being presented and if the information has been verified. Lastly, *Purpose* considers why the information has been made available, the author's intentions, and other potential biases that might affect it.

4.2 Strategies

The different strategies for conducting research can be seen in Figure 1. It shows how a two-pronged research strategy was chosen for this project to answer the stated research questions.

Part of RQ1 can be answered through the literature review, namely, which genres are common and which are not. However, the question remains about which genres are commonly enjoyed in general. Although statistics for genre preferences will be introduced in Part II, these only take American preferences into account and might differ from Norwegian ones. As such, the **survey** strategy was chosen. This strategy consists of obtaining standardised and systematic data from a large group of people and then looking for patterns that can be generalised to a larger population. It is commonly associated with questionnaires but can also use other data generation methods.

RQ3 and RQ4 are more specifically about the new game concept developed during this project, motivated by a genre's absence from the exergame market. As such, it is not possible to use an already existing game. Therefore, the **design and creation** strategy was chosen in conjunction with the **experiment strategy**. Specifically, a prototype will be created and later tested for motivation/enjoyment and exercise benefit.

Within information system and computing research, the *design and creation* strategy focuses on developing technology products or artefacts. A vital aspect that separates this type of research from simply showing off technological skills is that it contributes to knowledge in some way. Oates et al. describes three ways of doing this. Firstly, the end product might be the main focus of the research, e.g. by demonstrating that it is possible to make something in a specific way. Secondly, by studying the development process itself. For example, by creating the same product with two different methods and comparing them. Thirdly, and most relevant to this thesis, is using the product as a tool to research something else. An example is using a prototype in a case study or experiment to study how users interact with or are affected by it. Using other strategies alongside this one is common if the latter option is used.

The *experiment* strategy focuses on proving or disproving a hypothesis by observing and measuring certain factors and then observing changes made when specific elements are altered. Measurable data include self-report responses to a questionnaire and counting how often particular behaviour occurs during the experiment. It is necessary to control all variables, through methods like having control sessions or using a random selection of subjects, to ensure that the factor being studied caused the change and not something unrelated. However, having complete control over every factor regarding human behaviour can be nearly impossible.

4.3 Data Generation Methods

Three data generation methods have been chosen for this project. Firstly, the **questionnaire** method will be used in the survey strategy and as a means of quantitative data in the experiment strategy. A questionnaire is defined as a specific set of questions asked in a predetermined order to a large number of people. By posing identical questions and controlling the available range of answers, it is possible to obtain standardised data. It is crucial that the questions are understood the same way by various respondents and that the responses can be decoded in a useful way without the ability to ask clarifying questions.

The second data generation method used is **observation**. Despite sight being the most commonly thought of sense for this, research-based observation concerns all five senses. Technology, like heart-rate sensors, can also be used. An important decision when planning to use observation for research is whether to observe covertly or overtly. If observing someone covertly (without them

knowing), the researchers must carefully ensure that the observation remains ethical and protects the rights of the people participating. It might also be more challenging to ask questions, as people can become upset or angry. On the other hand, overt observation has the benefit of being able to obtain consent but the disadvantage of people modifying their behaviour because they know they are being observed (known as the Hawthorne Effect (Cook, 1962)).

Lastly, **interviews** will be used to gain a more in-depth understanding of the experiment participants' experiences. In this context, an interview refers to a structured conversation where one person leads the discussion towards specific topics. Oates et al. points out that interviews are useful for obtaining detailed information. It is also a unique opportunity to ask complex questions that might need further explanation, that are open-ended, or that might need to be posed differently depending on the person. Additionally, this method allows the exploration of emotions, experiences or feelings that might not be otherwise observable. The interviewer must avoid asking leading questions that might alter the interviewee's answer. For similar reasons, the interviewer should appear non-judgemental and control their body language.

4.4 Qualitative and Quantitative Data

The data generated by the discussed methods are mainly valuable if adequately analysed, turning information into knowledge. However, the data analysis process differs depending on whether the data is **qualitative** or **quantitative**. Oates et al. defines quantitative data as "data, or evidence, based on numbers", while qualitative data is described as "all non-numeric data". Both have advantages and disadvantages. Quantitative data makes it possible to use statistical methods to process the data and make patterns more visible. Still, it risks missing important nuances regarding complex subjects like the human experience and emotions.

On the other hand, qualitative data allows for a deeper understanding but can be more complex and time-consuming to process. While it is possible to use quantitative analysis on qualitative data, most qualitative analysis consists of abstracting themes and patterns from the raw data. These processes often depend on how well the researcher can recognise patterns and take more time. For instance, it is estimated that one hour of audio recordings takes four to five hours to transcribe.

For this project, a combination of quantitative and qualitative data will be used, as a mix of the two makes it possible to gain an in-depth understanding while getting comparable data to make patterns more visible.

Qualitative data collected through the described data generation methods will consist of:

- Written notes and audio recordings from the interviews
- Written notes from observation
- Text answers from the questionnaires

Quantitative data will be collected in the form of:

- Questions with limited answer formats in the questionnaires, both in the survey and in the experiment
- Heart-rate data from observation

4.5 Summary of Research Method

The conceptual framework, including how the research was structured, is based on common research strategies found during the literature review. The latter, along with personal and societal motivations and experiences, was also used to form the research goal and questions. Three strategies were

chosen to answer the research questions, resulting in a two-pronged approach. First, a survey will be conducted to answer RQ1 and RQ5 by sending out a questionnaire to generate data that can be used to make assumptions about a larger demographic. Secondly, a prototype will be created and tested to answer RQ3 and RQ4 and provide more insight into RQ5. This can be categorised into the design and creation strategy, commonly conducted in conjunction with experiments, like in this case. This approach will use interviews and observations to generate qualitative data, while a questionnaire will provide more quantitative data to support the findings.

5 Project Outline

This project report consists of eight parts: *Introduction*, *Pre-study*, *Game Concepts*, *The Prototype*, *Methodology and Data Generation*, *Results*, *Discussion* and *Conclusion and Further work*. The *Introduction*, *Pre-study* and *Game Concept* are based on the authors' previous specialisation project, with modifications and additions to better suit this project (Elnan and Stabell, 2022).

Part I - Introduction

This part has introduced the project, the research goal, the research questions and the motivations behind them. In addition, the research method has been explained.

Part II - Pre-Study

The Pre-Study will start with an introduction to video games, different game genres and player types. After that, game design theory will be presented, focusing on motivation and enjoyment in games and a classification of reward systems. This will be followed by exercise theory, which includes definitions of exercise measurements and exercise types. The part will then define exergames and present different existing exergames and the studies done around them. This will end with evaluating these exergames based on the described theories before discussing different commercial exerbikes. Finally, the part will describe the prototype bike used during the experiments, ending with discussing possible game engines.

Part III - Game Concepts

The third part explains different game concepts and the method for generating them and will end with an in-depth explanation of the chosen game concept. Finally, the game mechanics and design choices will be discussed based on information gathered in Part II. Readers are encouraged to adopt the unused game concept if they feel inspired by them.

Part IV - The Prototype

Part IV concerns the prototype made from the game concepts in the previous part. Here the development method, requirements and software architecture will be described, in addition to a complete description of the completed prototype. Finally, the part will end with an evaluation of the finished product based on requirements made at the beginning of the development process.

Part V - Methodology and Data Generation

This part will explain how data was collected during the research project. For this project, there were two primary data-gathering sources: an in-depth experiment with a small number of participants and a short survey with a larger number of participants. The part starts with a brief introduction about the participants and how they were recruited and then discusses the ethics and privacy concerns that follows this type of data generation. After that, the two main data generation methods are described, followed by a chapter regarding how the data was analysed. Finally, this part ends with a short discussion about reliability and validity.

Part VI - Results

Next, the results from the experiments and the survey will be presented. This part will start by presenting the results from the general survey, followed by the results gathered during the experiments. The experiment results follow the structure of observations and interviews, heart rate, and answers from the anonymous questionnaire.

Part VII - Discussion

Part VII will discuss the results from Part VI in the context of the research questions. The part will end with a discussion of different experimental concerns that might have affected the experiments.

Part VIII - Conclusion and Further Work

Finally, this part will summarise the study with the help of the research questions introduced in Part I and discuss what further research and improvements to the prototype could be made.

Part II

Pre-Study

> "*If I have seen further it is by standing on the shoulders of Giants.*"
> Isaac Newton (1675)

Part II looks into existing research in the relevant research areas so that later discussion and choices can be based on a foundation of established knowledge, instead of rambling on based on nothing but wild guesses. The different topics will follow the structure of existing theories and knowledge, then a brief analysis of existing solutions in light of said theory, and finally, a brief overview of technical details pertaining to the themes discussed. This part is based on the authors' specialisation project (Elnan and Stabell, 2022).

6 Video Game Genres

Video games can be defined as "a game played by electronically manipulating images produced by a computer program on a monitor or other display" (*Oxford English Dictionary* n.d.). This broad definition includes a wide variety of games which appeals to different types of people. Additionally, there is a constant influx of new video games, with almost 11 000 games being released on Steam in 2022 (Clement, 2023). Because of this, more and more terms are attempting to categorise these games into different genres. This process is further complicated as games often fall into several genres, and different definitions are used for the same genre names. For consistency, the scope of this text has been limited to 9 of the most general genres, based on the definitions from MobyGames' complete video game genre list (MobyGames, 2022). In addition, the Entertainment Software Association's (ESA) (2022) statistics about genre preferences will be used for insight into player preferences. Keep in mind that some of the examples mentioned below may fit into more than one genre.

6.1 Action

Action games are games that focus on one or more of the following; accuracy, movement, quick decisions, reflexes and timing. Gameplay often revolves around violence and the use of firearms. It is also common with cutscenes that contain quick-time events. Examples of games like this are Doom, Counter-Strike, Tomb Raider, The Last of Us (Figure 2) and Fortnite. ESA lists three categories that fit our definition of action games. The categories Action, Shooter and Fighting are enjoyed by 43%, 42% and 38% of players, respectively. However, it should be noted that these scores are not additive, as a player can have reported that they, for example, enjoy both Shooter and Fighting games and thus have contributed to both scores.

Figure 2: Gameplay of the action game The Last of Us. Screenshot from IGN (2022)

6.2 Adventure

Adventure games mainly focus on storytelling, with heavy use of dialogue and puzzle solving. The usual game mechanics in such games are dialogue options, various ways to interact with puzzles, and cutscenes. Examples of games like this are The Secret of Monkey Island, Portal, Life is Strange and the various Telltale games (Figure 3). Unfortunately, the ESA statistics do not have a category that directly correlates to this genre.

Figure 3: Dialogue game mechanic from the adventure game by Telltale: Tales of the Borderlands. Screenshot from IGN (2015)

6.3 Idle

Idle games are categorised by continuing to run without player interaction. These games primarily focus on amassing resources, often allowing users to generate resources or in-game currency when not actively playing. Cooldown timers are a common way to achieve this by, for example, providing the player with x amount of resources per specialised unit they have unlocked. Examples of games include FarmVille, Hay Day (Figure 4), Cookie Clicker and Clash of Clans. Like adventure games, this genre is not directly represented in the genre preference statistics.

Figure 4: Gameplay from the idle game Hay Day. Screenshot from Anonymous Poster on Lemon-Clip (2014)

6.4 Party

Party games foster social interaction through multiplayer, often with straightforward controls and multiple minigames. These games usually have short sessions or rounds and tasks that encourage socialisation outside the game. Due to the variety of minigames, gameplay can differ between different party games. However, the control scheme stays fairly consistent per game and usually only consists of a few buttons to make it easy for players to learn new minigames. Examples are Mario Party, The Jackbox Party Pack (Figure 5), the SingStar franchise, the Buzz! franchise, and Overcooked. Although the ESA category Arcade & Others is broader than this project's definition of party games, it is still similar enough to consider. With 57% reporting that they enjoy this category, it is the second most liked type of game.

Figure 5: Gameplay from the minigame Quiplash, from the Jackbox Party Starter game. Screenshot from Victor (2022)

6.5 Platformer

Platformer games are games where navigation is a significant part of the game, mainly consisting of jumping or climbing on platforms. Gameplay usually consists of traversing different levels that become increasingly difficult as the player becomes more familiar with the control scheme. Though the genre is often associated with 2D games, some 3D games also fit the definition. Examples of platformer games include Castlevania, the Donkey Kong franchise, the Super Mario Bros franchise (Figure 6) and Cuphead. Platformer games are not explicitly represented in ESA's categories.

Figure 6: Gameplay from the platformer game Super Mario Bros. Screenshot from Dornbush and Morales (2015)

6.6 Puzzle

Puzzle games mainly focus on solving puzzles, usually with little to no focus on a story. Game mechanics are often specific to the type of puzzle in the game. Since the challenge lies in figuring out the puzzle, the game mechanics are often simple and easy to learn. Examples include Angry Birds, Candy Crush, Minesweeper (Figure 7) and Tetris. According to ESA, puzzle games are the most commonly enjoyed game type, with 65% of players enjoying them.

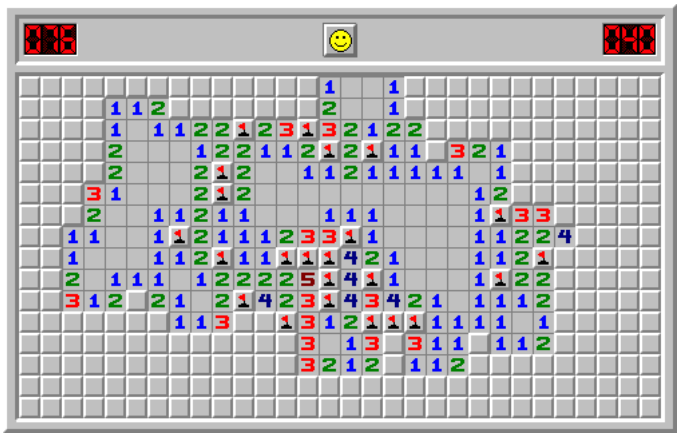


Figure 7: Gameplay from the puzzle game Minesweeper. Screenshot from Minesweeper Online (2022)

6.7 RPGs

Role-Playing games (RPGs) focus on character development and often include quests, narrative and tactical combat. In order to allow the user to be in charge of how the characters evolve, a lot of RPG games involve skill trees or other mechanics for choosing what the character should advance in. There are many sub-types of RGP games; one of the most popular ones is Massive Multiplayer Online RPG (MMO), where many players within the same game world can interact with each other through, for example, trading or combat. Examples of RPGs include World of Warcraft (MMO), The Witcher Franchise, The Dragon Age Franchise (Figure 8) and The Final Fantasy Franchise. RPGs are enjoyed by 41% of players.

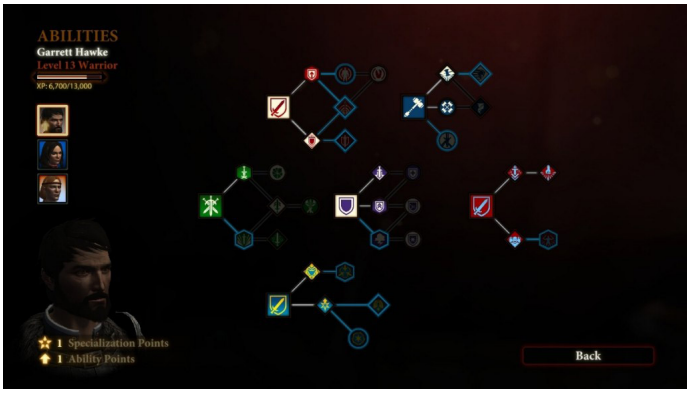


Figure 8: Skill tree from the RPG game Dragon Age II. Screenshot from BioFan (2014)

6.8 Simulation

Simulation games try to model real-life situations, often focusing on realism. The real-life inspiration that such games simulate can vary, but typical simulations are life, vehicle, and sports simulations. Examples of games include The Sims Franchise, the FIFA franchise and the F1 franchise (Figure 9). ESA splits this genre into Simulation, Racing & Vehicle Simulation and Sports, which are enjoyed by 41%, 38% and 28%, respectively.

Figure 9: Gameplay from the simulation game F1 2021. Screenshot from Andersen (2021)

6.9 Strategy

Strategy games are about resource management and strategic decisions. The most common game modes are real-time, persistent or turn-based. Typical gameplay includes constructing buildings or units in strategic places and upgrading them to increase the number of resources gained or protection provided. Such games include Plant vs Zombies, The Civilization franchise (Figure 10) and Total War: Warhammer. Strategy games are reported by the ESA as enjoyed by 40% of players.

Figure 10: Gameplay from the strategy game Civilization 6. Screenshot from IGN (2016)

6.10 Summary of Video Game Genres

In summary, this thesis will base itself on the abovementioned genre definitions. In addition, the ESA statistics provide valuable insight into player preferences, although they do not align completely with the chosen genre definitions. A list of the genres by order of popularity can be seen in Table 1. The genres adventure games, idle games and platformer games are not included as the provided categories did not sufficiently represent them.

Table 1: Genre preferences, based on definitions from MobyGames (2022) and statistics from the Entertainment Software Association (2022). Genres not associated with any ESA categories are not included

Rank	**Genre**	**ESA Category**	**Score**	**Notes**
1	Puzzle games	Puzzle	65%	
2	Party games	Arcade & Others	57%	ESA category is broader than genre
3	Action games	Action, Shooter, Fighting	43%, 42% and 30%	Most likely overlap
4	Simulation games	Simulation, Racing & Vehicle Simulation, Sports	41%, 38% and 28%	Most likely overlap
5	RPGs	RPG & Narrative	41%	
6	Strategy games	Strategy	40%	

7 Player Types

Different genres appeal to different types of players, and different players enjoy different elements and playstyles, even within the same game. Understanding what defines these player types and what makes them tick has become a vital research area for the games industry. According to the ESA (2022), 66% of the USA's population play video games at least weekly. With such a large demographic to pander to, this research is both important to make sure that all players can find something they like in the game and to be able to market a game to the right audience. As such, there have been many attempts to create suitable classification systems.

7.1 Bartle's Player Types

Perhaps the most commonly used categorisation is from Bartle (1996) about player types in multi-user dungeons (MUDs). He defined four distinct player types: Achievers, explorers, socialisers, and killers. These types are based on where their primary interest in games lies. Bartle defines two axes to determine this as shown in Figure 11; is the player more interested in the game environment or other players, and are they interested in interacting with or acting on that focus area?

Achievers are players interested in mastering the game and being in control. Competing with other players can be a part of this, but it is not the primary motivation. *Explorers* are similar in their focus on the game world; however, they would rather interact with the game and have it surprise them. Small details and game knowledge interest them, and they are often proud of how much they know about the game. On the other hand, *socialisers* enjoy interacting with players rather than the world. They view the game as a setting to talk to and learn about other people. Finally, while *killers* also find an interest in other players, their motivation is in competing against people. Bartle defines killers as players who want to show that they are superior to others and prefer in-game actions that would be illegal in real life.

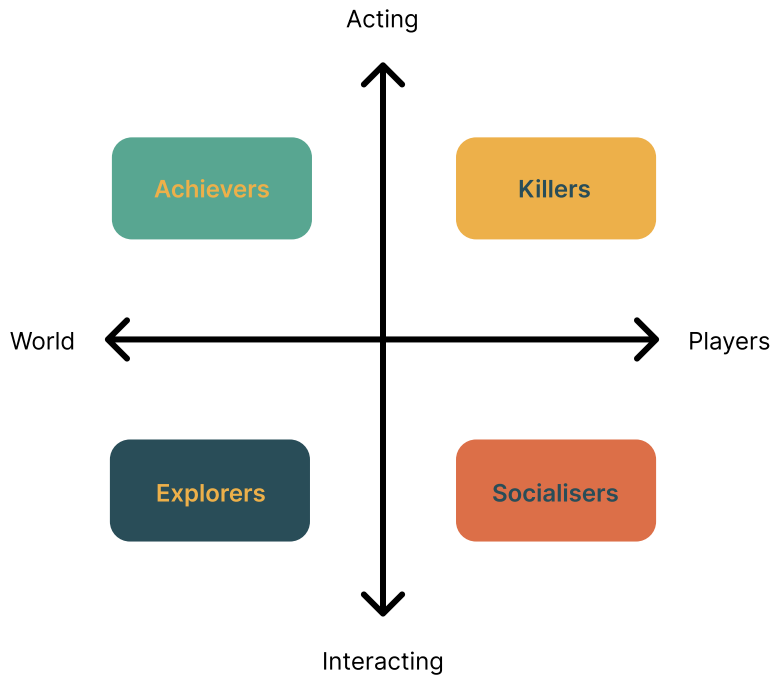


Figure 11: Bartle's player types and their interests. Based on the diagram from Bartle (1996)

7.2 Hamari and Tuunanen's Archetypes

Hamari and Tuunanen (2014) have tried to identify the commonalities in the many theories (including Bartle) and unite them into one model. They stress that these should be seen as archetypes, not absolutes, as people are complex and multifaceted. The first concept revolves around *gaming intensity and skill*, often seen as the difference between hardcore and casual players. Secondly, *achievement* includes different ways players feel accomplishment in games, like having a high-level character, getting rewards or beating the game as quickly as possible. Thirdly, *Exploration* includes players curious about the game world and eager to interact with game elements like story and puzzles. Next, *sociability* consists of players who utilise the built-in social features of a game or make their own outside the game to cooperate with other players and cultivate a community. On the other hand, is *domination*, which describes players who enjoy competing against other players or the game world. Next, *Immersion* includes players who want to be captivated by the game's story, world and game mechanics. Lastly, *in-game demographics* is a concept that considers how groups and communities form within games from having something in common. Examples of this are players who find a sense of belonging from being in a guild or having chosen certain character traits.

It is worth noting that a disproportionate number of research projects have focused their studies on MMO players, which should be remembered when creating games in other genres.

7.3 Summary of Player Types

In summary, Bartle's player categories of Achievers, Explorers, Socialisers and Killers mainly focus on whether a player enjoys interacting or acting on the game world or other players. Hamari and Tuunanen identified commonalities between this classification and others. Their proposed archetypes consist of: Gaming intensity and skill, achievement, exploration, sociability, domination, immersion, and in-game demographics.

8 Game Design Theory

Before a game can be developed and released into the wild, it must go through a design phase to determine what it will contain and how it will capture the minds and hearts of its audience. For what good is a game no one enjoys or wants to play? This chapter will explore theories about what motivates players, what aspects are needed to captivate them and create an enjoyable experience they want to return to, and how to integrate motivating and useful reward systems.

8.1 Intrinsic Motivation

Malone (1980) defines three essential characteristics for good computer games; Challenge, fantasy and curiosity. For the first characteristic, he states that "in order for a computer game to be *challenging*, it must provide a goal whose attainment is uncertain". A few methods are suggested for achieving this. The first is varying the difficulty level by either changing it dynamically based on player actions, letting the player set it manually or strategically pairing them up with opponents that can challenge them. The second method is to have different levels of goals, like metagoals or subgoals. Metagoals are goals the player set for themselves to do better and can be encouraged by scorekeeping or timing the players' attempts. Subgoals are smaller, more manageable goals that can keep the player motivated as they work towards the overarching main goal. The third method is to provoke curiosity and challenge by selectively revealing information to the player, while the fourth is to include randomness. In addition to these methods, Malone states that simple games should provide obvious goals that should ideally be based on the in-game fantasy or something practical instead of the goal of simply using a skill. Players should also be able to know if they are getting closer to the goal or farther away through performance feedback.

Malone argues that *fantasy* in games makes video games more interesting. He distinguishes between extrinsic and intrinsic fantasy (Figure 12). *Extrinsic fantasy* is a fantasy that is affected by the player's skill but does not affect them in return. He explains that such fantasies are usually interchangeable and often involve getting closer to success or disaster. The game Hangman is presented as an example of this. *Intrinsic fantasy* is described as being affected by the player's actions, like extrinsic fantasies, but also affecting those actions in return. His examples include a dart game about shooting balloons, where the position of the balloons will determine where the player aims.

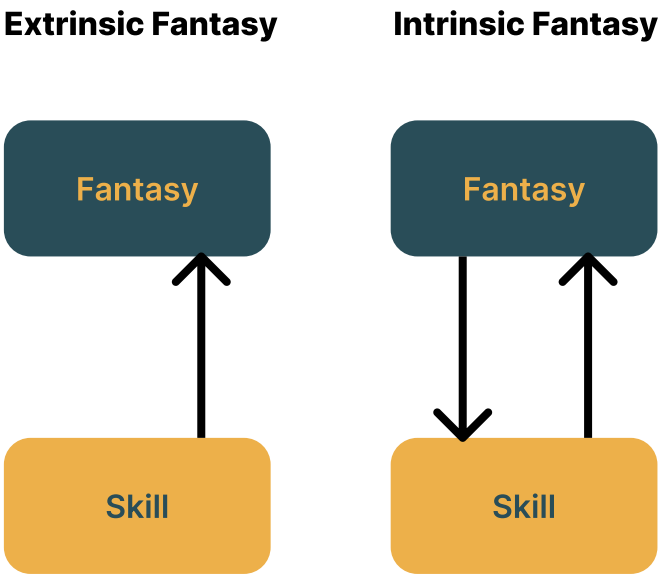


Figure 12: The difference between extrinsic and intrinsic fantasy. Based on the diagram from Malone (1980)

Curiosity is defined in the article as "the motivation to learn, independent of any goal-seeking or

fantasy-fulfilment". Malone argues the importance of an optimal level of informational complexity based on what a player can understand rather than what a player is capable of doing, which falls under the challenge characteristic. The optimal complexity is described as there being enough information for the player to have expectations but sometimes be surprised. He defines two types of curiosity: *Sensory curiosity* and *cognitive curiosity*. Sensory curiosity is mainly about grabbing the player's attention through sensory stimuli such as audio and visual effects. Four ways of utilising this is suggested. The first is to use it solely *as decoration* in a way that does not affect the gameplay. However, it is argued that such use will become boring after a while. The second approach is *to enhance fantasy* by letting the decorative elements give the players associations to the wanted fantasy. Thirdly, sensory elements can be used *as reward* by giving goals more importance and increasing the feeling of challenge. Despite this, the article warns that too much focus on rewards can decrease curiosity and interest by inspiring too much focus on the challenge. Lastly, sound and graphics can be used *as a representation system* as images and sound often can convey information quicker and better than text and numbers. "*Cognitive curiosity* can be thought of as a desire to bring better 'form' to one's knowledge structures." (Malone, 1980). Malone claims that a player's curiosity can be engaged by selectively giving information and making their knowledge structures seem incomplete, inconsistent, or unparsimonious. A method of doing this is by using informative feedback to make the game seem responsive. He stresses that feedback should be surprising, through randomness or by giving information that makes previous information make sense. Additionally, feedback should be constructive and help the player improve.

8.2 Enjoyment in Games

The basis for current literature's understanding of what makes experiences enjoyable mostly comes from Csikszentmihalyi (1990), who spent 20 years studying the phenomenon in different settings and with a diverse set of people. His findings revealed that the state of mind during the experience is what makes it satisfying. Specifically, an experience is the most satisfying when the person is concentrating enough to be wholly absorbed in what they are doing. The concept of *flow* was defined through eight major components, and Csikszentmihalyi claimed that interviewees would mention at least one, but often all, when describing their most positive experiences.

1. *We confront tasks we have a chance of completing*
2. *We must be able to concentrate on what we are doing*
3. *The task has clear goals*
4. *The task provides immediate feedback*
5. *One acts with deep, but effortless involvement, that removes from awareness the worries and frustrations of everyday life*
6. *One exercises a sense of control over their actions*
7. *Concern for the self disappears, yet, paradoxically the sense of self emerges stronger after the flow experience is over*
8. *The sense of duration of time is altered*

Csikszentmihalyi, 1990

These components indicate that the most significant potential for enjoyment lies in structured activities where the participant has a good overview of how they are doing and what to do next. Furthermore, such activities allow them to reach the necessary mindset to be wholly concentrated on the task at hand, forgetting the world around them to the point of losing track of time. In fact, Csikszentmihalyi states that the enjoyment from such experiences is rewarding enough that people are willing to spend a considerable amount of energy and resources to feel it.

8.2.1 The GameFlow Model

> "*Player enjoyment is the single most important goal for computer games. If players do not enjoy the game, they will not play the game.*"
> Sweetser and Wyeth, 2005

The above quote was the motivation of Sweetser and Wyeth (2005) to develop the GameFlow model by adapting the concept of flow to games. They argued that the current literature (in 2005) mostly viewed usability in the light of the technical aspects of games instead of focusing on player enjoyment. In response, they developed a model to measure if and how players might enjoy a specified game. GameFlow is mainly a tool meant to analyse existing games but can be helpful if considered during game development. The model consists of eight elements, each with specified criteria. However, the authors have stated that some criteria are more or less applicable depending on the genre and type of the game in question.

The first element of GameFlow is *concentration*, which states that concentration should be needed to play the game and that players should not lose concentration while playing. Criteria for this element include that the game should grab the player's focus at the beginning of the game, that there should not be tasks that feel like a burden and that the players should have a high workload without getting overwhelmed.

Secondly, *challenge* asserts that the game needs to be challenging for players regardless of skill level. They reason that too great a challenge induces anxiety, while too small a challenge leads to apathy and boredom. The measuring criteria for this element centre around tuning the challenge to the player's skill level and increasing the challenge as the player gets better at the associated skills. Parallels can be drawn between this element and Malone's challenge characteristic.

The third element, *skills*, focuses on facilitating the development and mastering of skills. The player learning and improving through gameplay is ideal. Additionally, using button mappings and game mechanics the player is familiar with makes this process easier. This element is the one with the most criteria (7). Among these are the criteria that learning the game mechanics should be enjoyable and should feel like playing the game rather than reading a manual. Effort should also be awarded appropriately.

The next element measures how much *control* the player has over in-game matters like their avatar and more technical matters like the button mappings. Players can get frustrated and helpless if they feel control is being taken away from them. This element is measured through criteria stating, among other things, that the player should feel in control of their avatar. They should feel like their actions matter and be supported in recovering from errors, though ideally, errors should not be possible. Additionally, the players should feel like they can play the game their way and not be forced to play how the developers intended.

Further, they present the element of *clear goals*, with only two criteria. The first states that clear and overarching goals should be communicated early to guide the player in the right direction. While the second expresses that subgoals should be used appropriately to keep the tension and motivation while the player works on the main goals.

Feedback follows, being presented as a means to keep the concentration going and to give the players an overview of their progress. Criteria for this element describe that actions should trigger immediate feedback, that the players should receive feedback on their progress, and that the player should always be aware of their score and status.

The next element, *immersion*, is based on the established flow element that implies that players should be so involved in the game world that they lose track of the real one. This immersion should be effortless yet deep. The stated criteria of this element describe flow in that the player should be less aware of their surroundings, less self-aware and have an altered sense of time. Additionally, the players should feel emotionally and viscerally involved in the game.

Lastly, Sweetser and Wyeth state that *social interaction* should be supported. This element is different from the others in that it is not an element of Csikszentmihalyi's concept of flow. Fur-

thermore, it can sometimes disrupt the immersion players feel by reminding them of the real world. However, it is included in GameFlow because many players enjoy it and seek it out. The criteria state that games should support competition, cooperation, and social interaction between players. Games should also support social communities within and outside the game.

8.2.2 Summary of Enjoyment in Games

The concept of flow describes commonalities between memorable experiences of enjoyment that people spend a lot of effort and energy trying to replicate. The GameFlow model adapted this concept to analyse if and how games are enjoyable. It consists of eight elements, some more or less applicable depending on the genre. The elements are concentration, challenge, skills, control, clear goals, feedback, immersion and social interaction. Although the latter is not an element of flow, many players enjoy it and seek it out.

8.3 Reward Systems

H. Wang and Sun (2011) studied how games reward the player to "foster intrinsic motivation while giving extrinsic rewards". They investigated the social functions of rewards while keeping in mind that different player types are motivated by different types of rewards.

8.3.1 Reward Forms

Eight distinct reward forms were defined, though the authors clarified that the list is incomplete and only represents the main commonalities. The first reward form, *score systems*, displays the player's performance with numbers. Malone used this reward form when making his characteristics for good computer games. Though it is rare for scoring to affect gameplay directly, it is often used to give the player an understanding of how they performed, allowing them to compare themselves to other players more easily.

Secondly, *experience point reward systems* show progress through unlocking new abilities and increasing attributes. This reward form is often used in RPGs, where the player avatar earns experience points and levels up to get more powerful as the game progresses. However, as experience points are accumulated through time and effort rather than skill, this reward form is rarely used to rank players.

Thirdly, *item granting reward systems* motivate players by rewarding them with in-game items or equipment. Such items are often meant to keep the player motivated between exciting plot points and goals, and rare items are often seen as a status symbol among players who recognise the effort needed to get said items. Especially MMO players will spend considerable time and money gathering items. Depending on the game, items can either directly impact gameplay by making the avatar or player stronger or can be motivating solely based on their appearance and bragging rights.

The next reward form revolves around *resources*, which, while collected to affect gameplay similar to items, are mainly used for practical in-game purposes and are not considered impressive by other players. An example is an RPG where the player must collect a certain amount of steel (resources) to craft a rare sword (item). Though resources lack the social status and feeling of progression, players often spend a lot of time and money (in-game or real) gathering them.

Further, *achievement systems* grant players titles in-game or on the game launcher platform when they fulfil specific criteria. Achievements do not direct gameplay but are used to show that the player did something challenging, played in a certain way or explored the game world. In light of Malone's criteria, achievements count as metagoals. There is social status in earning particularly challenging achievements, and some players find motivation in collecting all of them.

Feedback messages, similarly to the feedback element in the GameFlow model, consists of instant

rewards to praise the player for doing something right or well. They are not persistent and cannot be collected or shown off. Neither do they affect gameplay. However, they provide the immediate feedback described in flow and can affect the player's emotions. Despite the message part of the name, feedback messages can consist of video, audio, images, and text.

The reward form *plot animations and pictures* rewards the player for reaching momentous events. Usually, this celebrates reaching a new milestone, like overcoming a difficult obstacle or ending the game. The primary purpose of this reward form is to motivate the player to advance the story and to provide fun through aesthetically pleasing visuals and audio. However, long animations can be a double-edged sword, as some players prefer to skip them to return to the gameplay.

Lastly, *unlocking mechanisms* limit access to certain game content until the player meets the specified requirements. Examples include getting access to competitive game modes when the player reaches a certain level in MMOs or unlocking a special mini-game once they complete all the regular levels in a puzzle game. This form gives players something to work towards and look forward to while catering to Malone's concept of invoking curiosity by withholding information.

8.3.2 Reward Attributes

Different player types respond to rewards differently and prefer some reward types over others. To analyse this further, four reward attributes were defined. Firstly, *social value* encapsulates rewards that can be used for comparison or in social interactions. H. Wang and Sun consider score systems one of the best reward forms for this attribute, as scores are easy to compare and present. Items and achievements are also easy to show off in-game or in other ways, like social media.

Secondly, *how awards affect gameplay* will attract different types of players. As discussed when presenting the reward forms, their effect on gameplay varies from having no impact to advancing a game or unlocking new content. The authors point out that observing what rewards players seek out and work towards helps categorise players into Bartle's player types. For example, where a person in the killer player type will focus on developing their character and overcoming obstacles, a socialiser will want the attention of other players and will seek out social interactions rather than game progression.

Next is the reward's *suitability for collection and review*. This attribute revolves around how easy it is to present and review the reward and how it contributes to a sense of accomplishment and nostalgia if looked back on. A collectable the player can look back on will facilitate a sense of completion and perfection that players often seek out.

Lastly, the *time required to earn or receive a reward* can give the player a sense of accomplishment and value if done right or make them give up and stop playing if done poorly. It is challenging to balance, as players have different expectations and willingness to wait. As mentioned when discussing Malone's challenge characteristic, a single game can have different timings and values of rewards and challenges. Immediate feedback might stave the player over so they can hold out and feel more satisfied when they reach a more momentous achievement later.

8.3.3 Classification of Reward Usage

Players use rewards differently and value some rewards over others. H. Wang and Sun categorised this reward system through a duo-axis system of reward usage, consisting of the *self* versus *others* axis and the *progress* versus *casual* axis (Figure 13). They stress the importance of having a flexible reward system that caters to all four categories and, therefore, different types of players. The 'Self' part of the first axis refers to players primarily motivated by individual play, while the 'others' part focuses on motivation through social rewards. 'Progress' refers to the more hard-core mindset of players who spend much time on the game and are motivated by factors like progression and achievements. On the other hand, 'casual' is based on casual players, as the name suggests. Specifically, casual players play shorter sessions and are not expected to be as motivated by getting more skilled and gaining rare items or achievements.

Where 'self' and 'progress' meet is the category *advancement*, which prioritises rewards that make the game progress, making the players feel like their skill is improving. The next category is *review*, which combines 'self' and 'casual'. 'Review' focuses on players who are motivated by looking at their collection of achievements and items. These players enjoy seeing their avatars wearing the rare items they have earned and watching the animations they unlock when reaching milestones. Using rewards to represent memories of game events is important to them. *Sociality* is between 'others' and 'casual' and promotes rewards that enable socially motivating activities like showing off to other players and sharing information. Lastly, *cooperate/compete* lies in the intersection of 'others' and 'progress' and focuses on helping others by trading and sharing or using rewards to better compete against them.

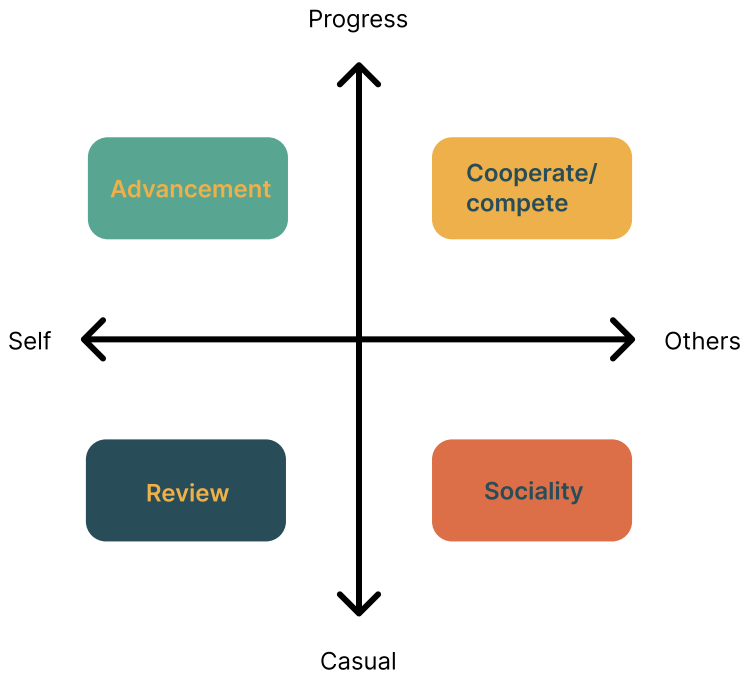


Figure 13: Classification of reward usage. Based on the diagram from H. Wang and Sun (2011)

8.3.4 Summary of Reward Systems

H. Wang and Sun (2011) looked into how rewards can foster intrinsic motivation. To this end, they present different reward forms that are common in games but are not to be considered a complete list. Additionally, four reward attributes help to understand what different player types like about the different reward forms. The attributes consist of social value, how rewards affect gameplay, suitability for collection and review and time required to earn or receive a reward. Lastly, a duo-axis classification system impresses the importance of catering to all player types by including rewards for each category.

8.4 Summary of Game Design Theory

In summary, several game design principles should be considered when designing a video game, especially when the game depends on the player being motivated to keep playing, like exergames. Firstly, the game's challenge needs to be supported by clear subgoals or metagoals rooted in the fantasy provided by the game. Victory should not be guaranteed; however, the player should not feel overwhelmed or unable to complete the task. The difficulty level can either be chosen manually or dynamically. The player's understanding should also be challenged, not just their skills, to provoke curiosity. Sensory elements like audio and visual effects increase sensory curiosity while selectively revealing information and giving randomised, surprising, and cognitive feedback promotes cognitive curiosity.

The GameFlow model can measure the potential for flow, and therefore enjoyment, in games. Ideally, the player should be able to concentrate on and be immersed in the game enough to lose track of time and the world around them. The challenge should be balanced with the player's skill to avoid apathy or anxiety. The player should feel in control as much as possible, from controlling their avatar to the more technical aspects like button mappings. Social interaction should also be supported through in-game mechanics or by encouraging the players to create social communities outside the game.

There are many different types of rewards, which are valued differently by different players. If a game aims to target specific player types, it is vital to utilise rewards that appeal to them. Clear lines can be drawn between the different player types (Figure 11) and the classification of rewards usage (Figure 13). When designing the game concept for this project, it will be vital to choose reward forms that fit the intended audience, as the chosen reward forms will directly impact the motivation and enjoyment of the game.

9 Exercise Theory

Exercise is defined as "bodily exertion for the sake of developing and maintaining physical fitness" (Merriam-Webster, 2022). Park et al. (2020) express that a sedentary lifestyle can increase all-cause mortality and cardiovascular disease mortality while also increasing the risk of getting cancer, metabolic disorders, musculoskeletal disorders, depression and cognitive impairment. Additionally, they state that one-third of the world's population over the age of 15 engages in insufficient physical activities. However, even just one moderate exercise session a week has been shown to positively affect aerobic capacity, cardiovascular fitness, power and muscle strength (Hiruntrakul et al., 2011).

The Norwegian Institute of Public Health (FHI) and Norwegian Directorate of Health recommend that children and teenagers engage in at least 60 minutes of moderate- to high-intensity physical activity each day (Nystad, 2022). For adults, they give a weekly recommendation of 150 to 300 minutes of physical activity with moderate intensity, 75 to 150 minutes of physical activity with high intensity, or a combination of the two. In a mapping survey made by FHI and the Norwegian School of Sport Sciences (NIH), Hansen et al. (2023) found that 75% of the participants satisfied the minimum recommendation of 150 minutes of physical activity in a week, which is a slight increase from the earlier two surveys released in 2009 and 2014. The report also comes with an increased recommendation of 300 minutes of physical activity a week for adults who spend more than 8 hours a day sedentary. Only 30% of those seated more than 8 hours a day (80% of all participants) satisfied the increased recommendation.

9.1 Exercise Measurements

Heart rate (HR) and max heart rate (HR_{Max}) are often used to measure exercise intensity. For this thesis, these measurements will be used to compare the intensity levels during the different experiment sessions. HR is the number of heartbeats per minute, while a person's HR_{Max} is the maximum amount of heartbeats per minute possible for that person. During exercise, it is usual to measure HR with a heart rate monitor and compare it to HR_{Max}, which has either been measured by performing an HR_{Max} test or by an estimate based on a person's age. The standard estimation is $220 - age$, so an estimate for a 23-year-old's HR_{Max} is $220 - 23 = 199bpm$. This estimation is rough, and a new estimation was found during the third health examination in Nord-Trøndelag, HUNT3 (Nes et al., 2013). NTNU measured the HR_{Max} of 3320 healthy women and men between the ages 19-89 and found that a better formula which can be seen in Equation (1).

$$HR_{Max} = 211 - 0.64 * age \tag{1}$$

This means that a better estimate for a 23-year-old's HR_{Max} would be $211 - 0.64 * 23 = 196bpm$. The second estimation equation will be used during the user tests for this thesis. Based on percentages of HR_{Max}, there are different Heart Rate Zones that represent different intensity levels. There are no set definitions of the zones and how many there are, but Polar (2020) defines five zones (see Table 2). It is important to note that the Norwegian Directorate of Health's definition of moderate intensity is not the same as Polar's definition of moderate intensity. The Norwegian Directorate of Health defines *moderate intensity* as an activity that causes faster breathing than usual, for example, walking fast. This would then include Zone 2 and Zone 3 in Polar's definitions. The same goes for *high intensity*, which includes Zone 4 and Zone 5.

Table 2: Definition of HR zones based on Polar (2020)

Zone	Intensity	Percentage of HR_{Max}	Description
Zone 1	Very light	50–60%	Exercise in this zone can improve recovery and prepare the body for exercise at a higher intensity.
Zone 2	Light	60–70%	Exercise in this zone can improve endurance, increase fat burning and improve muscular fitness. This is a zone that the heart can endure for a long time.
Zone 3	Moderate	70–80%	Exercise in this zone can improve blood circulation in the heart and skeletal muscles. This is the zone where the lactic acid starts to build up.
Zone 4	Hard	80–90%	Exercise in this zone can improve speed-endurance and increase the levels of lactic acid a person can withstand. Additionally, the body can get better at using carbohydrates for energy.
Zone 5	Maximum	90–100%	Exercise in this zone will have the heart, blood and respiratory system working at their max capacity. A person can stay in this zone for a limited amount of time because of the lactic acid building up.

Another helpful measurement used in exercise research is aerobic capacity, VO_{2Max}, the maximum amount of oxygen your body can effectively use during intense exercise (Patel et al., 2017). When a person breathes in oxygen, it is transferred to the muscles via blood pumped from the heart. In the muscles, oxygen and glucose work together to create adenosine triphosphate (ATP), which fuels the muscles. Since the muscles require more fuel during exercise, the heart needs to pump more blood, increasing the heart rate. In addition, the higher a person's aerobic capacity, the higher intensity is needed to increase their heart rate, as the body can more effectively use the amount of oxygen transferred per beat.

9.2 Exercise Categories

U.S. Department of health and human services (2006) split physical exercises into three categories: aerobic, anaerobic, and flexibility. To limit this project's scope, only aerobic and anaerobic exercises will be discussed. According to Kvam (2020), *aerobic exercise* is exercise "with oxygen". This means the exercises focus on getting the heart to pump oxygen-rich blood to the muscles, which is usually achieved by more extended periods of exercise of moderate to high intensity. Examples of aerobic exercise are biking, jogging and skiing. Aerobic exercise can be used to improve cardiovascular endurance and aerobic capacity.

On the other hand, *anaerobic exercise* is "without oxygen" and is an exercise with short bursts of high intensity. During anaerobic exercise, the muscles are forced to work without enough oxygen, so lactic acid will be produced faster than the body can get rid of it. Therefore, anaerobic interval exercises usually have short intervals of high intensity (20-45 seconds). Furthermore, intervals should not be longer than 75 seconds since that is when the aerobic system kicks in (Gastin, 2001). Examples of anaerobic exercise are strength and resistance training, sprinting and high-intensity interval training (HIIT), focusing on building muscles. Studies have also shown that anaerobic exercise can improve the cardiovascular system (Patel et al., 2017).

Helgerud et al. (2007) compared four different training methods to see which would be most beneficial for increasing aerobic capacity by testing the difference in absolute VO_{2Max} before and after training. The four training methods were:

1. *Long slow distance running*, where participants ran for 45 min with a heart rate of 70% of HR_{max}.
2. *Lactate threshold running*, where participants ran for 24.25 min at lactate threshold (85% of HR_{max}).
3. *15/15 interval running* (15/15), with 47 repetitions of 15s intervals at 90-95% HR_{max} and 15s of active rest at 70% HR_{max} between each interval.
4. *4x4 interval running* (4x4), with 4 repetitions of 4 min intervals at 90-95% HR_{max} and 3 min of active rest at 70% HR_{max} between each interval.

Method 2-4 also included a 10 min warm-up and a 3 min cooldown, both at 70% HR_{max}. The study showed that in the 15/15 interval group VO_{2Max} increased by 5.5% and in the 4x4 interval group VO_{2Max} increased by 7.5%. In the test groups for long slow distance running and lactate threshold running there was no apparent change in VO_{2Max} (Helgerud et al., 2007). This study shows that if the goal is to improve aerobic capacity, interval exercise is the superior method, with 4x4 being more beneficial than 15/15. While this study was performed on a treadmill at a 5.3% upward incline, the results can be transferred to other types of interval exercise like cycling. In addition, studies have shown that health benefits from indoor cycling include improved blood pressure and the ratio of fat, bone, and muscle in the body, in addition to the benefits achieved during aerobic or anaerobic exercise (Chavarrias et al., 2019).

9.3 Warm-Ups

Warm-ups are an essential part of an exercise session and are recommended to prevent injuries and prepare the body for exercise (Woods et al., 2007). There are two types of warm-ups: passive and active. *Passive warm-ups* are defined as warming up the muscles by external means, like heating pads or warm showers. *Active warm-ups* are defined as performing physical activities. These can be general activities like jogging or cycling, or specific activities related to the exercise session that produce a mild sweat but are not too exhausting. Specific warm-ups have been shown to be more effective than non-specific warm-ups, as they mimic the upcoming exercise activity.

9.4 Summary of Exercise Theory

Exercise is defined as physical exertion to develop or maintain physical fitness. However, studies show that one-third of the world's population exercises less than recommended, which may lead to health risks. For this thesis, this means that more engaging and motivating forms of exercise are needed to engage people that are not motivated by what is currently available. To compare the exercise given by the prototype to known forms of exercise, the measurement and calculation of *HR* and HR_{Max} are needed. In addition, different heart rate zones can be used to compare the *HR* graphs after the experiment. Furthermore, studies have shown that 4x4 interval training has the most effect on aerobic capacity, which is helpful when designing an exercise-based game. In addition, an exercise session should include a warm-up in order to prevent injuries.

10 Exergame Theory

Several different definitions of exergames exist. Some understand it as exercise combined with video games, while others prefer it as exertion and video games. Oh and S. Yang (2010) proposes this definition: "An exergame is a video game that promotes (either via using or requiring) players' physical movements (exertion) that is generally more than sedentary and includes strength, balance, and flexibility activities." Avoiding the use of the term exercise in the definition is intentional, as it implies "the intention to maintain or improve fitness". With this definition, a player can play an exergame without the intention of working out but get the health benefits as a bonus. Because of this combination of video games and exertion, principles of both game design theory and exercise theory should be considered during the design process.

10.1 The DualFlow Model

This idea was developed into a model by Sinclair et al. (2007), who made the Dual Flow model based on Malone's three characteristics of what makes video games fun, the flow concept that GameFlow also based their model on and principles of exercise. As there are both digital (sound and graphics) and physical (equipment or body movements) components to an exergame, the concentration needed to reach a flow state is split. It is recommended that the game either has simple digital elements to put the focus on the physical aspects or that the physical equipment is intuitive enough that the player can focus on the gameplay. An exercise bike is used as a typical example of the latter.

Sinclair et al. argued that for an exergame to have enough health benefits, the exercise gotten through playing must have enough effectiveness. Otherwise, the player might as well be playing a regular video game. Additionally, since exercise needs to be done regularly and frequently, the game must be fun enough that players will keep returning to it (which Sinclair et al. have described as the game being attractive to players). With this in mind, they state that making a successful exergame is more complicated than making other games, since there are more factors to balance. This challenge is represented by the two-dimensional model in Figure 14, which illustrates how exergames must be tuned to support a state of flow in both the attractiveness and effectiveness dimensions. The attractiveness dimension shows that too much challenge for a player with too little skill will result in anxiety, while too much skill for the challenge will result in boredom. Too little of both will result in apathy. Similarly, the effectiveness dimension illustrates that too high intensity for the player's fitness level will make the player unable to finish the session. At the same time, too low intensity may decrease the player's fitness level. If both the player's fitness level and the game's intensity are too low, the player might as well have played a sedentary video game. On the other hand, if the axes are adequately balanced, the state of flow in attractiveness will lead to enjoyment and the state of flow in effectiveness will lead to improved fitness (with continuous exercise).

However, it is pointed out that tailoring challenge to skill is harder in exergames, as more external factors affect the player and the rate at which they improve. As such, extensive user testing is not enough to ensure the balance is reached. Sinclair et al. suggests making several difficulty levels for games where the physical elements are in focus, as the digital elements might be simple and cheaper to modify. When the gameplay is in focus, they suggest adapting the game to the player through feedback from the player or by analysing the play style or physical measurements like heart rate.

10.2 History of Exergames

Exergames have existed since the 80s, and an article by Johnson (2008) defines Atari's **Joyboard** from 1982 as the first commercial exergame. The Joyboard was a balance board that functioned as a joystick controller, and only one game was released for it. The board's four-position digital sensor did not offer nuanced control, and a challenge was made among developers to sit on the board without triggering the sensors. While the Joyboard was considered a failure, Atari had more

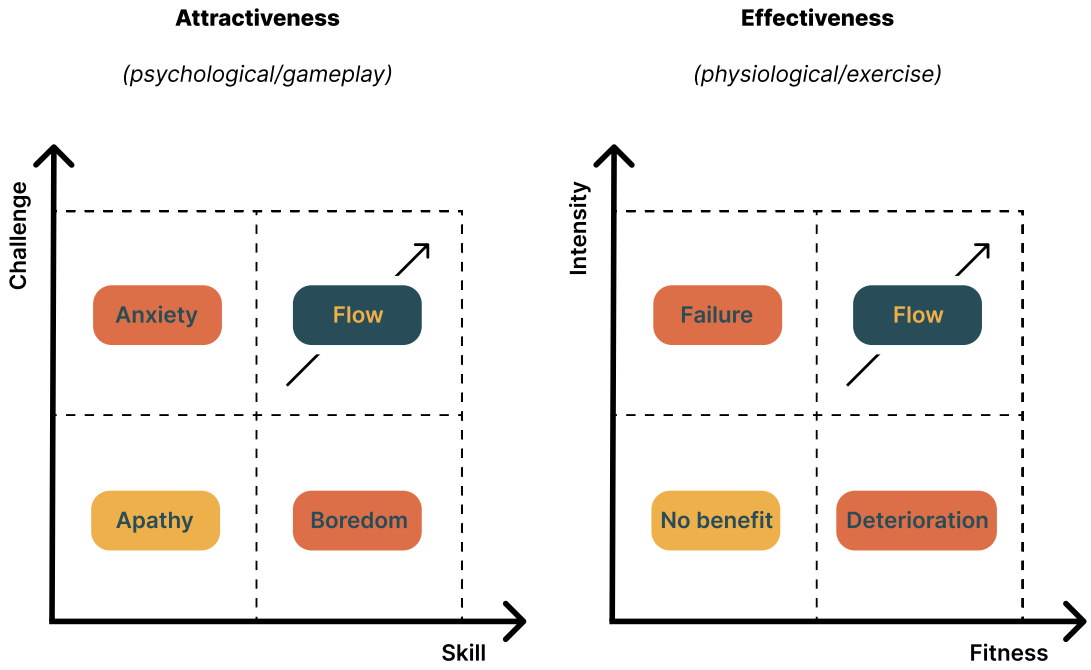


Figure 14: Dual flow model. Based on the diagram from Sinclair et al. (2007)

plans for exergames, starting with the **Puffer system** in 1982. The Puffer system was a range of different exerbikes that could connect to different Atari games, but unfortunately, Atari went bankrupt before the release. However, this was not the end of bike-based exergames, as several projects were released towards the end of the 80s and the beginning of the 90s, like **RacerMate's CompuTrainer** in 1986 and **Tectrix's VR Bike** in 1992. During the 90s and early 2000s, there was a considerable variation of exergames. However, the main one still relevant is **Konami's Dance Dance Revolution** from 1998, which is still being played today by a devout few. In 2006, as described by Overmars (2012), Nintendo launched a new console called Wii, which included the game **Wii Sports**, requiring just the standard Wii controllers in order to play. In 2008 they released **Wii Fit** with more exercise-based games, but this game required a balance board. Microsoft and Sony responded to the success of Nintendo's Wii controllers and launched **the Kinect system** in 2010 and **the Move system** in 2010, respectively. With the growth of mobile-based games in the 2010s, more mobile-based exergames got released, like **Pokémon Go** in 2016 and **Zombies, Run!** in 2012. In addition, better access to Virtual Reality (VR) headsets has also allowed VR-based exergames to gain ground (Bown et al., 2017). An example is **Beat Saber** (from 2019), likely becoming even more relevant after 2020 as the pandemic forced gyms to close, and people needed to exercise at home.

10.3 Summary of Exergame Theory

In summary, exergames have a relatively long history, with an uptick of interest in recent years due to the pandemic. However, creating a balanced exergame can be more challenging than a regular video game. In order to make an enjoyable exergame, the Dual Flow model can be used. It illustrates the needed balance in two dimensions: attractiveness (digital challenge versus skill) and effectiveness (physical intensity versus player fitness). While the attractiveness dimension is similar to purely digital games, it is more difficult to balance as physical factors can affect either the skill or challenge aspect. As such, focusing on either the gameplay or the physical elements is recommended. If gameplay is in focus, adapting the challenge based on feedback or analysing play style or physical measurements is suggested. The following chapter will present existing exergames, making it possible to evaluate whether this theory is implemented in practice.

11 Existing Exergames

This chapter explores a few existing exergames on the market and from research projects to build a foundation for discussing the common themes and potential pitfalls. Since most current exercise bike games are relatively similar (simulated bike rides), one of the most popular ones, Zwift, will be described as a representative. The presentation of games will start broadly with commercial games for different exercise equipment. Then the chapter will circle in on games for exercise bikes and more research-based games with similar focuses as this research project, focusing on games specifically for PlayPulse bikes at the end. Despite some of the games not being commercially available, their results will give a better overview of what has been researched previously and what benefits and detriments were discovered.

11.1 Dance Dance Revolution

Dance Dance Revolution (DDR) is a rhythm-based exergame launched in Japan in 1998 by Konami. The game makes the players "dance" by using a gamepad with four arrows (up, down, left, and right), a screen, and speakers (see Figure 15). The players can choose between different songs, and during each song, they see four static arrows on the top of the screen, serving as the goal for other arrows moving upwards towards them. The players must hit the corresponding arrow simultaneously as the moving arrow hits the static arrow to gain points. While the game started as an arcade game, it has since been made available for ordinary households. As DDR has gained success, several studies have been made over the years regarding how well DDR provides exercise, with one study showing that DDR can be a form of endurance exercise and can help with weight loss (Hoysniemi, 2006). In addition, the study showed that DDR can be a great motivator for people who do not regularly exercise. Another study established that DDR is a motivating, practical and safe way for people with Huntington's disease to exercise (Kloos et al., 2013), while yet another found out that for older people, DDR was a good alternative to enhance cognitive function and was as effective as brisk walking in improving inhibitory control (Chuang et al., 2015).

In 2009 another dance-based game called Just Dance was released, requiring players to match poses and movements shown on the screen. As of spring 2023, there have been 14 primary Just Dance games and several spin-offs and exclusives. In contrast to Dance Dance Revolution, Just Dance does not require a mat but instead requires a camera, controllers or a smartphone that the player holds while dancing. It has been released for all major consoles, making it highly available.

Figure 15: Two people playing DDR. Photo by Runberg (2017)

11.2 Beat Saber

Beat Saber (2022) is a popular VR rhythm and exergame released in 2019 by Beat Games. The gameplay involves cutting incoming cubes in half with lightsabers in time with the music (see Figure 16). Players can choose from a steadily growing collection of songs by the Beat Games team and the extensive community surrounding the game willing to make game levels for their favourite songs. Each song generally offers five difficulty levels: Easy, Normal, Hard, Expert, and Expert+. The game also offers several game modes: Campaign, Solo, Online and Party. *Campaign mode* uses predefined songs, levels with unique challenges and a predetermined learning curve. *Solo* is for self-chosen songs in singleplayer. Similarly, *Online* offers self-chosen songs where the scores are compared to other online players. *Party mode* is the same but with local leaderboards instead. Several research projects have studied the effect of Beat Saber and concluded that it provides aerobic exercise on par with more common methods but in a more motivating medium (Thai, 2019; Kivelä et al., 2019). In addition, Tammy Lin et al. (2022) found that Beat Saber's multi-angle modes can further increase physical activity and enjoyment for players with a greater need for cognition. Beat Saber has also been proven to positively affect the speed and stability of the "hand-to-mouth" movement for people with multiple sclerosis (Pau et al., 2023).

Figure 16: Gameplay of Beat Saber. Screenshot from Swanepoel (2018)

11.3 Ring Fit Adventure

In October 2019, Nintendo launched Ring Fit Adventure, a fitness RPG-based exergame for the Nintendo Switch (Nintendo, 2020). In order to track the users' movements, the game requires a leg strap and a Ring-con, which the Nintendo Switch Joy-Cons can be fastened to. This leg strap and Ring-con can be seen in Figure 17a. The game consists of several modes, but the main one is the *Adventure mode*, where the player can explore a world while defeating various enemies and overcoming diverse obstacles using various exercises. An example of this can be seen in Figure 17b, where the player must squat to gain momentum on a swing. Another mode is *Quick Play*, where the player can choose between mini-games, try to beat previous highscores, and compete against friends. There are also the Simple, Set and Silent modes, where *Simple* allows the player to choose different exercises, *Sets* allows them to choose which muscle groups they want to focus on, and *Silent* chooses exercises that do not require a lot of loud movements. The final mode is *Multitask mode* which allows the player to do pull or press repetitions with the Ring-Con, which can later be synced with the game.

A study from March 2022 showed that using Ring Fit Adventure for 30 min three times a week either improved or maintained an individual user's physical fitness and could therefore help provide a good exercise routine (Wu et al., 2022). Shah and Khatri (2022) researched the effects Nintendo Ring Fit had on core muscle endurance and enjoyment in young adults and concluded that Nintendo Ring Fit offers a more enjoyable form of exercise while improving the muscle endurance of young adults. Another study from 2022 found that using Ring Fit for 45 minutes twice a week over eight weeks significantly changed body composition and fitness for adult women (Suire et al., 2022). This study showed a significant increase in lean mass, bone mineral density, heart rate recovery and handgrip strength for both the dominant and non-dominant hand.

(a) Leg brace and Ring-con for Ring Fit from Nintendo (2019)

(b) Screenshot from Ring Fit Adventure from Nintendo (2019)

Figure 17: Nintendo Ring Fit

11.4 Pokémon Go

Pokémon Go is a location-aware phone exergame made by *Niantic, Inc.* and *The Pokémon Company*, where players can collect Pokémon, battle other players, defeat gyms and complete event-based tasks. The game launched in the summer of 2016 and had a massive success with over 500 million downloads in the first 80 days (Perez, 2016). The game allows users to move around a digital map by walking around the real world (Pokémon Go, 2022). Different sights and landmarks in the real world are marked on the digital map, either as Pokéstops or gyms. At Pokéstops, the players can spin for resources every 5 minutes, and in gyms, players can defeat the current team or add their own Pokémon if their team is currently controlling the gym. As players walk around, Pokémon pop up on their screen, which the players can attempt to catch, as seen in Figure 18. The game also has an Augmented Reality (AR) element when catching Pokémon, as players can turn on their phone camera and watch the Pokémon appear in their surroundings. Players can also battle and trade Pokémon and send gifts to other players, adding a social aspect to the game. A study from 2016 found that among people highly interested in the game, their average daily steps had increased by 25%. In addition, Pokémon Go managed to reach parts of the population with a low activity level, where most fitness apps are only used by people who are already active (Althoff et al., 2016). A systematic review by A. I. Wang (2021) found that Pokémon Go positively affected players' physical, mental and social health, but only as long as they kept playing. They also found that people stopped playing due to technical issues, slow progress requiring more effort, and the content becoming more monotonous. In addition, a study by A. I. Wang and Skjervold (2021) showed that the game had the best effect on unemployed male gamers who were not physically active before they started playing and that Pokémon Go managed to motivate player groups that generally are difficult to motivate.

In 2019 *Niantic, Inc.* released a similar game, Wizards Unite, based on the Harry Potter franchise, but it was short-lived and shut down in 2022 (Gideon, 2022). *Niantic, Inc.* released a new game in 2023 called *Peridot*, which is an AR phone game where players explore the world with magical pets (Peridot, 2023).

Figure 18: Screenshots from Pokémon Go, showing capturing of a Pokémon and a battle between friends. Image from Pokémon GO (2016)

11.5 Exermon

Inspired by Pokémon Go, Exermon was created for a research project to further the research on exergames (Høivik and Olsen, 2016). Exermon is distinct from most other exergames in that it focuses on strength exercises rather than endurance. The gameplay involves evolving a creature (see Figure 19) through various body-weight exercises measured by the proximity and accelerometer sensors on smartphones. The creature can then be used to battle the computer-controlled creatures of other players or strong bosses. The player can buy various boosts with in-game currency and earn badges for reaching various achievements. Detailed instructions are available for each exercise to prevent the player from injuring themselves or getting a less efficient workout. Different game elements were included to support flow, and A. I. Wang, Hagen et al. (2017) found that while most players were motivated by the game, which aspects and game elements they were motivated by varied between the test subjects. Interviews revealed that 50% of the test subjects exercised more due to playing the game. However, the enjoyment of the game descended over time, as the game was lacking in the amount of content. A flaw was discovered where players could fake their results by, i.e. shaking their phones. Similarly, the sensors had occasional problems with detecting the correct player movements, leading players to be frustrated by their unrewarded effort.

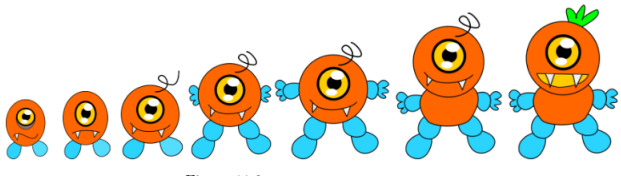


Figure 19: The evolutions of an exermon. Image from Høivik and Olsen (2016)

11.6 PaperDude

PaperDude is a VR cycling exergame prototype based on the arcade game Paperboy. It was created to see if combining head-mounted virtual reality and exergaming could increase immersion while reducing the motion sickness that can occur when using VR. The gameplay consists of players attempting to finish a newspaper route in a suburban neighbourhood. Players score points for throwing the mail into mailboxes and lose points if they crash into obstacles. The biking speed of the player determines the speed of the virtual character. In addition to speed sensors in the bike and the virtual reality headset, the game also utilizes a Microsoft Kinect camera to track the player's arm movements and have the virtual character move accordingly. This is also used to throw the papers, as seen in Figure 20. The Oculus Rift Virtual Reality headset is used to

immerse the player in the game properly. Having the player see the environment around them change according to their movements was seen as a method to create engaging exergames while reducing the motion sickness that certain users experience with VR headsets (Bolton et al., 2014). As of May 2023, no other research has been found documenting the exercise benefits of the game.

Figure 20: Person playing Paperdude. Image from Bolton et al. (2014)

11.7 Zwift

Released in 2014, Zwift is an online cycling game that allows players to train and compete in races against other players in various virtual worlds (Simon von Bromley, 2019). The game has 11 different worlds where users can go on preset routes or bike freely around the map. In addition, the player can use the game for structured workouts or to compete in races. Like some other exergames, Zwift requires special equipment, but in contrast to many, the player can choose the equipment suited to their needs and price range. The necessary equipment includes a bike (standard or a smart bike), an ANT+ or Bluetooth measurement tool (this can be a power meter, a smart trainer or a speed/cadence sensor) and something to run Zwift on (computer, smartphone, tablet or tv). In addition, if the player is using a regular bike, they would also need a set of rollers or a trainer, which are bike stands that allow for indoor biking, as seen in Figure 21. Zwift can also simulate the courses by adjusting the resistance according to the slope, but this requires the user to have a smart bike or a smart trainer. In order to gamify the experience, users can level up as they exercise more, and leaderboards can be seen after courses and races. Players can ride with other players or simulated characters and gain power-ups during courses. Some studies have been done about Zwift, but most focus on doping and cheating (Richardson et al., 2022), and its use during virtual competitive racing (J. Bjärehed and M. Bjärehed, 2022). However, a qualitative study by Westmattelmann et al. (2021) found that Zwift was seen as valuable exercise, and a pro-athlete described it as “a very good training alternative”. Users mentioned the benefits of the social aspect and how they found it positive that they could ride with friends and make connections through the application. In addition, Zwift provides a way to bike on realistic roads without worrying about the dangers of traffic and cars.

Figure 21: Promotional image of Zwift from Zwift (2022)

11.8 Peleton Lanebreak

In February 2022, Peleton launched its first official game, Peleton Lanebreak. The game's goal is to collect points while riding a wheel on a racetrack, as seen in Figure 22. The track has six different lanes, where the bike's resistance determines what lane the wheel is in. The game has three types of challenges that can appear during a round. These will earn the player points and move them higher on the leaderboards. The first challenge is the *Beats* challenge, where points are earned by staying in the right lane and having a cadence (frequency) over 20. The second challenge is the *Breakers* challenge, where the player gains points by 'charging' the wheel by increasing the cadence. The final challenge is the *Streams* challenge, where points are earned by keeping the cadence within a specified range. The game comes with several playlists of varying lengths and music choices, ranging from 5-minute- to 30-minute workouts. In addition, players can choose between four difficulty levels after choosing a playlist, which determines the resistance levels on the lanes (Chris L, 2022b). As of May 2023, no research has been done on Peleton Lanebreak and the exercise benefits of the game.

Figure 22: Gameplay from Peleton Lanebreak from Chris L (2022a)

11.9 Pedal Tanks

Created as part of a master thesis project in 2015, Pedal Tanks is an online multiplayer bike exergame based on the game Capture the Flag. A screenshot from the game can be seen in Figure 23. Players can compete against each other or against a computer in a game with a preset number of rounds, and each round lasts until a team has captured the other team's flag or until the 2-minute timer runs out. The players can choose between various tanks with different attributes and special abilities, which allows players to use various strategies. At the end of each game, experience points are rewarded, and new tanks may be unlocked. The game focuses on strategy and speed, and the combination of this and the variation of tanks helps each round feel unique. The game is controlled via the PlayPulse ONE exerbike (see Section 13.1), where the wheel's speed determines the tank's speed, and six buttons on the handlebars are used for the different abilities each tank offers (Hagen et al., 2015). A prototype of the game was created as part of a master thesis in 2015, and a finished version of the game is now part of the PlayPulse platform (PlayPulse AS, 2023a). Results from the master thesis showed that the participants enjoyed Pedal Tanks considerably more than walking, which was what the game was tested against, with walking earning an average score of 38.9 out of 100 for enjoyment, while playing Pedal Tanks earned an average score of 87.5 out of 100. In addition, participants spent more time playing Pedal Tanks, as their walking sessions had an average length of 17 minutes, while Pedal Tanks had an average play time of 44 minutes. Since 2015, Pedal Tanks has also been used in several research projects on exergaming (J. Berg and Moholdt, 2020; Moholdt et al., 2017). These studies show that Pedal Tanks can elicit moderate-to-vigorous intensities, and therefore it may be a more enjoyable way to experience high-intensity and aerobic exercise.

Figure 23: Gameplay from Pedal Tanks. Image by PlayPulse AS (2023a)

11.10 Lane Rider

Lane Rider was created for the master thesis of Schrøder and Hammersland (2020) and was developed for the PlayPulse bike prototype. Inspired by games like Temple Run and Subway Surfer, the game consists of driving a vehicle along a road while avoiding obstacles and collecting various boosts (see Figure 24). Three difficulty levels can be chosen, with the difference being the frequency of obstacles and boosts. As the game is intended to be a two-player multiplayer game, a speed boost is given to the losing player if they get too far behind, as it can feel discouraging for the losing player if they end up so far back that there is no hope of winning. The game was intended to provide high-intensity interval training, yet their user tests showed that only moderate intensity was reached. There is a possibility that this is because their device for measuring heart rate was reported to be lower than the actual heart rate of the test subjects. The testing also revealed that adjusting the bike resistance played a crucial role in balancing the effectiveness dimension of the DualFlow model, with too high resistance almost making players give up.

Figure 24: Gameplay from Lane Rider. Image from Schrøder and Hammersland (2020)

11.11 2D Boss Fighter

Inspired by the platformer and action game Cuphead, 2D Boss Fighter aims to bring a new type of game to exercise bikes. The game was designed, developed and evaluated in the master thesis of Rand and K. Østvik (2021) and used PlayPulse bike prototypes. The game concept revolves around a fox battling to defeat household technology gone rogue (see Figure 25). It is designed as a two-player cooperation game but can also be played singleplayer. Players are encouraged to pedal faster by connecting pedalling speed to shooting speed, and flying speed if the helicopter backpack is equipped. User tests were performed with 13 test subjects, and it was discovered that the game provides aerobic exercise with moderate to vigorous intensity. However, there were issues with motivating players to be physically active, partly from flaws in the prototype like missing

feedback, repetitiveness and a steep learning curve. An interesting finding in their report is that players were more likely to want to play the game again if they viewed it as entertainment rather than exercise.

Figure 25: Gameplay from 2D Boss Fighter. Image from Rand and K. Østvik (2021)

11.12 WaveRider

WaveRider was created for the master thesis of Sivaranjan and Haltbakk (2022) and is inspired by games like *SingStar* and *Gitar Hero*. The game was created for the PlayPulse bike prototypes, and the goal is to match the wheel's speed to the requested cadence in time with the music. The player chooses a song to play, and throughout the song, the player will encounter three different input types, allowing them to increase their score. The input types are *Single Point Input*, where the player has to match the cadence, *Drag Input*, where the player has to match the cadence for a more extended period, and a *Button Input*, where the player has to press the right button at the correct time. For the first 2, the score is calculated based on how close the registered cadence is compared to the goal cadence, and for the button input, the score is based on the timing. The game has a singleplayer mode, as seen in Figure 26, and two multiplayer modes, both collaborative and competitive. The player starts with a few songs to choose from, all with low difficulty levels, but more songs and difficulty levels are unlocked as they play and level up. The testing showed that the game managed to increase the hear-rate of the players to between 80-95% of their HR_{max} and that the competitive mode was the most engaging. On the other hand, the collaborative mode was the least engaging, partly due to difficulty with communication.

Figure 26: Gameplay from Singleplayer mode in WaveRider. Image from Sivaranjan and Haltbakk (2022)

11.13 Summary of Existing Exergames

To summarise, 12 exergames have been described, and others have been mentioned with fewer details. There are commonalities between the different games. Most games mentioned have elements of the action game genre defined earlier, like quick thinking and accuracy. Social functions are

common and range from simple leaderboards to real-time multiplayer. A potential disadvantage is that most games require specialised technology, with some games like RingFit and Dance Dance Revolution requiring equipment whose only use is playing that specific game. A more thorough analysis of these games will be discussed in Chapter 12.

12 Evaluation of Existing Exergames

This chapter will analyse commonalities and unexplored potential in the abovementioned games. The evaluation will mainly focus on aspects relevant to exercise bike games, which is most relevant to this thesis.

12.1 Game Design Theory

Chapter 10 mentioned the Dual Flow Model as a tool to measure the potential for flow in exergames. It illustrates the necessity of tuning the game's challenge to fit the player's skill (attractiveness) while balancing the intensity of the workout with the player's fitness (effectiveness). Effectiveness is somewhat naturally present in games for exercise bikes by manually adjusting resistance. However, adjusting the challenge to fit the player's skill can be more difficult, especially for the games that simulate bike rides. In these games, riding the bike is the associated skill, which complicates the challenge aspect by introducing physical factors to the usual game design concerns. The most common way of adjusting challenge in the games described, regardless of equipment, is to let the player choose or unlock more challenging levels. None of the mentioned games adjusts the challenge dynamically based on play style or physical measurements, as Sinclair et al. (2007) suggests is the best alternative for exergames. However, some games offer game mechanics the player can improve at without the gameplay getting more challenging, like throwing a pokéball in Pokémon Go.

All mentioned games except PaperDude have some form of social feature, ranging from leaderboards to cooperative or competitive multiplayer; This fulfils the GameFlow requirement of supporting social interaction and might help players get into the flow state easier. It is also likely to increase the motivation to challenge and improve themselves, to better help or defeat other players. In the classification of reward usage, such features fall under the cooperate/compete category. Rewards from the sociality category do not seem as common in exergames.

12.2 Genres

A strong commonality between all the games mentioned is that almost all fall under at least one of the action or simulation game genres. As mentioned, most exercise bike games simulate bike rides in various environments. The remaining few exercise bike games, and games from other mediums, tend towards the action genre. This discovery begs the question of whether it is simply a trend that is hard to break away from or if other genres would be a bad fit. Successful exergames like Ring Fit Adventure and Pedal Tanks delving into genres like RPG and strategy games point to the latter. Not present in the games mentioned are idle games, adventure games and puzzle games. Of the three, idle games seem particularly contrary to exergames, as the gameplay centres around the player being inactive. Adventure games may provide the necessary immersion, but providing enough story to last through a consistent exercise schedule might be challenging. Puzzle games seem promising for use in exergames, as the focus needed to solve the puzzle will satisfy the concentration requirement of GameFlow. As seen in Table 1, puzzle games are the most commonly enjoyed genre, which might lead to the inclusion of players not interested in action or simulation games. However, there is an argument for keeping at least some action traits. The definition of exergames requires reaching a certain intensity level, and gameplay eliciting quick responses from the player is an excellent way to achieve this. Nevertheless, the fact remains that many genres still need to be tested when it comes to exergames. Perhaps new games dipping their toes into other genres might make them compelling and novel enough to stand out.

12.3 Equipment

It should be noted that most of the mentioned games for exercise bikes focus on controlling some vehicle (or vehicle-part in Peloton Lanebreak's case) and that the pedalling speed is often directly connected to the digital vehicle speed. It can be argued that gameplay is more intuitive when what

the player controls in-game resembles the equipment they are using. This sentiment is especially relevant for VR games like Paper Dude, where the similarities between real and virtual equipment help prevent motion sickness. On the other hand, players who are using the game to distract themselves from the fact that they are exercising might not want to be reminded of exercise equipment. If exergames are intended to reach demographics that do not usually exercise, then more subtle exercise might be desirable.

Similarly, having to buy special equipment for a specific game might prevent players from trying the game out. While Beat Saber has the advantage of its required equipment (a VR headset) being marketed to gamers and not exercise enthusiasts, games like Ring Fit require equipment that can only be used for that game. The equipment for games like Zwift and PaperDude can be used for other games; however, it is likely that a player does not have all of the required components when deciding to buy the game. Here the PlayPulse ONE might have an advantage over other exercise bikes, as it offers several games and functions, so the player will not have to buy new equipment per game. Unfortunately, it still requires the player to buy an exercise bike, which they might not do if their primary interest is the games and not the exercise. A possible advantage to buying equipment is that the initial cost might motivate the player to get more use out of what they have bought, making them exercise more regularly.

12.4 Summary of the Evaluation of Existing Exergames

In summary, while the games offer options to balance the DuelFlow Model's attractiveness dimension, none adjust the challenge dynamically based on play style or physical measurements, as proposed by Sinclair et al. (2007). Additionally, the most popular genre, puzzle games, is not present in the reviewed games. However, with a focus on concentration and skill, puzzle games might be ideal for facilitating flow. On the other hand, a potential deterrent for new players is having to buy specific exercise equipment for a game they might not enjoy. Equipment that can be used for more than one game might reduce this barrier to entry. The next chapter will provide more context to this dilemma by presenting different commercial exercise bikes.

13 Commercial Exercise Equipment

Despite the constraint in this project of only having access to prototype PlayPulse bikes, this chapter will introduce competitors and investigate the advantages and disadvantages of using the bikes available. For a fair comparison, the commercial PlayPulse ONE bike is described instead of the limited prototype, as that is what will be available to end users. Although not discussed here, it should be noted that various bike sensors can be used to make a regular bike into an exercise bike, as mentioned in Section 11.7 about Zwift.

13.1 PlayPulse ONE

PlayPulse ONE is the first commercial bike made by PlayPulse. Leading up to this, the first PlayPulse prototype was created for the master thesis Pedal Tanks (see Section 11.9). After three years of using it for research around exergames, the request for a commercial product became clear (PlayPulse AS, 2023b). The PlayPulse ONE bike (PlayPulse AS, 2023a), as seen in Figure 27, boasts three different modes: Exclusive video games, STUDIO mode for more traditional workouts and a streaming mode where entertainment media is displayed as long as the user keeps spinning. Currently, three games are included with the bike, with more games promised to be added to the system later. The included games consist of Pedal Tanks, Helios and Bumper Cars, all based around controlling vehicles but belonging to different genres. During use, exercise data is collected to later display various statistics to the user to illustrate their progress. Currently, the bike is only available for pre-ordering and is estimated to be released in several batches in 2023. Developers are encouraged to make games for the bike and can get their finished games on the system through a review process (Arnkværn, 2022).

Figure 27: The PlayPulse ONE bike. Image by PlayPulse AS (2023a)

The bike can be controlled through pedalling with 'high precision pedal sensors', the touchscreen and controls embedded on the handlebars (Figure 28), which also measures heart rate and gives haptic feedback. Other heart-rate measuring devices can also be wirelessly connected. Additionally, resistance can be adjusted manually or automatically in accordance with what is happening on screen.

Figure 28: Handlebar controls on the PlayPulse ONE bike. Image by PlayPulse AS (2023a)

13.2 Peloton Bike

Peloton Interactive, Inc. (2022) is an American company that creates and sells various exercise equipment and video-based exercise programs. Their equipment includes treadmills, indoor rowers and the Peloton Bike (Figure 29). While this bike also features a screen like the PlayPulse ONE, it mainly focuses on traditional workout videos (live or on-demand) and simulated bike rides with accompanying music. However, their first game, Peloton Lanebreak, was released in early 2022, where the player adjusts the resistance and speed to control a virtual wheel (see Section 11.8). Because the user is not intended to interact as much during workouts, the available controls consist only of volume controls, a touchscreen and a knob to adjust resistance. The more expensive version of the bike also includes automatic resistance adjusting based on the workout class playing. Exercise statistics are also gathered and displayed to the user.

Figure 29: The Peloton Bike. Image by Peloton Interactive, Inc. (2022)

13.3 Expresso

The Expresso bike (Figure 30) from Interactive Fitness (2022) offers three modes of exercise: Cycling on virtual roads, on-demand workout classes and a game mode where the player pilots a vehicle to explore game worlds and gather items in a HIIT-session. The bike is controlled with the touchscreen and by turning the handlebars. Resistance can be adjusted manually or automatically to fit the terrain on the screen. Players are encouraged to compete against themselves and others through displayed statistics and leaderboards.

Figure 30: The Expresso bike. Image by Interactive Fitness (2022)

13.4 Summary of Commercial Exercise Equipment

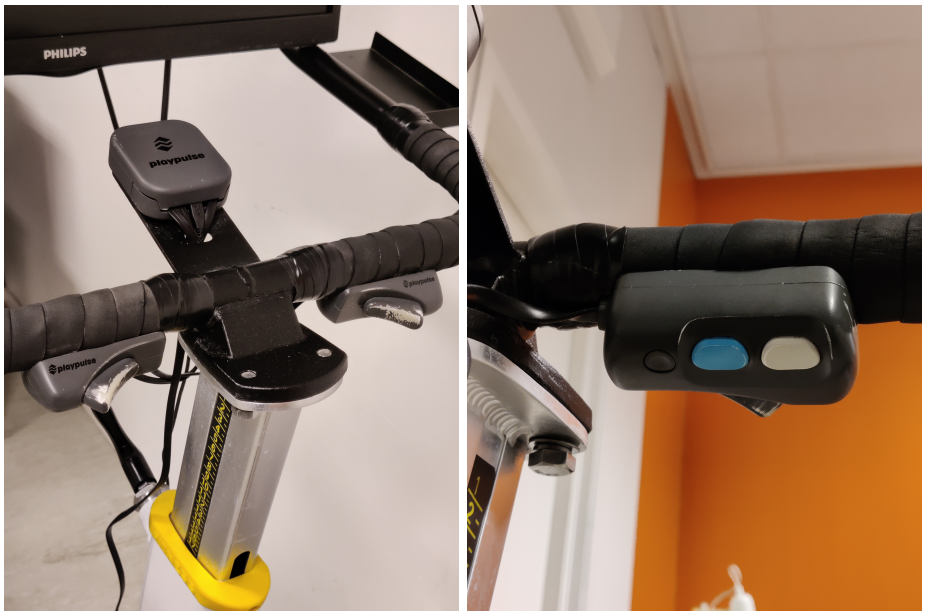
The bikes have many similarities, including touchscreens, adjustable resistance, on-demand workout classes and a gamified workout mode focusing on controlling vehicles. However, the Peloton and Expresso games seem to be either an afterthought or a version of their virtual rides with a few game elements added. On the other hand, the PlayPulse ONE is designed for gaming and offers more varied games, with more games and genres promised in their roadmap. This difference in focus is evident in the available controls, where the other bikes have some added functionality to a regular exercise bike, PlayPulse ONE has controllers more reminiscent of game consoles. This likely makes them appeal more to gamers and gives developers more to work with when designing how players will interact with their game world. Additionally, the PlayPulse ONE is the only exercise bike found during this literature review that provides support for external developers. The next chapter will present the PlayPulse Prototype Bike that will be used for the experiments.

14 PlayPulse Prototype Bike

Figure 31 shows the prototype PlayPulse bike used for the experiments. Appearance-wise, it differs significantly from the commercial PlayPulse ONE bike described in Section 13.1. However, the functionality is mostly the same, with a few limitations. For example, a knob for manually adjusting the resistance is available, but it is not possible to adjust the resistance automatically throughout the game.

Figure 31: The prototype PlayPulse bike available in this project

One of the most significant differences between the PlayPulse ONE bike and the PlayPulse prototype bike is the handlebar controls, as seen in Figure 32. Figure 32a shows the positioning of the two control units on the prototype bike. Similar to the PlayPulse ONE, there is one unit on each side of the handlebars, but the prototype controls are placed beneath the handlebars instead of being a part of them and more to the side. While the PlayPulse ONE controls are similar to console controllers that gamers might be used to, the prototype bike controls are more reminiscent of how gears are selected on standard bikes. There are also fewer buttons on the prototype bike, as seen in Figure 32b. While the PlayPulse One has four digital buttons and one analogue for each control unit, the prototype has three digital and one analogue in different positions.



(a) Handlebar controls can be found on both sides of the handlebars

(b) The handlebar controls consists of an analogue button and three digital buttons

Figure 32: The handlebar controls for the prototype bikes available in this project.

As mentioned, PlayPulse mainly supports games created in the Unity game engine (see Chapter 15), with plans for expanding to other games engines after the official launch (Arnkværn, 2022). The available prototype bikes can be connected to a computer for development by connecting the PlayPulse unit seen in Figure 32 to the computer with a USB cable and connecting the screen as a usual computer screen. The next chapter will present relevant game engines that can be used for building exergames.

15 Game Engines

An essential part of any game development process, and the resulting game, is deciding which game engine is best suited for the task. A *game engine* is a software framework that offers plenty of pre-built functionality and abstractions to let the developers focus on the more unique parts of the game. Not having to reinvent the wheel for every new game makes development much faster and easier. Comparing two of the most popular game engines will offer insight into the advantages and disadvantages of both, allowing for an informed decision. A highly discussed topic in the game industry is whether to use Unity or Unreal Engine, as both are well-known among game developers and players. Thus, they will be the ones discussed in this chapter.

15.1 Unity

Unity (2022) is known for being an easy game engine to learn and use (see the editor in Figure 33). It uses the programming language C#, which shares many similarities with other common programming languages, making it more likely that game developers already know it or can quickly learn it. The game engine is free to use and requires no royalty fees. However, if a business earns more than 100K USD a year, a subscription is required. Since Unity is a popular choice amongst game developers, serving approximately 61% of game developers (Kindig, 2022), there is a large community of people willing to help with problems or create tutorials. Because of this, the Unity Asset Store has over 65K assets available for purchase or for free. Generally, Unity is optimised for mobile games, prototypes or smaller indie games that do not require a lot of processing or heavy graphics. With this focus in mind, their broad list of supported platforms provides welcome opportunities for developers regardless of their chosen platform or intentions to make cross-platform games (Program Ace, 2021).

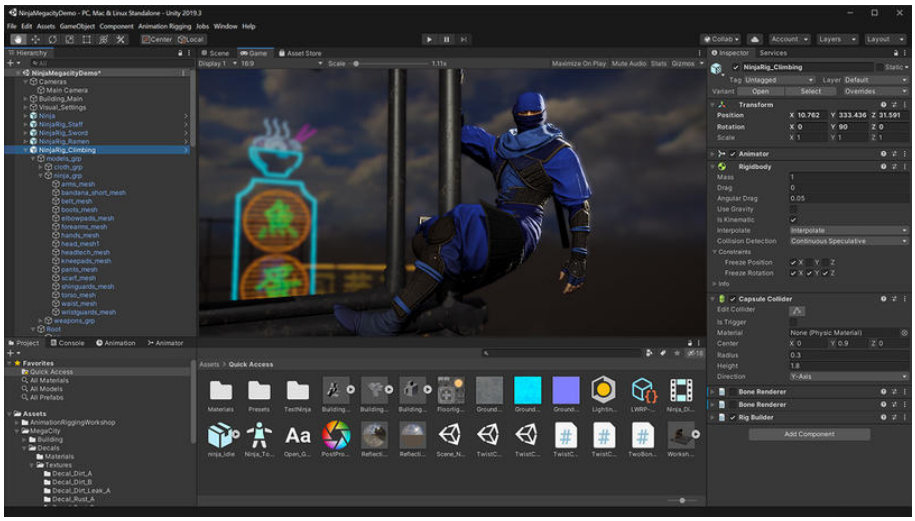


Figure 33: A standard configuration of the Unity editor. Image from Unity Technologies (2019)

15.2 Unreal Engine

Unreal Engine (2022), owned by Epic Games, is known for its beautiful and realistic visual effects and graphics, in addition to quick rendering and processing (the editor can be seen in Figure 34). The focus on processing makes it geared towards AAA games with extensive gameplay and expected playtime. It has a steeper learning curve than Unity, partly from its use of the programming languages C++ and Blueprint (exclusively used by Epic Games). The multi-platform support is slightly less than Unity but still broad enough that most game developers should be unaffected. Unreal Engine has a market share of 13%, which is considerably lower than Unity. This affects the community size that offers help or creates assets to use. However, over 16k assets in the Marketplace

are still a valuable resource. The pricing model is also different for this engine. Development is free, but a 5% royalty fee on all sales is required if the game earns more than 1 million USD (Program Ace, 2021).

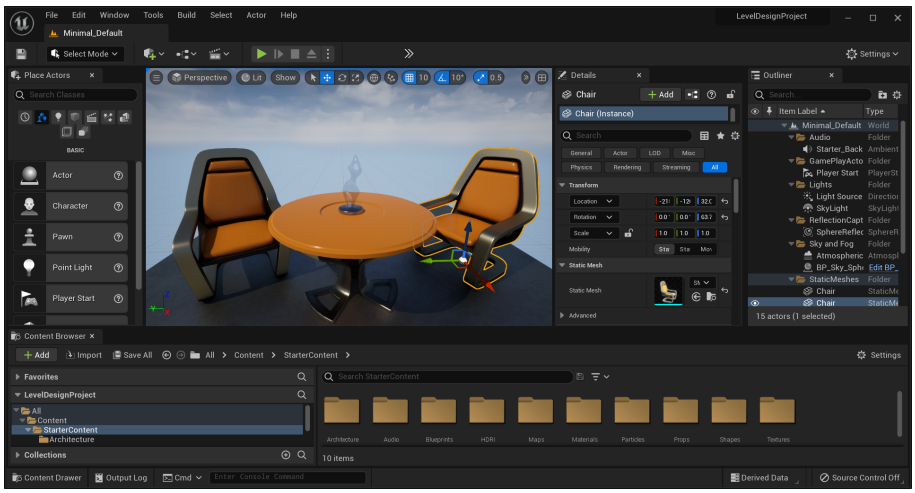


Figure 34: The level editor in Unreal Engine 5. Image from Epic Games, Inc. (2022)

15.3 Summary of Game Engines

As this project's main objective relies on quickly making a prototype to run tests, Unity is the better game engine alternative. This is because the ease and the minimal learning curve are ideal for making the game in a short time frame. In addition, there is neither the capacity nor an intention to develop a process- and visual-heavy game.

16 Summary of Pre-Study

The Pre-Study has consisted of the literature review done for this project and has gone into video games, player types, game design theory and exercise theory before using this to define exergames. The part has also presented existing exergames and game engines and discussed their positive and negative aspects. Additionally, different commercial exerbikes were discussed before comparing them to the PlayPulse prototype bike that will be used during the experiments.

While categorising games into different genres is tricky, nine genres were defined for this project; Action, Adventure, Idle, Party, Platformer, Puzzle, RPGs, Simulation and Strategy games. These genres will be useful when answering **RQ1:** *Are there commonly enjoyed game genres that are not sufficiently represented in the current exergame market?* Based on the Entertainment Software Association (2022) statistics and the existing exergames presented in this chapter, *Puzzle games* is a genre that is both commonly enjoyed and not sufficiently represented in the current exergame market. In addition, puzzle games often require skill and concentration, theoretically making them ideal for facilitating flow.

Malone defined three characteristics of what makes video games enjoyable; challenge, fantasy and curiosity. The concept of flow should also be considered, as it defines commonalities between enjoyable experiences. GameFlow uses this concept to analyse if and why games are enjoyable, and DualFlow looks into the added challenge of physical aspects when balancing exergames. In addition, it is important to include reward systems that cater to all player types. These reward categories are advancement, cooperate/compete, review and sociality.

For the game to facilitate moderate to high-intensity exercise, it needs to get the player's heart rate above 60% of the max heart rate. The formula $211 - 0.64 * age$ will be used to calculate the max heart rate of the participants. Studies show that 4x4 interval training affects aerobic capacity the most and that warm-ups are essential to prevent injuries and prepare the body for exercise.

This project will use a PlayPulse prototype bike, which includes a speed sensor and four buttons for each hand. In addition, there is a screen attached to the bike that allows the player to see the game. In the commercial market, there are several exerbikes with games available. However, only the PlayPulse One was made with gaming in mind instead of supporting games as an afterthought.

The next part will describe the game concepts created based on the theory and insight gained during this Pre-Study.

Part III

Game Concepts

> "*Creativity is not the domain of one single person. Through free-association of thoughts and brainstorming, an accidental suggestion can be the best solution.*"
>
> Joshua Fernandez (1998)

This part will present the final game concept and discuss the method used for generating ideas and other game concepts that were not chosen. First, the method and the alternative concepts are introduced, and then the chosen game concept is described in more detail. This part is based on the authors' specialisation project (Elnan and Stabell, 2022).

To generate game concepts suited to the research project, the Brainwriting method (Paulus and H.-C. Yang, 2000) was used. This method consists of each participant writing down ideas individually, focusing on quantity over quality. After a set time, the ideas are shared with the rest of the group before another individual session starts. In the second session, participants are supposed to use the most interesting ideas from the previous round as inspiration. This continues until the participants are satisfied or for a set number of iterations. Written and individual brainstorming like this allows more reserved participants to get their ideas heard, while the following iterations allow the benefit of group ideation and incubation of ideas. For this Brainwriting session, limitations derived from the hardware inputs and sensors on the exercise bikes had to be kept in mind. In addition, as this research project focuses on new and different genres, the potential game concepts should, at least partially, consist of genres other than action and simulation.

17 Potential Game Ideas

This chapter will introduce the unused game ideas produced during the Brainwriting session. Due to the method of idea generation, some of these concepts are more developed than others. The following sections will mention what advantages and disadvantages their concept presents in the context of this project. While these concepts were not chosen for this project, readers are welcome to use them as inspiration for their own games.

17.1 Instrument Rhythm Game

Based on the 2022 game Trombone Champ (seen in Figure 35), this game concept is about playing different wind instruments, for example, the flute, clarinet, trumpet, euphonium, trombone or tuba. The player uses the pedals to generate air, and to blow, whereas the low-brass instruments, like euphonium, trombone and tuba, require higher cadence to generate tones. At the same time, woodwinds, like flutes and clarinets, have long periods where moderate to high cadence is required. To change notes, the player uses the buttons on the handlebars. Players can unlock more songs and instruments after finishing songs, and when playing multiplayer, players have to choose different instruments.

Figure 35: Gameplay of Trombone Champ from Holy Wow (2022)

The advantage of this game is the authors' connection with several musicians, which would allow for recording notes and scales for different instruments. In addition, the differences between the instruments and the different song choices would allow players to choose their own type of exercise. The game could also score high on replayability, with the variation of songs and instruments, in addition to the unlocking aspects.

The disadvantage of this game is how closely it resembles WaveRider, which was created for research purposes in a similar thesis, as introduced in Section 11.12. As such, the game would likely not be unique enough to produce results that could not be found by simply using WaveRider. In addition, the game might be too specific for users not already in the orchestra or matching band environment. There is also a chance that people in these environments will not enjoy the game, as the mechanics and animations for their instruments are wrong.

17.2 Light Based Two-Player Platformer

This game concept is a platformer where two players cooperate to bring light back to a dark world. The game platforms only exist as long as a light is shined on them, so the players must use their

flashlights to light the path for their partner or find other light sources, like static streetlamps, if their partner cannot help. Using this mechanic, the players must complete different puzzles and levels. This game takes inspiration from other cooperative platformers like Fireboy and Watergirl (seen in Figure 36).

Figure 36: Gameplay of Fireboy and Watergirl: Fairy Tales from Oslo Albet (2021)

However, the concept is difficult to make compelling during this relatively short project since it relies heavily on good level design to make it fun, something none of the authors have much experience with. Additionally, finding an intuitive way to control the game with pedalling might be challenging. Finally, platformers like this can often be solved in different tempos, so planning a good exercise session for each level might pose a problem.

17.3 Trapped in Computer Platformer and Puzzle Game

With inspiration from the game There Is No Game (seen in Figure 37) and stick-figure animations popular years ago (example in Figure 38), this game concept is about being trapped inside a computer screen. The player controls a 2D sprite who can interact with elements on the screen to solve puzzles, for example, by opening useful apps or using a conveniently shaped icon.

Figure 37: Gameplay of There Is No Game: Wrong Dimension from Draw Me A Pixel (2020)

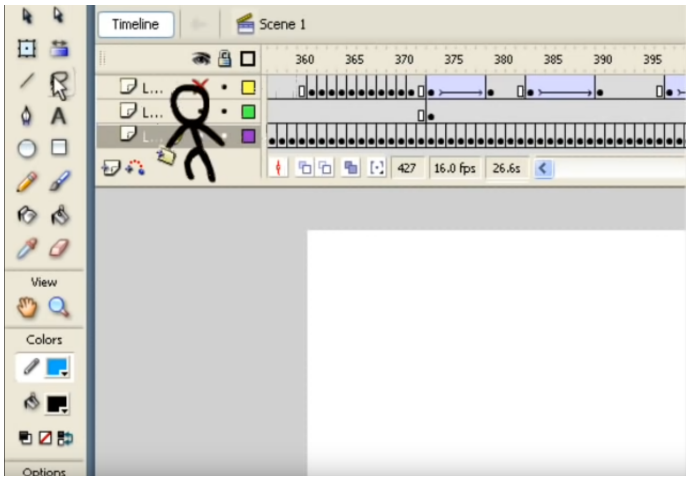


Figure 38: An animated stick figure throws an icon. Screenshot from the video by Becker (2007)

The downsides to this concept are that there is little to no replayability, and it requires a lot of puzzles and story for the player to have enough playtime to get the long-term benefits of the exercise the game might provide. Achieving flow might also be challenging in such a game if the story is the main focus, and the game can be played slowly if the player wants to. There would probably be a need for engaging game features like scoring, timed levels and rewards to promote a playstyle that offers efficient exercise.

17.4 Horror Based Plant Care

This idea is a game where the player has to water and take care of a plant to stop it from waking up and eating the player. The visual inspiration for the plant is Audrey II from Little Shop of Horrors (see Figure 39). Alternatively, the game could be about taking care of a plant so it can protect the players from incoming monsters. The game would have the user complete tasks for the plant by pressing different buttons and either charging up something by pedalling faster or keeping the cadence steady.

Figure 39: Audrey II from Little Shop Of Horrors. Screenshot from Butkovic, Leanne (2020)

By having the game consist of different smaller tasks, it would be possible to gradually make it increasingly difficult to survive. In addition, there is a possibility that the game would have a high replayability factor in the beginning since the players want to see if they can survive longer than their previous session.

The difficulties come from making this game engaging and replayable in the long run. Horror is difficult to create, as it should have good visuals and music to create a good ambience to immerse the player. As this project's time and resources and the authors' experience with horror games are limited, it would be difficult to make a game that would be useful for research.

17.5 Locked in Building Horror Game

This game concept is inspired by horror games like At Dead of Night (seen in Figure 40). In the game, the player runs around a house with a monster trying to kill them. They must avoid the killer by sneaking (pedalling slowly), peeking around corners and running (pedalling fast) to cover. The goal of the game is to collect components needed to fix the lights and banish the monster. To assemble the components correctly, the player's character must stand in an open area and solve puzzles with specific pedalling speeds and button inputs. Mistakes will cause sound and alert the monster. For example, when the player is hiding from the monster, they can hold their breath or hold the door closed by pedalling at a high and specific speed.

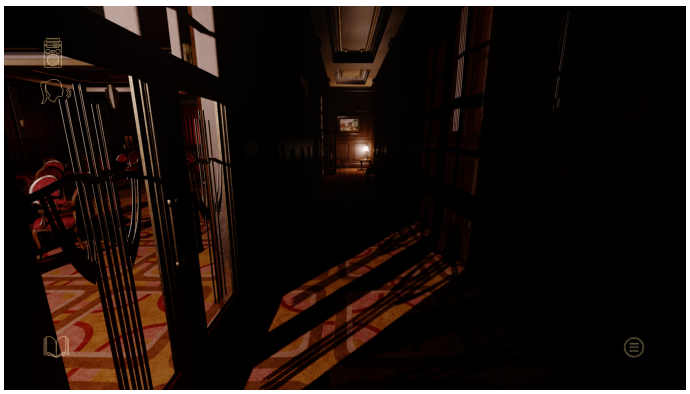


Figure 40: A screenshot from At Dead Of Night by Yu (2020)

This game concept comes with the advantage that the player will most likely be immersed in the game and lose focus on the exercise. In addition, the adrenaline associated with playing horror games will hopefully contribute to raising the player's pulse.

However, this concept has several downsides in regard to this project. Firstly, the visual and audio elements needed to create proper immersion would mean that the development period has to be extended and might potentially cause negative results during the experiments if the players are not immersed. This could lead to the wrong conclusion that horror or puzzles are a bad mix with exergames, when in fact, it was simply the prototype that was lacking. Secondly, a story-based game would likely have limited replayability, an essential aspect of exergames. Lastly, players might physically hurt themselves on the bike if they get jump-scared.

17.6 Summary of Potential Game Ideas

This chapter has introduced the unused game ideas produced during the brainwriting session. The first concept was a rhythm-based exergame similar to the game Trombone Champ and would have the player "play" instruments by biking. This idea was discarded both because it had a high resemblance to a previous master's thesis and because it was aimed towards a particular audience. The second concept was a multiplayer platform puzzle game where players can only step on illuminated areas. The downside of this idea was that it would be too difficult to make compelling during the available timeframe, in addition to having no clear way to include the exercise element. The third concept was inspired by games like There Is No Game. It concerned a 2D sprite being trapped inside the computer and having the player solve different puzzles. This concept was scrapped because of the lack of replayability, as the game would require a long story

and several puzzles to be playable for a long time. The fourth game concept was a plant-based horror game with players solving small tasks to take care of a plant. If they failed, the plant would either eat the player or fail to keep the player safe from other monsters. Again, this concept was discarded as horror is challenging to create, as it needs good visuals and music to create an ambience, which both authors need more experience in to achieve. The final discarded game concept was a game where the player is locked in a building with a monster trying to kill them as they try and solve puzzles in order to get out. Just as the fourth concept, this concept was discarded as horror is challenging to create, in addition to the replayability limitations with story games and the increased possibility of people hurting themselves if they get jump scared. After discarding these five concepts, one concept remained, which will be described in the next chapter.

18 Final Game Concept - FlipBoard

The final game concept is named FlipBoard and is a puzzle game where the goal is to balance a board. This is done through pedalling speed and clicking buttons. The game consists of three different game modes to create a varied and complex enough gameplay to foster replayability and avoid the pitfalls that games like Exermon fell prey to. The precision and skill-based gameplay will hopefully make the player concentrate on the game and help them enter a flow state. With sufficient concentration and correctly adjusted attractiveness and effectiveness dimensions, the players should ideally focus solely on the game and not the exercise they are getting. The game starts with a calibration test, which aims to adjust the effectiveness dynamically in contrast to the exergames discussed in previous chapters. As such, the intensity of the exercise and the achieved heart rate will be tailored to the player's fitness level on the given day. That being said, achieving the advantages this game concept advertises will depend on tuning during development. The finished prototype will have to be tested to see whether the goals of the game concept have been reached.

18.1 Inspiration

The main inspiration for this game concept is the classic labyrinth toy (see Figure 41) from 1946 (Brio, 2022), which is still popular and combines simple mechanics with a high skill ceiling and varied gameplay. The game's goal is to guide a marble through a maze while avoiding holes along the way. The labyrinth had two knobs to adjust the angle of the corresponding axis, which made it possible to tilt the maze in all horizontal directions.

Figure 41: The Deluxe Wooden Labyrinth toy from Ringo: Nordic Toy Team AS (2022)

The Shapes Mode described below is inspired by the shape-sorting toy toddlers play with (Figure 42). Gameplay with this toy consists of fitting objects with basic shapes into similarly shaped holes. The activity improves understanding of basic mathematical concepts like pattern recognition and geometry (Eisenhauer and Feikes, 2009).

Figure 42: Shape sorting toy from QZMTOY (2022)

18.2 Gameplay

The basis of the game is to balance a board while objects fall and land on the board. The board has an *equilibrium cadence*, which the player must match to keep it steady. The *equilibrium cadence* changes between sessions by running a calibration test in the loading screen, which aims to give each player an individual exercise and gaming experience. The game consists of four different steering modes and three different game modes, where one of the steering modes is a cooperative multiplayer mode. The length of each round will vary based on the game mode and the player's skill, but a round should not last more than 4 minutes. The player should also want to play more than one round in a sitting.

18.2.1 Steering Modes

When playing in singleplayer mode, the mechanics to control the board should change between three different steering modes during play. The board will tilt away from the player when the player has a higher speed than the *equilibrium cadence* and tilt towards the player when the player is pedalling slower than the *equilibrium cadence*, regardless of steering mode. As seen in Figure 43, the tilting axis of the board will stay the same, regardless of the board's rotation. The four steering modes are:

- **First steering mode:** The player can rotate the board a set amount of degrees by pressing buttons on the handlebar. Pressing the button on the right handlebar will make the board rotate, for example, 90 degrees towards the right, and by pressing a button on the left handlebar, the board will rotate the same amount towards the left. The number of degrees the board rotates will vary between rounds but will randomise between 30, 45, 60 or 90. In Figure 44, an example of how the board can rotate 45 degrees can be seen.
- **Second steering mode:** This steering mode is much like the first, except the board will rotate continuously when the user presses the button. Same as the first steering mode, the button on the right handlebar will rotate the board towards the right, and the button on the left handlebar will rotate the board towards the left.
- **Third steering mode:** This steering mode will not allow the user to rotate the board but instead introduces tilting on the left-right axis. This tilting is controlled by holding down the right or left button. The longer the button is held, the more downward force is generated on that side. This example can be seen in Figure 45. Figure 45a shows the board when balanced perfectly with a marble on the centre of the board. The player then keeps the same pedalling speed and presses the left button. This results in the board tilting towards the left and the marble rolling in that direction, as if force was applied to that side (Figure 45b). Next, the player increases their speed while still holding the left button down, making the board and marble tilt forward as well as left (Figure 45c).

- **Fourth steering mode:** This is a cooperative *multiplayer mode* where the two players control one axis each. The players play on different screens, and both will still have the same mechanic: the board tilts away and towards them, but they will see the board from different angles, as seen in Figure 46. Here, player 1's left-right axis is equivalent to player 2's forward-backwards axis and vice versa.

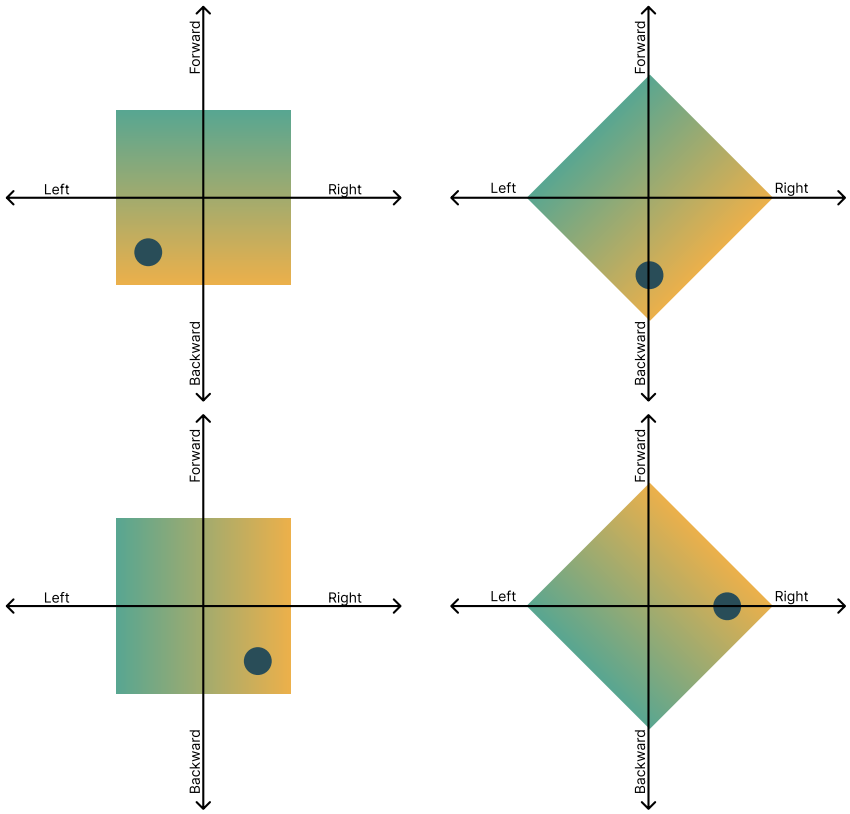
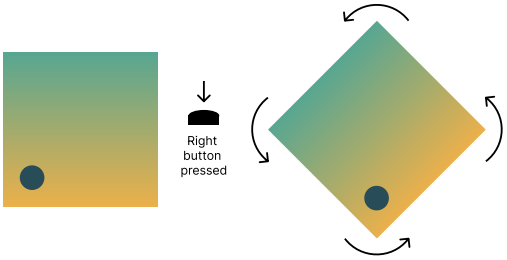
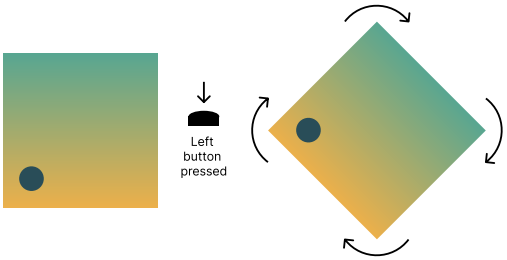


Figure 43: Top-down view of the board and its axis

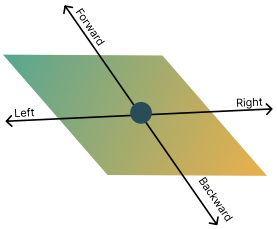


(a) Pressing the right button

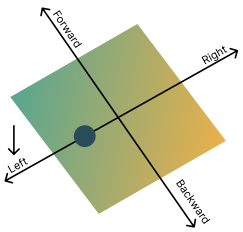


(b) Pressing the left button

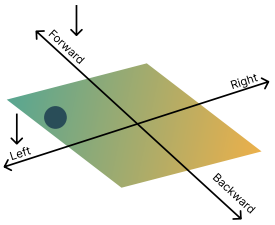
Figure 44: Examples of steering mode one with 45 degrees turns



(a) The board is balanced



(b) The board is flipped left



(c) The board is flipped both forwards and left

Figure 45: Examples of steering mode three. Arrows represent the force applied to each axis.

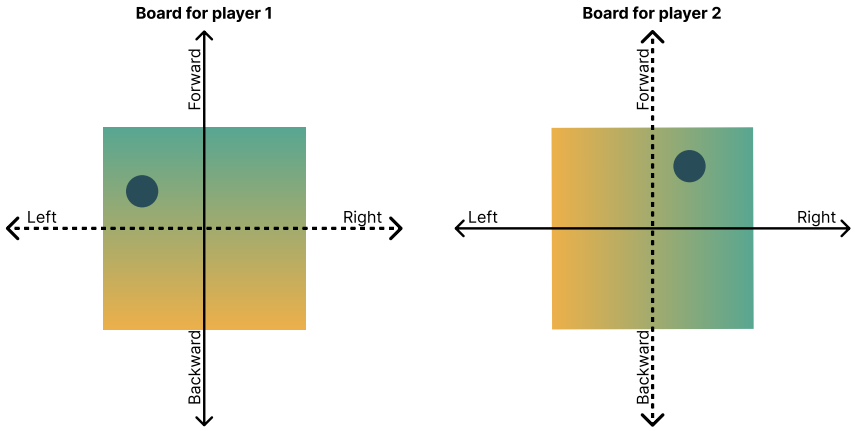


Figure 46: Multiplayer view

18.2.2 Game Modes

The game consists of three different game modes, Balance Mode, Shapes Mode and Marble Mode. Regardless of game mode, the difficulty should increase over time to put a soft limit on session length. The first game mode is *Balance Mode*, where differently sized objects fall on the board, and the objective is to keep the board balanced so the objects do not fall off. The round ends when a certain number of objects have fallen off the board. The second game mode, *Shapes Mode*, takes inspiration from the toddler game mentioned in Section 18.1. Like Balance Mode, objects will appear, but instead of keeping the objects on the board, the aim is to make them fall through holes in the board. Lastly, *Marble Mode* is similar to the maze game mentioned above. The board is shaped like a maze, and the goal is to safely guide a marble to the green-coloured hole at the end while avoiding the red holes along the way. The round ends when the marble goes through the green hole or if it falls through red holes or outside the board a certain number of times.

18.2.3 Calibration Test

On startup, a short calibration test is run to dynamically adjust the exercise intensity to the player's fitness level. This calibration test will be disguised as a sequence where the player must pedal to charge up a loading bar. Ideally, the player should not realise when the game is calibrating to avoid intentionally slowing down and making it easier for themselves. A minimum speed is needed to further protect against tampering and ensure that the cadence is high enough to get accurate sensor readings. The average cadence during the calibration test is used to calculate the equilibrium cadence needed to reach the balance point during the rest of the session.

18.2.4 Additional Features

Additional features should be added to increase motivation or improve the enjoyment of the game. However, it is unlikely that there will be enough time to implement all of them within the planned timetable for the master thesis. The features will therefore be introduced in order of priority. Firstly, local or online leaderboards could introduce more social functions and motivate players to improve their scores. With the same goal in mind, an overview of their stats and equilibrium cadence over time would indicate that they are improving and motivate them to keep playing. Next, power-ups in Marble Mode can create more variety, represent easier subgoals and increase the game's replayability. These power-ups could, for example, include getting an extra life, the ability to jump or a ghost mode to roll through walls or over holes. Similarly, power-downs in Marble Mode could present interesting new challenges. Examples include making the marble smaller or bigger, heavier or lighter, or inverting the controls. Lastly, introducing collectables and achievements could increase the game's presence in the reward classification of advancement, engaging players motivated by seeing their progress and unlocking new rewards. Such collectables could include visually different marbles and boards. Achievements could be triggered by getting a certain amount of points in specific game modes and playing a certain amount of games.

18.2.5 Summary of the Gameplay

To summarise, the gameplay of FlipBoard consists of balancing a board. The game consists of four different steering modes, with the first one being the board rotating a set number of degrees per button push. The second steering mode rotates the board continuously as long as the user is holding the button down, and the third steering mode tilts the board on the opposite axis of the speed-based tilting. Finally, there is a multiplayer steering mode, where two players control one axis each and work together to balance the board. The game also consists of three different game modes. The first mode is *Balance Mode*, where the goal is to balance items on the board, and the player loses lives each time an item falls off. Secondly, there is *Shapes Mode*, where the goal is to get the items to fall into differently shaped holes in the board. Finally, *Marble Mode* consists of navigating a marble through a maze and getting the marble to a green hole while avoiding the red holes. In addition, the game includes a hidden calibration test to adjust the session's intensity.

To increase motivation or improve enjoyment, additional features should be implemented if there is time. These extra features include power-ups and power-downs in *Marble Mode*, leaderboards, statistics, collectables and achievements.

18.3 Application of Theory

This section will cover how the game concept relates to the knowledge and discoveries covered in Part II.

18.3.1 Game Design

As this game concept is primarily a skill-based puzzle game, the explorer player type is among the target audience. However, the game also supports other player types, as the player types are generalisations, and players might not necessarily fit into just one player type. Achievers might enjoy the feeling of progression in competing against themselves in singleplayer and might find the planned reward forms of a scoring system and achievement system appealing. On the other hand, the multiplayer elements of the game appeal to players interested in interacting with other players, like Bartle's killers and socialisers.

For this concept, all three of Malone's characteristics for enjoyment in video games are accounted for. Cognitive curiosity can be encouraged through the puzzles and the player's desire to solve them successfully. Visual simulation, background music and sound effects will provoke sensory curiosity. Since the fantasy of the game world both affects how the player uses their skills and is affected by them, it falls under Malone's definition of intrinsic fantasy, which will provide a more fulfilling and exciting experience. Additionally, the challenge aspect is present through meta goals like improving a personal score and through subgoals provided by the achievement system.

In addition to the explicit goals of these subgoals, the challenge will be adjusted by scaling the difficulty as the game progresses, which will hopefully balance challenge and skill enough to enable the players to enter a flow state. Due to the high concentration needed to solve puzzle games, the player will likely be concentrated and immersed enough to lose track of time and their surroundings. To avoid immersion-breaking frustration, the game should allow the player to control the button mappings and settings like audio volume. As mentioned, social interaction is also supported, with the option of avoiding it for players who prefer singleplayer games.

The hidden calibration test will hopefully help dynamically balance the intensity against the player's fitness level, which tackles one of the main challenges presented by the physical aspect of exergames. Since the focus is on gameplay, rather than the physical movements, the dynamic adjustment should theoretically be better (Sinclair et al., 2007). As none of the existing exergames mentioned in this article feature such dynamic adjustment, this game concept will provide the opportunity of analysing the effectiveness of such an approach.

18.3.2 Exercise Theory

For this exergame to provide adequate exercise, it is essential to look at the studies and recommendations regarding exercise. As discussed in Chapter 9, aerobic and anaerobic exercise is best suited for exercise bikes, and 4x4 interval training is proven to be the most effective for increasing aerobic capacity. This game concept might struggle with a set timer of 4 minutes, as the time of each round changes based on the player's skill level and game mode. The game modes of Balance and Shapes can go on for several minutes if the player is skilled enough, while a round of Marble might last less than a minute. Changing the *equilibrium cadence* throughout the game can be one way to dynamically change the game's intensity, as it might force the player to push themselves and take breaks. For this game to help players reach the recommended amount of physical activity, it should allow the player to play for a long time in Zone 2 and 3 or for a shorter amount in Zone 4 or 5. The game allows for this by having different game modes and allowing players to change the resistance based on what kind of exercise they want. For people who do not regularly engage

in exercise, having a game that allows them to build up their endurance and muscular fitness can increase the motivation to keep going, as forcing them to begin at the same level as someone who exercises regularly might be demotivating. As the game starts with a calibration test, the game may work well regardless of fitness level. Additionally, a warm-up level with a lower *equilibrium cadence*, increasing over the course of 5-10 minutes, would sufficiently warm up the player before more rigorous exercise.

18.4 Summary of the Final Game Concept

To summarise the game concept, FlipBoard is a puzzle game where the player needs to balance a board by matching the cadence of the bike to a set *equilibrium cadence*. The concept consists of a hidden calibration test, three game modes and four steering modes, where one is a multiplayer steering mode. When looking at the player types, this game concept mainly caters to the explorer and achiever types because it is primarily a skill-based puzzle game. However, the concept also includes multiplayer elements that might appeal to the other two types as well. When it comes to Malone's characteristics for enjoyment, all three can be found. The puzzles will encourage cognitive curiosity, and the graphics, music and sound effects will encourage sensory curiosity. The game uses intrinsic fantasy since the game world is reacting to the player's skills, which are also affected by the game world. The challenge aspect is supported through meta goals like improving scores and subgoals provided by the achievement system. The calibration test and puzzle elements will hopefully make the game match the intensity to the player's fitness level and keep them concentrated enough that they do not notice that time passes. Furthermore, additional game elements like leaderboards and achievements will help the game cater to a broader audience, as well as increase the enjoyment of the game. Finally, the individualised *equilibrium cadence* will hopefully ensure the players reach moderate or high intensity.

19 Summary of the Game Concepts

This part has introduced the different game concepts that were created, as well as the final game concept. Five game concepts were scrapped, with the main reasons being lack of replayability, difficulties implementing exercise elements in a natural way and lack of time to implement the concepts. The chosen concept was named FlipBoard, and the core of the game is to use the pedals to balance a board. The game consists of three game modes: Balance Mode, Shapes Mode and Marble Mode. The goal of *Balance Mode* is to balance the board while objects fall onto it and try to keep the objects on the board. *Shapes Mode* is similar, but this goal is to get the objects into differently shaped holes in the board. This mode is based on the shape-sorting toys toddlers play with. The final game mode, *Marble Mode*, is based on wooden labyrinth toys, where the goal is to navigate a marble through a labyrinth without falling into the wrong holes. In addition, the game consists of four steering modes, where the first three have the player using buttons to rotate or tilt the board, while the final one is a multiplayer mode where two players control an axis each and has to collaborate. The concept also includes a calibration test that will allow the game to tune its intensity to the player's fitness level and other features like achievements and leaderboards to increase enjoyment and motivation.

When looking at the existing exergames in Chapter 12, not one can be classified as a puzzle game, which is what the ESA's statistics state is the most commonly enjoyed genre, making this game concept unique. Furthermore, FlipBoard aims to facilitate a state of flow by implementing game theory like Malone's characteristics for enjoyment, GameFlow and DualFlow. In addition, the concept aims to be replayable and intense enough to help people reach the recommended amount of exercise. The following part will describe the development and implementation of the finished prototype based on this game concept.

Part IV

The Prototype

> "*Programming without an overall architecture or design in mind is like exploring a cave with only a flashlight: You don't know where you've been, you don't know where you're going, and you don't know quite where you are.*"
>
> Danny Thorpe (n.d.)

This part presents the development process, the requirements and the software architecture before describing the implemented prototype in detail. Ultimately, the prototype will be evaluated against the game concept from Part III and the requirements from the beginning of the development process.

20 Development Process

The development process started mid-January and continued until the end of March, and followed the prototyping methodology. While this methodology has several definitions, this project followed the one described in Sommerville (2015). Sommerville describes a process split into four stages. The first stage is to establish the prototype objectives, which in this case is to help answer the research questions posed in Chapter 3. The second stage is to define the prototype's functionality, which was done by defining requirements seen in Table 3. Stage three is developing the prototype, and stage four is evaluating the prototype.

At the start of the development process, a planning meeting was held to create a set of functional and quality attribute requirements based on the game concept, in addition to plans regarding the software architecture. These will be discussed more in Chapter 21 and Chapter 22. The Unity game engine (see Figure 47) was chosen as the best-fitting game engine for this project, as mentioned in Chapter 15. In addition, all models were created in Blender (Blender, 2023) (see Figure 48), the user interface (UI) was created in Unity and with Krita (Krita, 2023) (see Figure 49), and the game audio was edited with FMOD Studio (FMOD, 2023) (see Figure 50). Git and GitHub (GitHub, 2023) were chosen as collaboration tools. A Kanban board was created on GitHub to track which functional requirements had yet to be implemented, what each developer was working on, and what was finished.

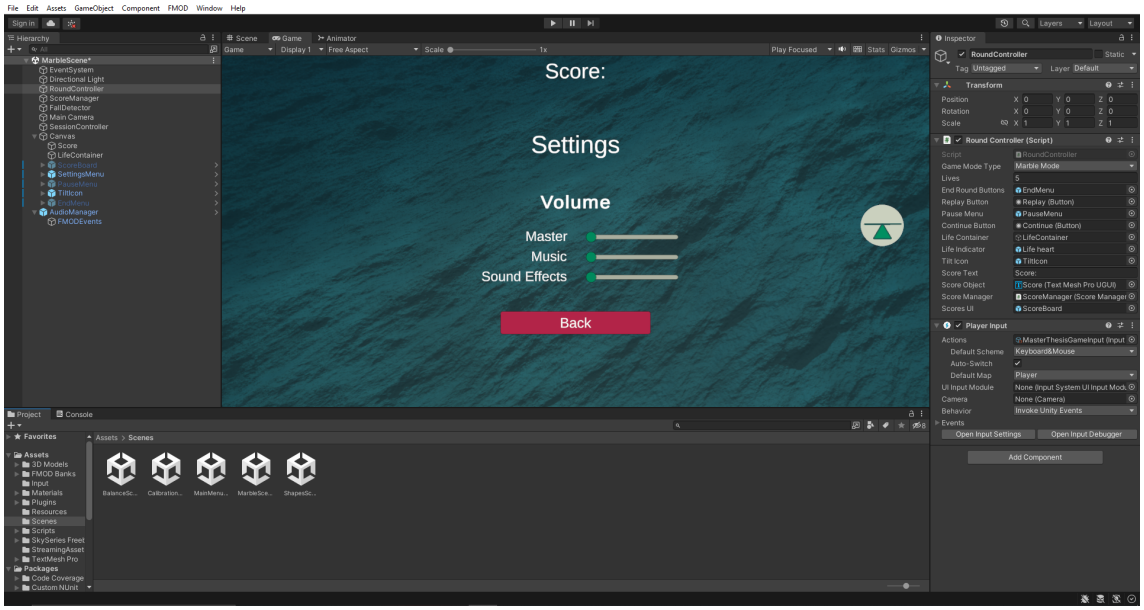


Figure 47: Screenshot from Unity

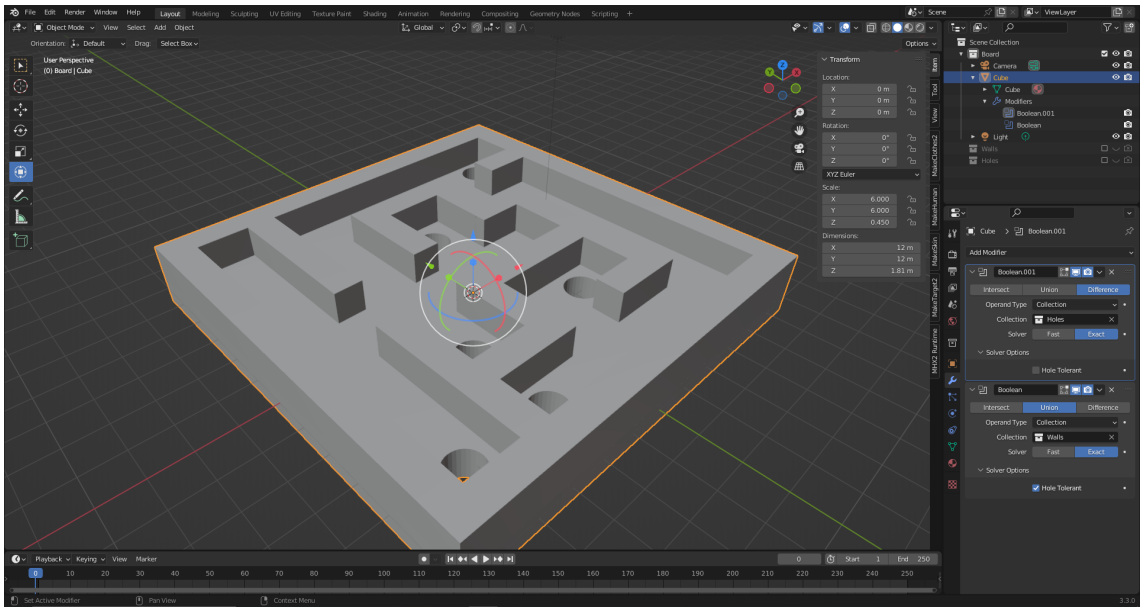


Figure 48: Screenshot from Blender

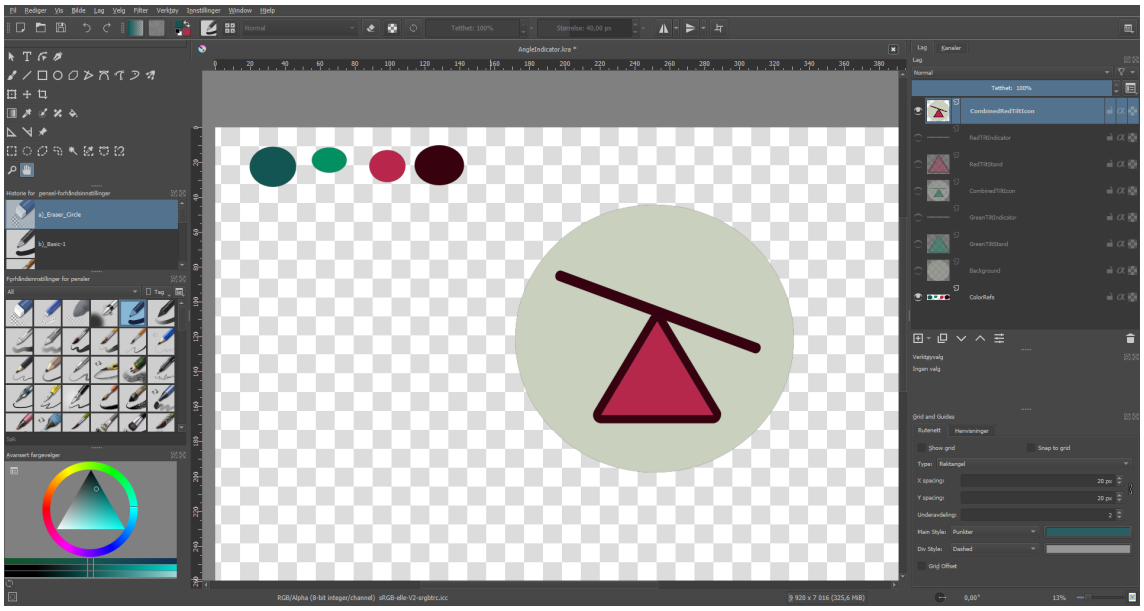


Figure 49: Screenshot from Krita

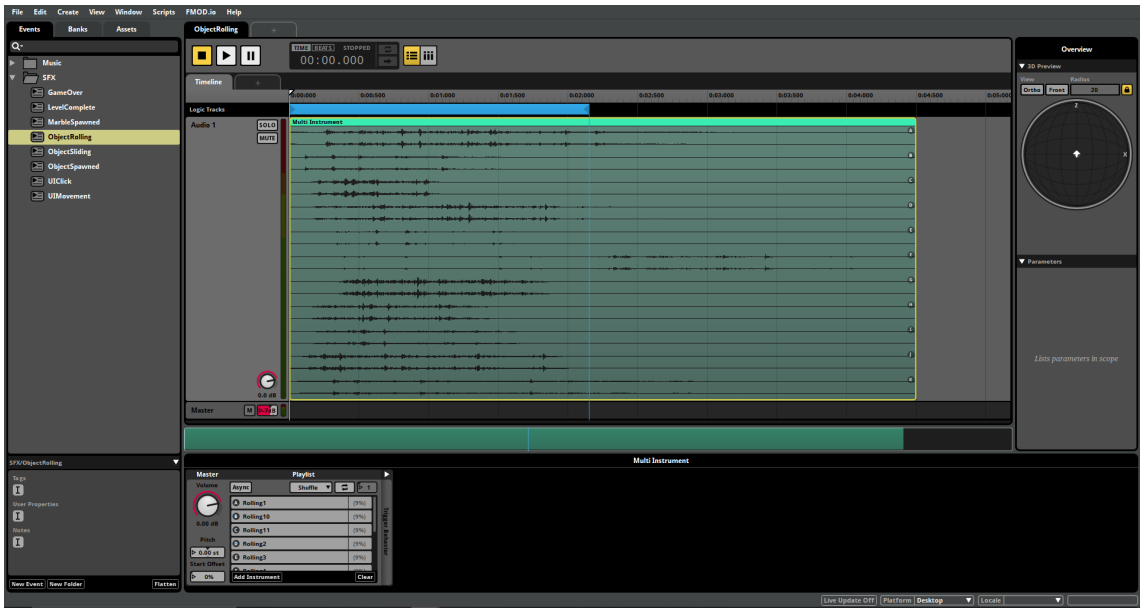


Figure 50: Screenshot from FMOD Studio

Throughout the development process, the researchers tested the game to ensure that the different functionality was working as planned. In addition, the game was tested by an external associate with no prior exposure to the game a few weeks before the experiments started. This test resulted in the discovery of several critical bugs, in addition to some important feedback regarding the gameplay. The supervisor for the project also tested the game throughout the development process, giving valuable feedback and suggestions.

21 Requirements

This chapter introduces the functional and quality attribute requirements created during the planning stages. The functional requirements are based on the game concept described in Part III.

21.1 Functional Requirements

Table 3 shows the different functional requirements created at the beginning of the development process. The table includes an id-number, a description and a priority rating. The priority is either high, medium or low, and the developers used these to prioritise the order of implementation. The list is also ordered by importance, with requirements that should be implemented first at the top. Requirements labelled as high are essential for the game, and if just these are implemented, then there is a functional prototype. The requirements labelled as medium are not necessary in order for the game to be played, but would highly increase the player's enjoyment. Lastly, the requirements labelled as low would increase the enjoyment, but the cost of implementation does not outweigh the enjoyment gained.

Table 3: A list of functional requirements and their priority

ID Nr	**Description**	**Priority**
FR 1	The board should tilt backwards and forwards based on the cadence of the bike	High
FR 2	Steering Mode 1: The board should rotate a set amount of degrees (unity enum: 30, 45, 60, 90)	High
FR 3	The player should be able to choose game modes in the main menu	High
FR 4	**Balance Mode, minimal viable product (MVP)**	High
FR 4.1	Objects should fall on the board in random places and with random sizes. Variable frequency. (also Shapes Mode)	High
FR 4.2	An object falling below the board should be noticed and counted towards the number of lives lost (also Shapes and Marble Mode)	High
FR 4.3	The round should end when all lives are lost (also Shapes and Marble Mode)	High
FR 5	A calibration test should be run on startup	Medium
FR 5.1	A minimum speed should already be set as a constant, to avoid sandbagging	Medium
FR 5.2	The average cadence should be used to calculate the equilibrium cadence	Medium
FR 6	**Shapes Mode MVP**	Medium
FR 6.1	There are holes in the board (corresponding with the shapes of the objects)	Medium
FR 6.2	When an object falls into a hole, points should be awarded	Medium
FR 7	**Marble Mode MVP**	Medium
FR 7.1	The board should be a maze, with red holes in the corridors	Medium
FR 7.2	One green hole should appear at the destination (other side of the maze)	Medium
FR 7.3	Lives should be lost if the marble falls through a red hole	Medium
FR 7.4	The round ends if the marble has fallen through the green hole	Medium
FR 8	Players should be able to pause and restart rounds	Medium
FR 9	Player should see a score at the end of rounds	Medium
FR 9.1	Scores should be collected in Balance Mode	Medium
FR 9.2	Scores should be collected in Shapes Mode	Medium
FR 9.3	Scores should be collected in Marble Mode	Medium
FR 9.4	Local leaderboards should track the player's highscore	Medium
FR 10	Steering Mode 2: The board should rotate continuously	Medium

FR 11	Steering Mode 3: The board should tilt on the left-right axis (controller)	Medium
FR 12	During a round, steering's modes randomly change at determined intervals	Medium
FR 13	Once a game mode is selected, the player can disable certain steering modes	Medium
FR 14	Players should be able to change settings	Medium
FR 14.1	Volume	Medium
FR 14.2	Invert controls	Medium
FR 14.3	Players should be able to disable steering modes from the menu	Low
FR 14.3.1	If changed from main menu settings: Change global default	Low
FR 14.3.2	If changed from pause menu settings: Change round choice	Low
FR 15	Steering Mode 4: Through multiplayer, two players control one axis each	Low
FR 15.1	The players can choose to connect to multiplayer from the main menu. This will lead them to another screen to finish the connection process	Low
FR 15.1.1	Players should be able to disconnect from multiplayer	Low
FR 16	Power-ups and power-downs should appear in Marble Mode	Low
FR 16.1	Extra life power-up	Low
FR 16.2	Jump power-up	Low
FR 16.3	Smaller marble power-down	Low
FR 16.4	Bigger marble power-down	Low
FR 16.5	Heavier marble power-down	Low
FR 16.6	Lighter marble power-down	Low
FR 16.7	Inverting controls power-down	Low
FR 17	A user-based overview of stats and equilibrium cadence over time can be viewed to track progress	Low
FR 18	Achievements can be gained by reaching predetermined requirements	Low
FR 18.1	Winning a number of games in a mode	Low
FR 18.2	Reaching a number of points in a mode	Low
FR 19	Collectables can be gathered	Low

21.2 Quality Attribute Requirements

In addition to the functional requirements, quality attribute requirements were made to ensure code quality and good user experience. The quality attributes that were considered most important during development were modifiability and usability. Modifiability was important because of the several game modes and steering modes planned, in addition to being able to tweak variables quickly during development and testing. Usability was also important for the game to be easily playable and not frustrating and ensure that the experiments ran smoothly. The design patterns and tactics used to reach these quality attributes will be described in Chapter 22.

21.2.1 Modifiability

The modifiability attribute concerns how easy it is for developers to add or extend the system's functionality. A system with high modifiability will have low costs and risks when implementing new changes. Tactics for increasing modifiability include reduced size of modules, increased cohesion and reduced coupling. Table 4, Table 5 and Table 6 shows three different scenarios for the modifiability attribute.

Table 4: M1 modifiability quality scenario. Developer wishes to add another steering mode

ID	M1
Source	Developer
Stimulus	Wishes to add another steering mode
Artefact	Source code
Environment	Design time
Response	Code added, changed and tested
Response Measure	Five hours

Table 5: M2 modifiability quality scenario. Developer wishes to add another game mode

ID	M2
Source	Developer
Stimulus	Wishes to add another game mode
Artefact	Source code
Environment	Design time
Response	Code added, changed and tested
Response Measure	Seven hours

Table 6: M3 modifiability quality scenario. Developer wants to change board reaction speed

ID	M3
Source	Developer
Stimulus	Wishes to change how fast the board reacts to changes in pedalling speed
Artefact	Source code
Environment	Design time
Response	Code added, changed and tested
Response Measure	10 minutes

21.2.2 Usability

The usability attribute focuses on how easily the user understands the system. This can be done by adding tutorials and well-known user interface elements and reducing the steps needed to navigate the application. Usability also focuses on minimising the impact user errors can have on the system and adapting the system based on user needs. Table 7 and Table 8 shows two scenarios for the usability quality attribute.

Table 7: U1 usability quality scenario. User wants to play Balance Mode

ID	U1
Source	User
Stimulus	Wants to play Balance Mode for the first time
Artefact	User interface
Environment	Runtime
Response	User is able to start the game mode
Response Measure	2 minutes

Table 8: U2 usability quality scenario. User wants to change the volume

ID	U2
Source	User
Stimulus	Wants to change the volume
Artefact	User interface
Environment	Runtime
Response	The user is able to navigate to the settings menu and change the volume
Response Measure	2 minutes

21.3 Summary of Requirements

During the planning stages 19 functional requirements, some with sub-requirements, and five quality attribute requirements were created. The functional requirements were labelled as high, medium or low priority, and ranked based on their importance to the game. The quality attributes modifiability and usability were considered the most important.

22 Software Architecture

In order to achieve the quality attribute requirements set in Section 21.2, a couple of design patterns and architectural patterns were chosen, in addition to a few that were already implemented by Unity. One of the patterns used was the *Singleton pattern*, which was used in the SessionController, AudioManager and FMODEvents classes, as they needed to stay persistent between scenes and contained game logic. This pattern ensures that there is only one instance of a class at a time and that the instance is available for the other classes. In addition, Unity supports the *Observer pattern*, which was used to trigger button inputs and collisions like objects falling off the board or objects falling through holes in Shapes Mode and Marble Mode. The *Entity Component System pattern* was also used, as entities like the goal colliders changed their behaviour depending on what components were added. Since the Unity game engine already supports the observer and the entity component system patterns, implementing these was relatively simple. Unity also uses the *Sequential Game Loop pattern* for updating and rendering views. In addition, the architecture is also inspired by the *Model-View-Controller (MVC) pattern*. In the MVC pattern, models are responsible for managing data, views are responsible for presenting the models, and controllers are responsible for handling user input and updating the models. The architecture in this prototype does not separate all views and controllers and therefore does not implement the MVC pattern but is instead inspired by it.

Figure 51 displays the interaction between Unity, the bike sensors, the bike screen and the database. The bike sensors send data to Unity, for example, the cadence of the bike and button inputs, and Unity projects the game on the screen attached to the bike. In addition, Unity saves high scores and volume settings into a local database between sessions and retrieves the data on startup. The code structure can be seen in Figure 52 and Figure 53. Figure 52 illustrates which public functions the audio management classes contain and how they interact with each other. For example, the ObjectSoundTrigger detects when an object is touching the board through OnCollisionEnter and OnCollisionExit, and uses that knowledge to play rolling or sliding sounds. The class then gets the EventReference from the FMODEvents class and calls on the AudioManager class to play the sound. In Figure 53, one can see how the main classes are set up and how they relate to each other. For example, one can see how the Singleton pattern is used in SessionController, as the SessionController contains a variable of itself.

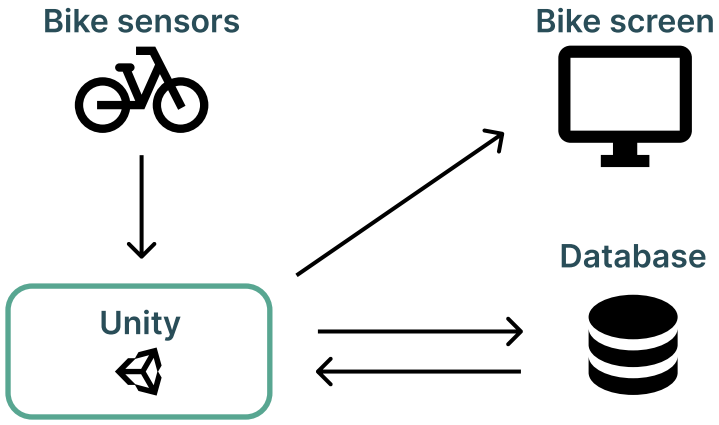


Figure 51: Interaction between the bike, Unity and the database

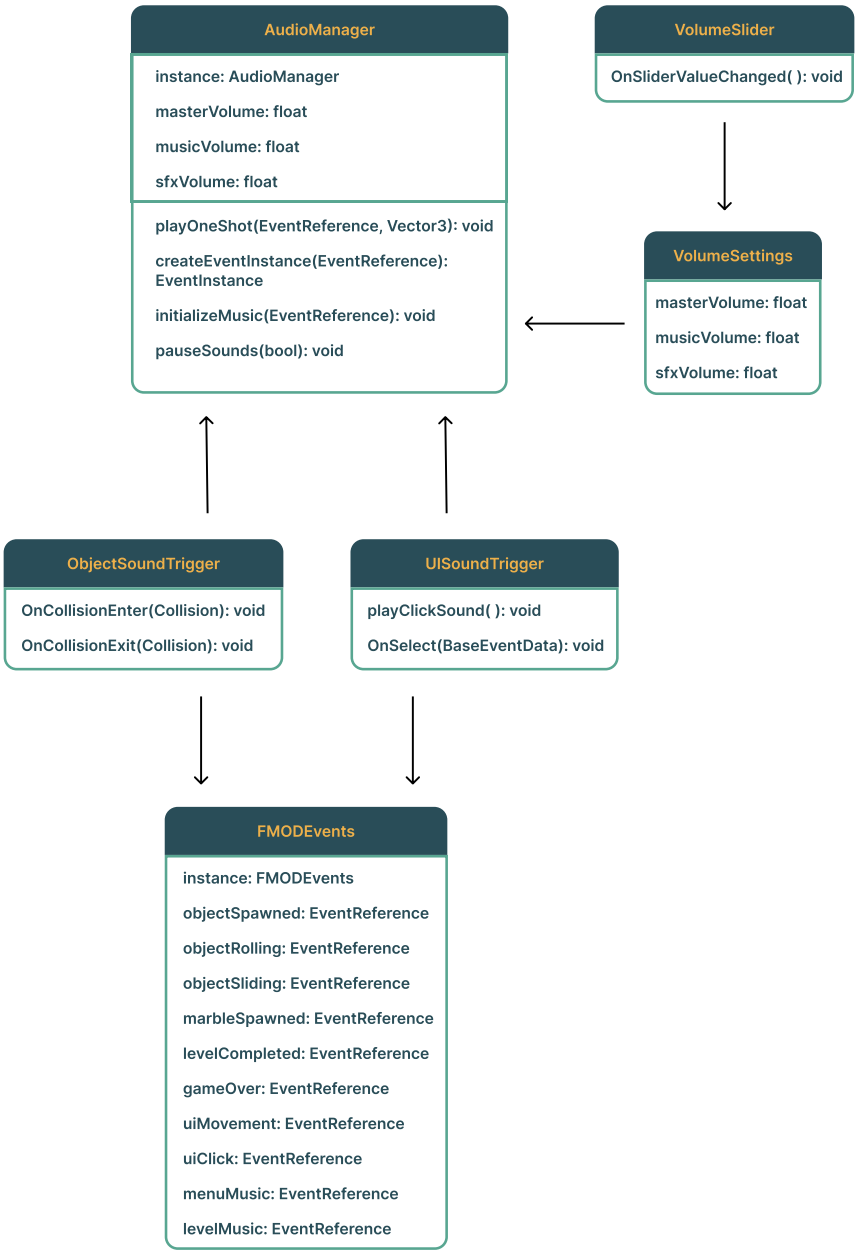


Figure 52: Class diagram for audio management

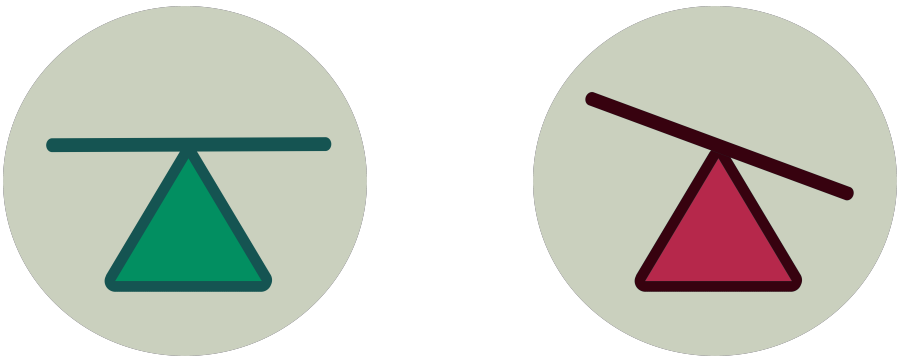
Figure 53: Main class diagram

23 Functionality

The finished game includes three different game modes, one steering mode and a start-up calibration test, all based on the concept introduced in Part III. This chapter will start by introducing the controls. Then, different parts of the game will be described, starting with the calibration test and moving on to the menus, before ending with the different game modes.

23.1 Controls

As mentioned in Chapter 14, the prototype bike includes two handlebars with four buttons each and a speed sensor on the wheel. The speed sensor is interpreted as a joystick by Unity, and after processing the data, the cadence is set to a number between 0-1. Unfortunately, the analogue buttons on the handlebars and the speed sensor are interpreted by Unity as the same kind of input. This means that these buttons are not used by the game other than to send incorrect data. Two tactics are being used to prevent the unwanted data of the buttons from affecting the gameplay. The first one is to take the average of samples, where the cadence is set as the average of the last 40 readings, with a read speed of 0.1 seconds. The other tactic is the removal of outlier samples, where the program does not change the cadence if the new cadence and the old cadence have a difference greater than 0.3. To help the player see if the board is steady or not, a *tilt indicator* (see Figure 54) is added to the UI, which imitates a sideways view of the board. The indicator is green when the board is within 10 degrees of the *equilibrium cadence*, and red if not (see Figure 54).



(a) The tilt indicator showing that the board is balanced

(b) The tilt indicator showing that the board is tilted backwards

Figure 54: The tilt indicator icon

While the original game concept included four different steering modes, the final prototype only has one. To turn the board, the player can use two buttons on each handlebar. When pressing either of the two buttons on the right handlebar, the board turns towards the right. When pressing the buttons on the left handlebar, the board turns towards the left. Whether the board turns 30, 45, 60 or 90 degrees at a time is randomised between rounds.

23.2 Calibration

As mentioned in Section 18.2.3, the game should include a short calibration test to adjust the intensity to the player's fitness level. This is accomplished by having the game start with a loading bar that the player needs to fill by biking for a certain amount of time (see Figure 55). The game reads the bike's cadence (a number between 0 and 1) every 0.2 seconds and adds up the samples until the sum is more than 50. When the sum passes 50, the calibration stops, and the *equilibrium cadence* is calculated (see Equation (2)) and used by the game for the rest of the session. To ensure that the player does not pedal too slowly, and to avoid inaccurate results from higher velocity, the range of the *equilibrium cadence* is set between 0.3-0.9. The range of $\frac{sumCadence}{usedTime}$ has

to be somewhere between 0 and 5 to reach a sum of 50, and the fastest completion time of the test is 10 seconds with 5 readings a minute. $\frac{50}{10} = 5$, which means the max value is 5. $\frac{sumCadence}{usedTime}$ is multiplied by 2 to get a number between 0 and 10 before it is multiplied by 6 and divided by 100 to get a number between 0 and 0.6. 0.3 is added to ensure the result is within the range of 0.3 and 0.9.

$$eqCad = \frac{\frac{sumCadence}{usedTime} * 2 * 6}{100} + 0.3 \tag{2}$$

Figure 55: Calibration test

23.3 Menus

After finishing the calibration test, players are taken to the main menu (see Figure 56), where they can choose which game mode to play, navigate to the settings menu or quit the game. For example, if the player presses the *Settings* button, the settings menu will open (see Figure 57), and they will be able to change the volume or return to the previous menu. During rounds, the players can pause the round by pressing the tiny button on the left handlebar. This will open the pause menu (see Figure 58), where they can restart the game, quit or enter the settings menu. In every menu except for the settings menu, the two bigger buttons on the left handlebar move the selector upwards, and the two buttons on the right handlebar move the selector downwards. The small button on the right handlebar is the *Select* button in all menus. The only place where the bigger buttons are different is in the settings menu, where the inner buttons move the sliders left or right, and the outer ones navigate between the sliders.

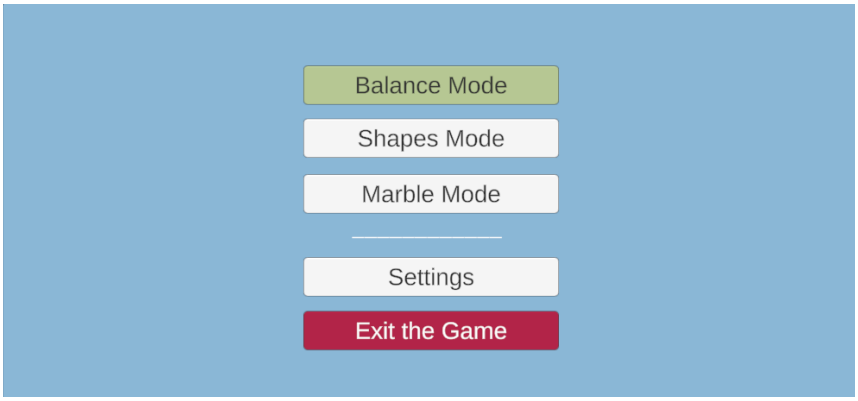


Figure 56: Main menu

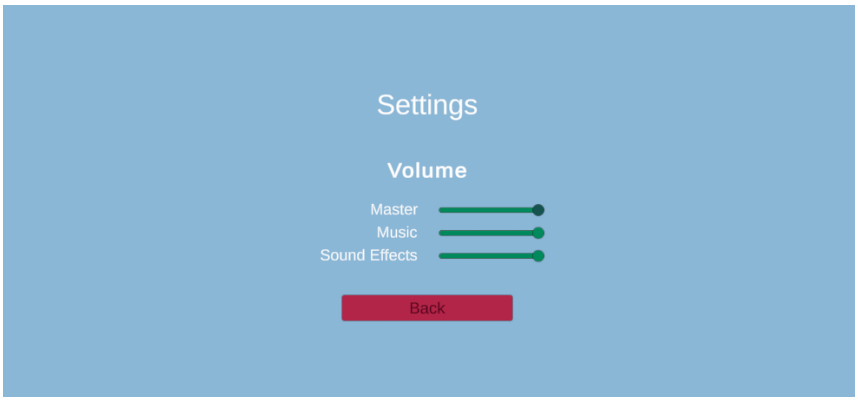


Figure 57: Setting menu

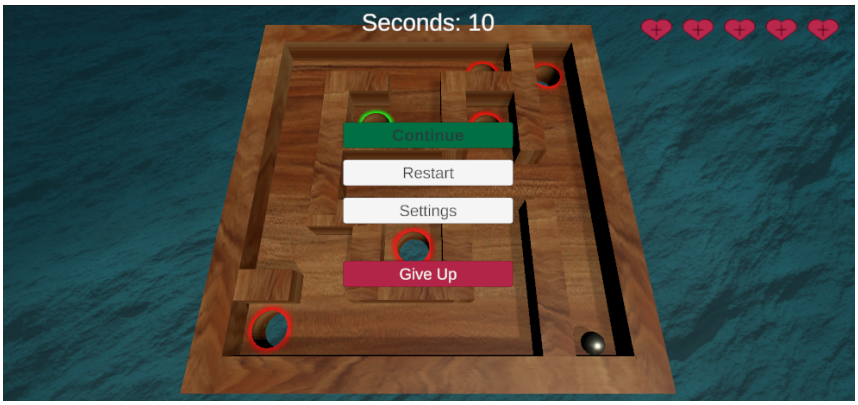


Figure 58: Pause menu

23.4 Balance Mode

When pressing the *Balance Mode* button in the main menu, players are shown information about the game mode and can choose to start a round or to go back to the main menu (see Figure 59). When pressing *Play*, the round starts, and the screen shows a board, the *tilt indicator*, the score and the number of lives left (see Figure 60). The score is based on seconds since the round started and counts upward during the game. Additionally, the player starts each round with five lives, and a life is lost when an object falls off the board. After 10 seconds, the first object will spawn. New objects will spawn with an increasing frequency as the round progresses. The round ends when all lives are lost, and the player is shown the leaderboard with the top three scores (see Figure 61).

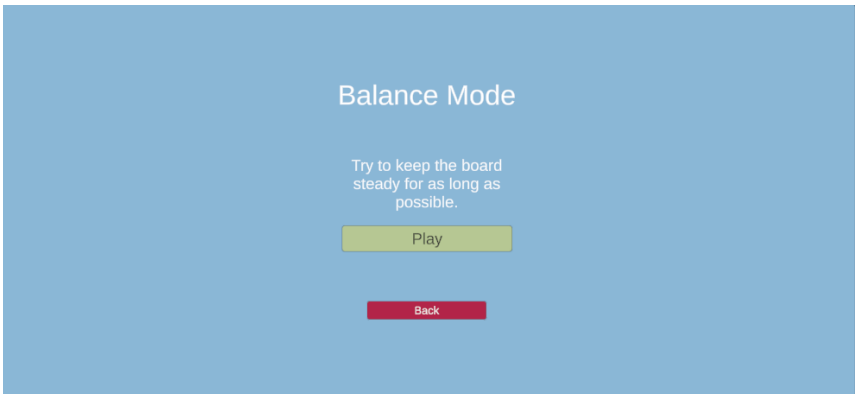


Figure 59: Balance Mode description

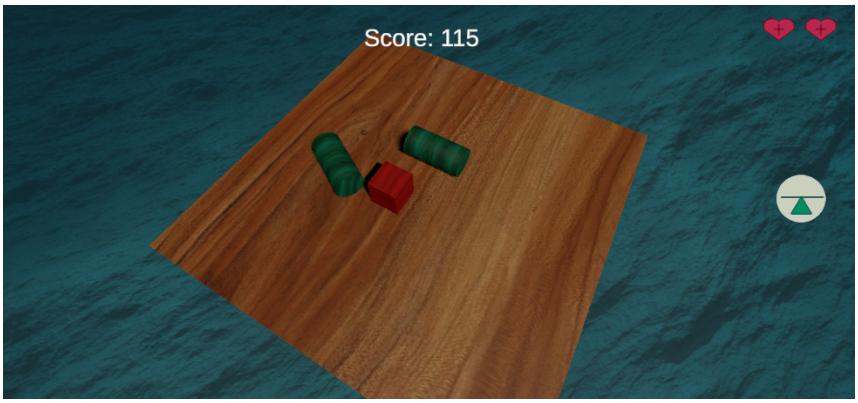


Figure 60: Balance Mode gameplay

Figure 61: Balance Mode leaderboard

23.5 Shapes Mode

Like with Balance Mode, pressing the *Shapes Mode* button in the main menu will show players information about the game mode, and they can choose to start a round or to go back to the main menu (see Figure 62). When the round starts, the players are shown the board, score ("Objects"), lives and tilt indicator (see Figure 63). As with the previous mode, the player starts with five lives, and lives are lost when objects fall off the board. Points are gained when an object falls into one of the three holes, regardless of whether the shapes match. Objects start spawning after 10 seconds, and the time between new objects decreases as the round goes on. When all lives are lost, the round ends, and the player is shown the leaderboard, where the top three scores are listed (see Figure 64).

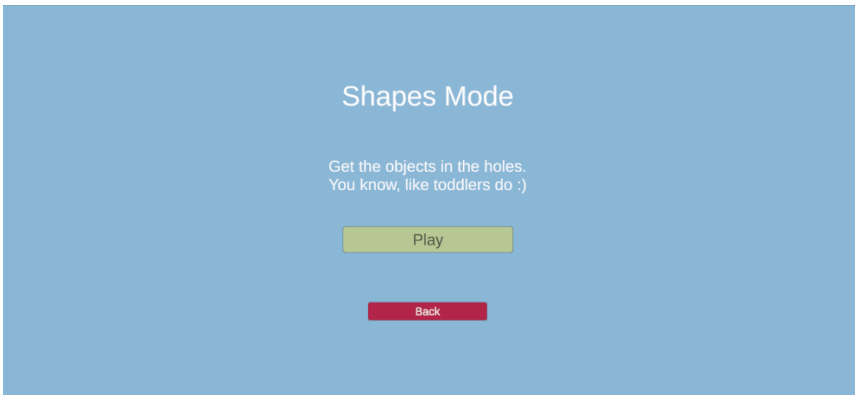


Figure 62: Shapes Mode description

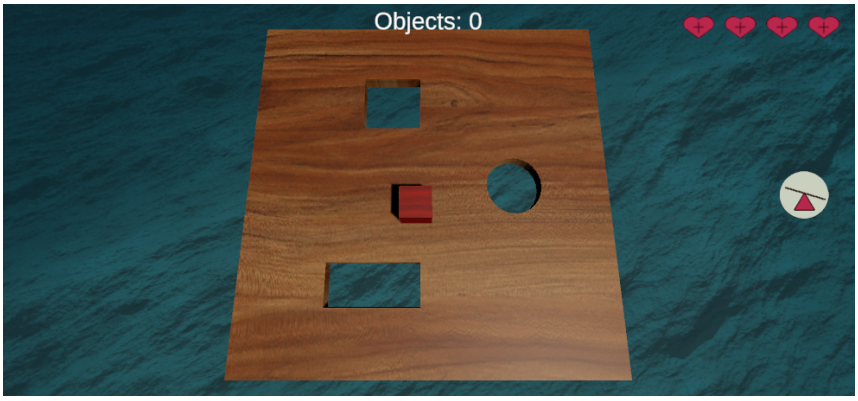


Figure 63: Shapes Mode gameplay

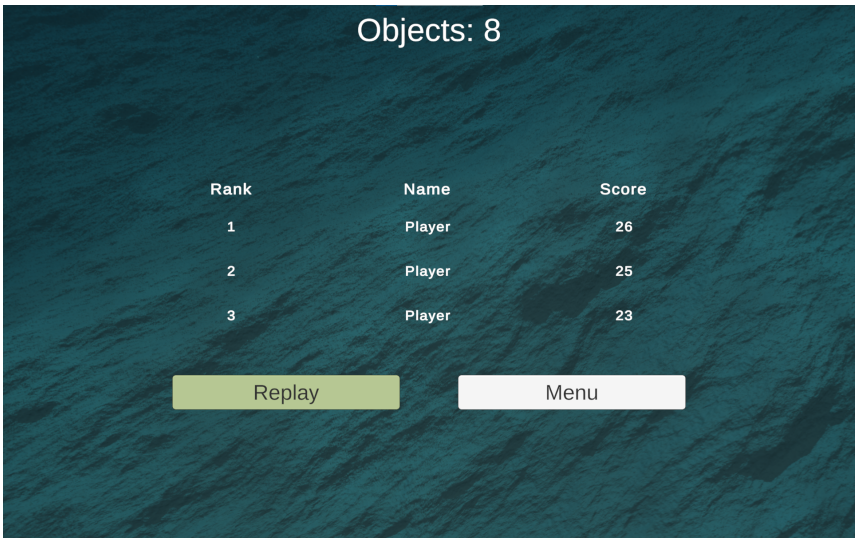


Figure 64: Shapes Mode leaderboard

23.6 Marble Mode

Again, pressing the *Marble Mode* button will show the player information about the game mode, in addition to buttons for starting a round and returning to the main menu (see Figure 65). When starting the round, the player is shown the board, the *tilt indicator*, the score ("Seconds") and lives

(see Figure 66). The score starts incrementing when the round starts, and the goal is to get the marble through the maze in the shortest time. Lives are lost when the marble falls off the board or into one of the red holes. In addition to losing a life, the fall adds 20 seconds to the timer. The round ends when all lives are lost or when the marble falls through the green hole. Like the other game modes, this will show the player the leaderboard with the top three scores (see Figure 67).

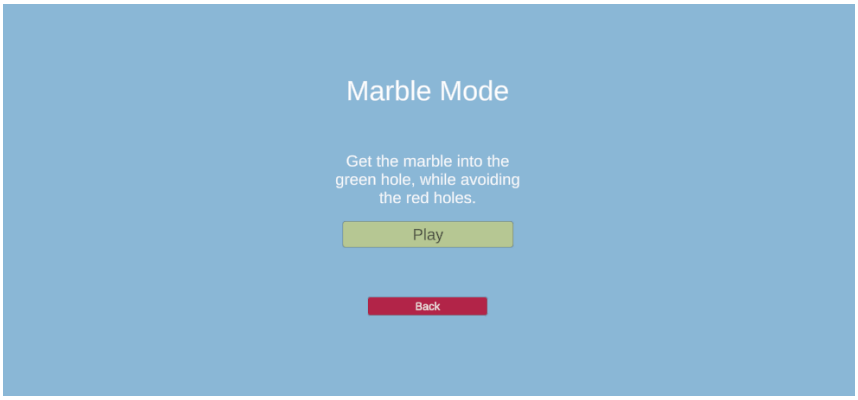


Figure 65: Marble Mode description

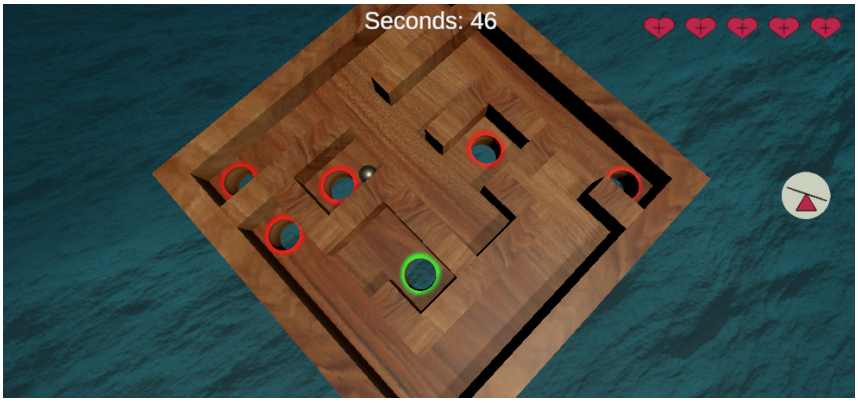


Figure 66: Marble Mode gameplay

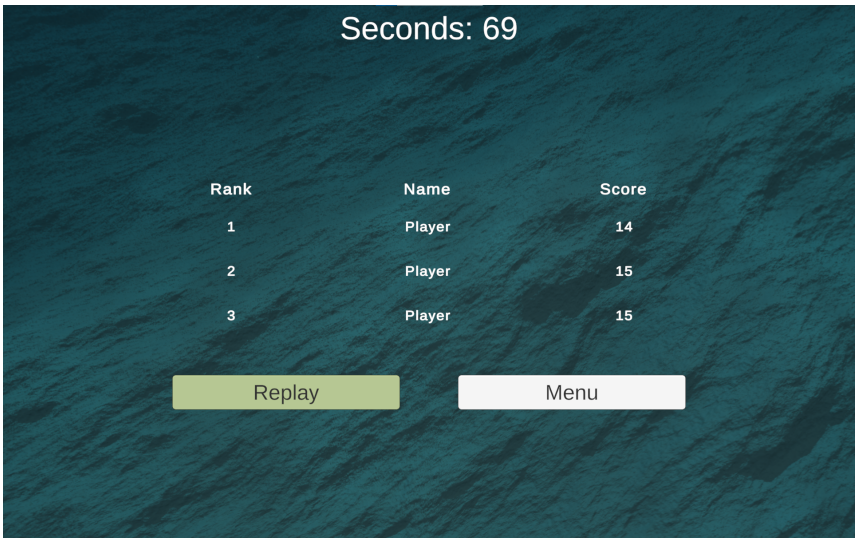


Figure 67: Marble Mode leaderboard

23.7 Summary of Functionality

The final prototype includes three game modes, one steering mode, a calibration test, three menus, and local leaderboards for each game mode. When starting a round, the calibration test calculates the *equilibrium cadence* based on how quickly the player fills the loading bar. The player is then taken to the main menu, where they can choose between the different game modes, change the settings and quit the game. Each game mode includes a board, the current score, the remaining lives and a tilt indicator. The player is shown the top three scores when the round is over. During each round, the player can pause the game and choose between continuing, restarting or quitting, and they may also access the settings menu.

24 Evaluation of Implementation

Not all functional requirements listed in Table 3 were implemented. However, all high-priority functional requirements (FR 1-4.3) and almost every medium-priority functional requirement (FR 5-9.4, FR 14 and FR 14.1) were implemented. Among the ones labelled as medium priority, only the ones regarding the extra steering modes and inverted controls were not implemented (FR 10-13). This was due to time and a shift in focus towards the end, where improving the feeling of the controls and fixing bugs found during the preliminary user tests were seen as a higher priority. Therefore, FR 14.2-19 were not implemented. Early in the planning stages, it was decided that the multiplayer option should be a low priority. Other game elements were deemed more likely to produce new insight, as several research projects have already studied the effects of multiplayer in exergames. Other low-priority requirements like achievements and power-ups were also not implemented.

Results from quality attribute testing can be seen in Table 9 to Table 12. M1 (Table 4) was never tested as only one steering mode was added. Unfortunately, U2 (Table 12) failed. This is likely due to the different control scheme in the settings menu compared to the rest of the game. The problem was not discovered until the experiments (when it was too late to make changes), as the volume sliders were not implemented until after the preliminary user tests.

Table 9: M2 quality attribute requirement test

M2: Developer wants to add another game mode	
Date	22.02.2023
Environment	Design time
Stimuli	Wishes to add a new game mode
Expected response measure	Seven hours
Observed response measure	Five hours
Evaluation	Success
Comment	A new game mode was added by adding a new board, writing the specific code for the game mode, and adding the game mode to the main menu.

Table 10: M3 quality attribute requirement test

M3: Developer wants to change board reaction speed	
Date	16.03.2023
Environment	Design time
Stimuli	Change how fast the board reacts to changes in speed
Expected response measure	10 minutes
Observed response measure	2 minutes
Evaluation	Success
Comment	Sample Size variable and board reaction time were changed and tested.

Table 11: U1 quality attribute requirement test

U1: User wants to play Balance Mode for the first time	
Date	23.03.2023
Environment	Runtime
Stimuli	Wishes to play Balance Mode for the first time
Expected response measure	2 minutes
Observed response measure	1 minute
Evaluation	Success
Comment	The user managed to navigate to the Balance Mode menu and start the game mode.

Table 12: U2 quality attribute requirement test

U2: User wants to change the volume	
Date	19.04.2023
Environment	Runtime
Stimuli	Wishes to change the volume
Expected response measure	2 minutes
Observed response measure	3 minutes
Evaluation	Failure
Comment	While the user managed to navigate to the settings menu within 2 minutes, there were difficulties navigating in the menu. The main complaint was that they were not used to the sideways motion in the control scheme.

25 Summary of the Prototype

The development of the prototype took two and a half months and followed the prototyping methodology. At the beginning of this process, a set of functional requirements and five quality attribute requirements were created. Modifiability and usability were prioritised when creating the quality attribute requirements. In addition to these requirements, software architecture patterns were chosen. These included: the singleton pattern, the observer pattern, and the entity component system. The final prototype did not implement all functional requirements but did implement all high-priority requirements and most of the medium-priority requirements. Three of the five quality attribute tests succeeded, with one not being tested and the last one being a failure. Ultimately, the final prototype included all three planned game modes, one of the four designed steering modes, the calibration test and leaderboards. The next part explains how the prototype was used to investigate the research questions.

Part V

Methodology and Data Generation

> "*Data is like garbage.*
> *You'd better know what you are going to do with it before you collect it.*"
> Mark Twain (n.d.)

This part will describe the strategies and data generation methods used during the research project. First, the part will describe the general survey, a questionnaire sent to a broader audience to gather information needed to answer **RQ1:** *Are there commonly enjoyed game genres not sufficiently represented in the current exergame market?* and **RQ5:** *Does the equipment needed for an exergame deter people from playing exergames?*

After that, the experiment will be described, which was used to gather information needed to answer **RQ3:** *Can such an exergame facilitate a state of flow?*, **RQ4:** *Can such an exergame contribute to more people reaching the recommended exercise amount?* and **RQ5**. The experiments were conducted with a smaller group of participants and consisted of three sessions per participant: a control session and two game sessions. Each session started with up to 30 minutes of exercise on the bikes, followed by an in-depth interview. Afterwards, the participants filled out an anonymous questionnaire about their experiences during that session.

26 General Survey

A general survey was conducted as a separate research strategy from the experiments. The reasoning behind this was to get a broader understanding of the target audience's (sedentary young adults) preferences in relation to video games and exercise routines. Generally, the survey provided quantitative data to gain insight into **RQ1:** *Are there commonly enjoyed game genres that are not sufficiently represented in the current exergame market?* and **RQ5:** *Does the equipment needed for an exergame deter people from playing exergames?*

More specifically, the questionnaire (see Table 13) begins with questions about the age group and gender to make potential patterns visible and make it possible to answer **RQ1.1:** *Does gender affect gaming preferences?* Further, the respondents are asked how frequently they exercise to determine if they are within the target demographic of this research project. Next follows several questions about video game preferences, focusing on genre enjoyment. This provides quantitative data to back up or dispute the assumptions that a significant amount of people prefer other genres, in addition to or rather than action and simulation games. As the ESA's (2022) statistics used in Chapter 6 relates to genre preferences in the United States of America, it was deemed necessary to ensure they were also reasonably applicable to Norway. Finally, some questions about the participants' usage and interest in exergames are posed. An optional text box is provided for more in-depth explanations of why they might not be playing exergames. GQ10 is specifically asked to gain insight into the barrier of entry from equipment cost (RQ5).

Table 13: Questions and answer formats of the general survey

ID	Question	Potential Answers
GQ1	How old are you?	**(Choose one)** Under 18, 18-24, 25-34, 35-44, 45-54 or 55+
GQ2	What is your gender?	**(Choose one)** Male, female, non-binary, prefer not to say or other
GQ3	How often do you exercise?	**(Choose one)** Daily, 2 or more times a week, once a week, every other week, once a month or less frequently
GQ4	How often do you play video games? (Among others, this includes mobile games, console games and computer games)	**(Choose one)** Daily, 2 or more times a week, once a week, every other week, once a month or less frequently
GQ5	Which video game genres do you enjoy?	**(Multiple choice, game examples provided)** Action games, adventure games, idle games, party games, platformers, puzzle games, RPGs/MMOs, simulation games, strategy games, none of the above or other
GQ6	Do you prefer playing singleplayer (by yourself) or multiplayer (with other players)?	**(Choose one)** Singleplayer, multiplayer, both or does not play video games / not applicable
GQ7	How often do you play exergames? (This includes, but is not limited to, location-based games like Pokemon Go, equipment-based games like simulated bike rides on exercise bikes and console-based games like Wii Sports or Ring Fit)	**(Choose one)** Daily, 2 or more times a week, once a week, every other week, once a month or less frequently
GQ8	If you do not play exergames, or have never tried them, why?	**Text answer**
GQ9	Would you be interested in playing exergames regularly (Assuming it is a game you find enjoyable, and you have access to the necessary equipment)?	**(Choose one)** Yes, no or maybe
GQ10	Do you have the space and economic capacity to buy an exercise bike that allows you to play video games? (As an example PlayPulse ONE (https://playpulse.com/), seen in the image, costs 16,000 NOK, and includes several exergames and other functions)	**(Choose one)** Have enough space but it costs too much, can afford it but do not have enough space, can both afford it and have enough space, can neither afford it nor have enough space
GQ11	Do you have any other comments?	**Text answer**

27 Experiment Design

The experiments aimed to generate quantitative and qualitative data to gain insight into **RQ3:** *Can such an exergame facilitate a state of flow?*, **RQ4:** *Can such an exergame contribute to more people reaching the recommended exercise amount?* and **RQ5:** *Does the equipment needed for an exergame deter people from playing exergames?* This chapter will describe the experiment, which consisted of an exercise session, an interview and an anonymous reflection questionnaire. It will start by describing how participants were recruited and which steps were followed to ensure their privacy. After this, the exercise part of the experiment will be described, followed by the set-up and layout of the room and equipment. A description of the interviews will follow, and the chapter will end with a description of the anonymous reflection questionnaire.

27.1 Participants, Ethics and Privacy Concerns

The experiment participants were chosen from the authors' network, resulting in 10 participants. Recruitment consisted of the authors sending out a recruitment form to friends and acquaintances, to which potential participants could respond (see Appendix A). The form included questions about how often the potential participants exercised and played video games and which game genres they preferred. This was in case the form got enough responses to be selective about which participants should be included. After the initial form, all communication with the participants was conducted over email.

As this experiment gathered different types of data about the participants, getting formal consent from them before the experiments started was necessary. A contract containing information about the experiment was sent to the participants before the experiment and was signed at the start of the control session (see Appendix B). The contract contained information about the following:

- *Data Collected:* The following data is collected: Heart Rate during each session, data about the participants' perceived exercise and gameplay experience, a voice recording of each interview, and the participant's name, age, gender and email.
- *Informed Consent:* Participants are informed of the data collected and can, at any time, withdraw their consent, and all data collected about them will be deleted.
- *Data Storage:* The data will be stored in SharePoint and will only be available for the authors and their supervisor. Names and emails will be replaced with a random code and will be stored separately from the other data.
- *Data Insight:* The participants can request a copy of data collected about them.
- *Anonymous:* All data will be anonymized before publication.
- *After project:* At the end of the project, all identifiable data will be deleted or anonymized.

Before starting the project, an application was sent to Sikt to gain permission to gather the necessary data. Sikt, the Norwegian Agency for Shared Services in Education and Research, was established in 2022 as a merger between the Norwegian Centre for Research Data (NSD), Uninett and Unit. Sikt provides data protection services to ensure legal access to necessary personal data for research (Sikt, 2022). The application was sent on the 20th of January, 2023 (see Appendix C) and was approved on the 21st of January, 2023 (see Appendix D).

27.2 Exercise Sessions

The experiment consisted of three exercise sessions, one control session and two game sessions. Before each session, the bike was adjusted to fit the participant, and after each session, the participant was run through a short stretching program. During the session, the participants were told

to choose and change the resistance whenever they wanted. They were also told that they could talk to the test facilitators if they wanted to but that they would have to initiate the conversation. Additionally, they were informed that they would not receive any help with how the game is played or what the "correct" way to bike is. However, help was available regarding practical requests like filling up water bottles, changing the volume of the music or interacting with the fan. More specifically, the three different sessions consisted of:

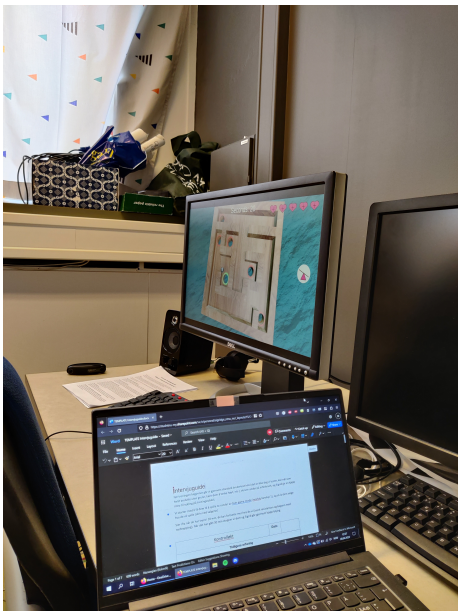
- **Control Session:** The participant was told to bike for 20 minutes while listening to a playlist. During the first song, the participants were given an introduction to the bike and spinning, which also served as a warm-up. After the 3 minutes, the participants were allowed to choose their own resistance, speed and bike position. They were told the time after 10 minutes and after 20 minutes. After the final time check, they were told that they were now allowed to stop but that they could keep going until the timer hit 30 minutes.
- **First Game Session:** Before starting the game, the participant was informed of which buttons were used during the game but not what they did. After starting the game, the participant was directed to play the three game modes, starting with Balance Mode, then Shapes Mode and finally Marble Mode. After this, they were allowed to choose game modes freely. The participant was told when 20 minutes had passed and was then allowed to quit if they wanted to, but was allowed to play until the 30-minute mark.
- **Second Game Session:** Before starting the game, the participant was informed of the functionality of the various buttons in case they did not figure it out during the first game session. After starting the game, the participant was allowed to choose game modes themselves. Like the first session, the participant was told when 20 minutes had passed and was then allowed to quit whenever they wanted until the 30-minute mark.

27.3 Set-Up and Layout

The room was set up during the experiments so that the facilitators could observe the participants and the game. The placement of the facilitators was chosen to avoid distracting the participants while allowing the facilitators to observe them from different perspectives. The views from the facilitators can be seen in Figure 68 and Figure 69, and the view from the participant can be seen in Figure 70. Because of high temperatures in the room, a fan was brought in and angled towards the bike, as seen in Figure 69a.

Figure 68: View from the first facilitator

(a) View of bike and participant



(b) view of screen

Figure 69: View from the second facilitator

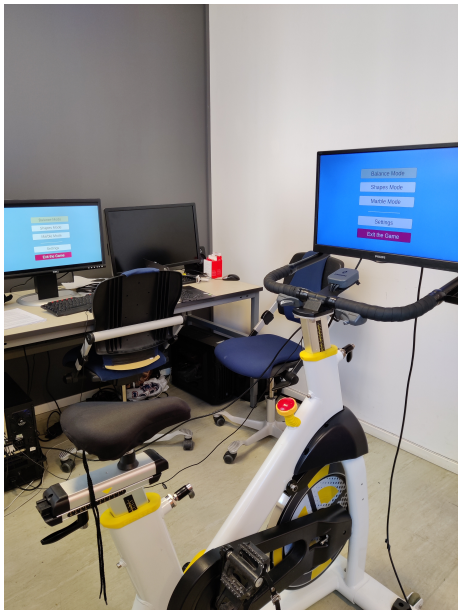


Figure 70: View from behind bike

27.4 Equipment

During the experiment, a PlayPulse prototype bike and a heart rate monitor were used. A description of the bike and its properties can be found in Chapter 14, and the following section will describe the heart rate monitor.

27.4.1 Heart Rate Monitors

The Polar H10 heart rate sensor was used to measure the subjects' heart rates during the exercise sessions. The sensor consists of a chest strap with a plastic electrode area that can detect the heart

rate and a connector that sends the heart rate signal to a receiving device (Polar, 2023c). A picture of the Polar H10 can be seen in Figure 71. The Polar H10 uses ECG (electrocardiograph), which implies that the heart rate is found by measuring the electrical activity of the heart (Polar, 2023a). When placed on the skin, the electrode area in the chest strap can pick up the electric signals sent through the body fluids as the heart beats. The electrode area needs to be wet and placed near the heart to ensure that the electrodes can pick up the signals. The correct placement of the chest strap can be seen in Figure 72. The connector uses Bluetooth and ANT+ to send the heart rate to the connected device. The study from Gilgen-Ammann et al. (2019) found that the signal quality of the Polar H10 was demonstrated to be 99.6% overall, in contrast to the medilog® AR12Plus, an ECG Holter monitor, which was found to have 94.6% signal quality. A Holter monitor is a medical device that continuously measures and records heart activity for 24 to 48 hours using electrodes placed on the skin (American Heart Association, 2015). In high-intensity activities, the Polar H10 had a signal quality of 99.4%, while the medilog® AR12Plus dropped to 89.8%. For this experiment, the Polar H10 was connected to a phone using the Polar Beats app, and then the data was synchronised with the Polar Flow app. After each use, the connector was detached from the chest strap, and the chest strap was cleaned using water and mild soap and left to dry.

Figure 71: The Polar H10 Heart Rate Sensor. Image from Polar (2023c)

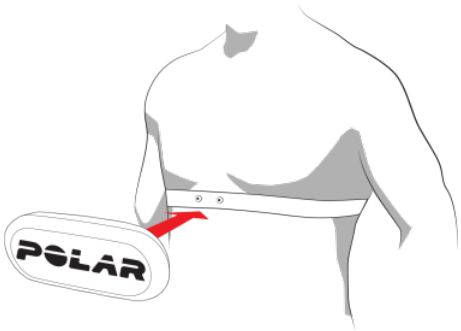


Figure 72: The placement of the Polar H10 Heart Rate Sensor. Image from Polar (2023c)

27.5 Interviews

After each exercise session, an in-depth interview was conducted. A generalised interview guide can be seen in Table 14, where IQ1 to IQ13 was asked during the control sessions, and IQ4 to IQ17 was asked during the game sessions. However, the questions were mainly a baseline to steer the conversation, and more specific questions were asked on a case-by-case basis to gain more insight into the participants' thoughts. There was a conscious effort by the interviewer to avoid leading questions or actions that would otherwise affect the results of the interviews. Audio recordings of the interviews were made to allow the authors to look back on the interviews more accurately.

The questions asked during the interviews were formulated based on the research questions for this thesis. IQ2 and IQ3 were asked to gain insight into which genres the experiment participants preferred, contributing to RQ1. To gain insight into whether the participants enjoyed themselves and entered a state of flow (RQ3), IQ4 to IQ7 was asked. In addition, IQ8 and IQ9 provided context

to what might have contributed or detracted from their state of flow. IQ13 to IQ16 concerned replayability and comparison between the different sessions, answering the second part of RQ3. Further, RQ4 about reaching the recommended exercise amount was answered by comparing the participant's regular exercise routine (IQ1) and their experiences in the control session (IQ15, IQ17) with their subjective experience of exercise benefit during the gaming sessions (IQ10-IQ12). Lastly, IQ14 aimed to gain more qualitative insight into RQ5, complementing the quantitative data from the general survey.

Table 14: Interview guide. The control session used IQ1-IQ13, while the game sessions used IQ4-IQ17

Earlier experience	
IQ1	How often do you exercise? What kind of exercise? (type, duration etc.)
IQ2	Gaming experience? Du you play video games (including mobile games)? How often? How long have you been gaming?
IQ3	Gaming preferences? (genres, singleplayer vs. multiplayer, how long are your sessions?)
Flow	
IQ4	Did you have fun when playing?
IQ5	Did you feel that time went slowly/fast?
IQ6	Was it easy to concentrate on the game?
IQ7	Did you think about the exercise while playing?
IQ8	Which parts of the game did you enjoy?
IQ9	Which parts did you not enjoy/would you change?
Exercise benefit	
IQ10	How did you feel about the exercise intensity? How was the progression?
IQ11	How did you feel about the exercise compared to the exercise you normally do? How was the exercise benefit in comparison?
IQ12	Did you feel like you fitness level restricted you progression in the game? If yes, what was the limiting factor (endurance, leg strength etc.)?
Replayability	
IQ13	Would you play this game again if you had access to the game and necessary equipment?
IQ14	Assuming you got access to this and similar exergames, would you have bought a PlayPulse bike?
Comparison to other sessions	
IQ15	How was it to play the game this session, compared to last session / the control session?
IQ16	Were you more/less motivated?
IQ17	Did you feel like you got more/less exercise benefit?

27.6 Anonymous Reflection Questionnaire

The participants were instructed to answer an anonymous reflection questionnaire within two days of each session. The intentions behind this data generation method were to gain quantifiable and comparable data and decrease the effect of the familiarity bias by providing an anonymous feedback mechanism to be answered away from the interviewers. A Likert scale was the main answering format, consisting of the options: Strongly disagree, slightly disagree, slightly agree and strongly agree. While such scales usually have a neutral option, it was removed for this questionnaire to avoid diluting the dataset and to force the participants to have opinions. Despite quantifiable data being the main purpose of this questionnaire, three questions asked for text answers. This was to prevent the respondents from being frustrated by limited options for topics where it would be nearly impossible for the authors to predict all possible answers. Such an answer format, when used sparingly, might also provide more context to the responses to other questions.

When formulating the questions, RQ3: *Can such an exergame facilitate a state of flow?* and RQ4:

Can such an exergame contribute to more people reaching the recommended exercise amount? were considered. The questions pertaining to RQ3 focused on whether or not the respondent had experienced the different aspects of flow, and what elements of the game might have detracted or facilitated that feeling. Relevant questions include AQ1, AQ3-5, AQ8, AQ10-14 and AQ18-19. Additionally, other questions explored the second part of RQ3 about replayability, notably AQ2, AQ6-7 and AQ15-17. While RQ4 was answered mainly by the second set of Likert questions (AQ20-27), some of the questions pertaining to flow, e.g. AQ2 and AQ6, can also be relevant here.

Table 15: Questions and answer formats of the anonymous questionnaire

ID	Question	Potential Answers	Session
AQ1	I had fun during the session	**Likert Scale**	Control Session, First Game Session, Second Game Session
AQ2	I want to exercise like this again	**Likert Scale**	Control Session, First Game Session, Second Game Session
AQ3	I though about being tired several times during the session	**Likert Scale**	Control Session, First Game Session, Second Game Session
AQ4	I wanted to end the session before it was done	**Likert Scale**	Control Session, First Game Session, Second Game Session
AQ5	I did not think about the fact that I was exercising during the session	**Likert Scale**	Control Session
AQ6	I would engage in this kind of exercise regularly if I had the necessary equipment available	**Likert Scale**	Control Session
AQ7	I want to play the game again	**Likert Scale**	First Game Session, Second Game Session
AQ8	The session felt more like gaming than exercise	**Likert Scale**	First Game Session, Second Game Session
AQ9	It was easy to understand how the game was played	**Likert Scale**	First Game Session, Second Game Session
AQ10	The buttons made intuitive sense	**Likert Scale**	First Game Session, Second Game Session
AQ11	It was easy to understand what speed I had to hold in order to balance the board	**Likert Scale**	First Game Session, Second Game Session
AQ12	I noticed that I got better at the game during the session	**Likert Scale**	First Game Session, Second Game Session
AQ13	I felt that the balance point was at a comfortable speed	**Likert Scale**	First Game Session, Second Game Session
AQ14	I was motivated to try to increase my highscore	**Likert Scale**	First Game Session, Second Game Session
AQ15	I would want to play this game regularly if I had access to the necessary equipment	**Likert Scale**	First Game Session, Second Game Session
AQ16	I had just as much fun this session than during the first game session	**Likert Scale**	Second Game Session
AQ17	It was easier to get into the game this time	**Likert Scale**	Second Game Session

AQ18	Rank these game modes after what you liked best	**Rank** Balance Mode, Shapes Mode, Marble Mode	First Game Session, Second Game Session
AQ19	Explain your answer	**Text answer**	First Game Session, Second Game Session
AQ20	I changed the resistance often	**Likert Scale**	Control Session, First Game Session, Second Game Session
AQ21	I changed the resistance in order to increase exercise benefit	**Likert Scale**	Control Session, First Game Session, Second Game Session
AQ22	I changed the resistance because the previous resistance was too heavy or too light	**Likert Scale**	Control Session, First Game Session, Second Game Session
AQ23	I felt like the bike was uncomfortable to sit on after a while	**Likert Scale**	Control Session, First Game Session, Second Game Session
AQ24	I felt my stamina was limiting me	**Likert Scale**	Control Session, First Game Session, Second Game Session
AQ25	I felt like my leg strength was limiting me	**Likert Scale**	Control Session, First Game Session, Second Game Session
AQ26	Rank these elements after what you felt had the most negative impact during the session	**Rank** Muscle Strength, Stamina, Uncomfortable bike seat or other equipment, Boredom	Control Session, First Game Session, Second Game Session
AQ27	Explain your answer	**Text answer**	Control Session, First Game Session, Second Game Session
AQ28	Do you have any other comments?	**Text answer**	Control Session, First Game Session, Second Game Session

27.7 Summary of Experiment Design

The experiments consisted of three sessions: A control session and two game sessions, where each session started with up to 30 minutes of exercise on the bikes, followed by an in-depth interview. After each session, the participants filled out an anonymous questionnaire about their experience. The experiment had 10 participants that were recruited from the author's network. Before the experiments, all participants signed a consent form describing how the data collected during the experiment would be processed. During the experiments, a PlayPulse prototype bike and a Polar H10 heart rate monitor were used.

28 Data Analysis

As this project generated both qualitative and quantitative data, several methods were used for data analysis. The qualitative data came from the interviews and observations made during the experiments, and the quantitative data came from questionnaires and heart rate monitors.

28.1 Qualitative Analysis

The qualitative data from the interviews and observations were codified into categories to make recurring patterns or insightful findings more visible. A process consisting of four steps was utilised:

- **Step 1:** First, the audio recordings and written notes from the interviews and observations during the exercise sessions were combed through for interesting information regarding the research questions.
- **Step 2:** This information was then codified into one of 10 categories by colour-coding the notes and adding a condensed version of the sentiment to a separate document. The categories were based on topics the authors had noticed were prevalent while conducting the experiments. They consisted of:
  - Enjoyed elements
  - Disliked/improvable elements
  - Technical issues
  - Motivation
  - Flow
  - Replayability
  - PlayPulse bike
  - Exercise
  - Physical limitation
  - Experiment flaws.
- **Step 3:** When all data had been processed in this way, the categorised document was further condensed into another document, focusing on identifying recurring experiences or sentiments and patterns within those. This step involved discussion among the authors to evaluate which findings were significant and insightful.
- **Step 4:** Finally, the resulting document was used to write the findings into a more readable format that can be seen in Part VI.

28.2 Quantitative Analysis

The questionnaires were analysed by importing the data into Excel and sorting it into new tables based on the participant sub-groups (general survey) and sessions (anonymous reflection questionnaire). The sub-groups are 'physically active', 'not physically active', 'gamer' and 'not gamer' and will be discussed in Section 31.1.1. These new tables were used to create new graphs, which can be seen in Part VI. In addition, all open-ended questions were analysed by reading through them and noting interesting information regarding the research questions. Finally, similar answers were combined and counted to condense the information gained.

For each session, the heart rate monitors saved the heart rate every second, and the resulting data was imported into Excel. The max heart rate of each subject was then calculated based on the formula $211 - 0.64 * age$ (Equation (1)), as mentioned in Chapter 9. When the max heart rate had been calculated, the heart rate values were changed into the percentage of the max heart rate

instead. This allowed for comparison between subjects and comparisons to the heart rate zones. In Excel, heart rates were sectioned into a separate sheet per subject. In addition, one sheet was made for each session and included all the heart rates for that session and the average for each person per session. The data in these sheets were used to create the heart rate graphs seen in Part VI.

28.3 Summary of Data Analysis

Different methods were used for the analysis of qualitative and quantitative data. The qualitative data was analysed through a four-step process, where the first step consisted of combing through the written notes and audio recordings from the sessions and noting down information related to the research questions. The second step was to codify this information into ten different categories. Next, step three consisted of condensing the information based on recurring patterns. The final step was to write it down in a more readable format, as seen in Part VI. The quantitative data was analysed by exporting the questionnaire and heart rate data into Excel. The answers to the questionnaires were divided into different sub-groups before graphs and diagrams were made. The heart rate values were changed into the percentage of max heart rate based on the formula $211 - 0.64 * age$ before being used to create different heart rate graphs.

29 Reliability and Validity

This chapter will discuss some relevant reliability and validity concerns that might affect the results of this study.

29.1 Heart Rate Monitors

As discussed in Section 27.4.1, the Polar H10 was used, with a signal quality of 99.6%. The connected app required age, height, weight, gender and max heart rate, and these settings were left untouched, even when they did not match the subject. As the Polar Support page indicates, only the max heart rate would affect the data used in this project, as it is used to calculate the different intensity zones (Polar, 2023b). For the results, the zones will be re-calculated for each subject based on their age and the formula introduced in Chapter 9. Whether the user data has other impacts on the reported heart rates is difficult to guarantee without access to confidential code, but the support page indicates that it does not.

29.2 Sample Size and Diversity

Because of resources and time, only ten subjects were chosen for the experiment. This number was selected to ensure enough time for each subject to perform the in-depth experiment within the time frame. There are a lot of different methods for determining the necessary sample size, Hill (1998) discussed different literature about it. Several researchers recommend 30 or more in experimental research. Since the sample size of this experiment is less than that, there will be limitations on how conclusive the results can be when extrapolating to the larger demographic. However, it is also expressed that if in-depth qualitative data is gathered, like interviews, small sample sizes are justifiable. On the other hand, large sample sizes are more important when the total sample will be divided into sub-groups and compared against each other, like in the planned general survey. 380 participants are seen as a limit where any more would not provide enough new information to outweigh the cost. As the general survey received 80 responses, dividing them into two sub-groups of 40 might provide large enough sample sizes to be conclusive. However, as can be seen in Part VI, the smallest groups contained 18 and 27 respondents. These groups are smaller than the minimum recommendation of 30 for this type of research and should be kept in mind when making conclusions.

Regarding diversity, the experiment participants were all between the ages of 22 to 28, with an average age of 24.4 years, and the subjects consisted of four women and six men. However, the subjects engaged in more exercise than the target audience. Still, as the focus of the experiment focused more on the effect of the game in general, this was acceptable. The respondents for the general survey were mostly in the age group 18-24, and as with the experiment participants, the sample size engaged more in exercise than the target audience. However, this is a greater problem in the general survey than in the experiments since this research strategy aimed to uncover the preferences of the target audience.

29.3 Familiarity Bias

Due to recruiting participants from the authors' social network, there is a risk of familiarity with the authors skewing the feedback. Particularly, the participants might give more positive feedback and hold back potentially negative feedback to avoid damaging their relationship with the authors. Preventative measures to minimise the effect of this included reminding the subjects to be honest before each session and providing the anonymous reflection questionnaire mentioned earlier. The former consisted of informing them that all feedback is useful, specifically mentioning that they should not be afraid to give negative feedback.

29.4 The Hawthorne Effect

> "*The Hawthorne effect is a phenomenon characterised by an awareness on the part of the subjects of special treatment created by artificial experimental conditions. This awareness becomes confounded with the independent variable under study, with a subsequent facilitating effect on the dependent variable, thus leading to ambiguous results.*"
>
> Cook, 1962

In other words, the results of the planned experiment might have been affected by the participants knowing that they are under observation, or by other artificial factors introduced as a means of isolating the factors being studied. This should be considered when analysing and discussing the data received from the various data generation methods.

29.5 Summary of Reliability and Validity

Four reliability and validity concerns should be considered during the experiments and discussion, as they might affect the results. The first one is the concern regarding the heart rate monitors and the user data that stayed identical throughout the experiments. While the Polar support page indicates that it should not be a problem, there is no way to be sure. The second concern is with the sample size, as there was a higher focus on detailed experiment sessions and less on a larger sample size. The third concern is the familiarity bias, where there is a chance that the participants held back feedback to avoid damaging their relationships with the authors. An anonymous questionnaire and reminders to stay honest were used to try and negate this. The final concern is the Hawthorne Effect, where participants might act differently because they know they are being observed.

30 Summary of Methodology and Data Generation

This part has described the different research strategies used and how these methods aim to answer the research questions. The general survey was a questionnaire with questions regarding gaming preferences and exergame interest in an attempt to gain quantitative data regarding the research questions **RQ1:** *Are there commonly enjoyed game genres that are not sufficiently represented in the current exergame market?* and **RQ5:** *Does the equipment needed for an exergame deter people from playing exergames?*

The experiments used interviews, observations and an anonymous questionnaire to generate qualitative and quantitative data regarding the research questions **RQ3:** *Can such an exergame facilitate a state of flow?*, **RQ4:** *Can such an exergame contribute to more people reaching the recommended exercise amount?* and **RQ5**. This part also explained how the generated data was analysed by codifying and condensing the qualitative data and processing the quantitative data in Excel. Potential reliability and validity issues that might affect the results, like inaccurate sensor data, sample size and diversity, familiarity bias and the Hawthorne effect, were also discussed. Further, the next part will present the results gathered during the general survey and experiments.

Part VI

Results

> "*It is a capital mistake to theorise before one has data. Insensibly one begins to twist facts to suit theories, instead of theories to suit facts.*"
>
> Sir Arthur Conan Doyle (1891)

This part presents the results from the general survey and the experiments. The experiment results consist of data gathered during the interviews, the heart rate data and observation notes from the exercise sessions and the results from the anonymous reflection questionnaire.

31 General Survey

This chapter covers the results gathered from the general survey. The questionnaire was sent out on the 18th of April 2023 to the researchers' networks, shared in Facebook groups, and accepted answers until the 10th of May.

31.1 Demographic

The general survey got 80 responses, with the majority of the respondents being in the age range 18-24 (see Figure 73). Figure 74 shows the gender distribution, and Figure 75 and Figure 77 shows the exercise and gaming frequency of the participants. Figure 76 and Figure 78 show the exercise and gaming frequency of the participants separated by gender. Since the sizes of the groups are not identical, the graphs are based on percentages. As only one of the respondents was non-binary, the sample size was not considered big enough to provide insight into the larger population. Therefore that person's answers are not included in these graphs.

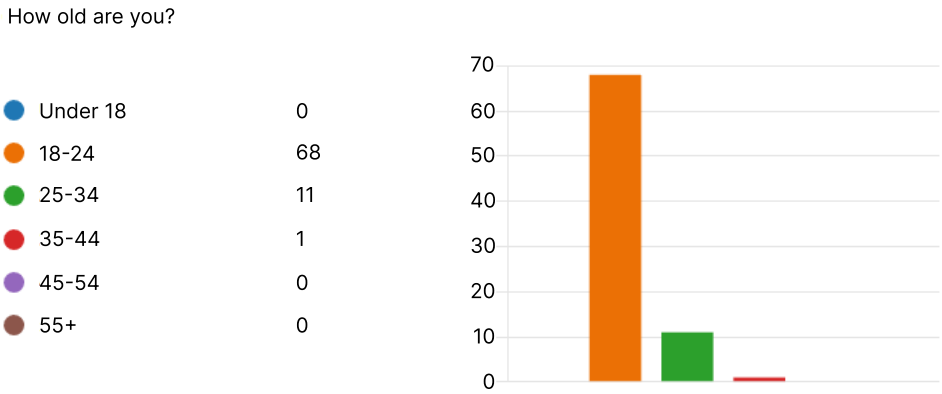


Figure 73: Age distribution from the general survey (GQ1)

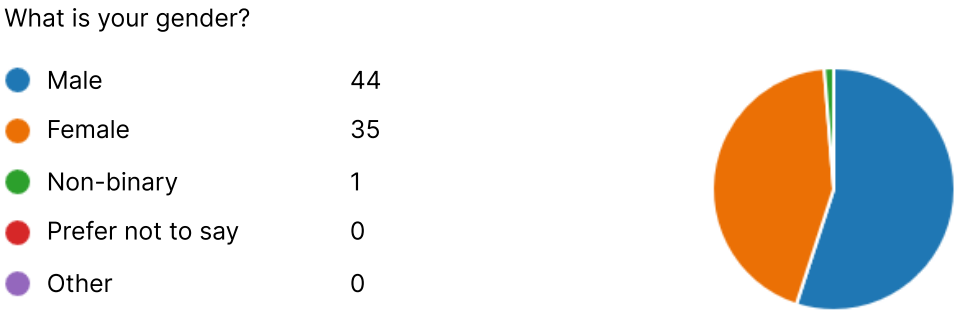


Figure 74: Gender distribution from the general survey (GQ2)

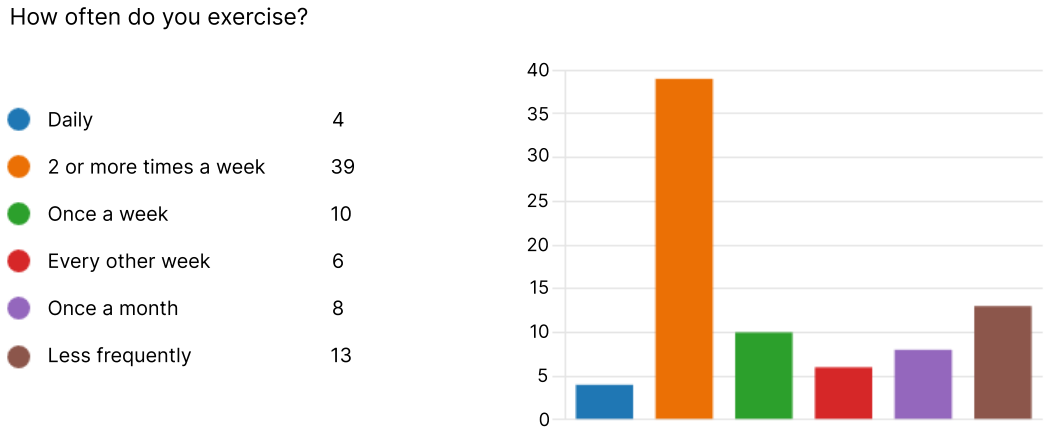


Figure 75: Exercise frequency (GQ3)

Figure 76: Exercise frequency - Men vs Women (GQ3)

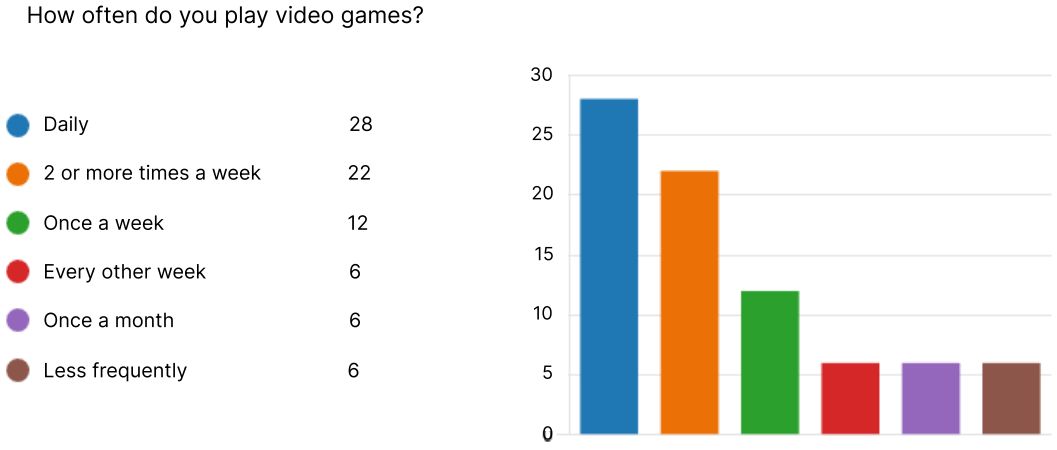


Figure 77: Gaming frequency (GQ4)

Figure 78: Gaming frequency - Men vs Women (GQ4)

31.1.1 Sub-Groups

The participants were split into sub-groups, depending on if they were labelled as 'physically active' or 'not physically active' and 'gamer' or 'not gamer'. The people who responded with "Daily", "2 or more times a week" or "Once a week" on GQ3 were placed into the *Physically Active* sub-group, and the ones who responded with "Every other week", "Once a month" or "Less frequently" were placed into the *Not Physically Active* sub-group (see Table 16). The same distinction was made with the sub-groups *Gamers* or *Not Gamers* through GQ4 (see Table 17). As this questionnaire was sent out with a description that encouraged people who played video games to reply, the *Not Gamers* sub-group is noticeably smaller.

Table 16: Distribution of Physically Active and Not Physically Active respondents

	Respondents	**Percentage**
Physically Active	53	66,25%
Not Physically Active	27	33,75%

Table 17: Distribution of Gamers and Not Gamers respondents

	Respondents	**Percentage**
Gamers	62	77,50%
Not Gamers	18	22,50%

31.2 Genres

Figure 79 shows the overall distribution of which genres are enjoyed. Nine people (11.25%) checked the "Other" box, and their answers included "MOBA", "FPS", "Racing", "Soulslike" and "Minecraft", which fit into the provided genres and are therefore ignored for the rest of this chapter. Figure 80 and Figure 81 show the distribution based on the different sub-groups. Percentages are used to compare sub-groups of different sizes better. It should be mentioned that the *Not Gamer* sub-group was significantly smaller than the *Gamer* sub-group, so while a higher percentage of *Not Gamers* answered that they enjoyed puzzle games, there were 29 (47%) *Gamers* and 15 (83%) *Not Gamers* who checked off "Puzzle". Figure 82 shows the distribution based on gender through percentages, as there were not an equal amount of men and women in the study. As only one of the responses was non-binary, there was not a large enough sample size to give any insight into the larger population, and therefore the answer is not included.

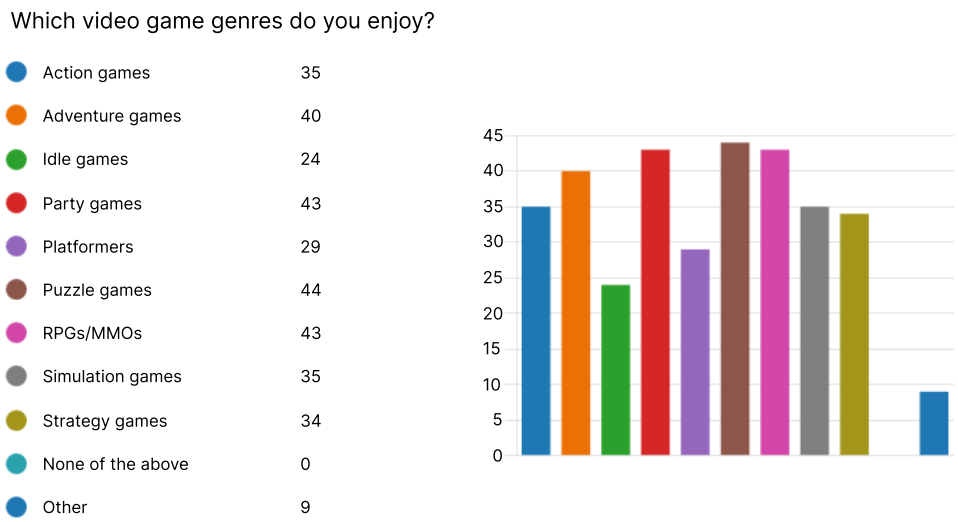


Figure 79: Preferred Genres (GQ5)

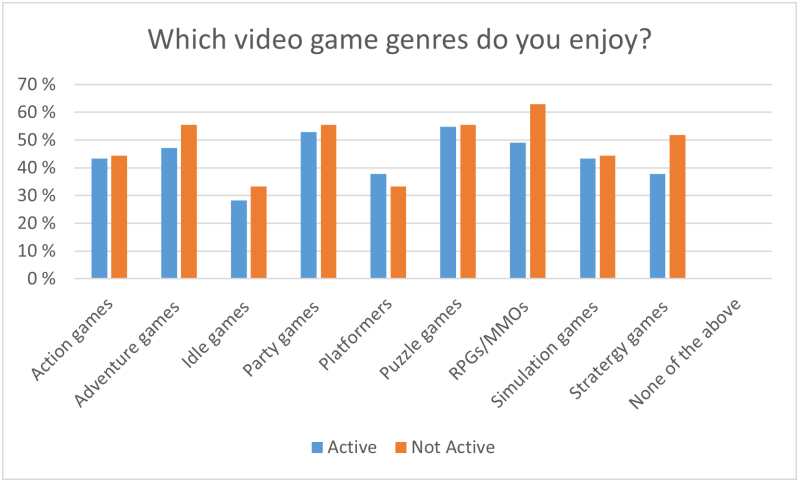


Figure 80: Preferred Genres - Physically Active vs Not Physically Active (GQ5)

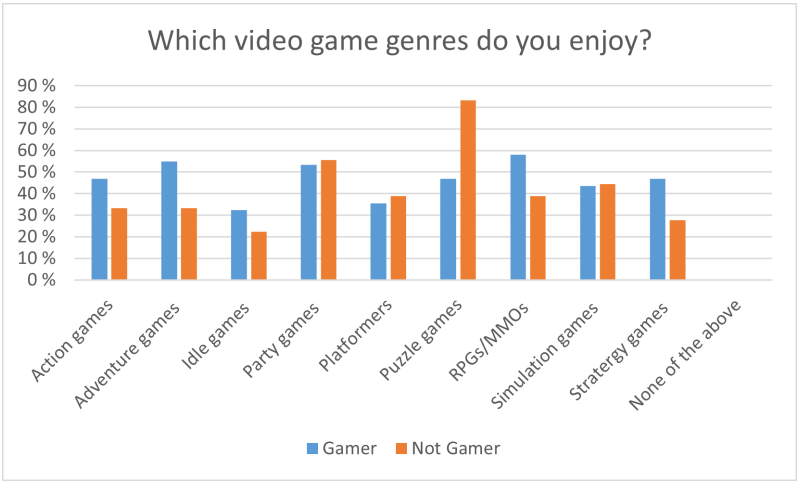


Figure 81: Preferred Genres - Gamers vs Not Gamers (GQ5)

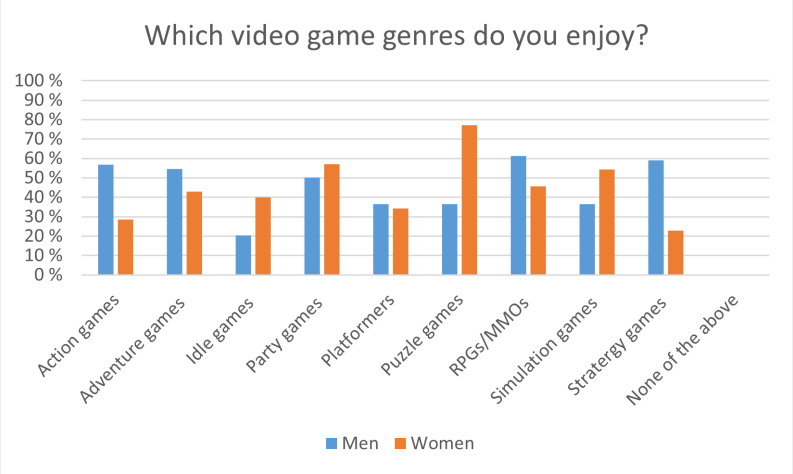


Figure 82: Preferred Genres based on gender (GQ5)

31.3 Singeplayer vs Multiplayer

Figure 83 shows the preferences of singleplayer vs multiplayer. Figure 84 and Figure 85 show how the different sub-groups replied, where the first number is the number of people who replied, and the second is the percentage. Figure 86 shows how the different genders replied, and as only one of the responses was non-binary, there was not a prominent enough sample size to give any insight into the larger population, and therefore the answer is not included.

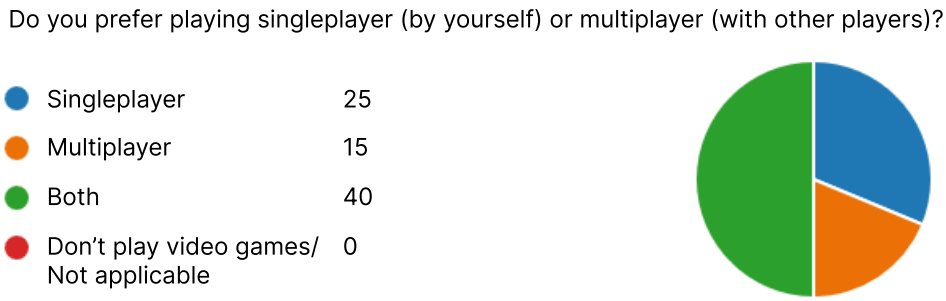
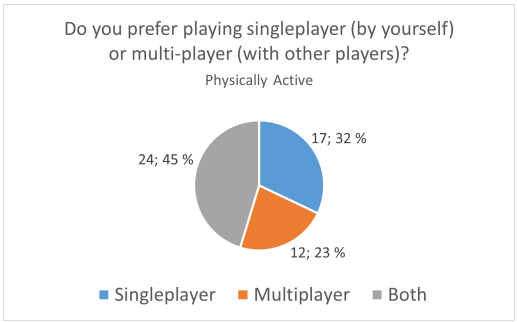
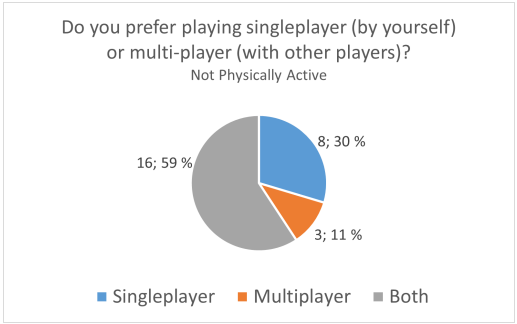


Figure 83: Singleplayer vs Multiplayer (GQ6)

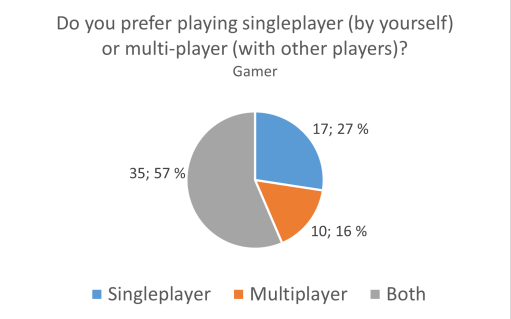


(a) Physically Active

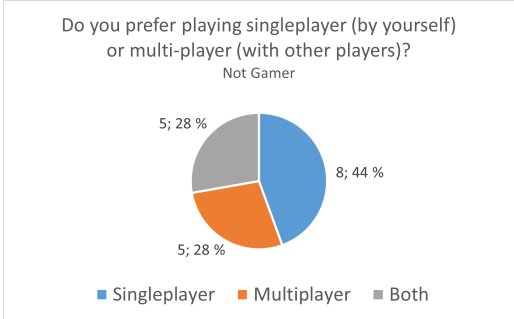


(b) Not Physically Active

Figure 84: Singleplayer vs Multiplayer - Physically Active vs Not Physically Active (GQ6)

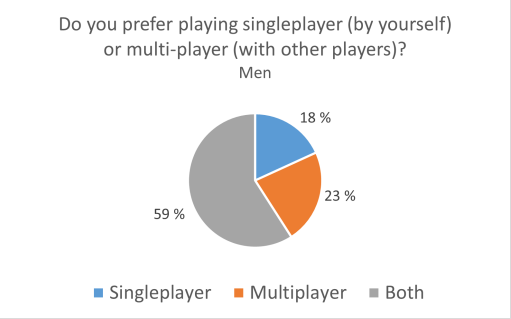


(a) Gamers

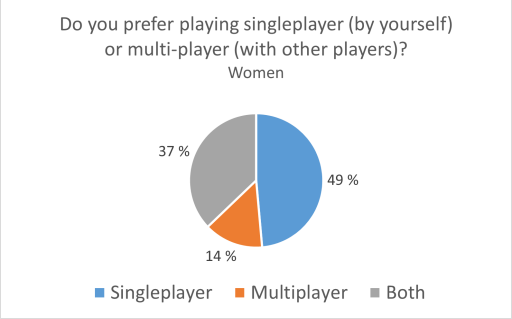


(b) Not Gamers

Figure 85: Singleplayer vs Multiplayer - Gamers vs Not Gamers (GQ6)



(a) Men



(b) Women

Figure 86: Singleplayer vs Multiplayer - Men vs Women (GQ6)

31.4 Exergame Frequency

Figure 87 shows how often the respondents play exergames, and Figure 88 and Figure 89 shows how the different sub-groups responded. Again a percentage is used to compare the sub-groups, as they were of different sizes. When asked why they do not play exergames, 13 people (16.25%) commented that most exergames require equipment they do not have access to, and the equipment is too expensive or takes up to much space. Some commented that mobile exergames require them to look at their phone when outside and that they would much rather look at nature. Seven people (8.75%) commented that the games they have tried have been boring or got too repetitive after a while. Additionally, four people (5%) felt like they did not know what options there were, and 4 (5%) felt like there were no games for them.

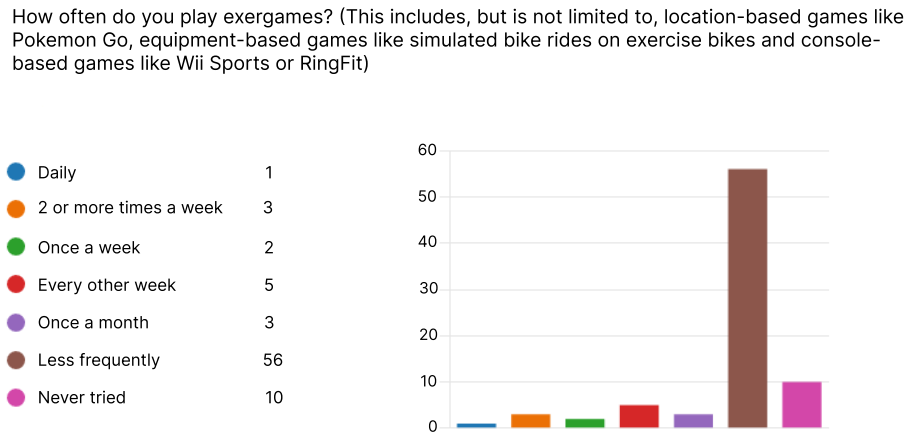


Figure 87: How often do you play exergames? (GQ7)

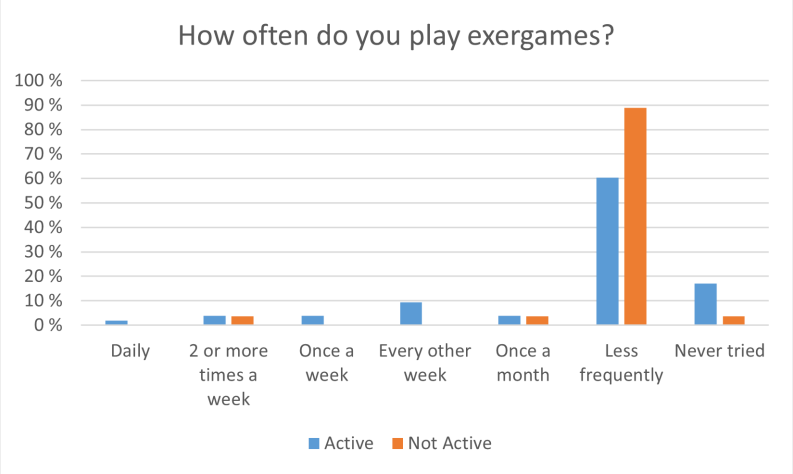


Figure 88: How often do you play exergames? - Physically Active vs Not Physically Active (GQ7)

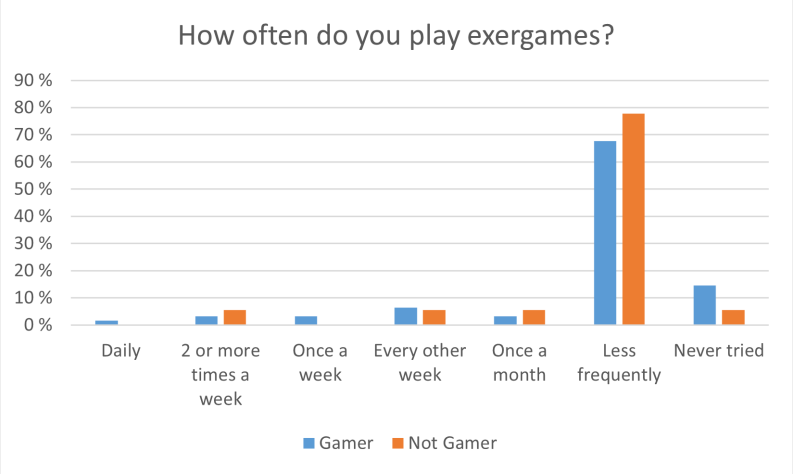


Figure 89: How often do you play exergames? - Gamers vs Not Gamers (GQ7)

31.5 Exergame Interest

Figure 90 shows how interested the respondents were in playing exergames regularly, assuming that it was a game they enjoyed and that they had access to all necessary equipment. Figure 91 and Figure 92 shows how the different sub-groups responded.

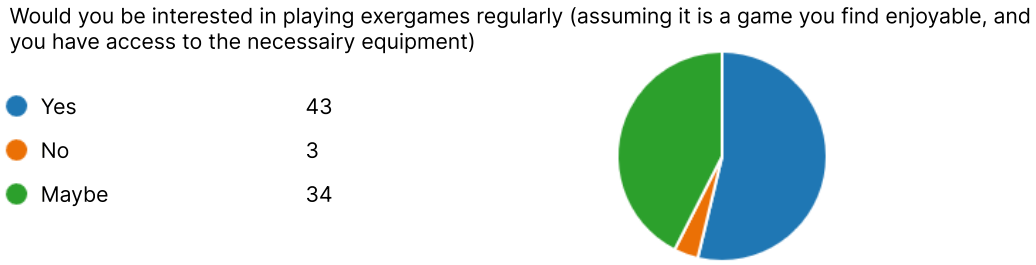
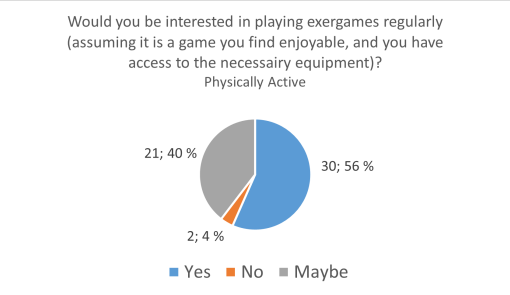
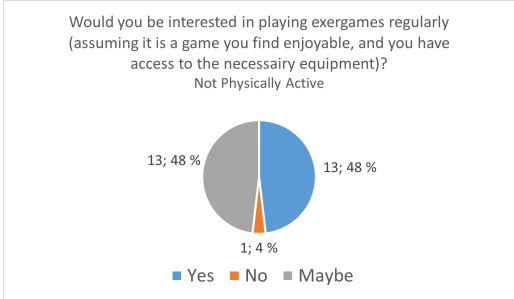


Figure 90: Would you be interested in playing exergames regularly? (GQ9)

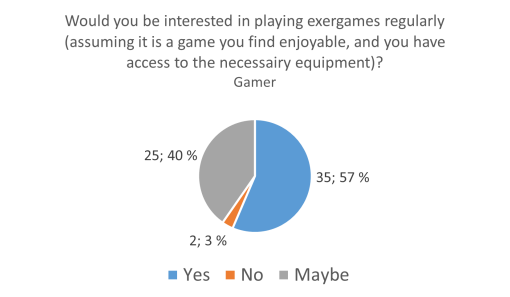


(a) Physically Active

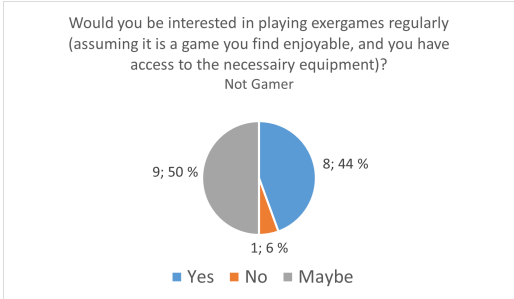


(b) Not Physically Active

Figure 91: Would you be interested in playing exergames regularly? - Physically Active vs Not Physically Active (GQ9)



(a) Gamers



(b) Not Gamers

Figure 92: Would you be interested in playing exergames regularly? - Gamers vs Not Gamers (GQ9)

31.6 Exerbike

Figure 93 displays whether respondents think they have the space for and the money to be able to buy an exercise bike, regardless of interest.

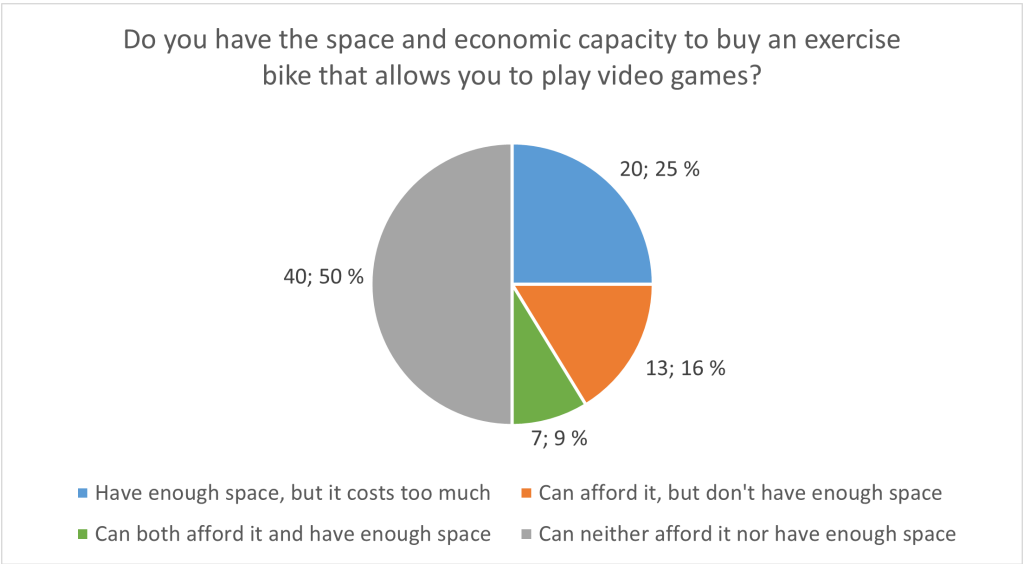


Figure 93: Do you have the space and economic capacity to buy an exercise bike that allows you to play video games? (GQ10)

31.7 Other Comments

On the open comment field at the end, there were eight comments. Two commented that even though they could buy the exercise bike, they probably would not spend money on such a machine. One person commented that 16k is a significant investment for someone who has never tried or even heard about such an exercise bike and that their first thought was that it would probably need to be more visible on streaming sites and social media such as Twitch and YouTube to attract more of the mainstream audience. The rest of the comments were not relevant.

32 Experiment Results

The following chapters will present the data from the results gathered during the experiments, which were held between the 17th of April and the 28th of April. As explained in Part V, each participant took part in three exercise sessions, where they were given a heart rate monitor and biked for a minimum of 20 minutes, once while listening to music and twice while playing FlipBoard. After biking, a short interview was held, and after each session, they were sent an anonymous reflection questionnaire that they were instructed to answer. The following chapters will first present information about the participants, followed by the data gathered during the interviews and observations. This data is grouped into sections in order to make it more readable. After, the heart rate data will be presented, followed by the results from the anonymous reflection questionnaire. The questionnaire results are also grouped into sections.

32.1 Participants

Ten people participated in the experiments, all from the researchers' networks. The group consisted of four women and six men, all in the age group 22-28, with an average age of 24.4 and the median age of 24. Half of the participants engaged in exercise once a week (see Figure 94), and 40% played video games every day (see Figure 95). A list of all participants, their gender and if they classify as active or gamer can be seen in Table 18. Participants were classified as active if they engaged in physical activity at least once a week, and the same criteria were given for the gamer category.

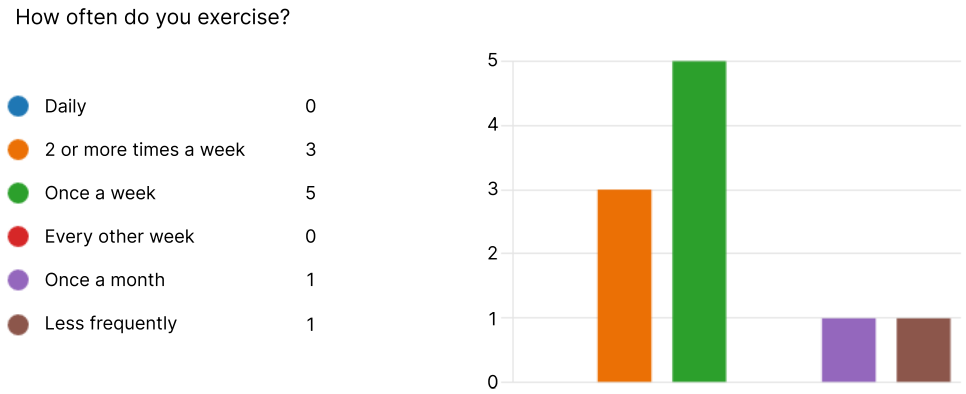


Figure 94: Exercise frequency among participants

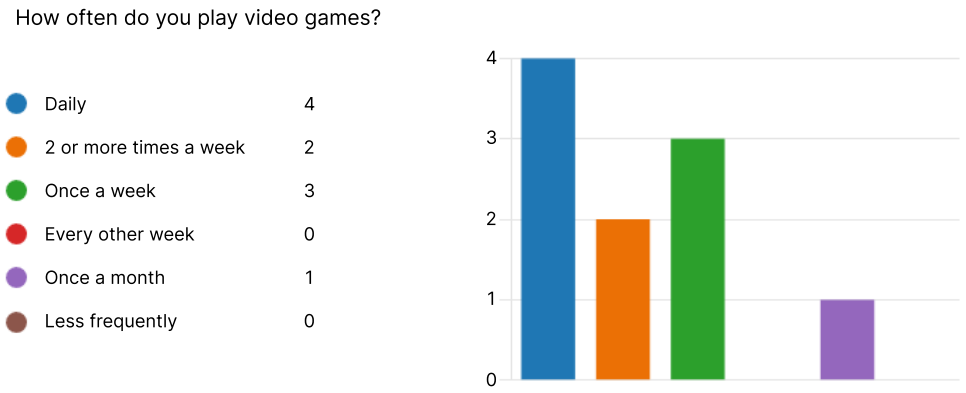


Figure 95: Gaming frequency among participants

Table 18: Experiment participants

ID	Gender	Physically Active?	Gamer?
1	Female	Yes	Yes
2	Male	Yes	Yes
3	Male	Yes	Yes
4	Male	Yes	No
5	Female	Yes	Yes
6	Male	Yes	Yes
7	Male	No	Yes
8	Female	Yes	Yes
9	Male	Yes	Yes
10	Female	No	Yes

33 Insights from Interviews and Observations

The insights gained during and after the exercise sessions will be presented, beginning with those relevant to flow and motivation (RQ3). Followed by what the participants liked or disliked, along with their suggestions for improvement. Further, their perception of the exercise benefit and intensity will be detailed, including any physical limitations experienced (RQ4). Whether or not they would play FlipBoard again and why will then be reported, along with the draw of buying a PlayPulse bike (RQ5). Lastly, technical issues and flaws with the experiments will be described.

33.1 Time Perception

Altered time perception was among the most noticeable factors during the experiment. 6 out of 10 (60%) participants expressed that they felt time went at least slightly faster than expected during the control session (indoor biking with music), with Subject-1 elaborating that it was caused mainly by being unfamiliar with the exercise form and thus thinking 20 minutes would be a long time. Three participants felt that time went slower than usual, two of them specifying that it happened more when they got tired.

In contrast, **all participants felt time went faster than usual during both game sessions.** How fast differ; one participant mentioned that 20 minutes felt like 15, while others experienced it as 10 or 8 minutes. Subject-6 expressed that time went by faster than during his usual exercise routine. Two participants mentioned being reminded of the normal flow of time when playing Balance Mode, where the scoring system is based on seconds. One of them also pointed out Shapes Mode as slower because of having to wait for objects to spawn. **Three participants felt that time went faster during the second game session than the first**, while Subject-2 experienced the opposite. Interestingly, the same reason was given for both Subject-2 and one of the former; that they knew what to expect now.

33.2 Concentration

Whether or not the participants were concentrated was based on observations made during the sessions and their answers during the interview. **only two participants reported being concentrated during the control session.** Subject-2 specified that the music helped him "disappear into the zone", while Subject-6 felt less concentrated when he got tired. Others expressed that there was not much to concentrate on with just biking and music. However, two other participants managed to avoid being distracted by loud sounds from outside. Lack of concentration was evident through the amount of small talk from five of the participants. Two of them expressed that the session would have been boring without this social aspect. **8 out of 10 (80%) participants thought about exercise during the session; most of them considered it a negative.** However, Subject-1 used it to actively make the exercise more effective, while Subject-6 said it was positive when he felt powerful (but negative when it hurt). On the other hand, **Subject-9 commented after 15 min that he would not have been able to focus on a game with how tired he was.**

all participants reported being concentrated during the game sessions. Three of them found themselves too concentrated to form sentences during the round and either forgot the feedback they wanted to give or had to wait until the menu screen before giving it. Subject-5 stated that she was in her own world and did not think about the test facilitators or the noise from outside. Likewise, three others also had much noise outside that they either were not distracted by or did not notice. **Five participants specifically commented that it was effortless to be concentrated on the game, and 7 out of 10 (70%) participants eagerly reported that they were *very* concentrated.** Subject-4 felt more concentrated during the second game session, while Subject-3 noticed exercise more that session because of increased resistance. On the other hand, Subject-9 reported thinking about exercise during the second game session but considered the game a good enough distraction from it. In contrast, no one except for Subject-10 thought about exercise during the first game session. Subject-1, who did not think about exercise

in either session, explained: "When I have to think about what I'm doing and focus more, it is easier to not think about other things." When explaining that he saw that as a big positive, Subject-2 contrasted it to a treadmill: "[A] treadmill is [super] boring since you stand and breathe in the same air for half an hour and don't have anything to look at."

33.3 Enjoyment

Enjoyment during the control session was lacklustre, with only two participants reporting that they had fun, and two expressing that it was not as boring as expected. The others were neutral, with two commenting that they were bored and did not have fun. On the other hand, **all the participants expressed having fun during both game sessions**, with several specifically mentioning that they had a *lot* of fun. Enjoyment during the game sessions was also evident in the number of reaction sounds and expressions made by all participants. Although everyone made reaction sounds during both game sessions, there was a noticeable increase in people cursing and making more reaction sounds between the first (5 and 6 people, respectively) to the second game session (7 and 8). There were also plenty of more unique behavioural indicators of excitement, some examples being Subject-1 loudly shouting whenever she talked, seemingly without realising, and two participants starting to narrate to themselves in their second language. Players were also excited when they managed to play in ways they thought were not intended, like throwing the marble over walls in Marble Mode. Different play styles and strategies also emerged, like Subject-6 keeping a challenging sphere on the board for a long time in balance by boxing it in with other objects.

The leaderboards were reported as a significant source of enjoyment, which was especially evident through celebrating new records (personal or public). Examples of this are expressions like "Wow, is that me on the top?!? YES!" from Subject-5, "It's better than last time at least. A lot better than last time actually!" from Subject-1 and general shouting of "YES!" while throwing their hands into the air from several others. Subject-6 celebrated like the latter, before immediately starting another round while stating "It can be better!". He got two more highscores and kept laughing and smiling during stretching. As a final example, Subject-7 started playing Balance Mode to calm down after his second highscore in Marble Mode but stopped the round to return to the Marble leaderboard and send a picture of his highscore to a group with many of the participants.

33.4 Motivation

While three participants reported feeling motivated by the music during the control session, Subject-10 commented that she got no motivation to push herself from this exercise form. **8 out of 10 (80%) participants found themselves more motivated during the first game session than the control session**, with the remaining two being motivated the same as the control session. Specifically, Subject-1 and -6 commented that they could keep going for a lot longer than if they were only biking because of the distraction the game provided. Four participants were more motivated during the second game session than the first, while two were slightly less motivated than the previous session. The latter was caused by soreness and being demotivated from the leaderboards. The remaining four participants felt similarly motivated in both game sessions. Subject-6 pointed out that he felt slightly less motivated when doing worse in Marble Mode than in the previous session but that it was good that there are three different modes to help him change it up a bit. **Three participants also commented that playing the game was more fun than their usual exercise form.** One of them pointed out that it required more concentration, while another does not regularly exercise and sees this as a better alternative than running, which he finds boring.

The primary source of motivation in the game seems to be the leaderboards, which 8 participants (80%) mentioned as a motivating factor. Participants who knew each other talked about their scores between sessions, and three participants specifically mentioned trying to beat their friends' scores as a motivating factor. Two participants commented that trying to beat highscores made them give more than they had planned, while another felt like he could go longer

because of it. Additionally, three others reported that having a goal to beat motivated them greatly. For example, once Subject-3 reached a new record in Marble Mode, he demanded that we let him know if the record got beaten. Regardless of whether his record got defeated, he wanted to play the game again after the experiments to get a better score. On the other hand, **two participants felt a bit demotivated by being far away from the scores on the leaderboard**. Subject-5 exclaimed after seeing the leaderboard in Shapes Mode: "Aaa, [current highscore]! I don't have anything to compete with against those people", before changing the game mode. However, as all game modes had difficult highscores to reach, she felt demotivated by all of them.

Six participants pointed out that they felt mastery and improvement during the second game session, caused by reaching new highs on the leaderboards, feeling like they were more in control of the game or feeling like they were getting better at it. **Subject-6 excitedly commented that he felt like the game has a high skill cap** and that it would be fun to see how much he progressed after a few weeks, as he felt like he got better at the game very fast.

The participants' motivation was also visible in their actions during the sessions. For example, when hearing the alarm signalling the end of the 20 minutes, Subject-10 interrupts the test facilitator to declare "No, I don't want to stop!". She eventually ended the game after 9.5 minutes with the caveat that she got to play more after the interview. Similarly, Subject-9 considered closing the game one round after the 20 minutes but ended up playing two more rounds. Finally, he reluctantly closed the game after 8 minutes when he calculated that reaching a new highscore within the remaining time was impossible.

33.5 Likes and Dislikes During the Control Session

Despite not being overly motivated during the control session, the participants liked several elements of the exercise form. Firstly, **two participants mentioned that using an exercise bike is safer than biking outside amongst traffic**. Subject-10 added "Unlike out in traffic, where you can be run over, you can zone out. It is preferable not to be run over." Additionally, two participants liked how indoor biking is more predictable than outdoor biking. Specifically, it was nice to be able to control the change in resistance themselves rather than encountering hills and other natural terrain. Aside from that, two other participants enjoyed the social aspect of small talking and listening to music. Additionally, three participants enjoyed the feeling of pushing themselves, which Subject-1 pointed out was enabled by the structured setting of the experiment. In general, four people stated that they liked the exercise form. Mainly because of its simplicity for Subject-2, while Subject-7 liked it in contrast to running, which is harmful to him for medical reasons. Subject-7 also mentioned that biking is gentler on his ankles, which he is worried about overworking.

However, there were also some complaints about the exercise type. Several participants complained about the bike seat being uncomfortable, while two others were frustrated with the way resistance was changed manually and without visible numbers to make it easier. **Two participants expressed that they prefer biking outside to enjoy the scenery and be out in nature.** Lastly, Subject-4 pointed out that he is prevented from exercising this way because of time restrictions.

33.6 Liked Game Elements

Different participants enjoyed different parts of the game, and **each game mode had players that preferred it the most and disliked parts of other game modes. However, several participants appreciated having a good variety of game modes available.** Subject-10 mentioned that she thinks the game modes are different enough that everyone can find something they like. Similarly, Subject-4 liked that he had to "wire his brain differently" (think in different ways) in the different game modes.

Balance Mode was generally preferred by those who enjoyed the challenge of keeping the speed steady without other distractions requiring focus. Subject-10 preferred it

because she saw it as less challenging than the other game modes, which made it possible for her to multitask and zone out after a long day at work. On the other hand, Subject-8 (who preferred Shapes Mode) felt like Balance Mode was an excellent way to learn how to balance the board, like a tutorial. She also saw it as a good warm-up before moving on to more entertaining game modes. **Her preference for Shapes Mode mainly originated from it having more to focus on than Balance Mode.** Likewise, Subject-2 preferred Shapes Mode because he saw it as a good balance between concentration and exercise, where he felt focused on the game but not too focused to lose the capacity to make the exercise more effective. **Marble Mode was the most popular game mode, preferred by those who enjoyed a more fast-paced game about precision.** Three participants enjoyed that they did not have to focus on keeping the board steady. Additionally, Marble Mode felt like a finished game (Subject-4) utilising all the functionality like tilting and rotating (Subject-7), with more to do than the other game modes (Subject-5). It was also seen as more challenging than the other game modes, with a classic feel.

Additionally, six participants brought up the control scheme as an element they liked. Subject-4 felt like the buttons were exceptionally intuitive and that the speed mechanic was well thought out and felt good. Next, Subject-3 liked that it was easier to balance when the resistance was higher, and Subject-8 liked being able to adjust the resistance and make it easier or harder to balance the board. The ability to adjust the volume was something Subject-10 liked. She also liked the sound effects, especially from the objects rolling or sliding on the board.

33.7 Disliked Elements and Improvement Suggestions

Complaints about the game mainly revolved around problems with the speed controls. Specifically, six participants complained about the sensor delay caused by the filtering method that was used to filter out erroneous data (see Section 23.1). Additionally, four participants pointed out that the camera placement combined with the Marble Mode board means that it is impossible to see the board if pedalling too fast. They complained that this incentivises keeping a lower intensity rather than making players push themselves. Three participants also complained that the music in the game was too repetitive and would get annoying over time.

There were more suggestions for further development than complaints. In Balance Mode, three participants suggested scaling the score based on the number of objects on the board. Rather than intentionally letting the challenging spheres fall, they wanted to incentivise juggling multiple objects simultaneously. Additionally, it was frustrating for players to immediately lose the round if they had five or more objects that fell at once, as it was common to lose everything once something went wrong. Four people expected to only score points in Shapes Mode when objects were dropped in the correctly shaped hole, not every hole. Two of which suggested adding this as a difficulty level with a separate leaderboard. **More levels in Marble Mode were requested by six participants.** Subject-7 was also excited about the idea of power-ups and -downs in Marble Mode when presented with the idea during an interview.

The control scheme also has some improvement potential. Firstly, Subject-6 missed a tutorial or other in-game explanation of the control scheme. **Several participants found the buttons unintuitive in the settings menu**, mainly because of the sideways motion not present in the UI in the rest of the game. Two participants wanted rotation to be possible with only one hand. Additionally, four participants were annoyed when rotation degrees other than 90 and 40 were selected, making it difficult to get the board back to being parallel with the screen. **Two participants suggested a solution: having one button on each hand rotating 90 degrees while the other rotated 45 degrees.**

Other improvement suggestions include letting the player choose which objects will spawn (suggested by three people), alternatively as difficulty levels with separate leaderboards. Two participants wanted the time between objects spawning to be shorter, and Subject-10 wished that objects affected the weight balance of the board. To promote higher exercise intensity, Subject-6 suggested adjusting scores based on intensity and resistance, while Subject-2 suggested incentivising sprints and relaxation periods with spawn positions. Finally, subject-10 requested personal leaderboards and statistics, as well as leaderboards between friends showing who plays the most frequently.

33.8 Exercise Benefit

After the control session, five participants felt like they gained the same exercise benefit as their usual exercise routine, while three felt like they got more benefit than usual. Of the latter, Subject-3 felt that the extra intensity and benefit were gained at the cost of enjoyment, while Subject-7 was expecting to go longer and could have pushed himself more. From those that felt a similar level of benefit as usual, Subject-6 felt like his pulse was too high for a cardio workout, Subject-2 thought the intensity was too high for his condition that day, but Subject-4 felt like he had more to give. Only Subject-10 felt like she got less benefit than her usual routine, but pointed out that she chose to keep a low intensity during the session.

For the first game session, two participants reported getting more benefit than their usual routine, one reported getting the same benefit, and one got less than usual. This number changed to two getting more and three getting less during the second game session, though Subject-9 felt like she had more fun and that it was easier to keep going than her usual routine. Subject-6 also pointed out that even though the intensity was less, he considers that positive when doing cardio. For Subject-10, the second game session was less intense than some of her exercise routines but more intense than others.

Additionally, **four participants felt that they got more benefit from the first game session than the control session**. Subject-7 pointed out that the first game session cost a lot less of him because it distracted him in a good way, making him less bored than last time while giving the same or better results. The game also prevented several from slacking off. On the other hand, **six participants experienced less benefit than the control session**. Four of them explained that it was because they focused more on exercise during the control session, while Subject-8 felt limited by having to balance the board instead of pushing herself. However, Subject-2 stated that he had a lot more fun and that the intensity was good and steady. Similarly, Subject-9 felt that the decreased intensity made it possible to keep going longer. Although Subject-6 felt less intensity than in the control session, he felt the first game session was tougher on endurance. Two of those that got less benefit, and one that got more, **felt like they could have adjusted the resistance more, but were too focused on the buttons or tilt indicator to do so**.

Seven participants felt they got more exercise benefit from the second game session than the first one. Four argued that they could increase the resistance because they, among other things, knew the game better. Two participants felt that the highscores made them give more and keep going for longer. However, two participants felt they got less benefit out of this session. For Subject-10, this was because she had a long day and appreciated being active without pushing herself too hard. Subject-5 had to decrease the resistance to make it easier to balance the board. On the other hand, Subject-3, who got more benefit in the second session, increased the resistance to achieve the same.

Other exercise-based comments include Subject-6 mentioning that FlipBoard is a fun and easy way to get a cardio session into his exercise routine. It was also interesting to see that several participants kept biking fast while in menus between rounds, some even biking while taking a break to drink water. Several participants also tried increasing intensity by tilting the board forward rather than backwards whenever possible. Subject-8 even tried playing while standing but found it easier to control the game while sitting.

33.9 Physical Limitation

Due to only a few participants being used to biking and, as stated by Subject-1, “biking uses muscles I didn’t know I had”, there were some physical limitations during the experiment. Leg strength was a limiting factor for three participants during the control session, while two and one felt the same during the first and second game sessions, respectively. The number of people that were tired or had lactic acid in their legs but did not find it limiting was two during the control session, one during the first game session and four during the last game session. Stamina was less of a limiting factor, as only two felt limited by it during the control session and only one during the second game session. The latter was mainly caused by sickness and not by the game. However,

when playing the game, two people felt slightly limited by coordination or focus. One of which was Subject-6, who felt that it prevented him from going max intensity, which he stated is a good thing for cardio.

33.10 Replayability

After the control session, only two participants said that they would exercise like that again. Subject-6 explains that biking is gentler on the ankles than his usual exercise routine, as he is concerned about overworking his ankles. Of the eight that would not want to exercise in such a way again, four say they lack motivation, while two explain that they do not have enough time. Four participants prefer their usual exercise routine. Subject-10 begins saying that she would but remembers that she has access to an exercise bike she never uses. Similarly, Subject-7 expresses that he would not have been able to make himself work out, even if he had access to a bike and a schedule with himself of when to exercise. It is easier for him when he has something scheduled with other people.

Every participant answered that they would play the game again after both game sessions. After the second game session, two participants said they liked the game better than the first. Similarly, **four participants felt like the game was easier to get into during the second game session because they knew what to do and how to play.** However, Subject-8 worried that she might play less frequently over time. She also expressed that she might play the game as part of a more extensive exercise session but not by itself, as she prefers higher-intensity workouts. On the other hand, Subject-2 considered the game a good alternative for other types of exercise when the weather is dreary and unsuitable for outdoor activity. Subject-5 would be especially motivated to keep playing if he had friends that also played, and Subject-7 was excited about improving his highscore.

33.11 Purchasing a PlayPulse Bike

9 out of 10 (90%) participants would not have bought a PlayPulse bike because they think it is too expensive. Additionally, three of those also do not have enough space to have an exercise bike, while two are generally not interested in purchasing one. However, **everyone except one participant would use such a bike if available at a gym they had access to**. Three participants do not like gyms or find them scary, but one would go if there were an exergame gym or the bike was in an isolated area with few people. Subject-9 clarified that he would not purchase a gym membership for the bike but would have used it if he got a membership for a different reason. Likewise, Subject-8 said she would not go to the gym only to use the PlayPulse bike.

On the other hand, **Subject-1 seemed interested in buying a PlayPulse bike if it had a good collection of games**. The additional functionality offered by the PlayPulse bike excited her as well. She considered the price fair but explained how buying an exercise bike is not her priority. It would be more motivating for her to buy one if she did not live alone, as it is "more ok to use money if it also benefits someone else".

33.12 Technical Issues and Experiment Flaws

Unfortunately, some technical issues might have affected the results. As mentioned in Section 23.1, **there was an issue with data from two buttons being interpreted the same way as the speed sensor, which 8 out of 10 (80%) participants noticed when the board went a different way than what they wanted it to**. In addition, five subjects had the board get stuck in a vertical position by one of the tactics preventing incorrect data from affecting the board. Several of these subjects started to bike faster in reaction and had to be told to slow down for the board to get unstuck. Another issue was a bug that two subjects found where if they pressed the pause menu on the leaderboard screen it opened the pause menu, and the only way to exit was to

use the pause menu to go to the main menu. Fortunately, this bug did not prevent the scores from being added to the leaderboards.

There were also a few flaws with the experiment as a whole. During the control session, Subject-10 commented that she felt like a mouse in a wheel and joked that the facilitators should wear white lab coats and have clipboards. **This is a good example of the Hawthorne Effect**, as mentioned in Chapter 29. However, **she commented during the first game session that she no longer felt like a lab rat**, as she no longer thought about there being other people in the room. In addition, Subject-10 did not realise the intent of the control session, which caused her to give less, until she increased intensity when she realised. There is no way to tell if other subjects had the same misconception, but there is a chance.

The room used was also not ideal for experiments, as the temperature was relatively high and the air quality was poor. As a result, Subject-2 mentioned during the control session that if this were a gym, he would not return. The heat and air quality resulted in having to keep the window open during all tests. Unfortunately, **the room was located directly adjacent to an active construction site** producing considerable noise. While this was not ideal, it also allowed for a way to test how concentrated the players were, as several subjects mentioned that they did not notice any loud noises or movement during the game sessions.

The bike was set up wrong for two participants during the control session, leading to some discomfort and minor pain. The problem was rectified for the game sessions but could have been harmful if part of a routine. In addition, some life events had five subjects not feeling their best during the sessions. Two subjects reported feeling sore, with Subject-1 having a scheduling conflict which caused her to have two sessions on consecutive days. She said it made her less motivated for the second game session. Two other subjects reported feeling slightly sick but not to the point of staying home and cancelling the session.

33.13 Summary of the Interviews and Observations

The preceding chapter has presented various findings from the qualitative data gained during the interviews and exercise sessions. Overall, there was a noticeable increase in experienced time alteration and concentration during the game sessions. Additionally, enjoyment and motivation increased, mainly due to the leaderboards. They were, however, demotivating for two subjects. Positive and negative aspects of the game and exercise form were also detailed, including suggested improvements from the participants. Regarding exercise, eight subjects felt they benefited equally or more than their regular exercise during the control session. Also, while six participants benefited less from the first game session, seven felt increased benefit during the second. Only minor physical limitations were discovered. Furthermore, all participants were interested in playing again but would prefer playing in a gym rather than buying the necessary equipment. Lastly, technical issues and experimental flaws, like sensor problems and the Hawthorne Effect, might have affected the results.

34 Heart Rate

All participants wore a heart rate monitor during the sessions, as discussed in Section 27.4.1. The subjects' heart rates can be seen in Figure 96 to Figure 105. Here the heart rates during the three different sessions are shown, where the percentage is how high the heart rate is in relation to their estimated HR_{max}, as discussed in Chapter 9. The blue line is the control session, the orange is the first game session, and the grey is the second game session. Where the graphs stop is where the subject chose to end the session; so the graphs can also be used to see how long a user spent on each session. 4 out of 10 (40%) subjects had the control session as the shortest session, and only Subject-2 spent the most time on the control session (see Figure 97). Subject-1 was the only one who chose to spend almost the entire session length each time (see Figure 96). The most significant difference between lengths can be seen in Figure 100, where Subject-5 spent 29 minutes during the first game session but chose to end the control and second game session around 21.5 minutes. 60% spent more time on the second game session than the first game session.

As can be seen in Figure 98 to Figure 103, 8 out of 10 (80%) subjects had a higher heart rate during the control session than during the game sessions. Subjects-2 and -3 had a lower heart rate during the first game session than the control session and increased the intensity during the second game session (see Figure 97 and Figure 98). Subjects-1 and -7 had their lowest heart rates during the control session (see Figure 96 and Figure 102).

Figure 106, Figure 107 and Figure 108 show the heart rate average for each session (blue), in addition to the subject with the highest heart rate average (orange) and the subject with the lowest heart rate average (grey) for that session. Here all the graphs end after 20 minutes, as that was the minimum time. As seen in Figure 108, Subject-2 ended slightly before the 20-minute mark. This was caused by a miscommunication between the facilitators when the game needed to be restarted, resulting in the timer not being restarted when the heart rate measuring was. As seen in Figure 106, the heart rates were higher during the control session than during the game sessions, with the highest heart rate reaching the max heart rate for that participant. In contrast, the maximum for both game sessions was around 90%. The lowest during the control session stayed above 60% for 14 minutes, while the lowest for the first game session spent 4 minutes above 60%. During the second game session, the same subject only had short peaks reaching above 60% but stayed between 50%-60% for most of the session.

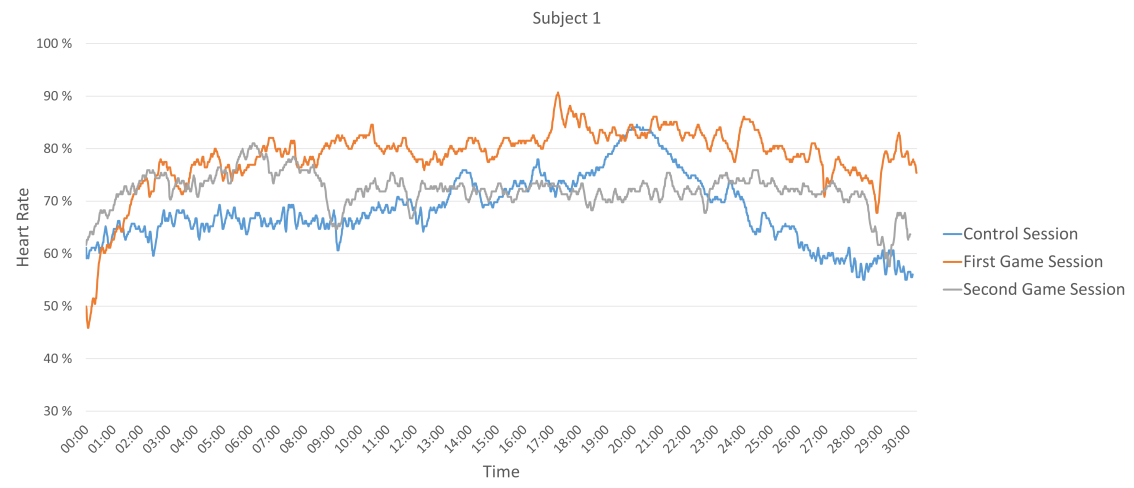


Figure 96: Heart rate of Subject-1

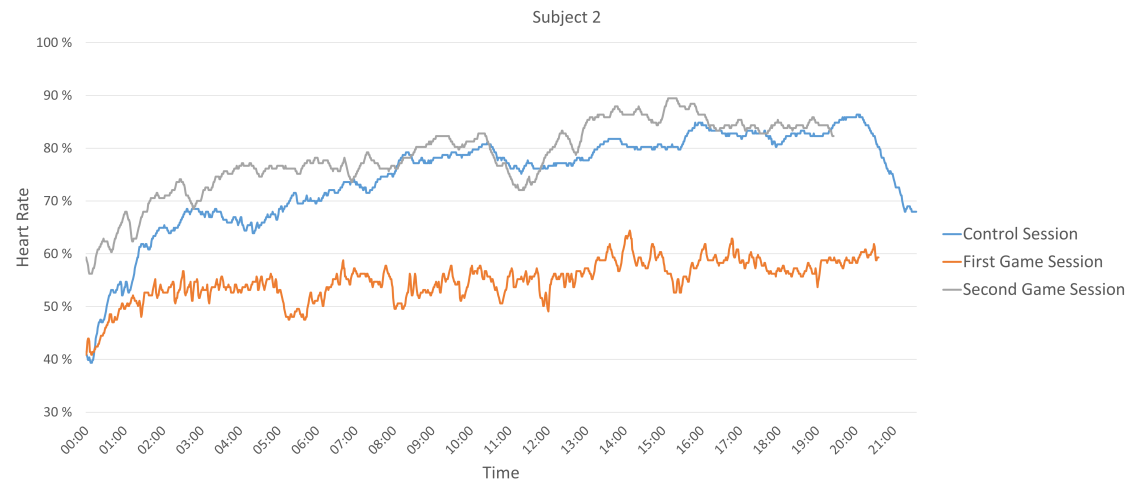


Figure 97: Heart rate of Subject-2

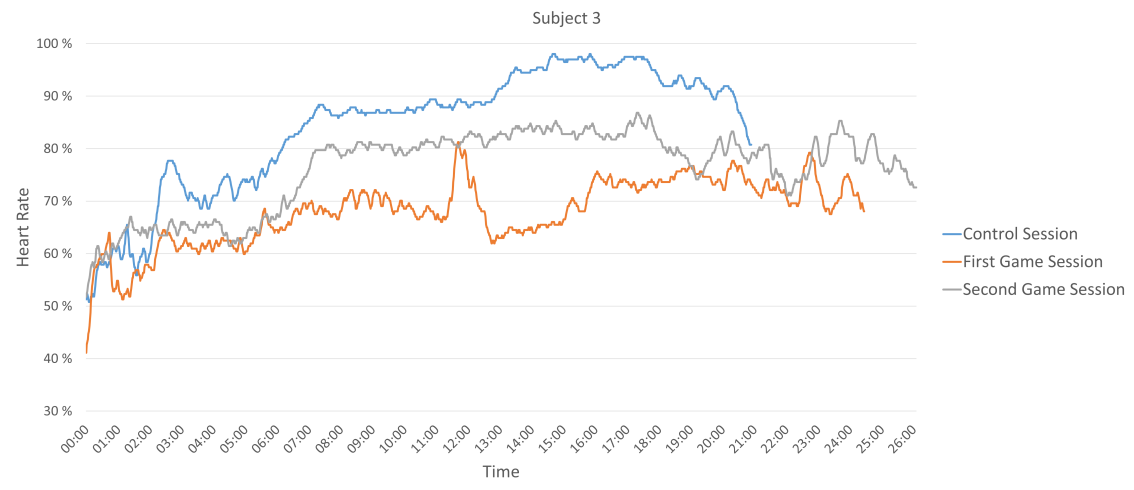


Figure 98: Heart rate of Subject-3

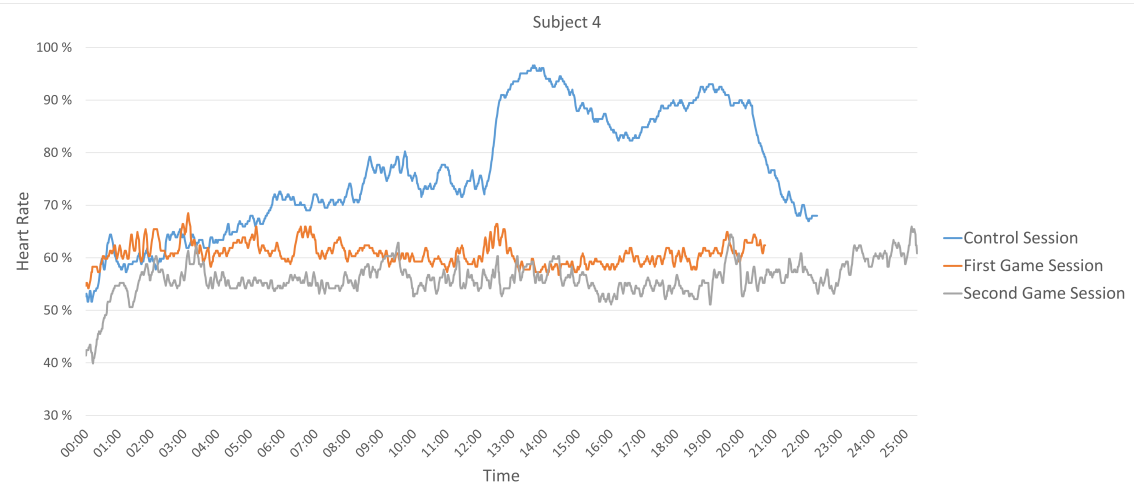


Figure 99: Heart rate of Subject-4

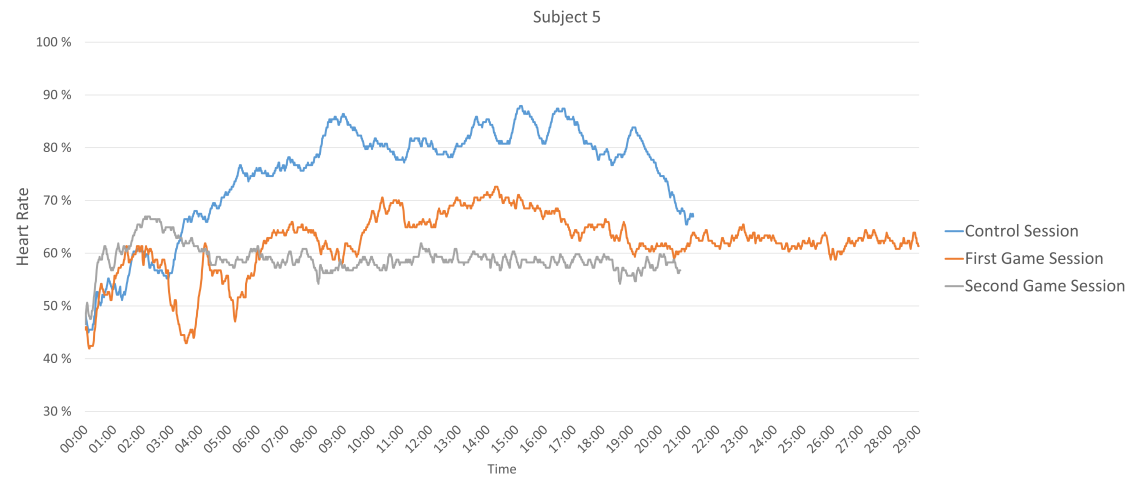


Figure 100: Heart rate of Subject-5

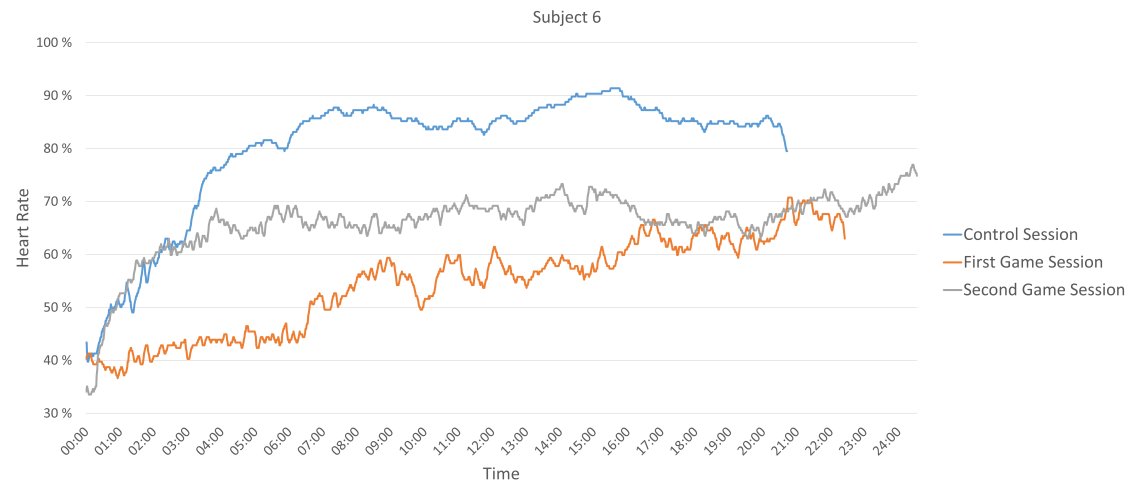


Figure 101: Heart rate of Subject-6

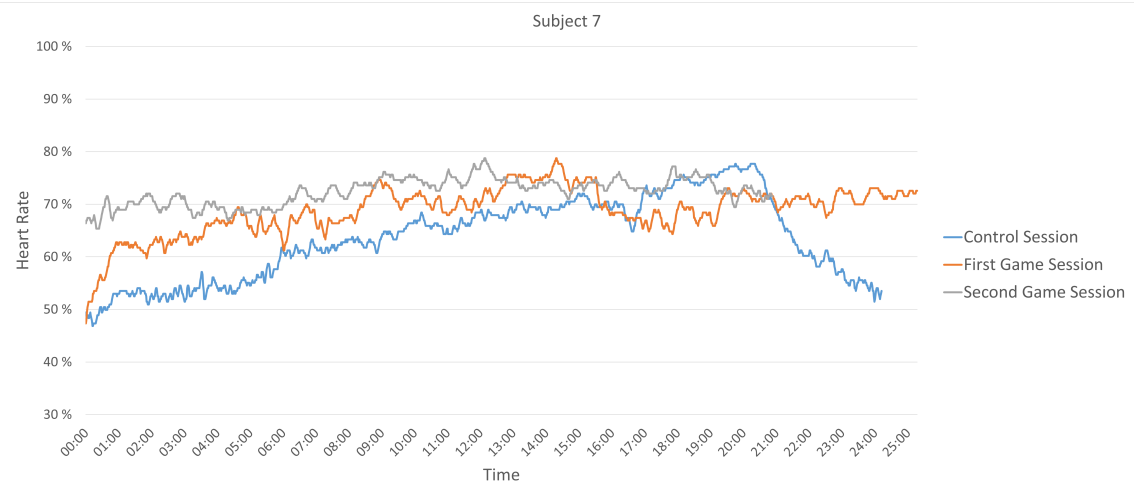


Figure 102: Heart rate of Subject-7

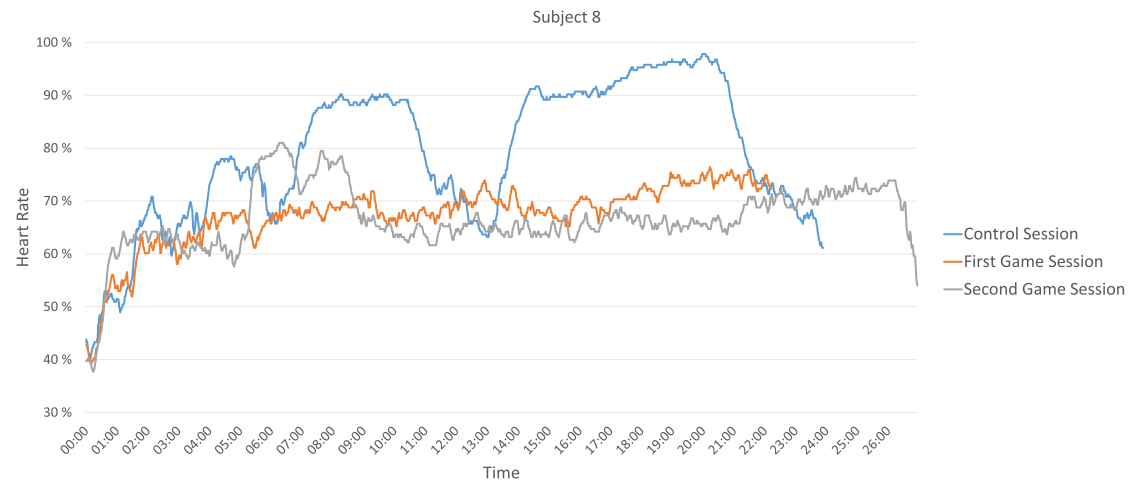


Figure 103: Heart rate of Subject-8

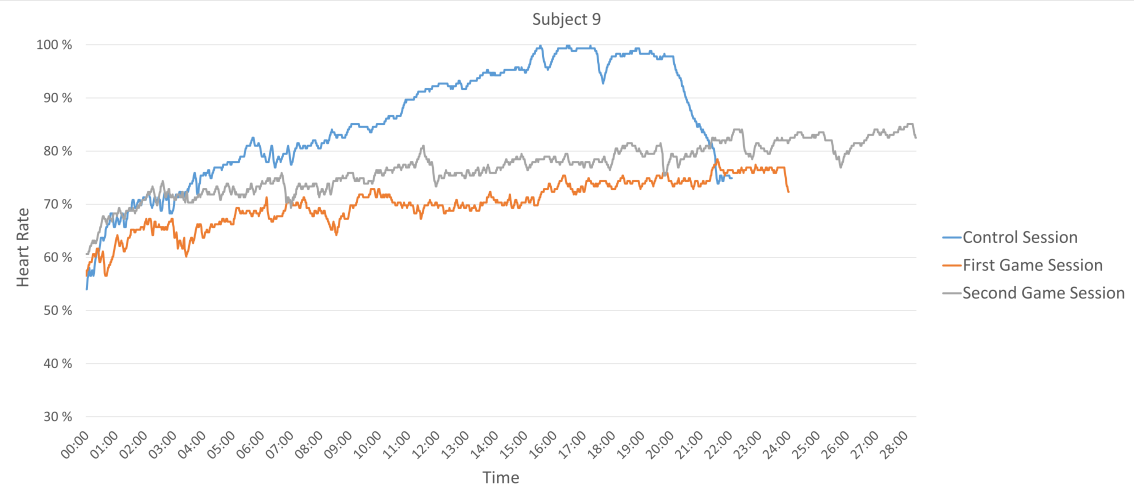


Figure 104: Heart rate of Subject-9

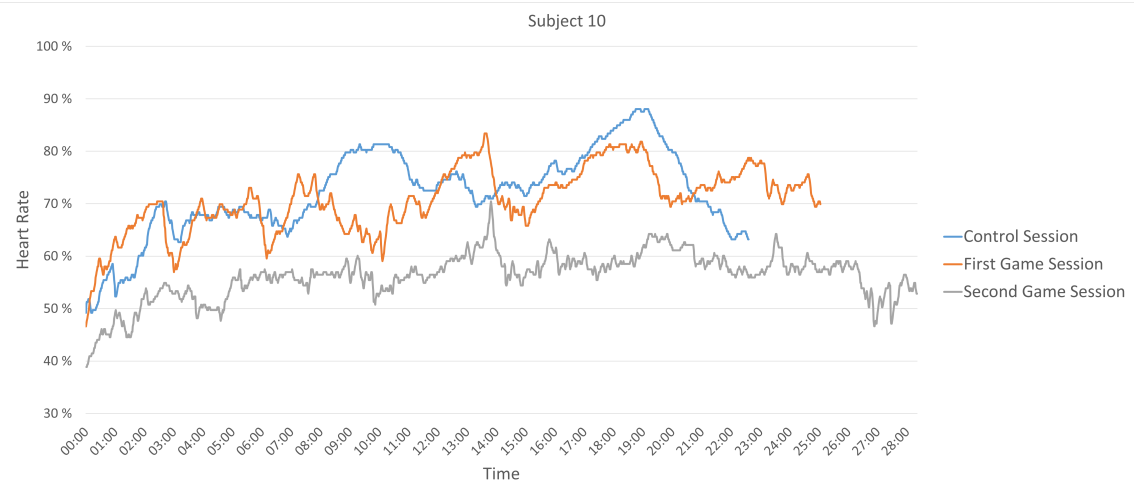


Figure 105: Heart rate of Subject-10

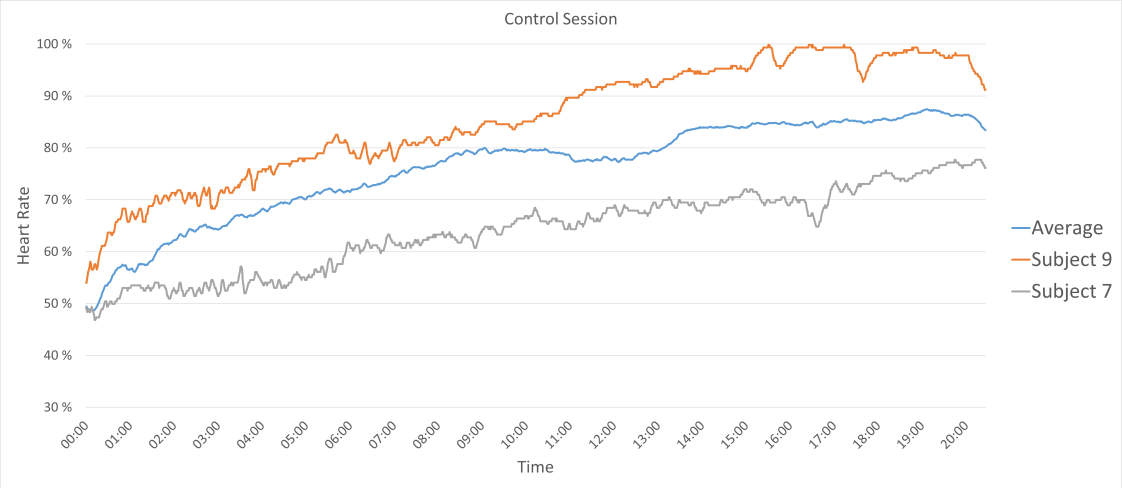


Figure 106: Average heart rate, and heart rate of subjects with highest and lowest averages during the control session

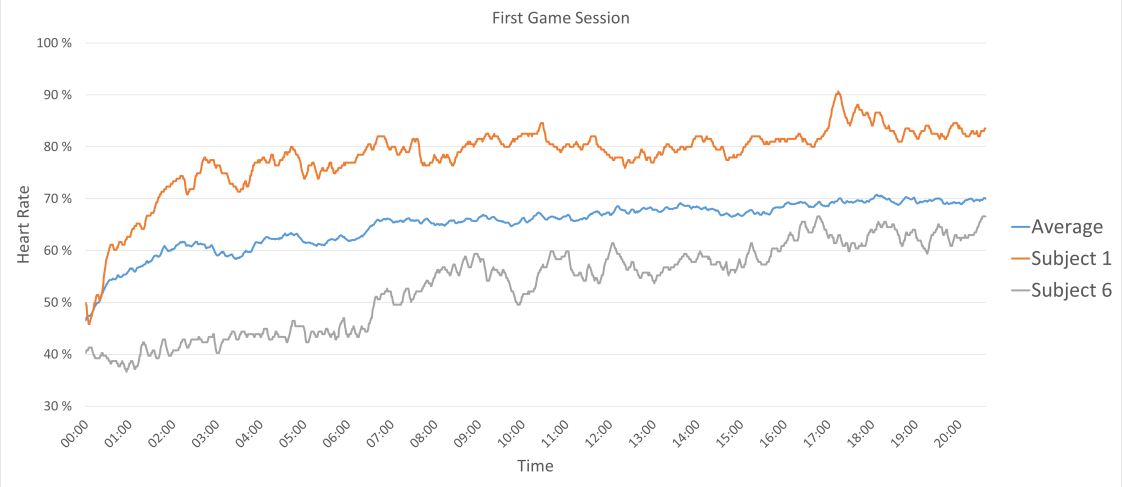


Figure 107: Average heart rate, and heart rate of subjects with highest and lowest averages during the first game session

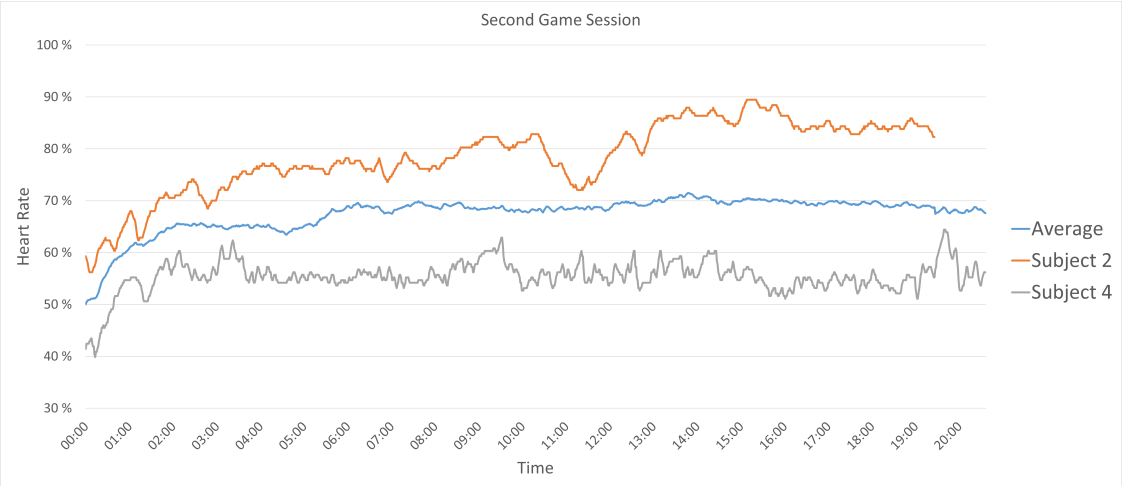


Figure 108: Average heart rate, and heart rate of subjects with highest and lowest averages during the second game session

35 Anonymous Questionnaire

This chapter consists of the results from the anonymous questionnaire sent out after each session. Since the questionnaire was anonymous, there was no way of checking who had answered, which lead to one person not answering after the last session. This was a known risk, but the benefit of having an anonymous questionnaire outweighed the loss of one result.

35.1 Session Specific Reflection

Figure 109, Figure 110 and Figure 111 shows the results to AQ1-17. Each question was answered with a Likert scale of "strongly disagree" (red), "slightly disagree" (orange), "slightly agree" (light blue) and "strongly agree" (dark blue). The numbers next to the questions are references to Table 15. The figures also include the percentage for each option in order to make it easier to read.

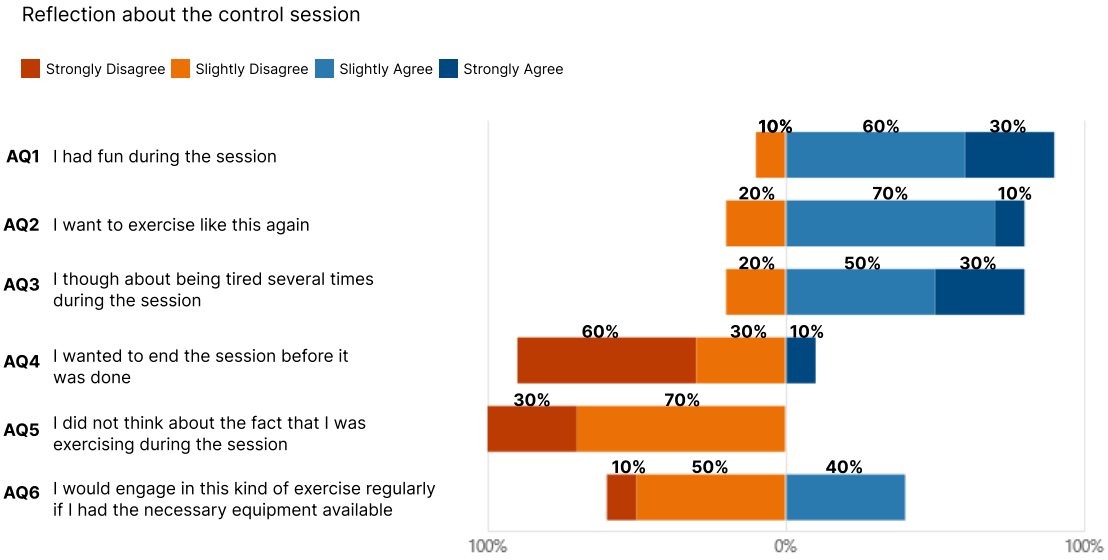


Figure 109: Answers to AQ1-6 after Control Session

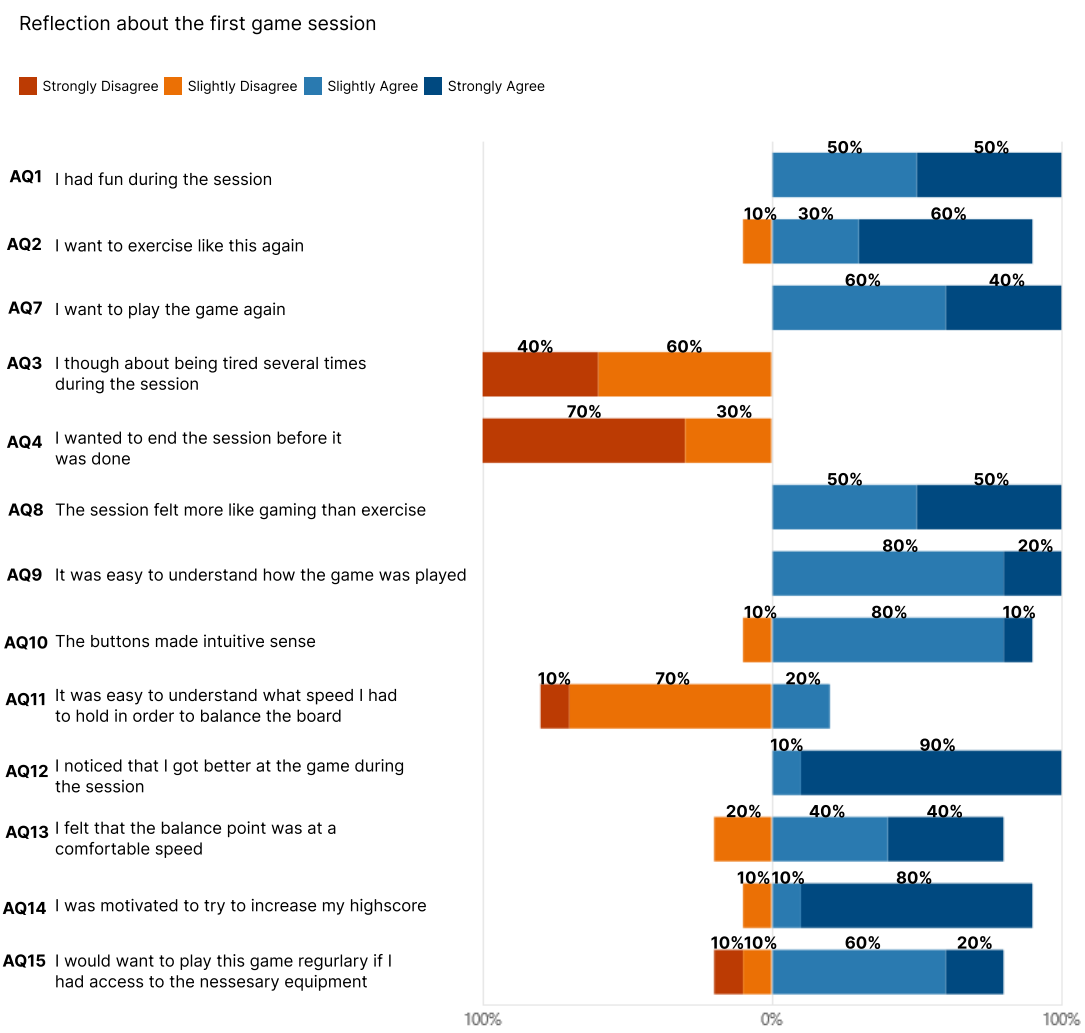


Figure 110: Answers to AQ1-4 & AQ7-15 after First Game Session

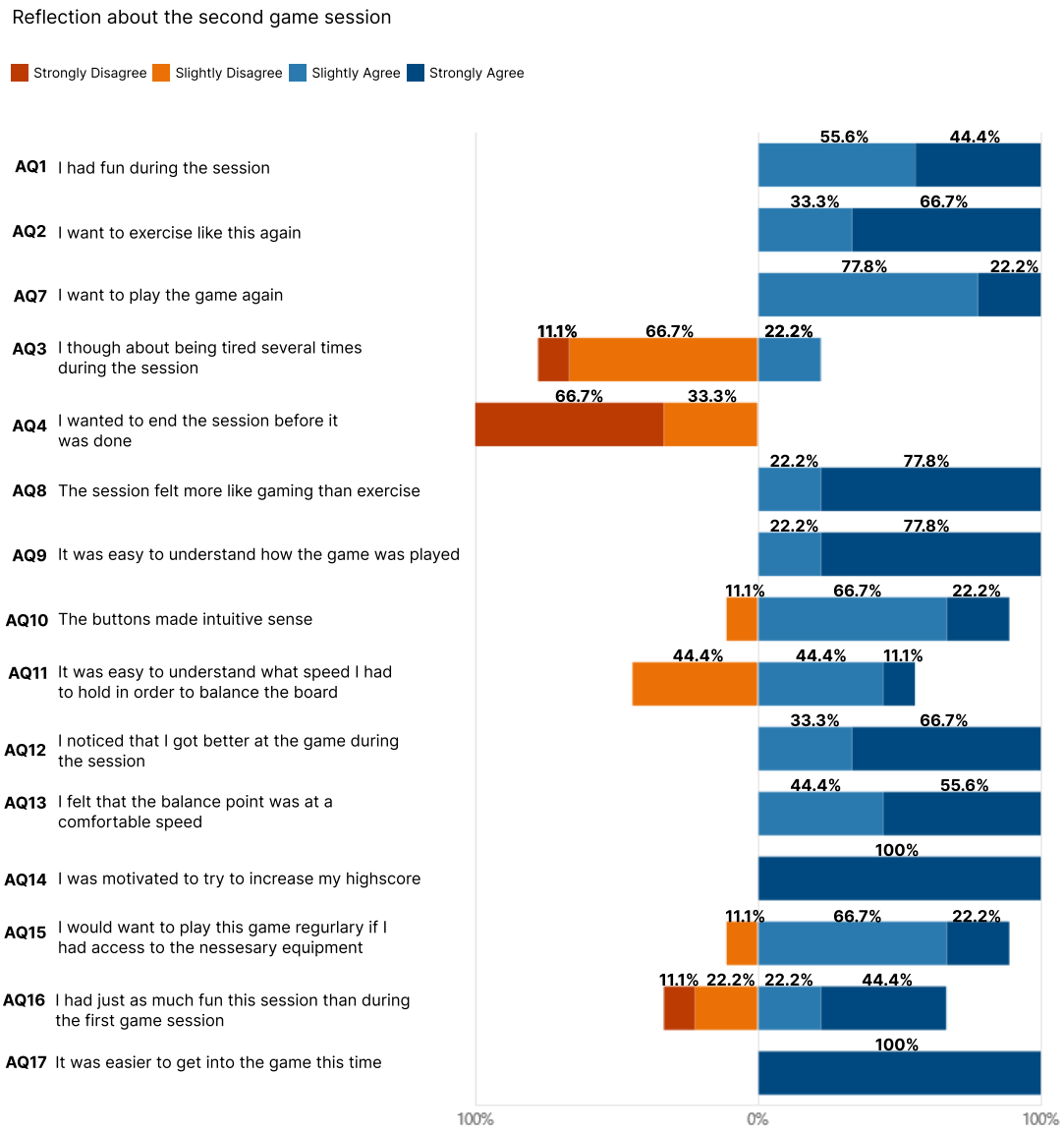


Figure 111: Answers to AQ1-4 & AQ7-17 after Second Game Session

35.2 Game Modes

Figure 112 shows how the participants ranked the game modes based on which they liked the most after each session. Here one can see that the second game session is missing one answer, as one of the subjects did not respond to the final questionnaire. AQ19 asked them to elaborate, and the reasons for liking and disliking the different modes varied. For *Balance Mode*, people commented that it felt more like a warm-up and intro to the system and that it was too monotonous. In contrast, someone else commented that it was the most difficult and boring since there was very little going on. For *Shapes Mode*, someone commented that it felt like the best combination of exercise and concentration, and someone else commented that it felt like a more boring version of Balance Mode. There were most opinions about *Marble Mode*, where the positive pointed out that it had more stuff happening and required the most attention, making them think less about the exercise. A person ranked it number one and called it the most difficult, and someone else pointed out how it was a familiar concept and that it was the most fun since it combined both speed and the use of buttons. The negative opinions on Marble Mode commented that the rounds were too short and that they wanted to have more maps since it got a bit boring when they had managed to beat it once.

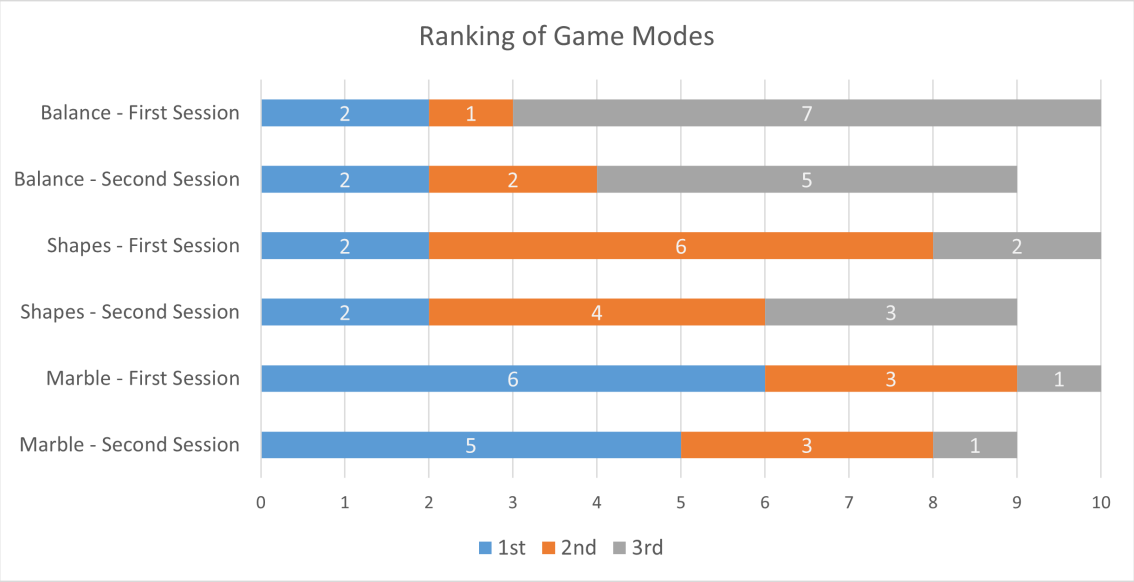
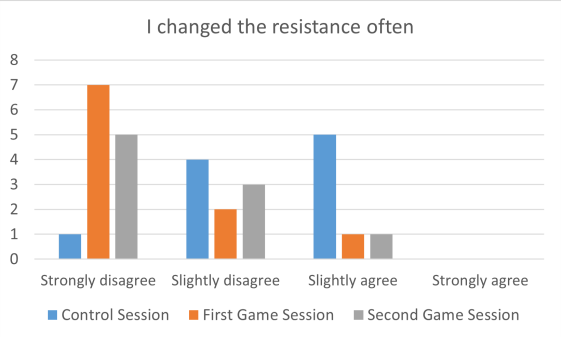


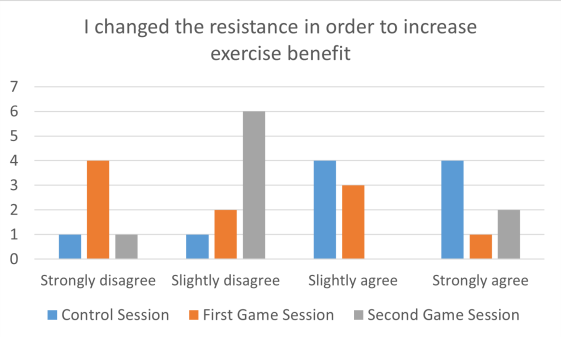
Figure 112: Ranking of the different game modes after each game session (AQ18)

35.3 Exercise Reflection

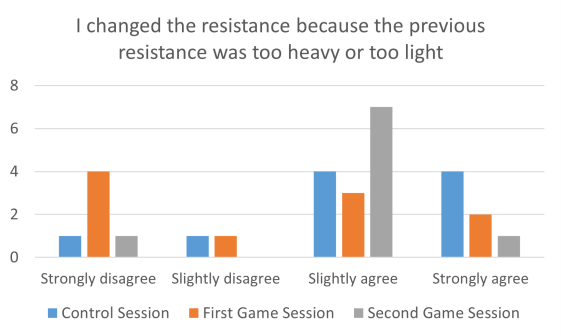
Figure 113 shows the results from AQ20-AQ25, split between each session. The form asked them to rank different elements based on what had the biggest negative impact on the session out of stamina, muscle strength, uncomfortable equipment or boredom. (see Figure 114). Again, there is one less answer for the second game session, as one of the subjects did not respond. When asked to elaborate, five respondents felt that none had any negative effect, where three of the answers were given after the first game session, and the remaining two were from the second game session. After the control session and the first game session, two people felt like only their number one rank had any effect, and one person echoed this sentiment after the second game session. After the control session, one person commented that it was not that exciting to bike and look at a white wall, and another commented that they biked as hard as they could, but it was difficult to keep the motivation up. One wrote that they noticed that their legs were tired before they noticed it in their stamina, but that they think it is a positive that they felt it, as it let them know that they were exercising. After the first game session, one commented that they had a low resistance because they needed it to balance the board and that they mostly just had fun. They thought that the "right" intensity would be a bit higher but that it could be a separate setting. After the second session, one commented that since they had already played the game once, it was less interesting than last time.



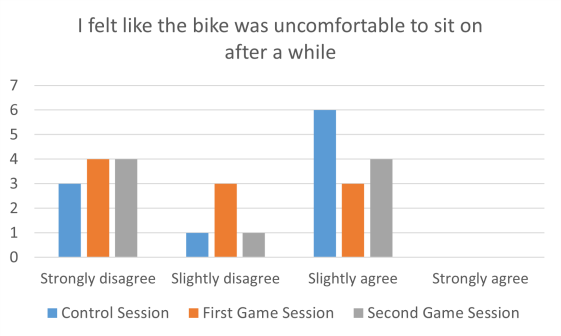
(a) I changed the resistance often (AQ20)



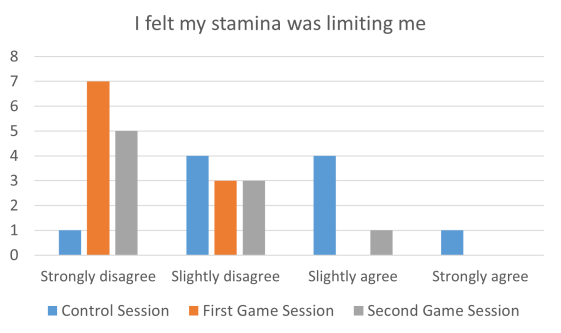
(b) I changed the resistance in order to increase exercise benefit (AQ21)



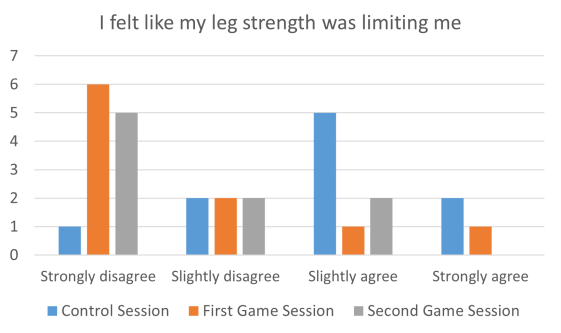
(c) I changed the resistance because the previous resistance was too heavy or too light (AQ22)



(d) I felt like the bike was uncomfortable to sit on after a while (AQ23)



(e) I felt my stamina was limiting me (AQ24)



(f) I felt like my leg strength was limiting me (AQ25)

Figure 113: AQ20 - AQ25, for the Control Session, First Game Session and Second Game Session

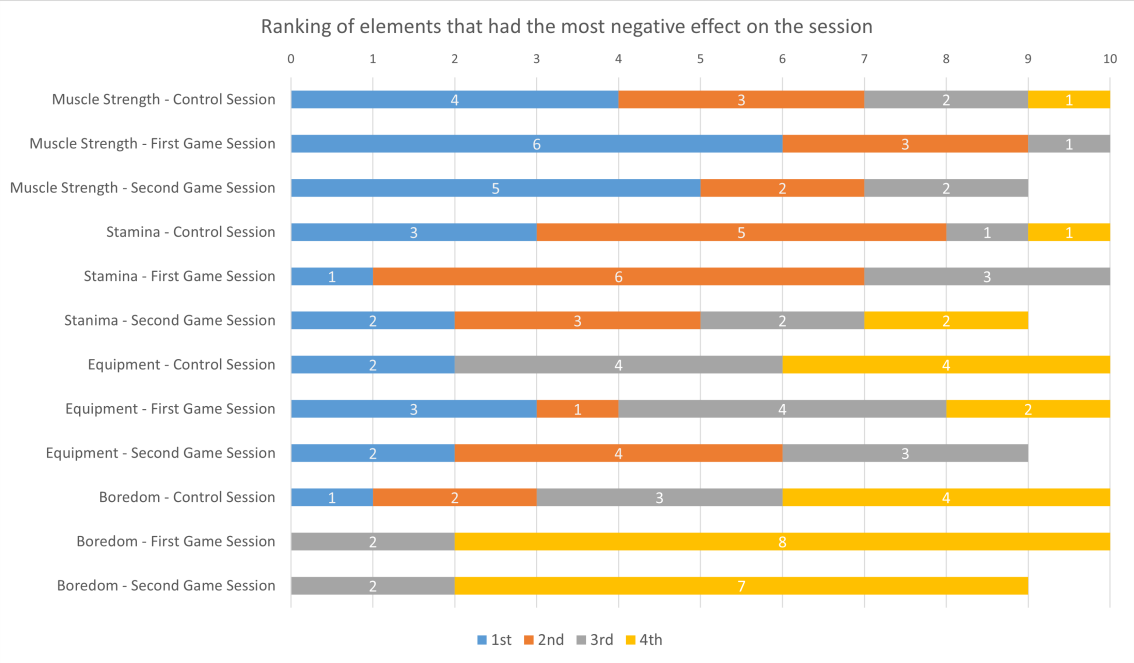


Figure 114: Ranking of the elements that had a negative effect on each session, where what was ranked 1st had the most negative effect, and what was ranked 4th had the least negative effect (AQ26)

36 Summary of Results

This part presented the results from the general survey and the experiments. The general survey had 80 respondents, and the experiments had 10 participants. Results from the experiment have consisted of insights from interviews and observations, heart rates during the sessions and answers from the anonymous questionnaire. The next part will discuss these results in the context of the research questions.

Part VII

Discussion

"*The goal is to transform data into information, and information into insight.*"
Carly Fiorina (2004)

This part will discuss the results from Part VI based on the research questions from Part I. Some experimental concerns will also be discussed to ascertain the validity of the findings.

37 RQ1 Enjoyed Game Genres

RQ1: *Are there commonly enjoyed game genres, or other gaming preferences, that are not sufficiently represented in the current exergame market?*

Short answer: Yes. For a longer answer, Chapter 12 pointed out that most exergames are action games, simulation games or both, while idle, puzzle and adventure games are absent. The puzzle games genre is, as seen in Figure 79, the most commonly enjoyed genre of the respondents of the general survey, followed closely by party games and RPGs. In comparison, only 35 out of 80 (44%) enjoy action, simulation games, or both. Even though this was a multiple choice question and there can be respondents that, for example, like action games but not simulation games and vice versa, there is likely a significant portion of the respondents that do not like either. The main difference between the gathered statistics and ESA's statistics (2022) is that RPGs were more popular (54% vs 41%) and that action and simulation games were lower on the list than in ESA's statistics, where they were number 3 and 4 most popular, respectively. While those physically active share the same top three as the general graph, the rankings for the *not* physically active group place puzzle games in a shared second place with adventure and party games (RPGs are at the top). The puzzle games genre is also a clear preference amongst non-gamers. However, this might be because of the low number of non-gamers that responded to the questionnaire making the percentage look more conclusive than it is. Regardless, **it is clear that the most commonly enjoyed genre in this survey (puzzle games) is not present in the current exergame market. Adventure games are not present either, despite also being the second most liked genre for people that are not physically active (in this survey).**

Another gaming preference appears between singleplayer and multiplayer. While half of the respondents answered that they like both, **there are more people that only like singleplayer (31%) than there are those that only like multiplayer (19%).** However, it is possible that the distinction between cooperative and competitive multiplayer might have made a difference. For those physically active, there is a slight increase in the amount that only likes multiplayer, at the cost of those that like both. On the other hand, the not physically active group has a reduction of multiplayer-only answers, with only three respondents (11%) choosing that option. The biggest difference is in non-gamers' answers; however, the small number of respondents in that group makes those statistics speculative. Regardless, 44% in that group prefer singleplayer, while the rest are split evenly between multiplayer and both. Chapter 12 discussed how every exergame examined except one has social features ranging from leaderboards to direct competitive or cooperative multiplayer. Many games still have some form of singleplayer option, and several respondents likely did not consider leaderboards multiplayer. That being said, **new exergames should consider the preference for singleplayer amongst those not physically active if that is their target audience.**

Interestingly, while 70% do not play exergames anymore or have never tried them (13%), only three of the respondents are entirely uninterested in exergames and over half (54%) would definitely be interested. Generally, gamers and physically active respondents are more interested, but the percentage of those not interested at all stays about the same for all groups. On the other hand, a higher percentage of not physically active respondents have tried exergames than those physically active. The same goes for non-gamers over gamers; however, this is likely caused by the small number of non-gamers who responded.

37.1 RQ1.1 Gender Preferences

RQ1.1: *Does gender affect gaming preferences?*

While some genre preferences (like platformers and party games) are similar between the men and women that responded, there are also some significant differences. **The largest gaps are puzzle games (Women: 77%, men: 36%), which a lot more women enjoy than men, and strategy (Women: 23%, men: 59%) and action games (Women: 29%, men: 57%) where the opposite is the case.** In fact, the puzzle games genre is by far the most commonly

enjoyed genre for women, while it is sharing second to last place with two other genres for men. On the other hand, strategy and action games are a close number two and three most commonly enjoyed by men respectively, but last and second to last for women. Since this survey did not distinguish between mobile games and other games, there might be a correlation between which device is used for gaming and which genres are preferred, as the puzzle games genre is a common genre for mobile games. However, It is impossible to reach a conclusion about this with the data set from this survey.

Another big difference is in the preference between singleplayer and multiplayer. **Almost half of the female respondents (49%) prefer singleplayer and only 14% prefer multiplayer.** On the other hand, over half of the men (59%) like both, with only a slight preference for multiplayer from the rest (23% against 18%). This thesis can not conclude with a reason for this based on the data gathered, but it could be an interesting topic for further research. Some potential factors that might cause this preference for singleplayer among female players are the trend of harassment online towards women and societal norms that might make it easier for men to admit to playing video games and form groups to play with. The preference towards singleplayer amongst women might affect which genres they prefer or be caused by their genre preferences, but this is again something that would require further research.

Interestingly, a higher percentage of women play daily than men (40% versus 32%), and it would appear that the female respondents tend to either play very frequently or very infrequently (Though there are a lot more that play regularly than infrequently). In comparison, men mostly play frequently, with a peak at two or more times a week, and few responded less frequently than once a week (12% total). It would also be interesting to know the percentage of mobile game players versus others and if that has an effect. Regardless, **the results show that plenty of women play regularly, indicating that their preferences should also be considered when deciding on game elements like genre and reward structures.**

38 RQ2 Game Design and Exercise Theory

RQ2: *How can existing game design and exercise theory be combined with a new exergame genre into a unique game concept?*

By looking at the results through game design theory like player types, reward systems and Malone's characteristics for good video games, it is possible to see what impact they had on the game. Game theory models like GameFlow (Sweetser and Wyeth, 2005) and DualFlow (Sinclair et al., 2007) are also essential to consider when making a new game concept. However, this chapter will not address them, as they will be discussed thoroughly in the next chapter. Likewise, exercise principles will be considered during the discussion of RQ4.

38.1 Player Types

Hamari and Tuunanen's (2014) player archetypes can be used to ensure the game is enjoyable for all the different players in the target audience. However, it should be kept in mind that these archetypes were primarily based on MMO players, meaning there might be some differences for other genres, like puzzle games. Firstly, the archetype based on *gaming intensity and skill* revolves around hardcore versus casual players. In FlipBoard, a large part of the challenge stems from how much the player wants to push themselves, and it is up to the player how much time they want to spend on the game. This makes it possible for both hardcore and casual players to enjoy the game. Next, *achievement* concerns how players feel accomplishment through the game by getting a high level, being rewarded or beating the game quickly. Bartle's achievers player type falls under this archetype, as it describes players who enjoy mastering the game and being in control. The game concept caters to this by encouraging players to beat their own personal records, especially if personal leaderboards and statistics were to be implemented. Further, the *exploration* archetype and Bartle's explorers might be engaged in FlipBoard through interaction with the puzzle elements, finding good strategies, and understanding how the game works. *Sociability* is next, but is perhaps the least supported archetype, as there is no way to communicate or cooperate with other players inside the game. However, if the multiplayer steering mode was to be implemented, along with ways to find other players, this might change. In the experiment, the participants with such tendencies enjoyed talking with other participants outside of sessions, so it is possible that out-of-game communities would form. On the other hand, the *domination* archetype (Bartle's killers) is heavily supported in the game by providing leaderboards where players can compete against each other. Although there is no story in this puzzle game, players in the *immersion* archetype can still be captivated by the game mechanics. Lastly, although this game is not an MMO where guilds and such can form, *in-game demographics* can be visible through which game mode a player prefers.

38.2 Rewards

Reward systems can foster intrinsic motivation in the players (H. Wang and Sun, 2011). By ensuring that the game is designed to have rewards in all four categories of reward usage, one can ensure that all player types will find something to enjoy in the game. The main category in FlipBoard is *cooperate/compete* due to the score system (including leaderboards). The scores also allow the users to show off to other players but might be too difficult for casual players who enjoy the *sociability* category. A way to improve the game's presence in this category is to implement the planned achievement system. Another planned but unimplemented mechanic is the personal leaderboards and statistics, which would serve as rewards to be *reviewed*, in addition to the achievements. For the last category *advancement*, an unlocking mechanism could be implemented to unlock new levels in the different modes, thus rewarding the players by progressing the game. The unlocking mechanism would also provide a reward that affects gameplay to cater to that reward attribute. Additionally, it might contribute to the time required to earn a reward, though the achievement and score systems also contribute to this attribute in different ways.

38.3 Malone's Characteristics

Malone's (2014) essential characteristics for good computer games should also be considered when designing a new exergame. For the *fantasy* characteristic, FlipBoard uses an intrinsic fantasy to make the game more interesting. This can be seen by the player's skills being dependent on the game world (e.g. object's positions on the board) and not just the game world being dependent on the player's actions. Secondly, *Challenge* is present in the game by providing goals whose attainment is uncertain: Will the player be able to get a new (personal or public) highscore? The primary type of goals in the current version of FlipBoard (without achievements and other features) are meta goals; The player sets a goal for themselves about getting a better score. The scores also give the players an overview of their progress towards their goals, like Malone recommends. The suggested method of increasing challenge by including randomness was more negative than positive for the random angles in rotation. However, it might be seen in a more positive light if this randomness was more visible and less subtle. Lastly, *curiosity* is present through both sensory and cognitive curiosity. The former presents itself through visual game elements and audio, like music and sound effects. While the music turned out to be too repetitive, sound effects were more appreciated, especially by Subject-10, who enjoyed the sound of objects sliding and rolling. Cognitive curiosity is stirred in the players by making them focus and think about how to best approach the current situation of the board, be it strategies to keep the objects from rolling off or getting the marble through the maze in the most efficient way.

39 RQ3 Flow

RQ3: *Can such an exergame facilitate a state of flow?*

The discussion regarding this question will be structured after the different elements in GameFlow (Sweetser and Wyeth, 2005) (see Section 8.2.1), as it is a model created to measure if and how players find enjoyment and flow in a game.

39.1 Concentration

The concentration element in GameFlow states that concentration should be needed while playing the game and should not be lost.

This part of the GameFlow criteria is promising for FlipBoard, as **everyone reported being concentrated during both game sessions**, with 70% emphasising that they were *very* concentrated. In contrast, only two reported concentration during the interview after the control session. The high level of concentration was especially visible in three participants who found themselves too concentrated on the game to form sentences and either forgot what they wanted to say or had to wait until the round was over to talk. Additionally, **losing concentration did not seem to be an issue**, as five participants specified that it was very easy to be concentrated, and 70% felt themselves be very concentrated.

39.2 Challenge

Next, GameFlow states that the game needs to be challenging regardless of skill level. The challenge should be tuned to the player's skill and increased as the player improves.

In place of difficulty levels, FlipBoard's challenge comes from the players pushing themselves to do better in the different game modes. Having a variety of game modes was not only appreciated because all the participants could find something they enjoyed (shown through the ranking of the game modes (AQ18)) but also to offer different levels of challenge based on what each participant found challenging. As was made clear during the interviews, people found different aspects challenging. Those preferring Balance Mode enjoyed the challenge of balancing the board, either finding it too challenging with the additional elements that the other game modes introduced or feeling like different game modes were less challenging because the balancing was less critical. The comments from the anonymous reflection questionnaire revealed that a participant liked Balance Mode because it was easy enough to zone out, while another felt it was the most challenging mode. In contrast, it was mentioned during the interviews that Shapes Mode was liked because it was considered more challenging than Balance Mode while not being as hectic as Marble Mode. In turn, Marble Mode was considered by many to be the most challenging but was also the most popular game mode in the ranking (AQ18). However, because there was only one level in Marble Mode, it was only challenging for those who enjoyed trying to get a better score, not those who preferred only finishing the board once. That six participants requested more levels in Marble Mode gives more weight to this theory and highlights the need for this improvement if the game should be developed further.

39.2.1 DualFlow

As discussed in Chapter 10, the DualFlow model (Sinclair et al., 2007) expands on tuning challenge to skill to suit exergames better. A unique problem when designing exergames is that there is another dimension that affects enjoyment: Intensity versus fitness (effectiveness). Introducing physical elements makes it more difficult to tune challenge to skill (attractiveness) than in regular video games, as physical factors can affect either the game's challenge or the player's skill. Sinclair et al. (2007) recommended that challenge is dynamically tuned based on play style or physical

measurements like heart rate. However, Chapter 12 revealed that **none of the exergames examined in this thesis used this dynamic adjustment**.

FlipBoard's calibration scene that runs when the game starts adjusts the balance point for the rest of the session based on how fast the player is pedalling (see Section 23.2). **This dynamically adjusts the game's challenge based on the player's fitness level and condition per session.** The effectiveness of this can be seen by the few physical limitations reported during the game sessions. Whether this balanced the effectiveness dimension well can be seen by the amount of exercise benefit the participants got. As will be discussed for RQ4, the amount of exercise benefit depended on whether or not the player wanted to push themselves. As such, it can be argued that the dynamic adjustment during calibration is good enough to avoid the game being too intense or too relaxed while still leaving room for personal preference.

39.3 Skills

The element of skills examines whether or not the game facilitates the development and mastering of skills. Its criteria state that the game should reward effort and that it should be enjoyable to learn the game mechanics.

During the interviews **six of the participants mentioned that they felt mastery and improvement during the second game session** due to getting higher on the leaderboards and by feeling more in control and like they were getting better at the game. Subject-6 also enjoyed that the game had a high skill cap and that he got better at the game fast. All participants also agreed to the statement *I noticed that I got better at the game during the session* (AQ12) after both sessions, with 90% selecting *strongly agree* after the first session. Additionally, it is clear from the statement *It was easier to get into the game this time* (AQ17) after the second game session (that 100% strongly agreed with) that the participants felt themselves get better at the game, and that they had gotten more familiar with the game mechanics. Similarly, the celebrations of both personal and public records show how the game rewards effort. However, more rewards in the form of achievements might be beneficial for the long-term enjoyment of the game.

39.4 Control

Control in GameFlow concerns control of things like button mappings and the avatar the player is controlling. Players can get frustrated if they feel control is taken away from them or if they cannot play the game how they want to.

Unfortunately, the prototype did not include the ability to change the button mappings. However, **90% of the participants agreed that the buttons were intuitive** (AQ10), with only one person slightly disagreeing. Subject-4 expressed that he felt the buttons were very intuitive and that the speed mechanic was well thought out and felt good. **The game also allowed the participants to play it their way, with different play styles emerging through the sessions.** This took the form of both strategies to get further (like blocking in unruly spheres in Balance Mode) and ways to mess around and have fun (e.g. throwing the marble over the walls instead of navigating the maze in Marble Mode). When these different play styles worked, the participants who tried them got excited and happy.

There were some instances where the control was taken away from the players, which caused them to express frustration. Firstly, they were frustrated by the delay between changes in pedalling speed and their effects on the game. This can be seen as losing control of the avatar they were controlling (the board). Secondly, the randomisation of the rotation angles was confusing for many. Several participants thought they had clicked the button weirdly to cause the difference and got frustrated when they could not replicate the behaviour. A solution to this might be to implement the suggestion about one button on each hand rotating 90 degrees while the other rotates 45.

39.5 Clear Goals

Clear goals should be communicated to the player early to guide them. Subgoals can also keep the tension up while the player is working towards the main overarching goals.

The primary source of goals in the prototype is to get higher scores and set new records (personal or leaderboard records). While the leaderboard provided great entertainment and excitement, there was also an appreciation for the sub-goal of simply finishing a level after trying hard. Three participants expressed that having a goal to beat was very motivating, and two mentioned that trying to beat highscores made them give more than they had planned.

39.6 Feedback

The feedback element aims to keep the players' concentration going and give them an overview of their progress. Among other things, it states that players should always be aware of their score.

Feedback from the game was mainly in the form of scores and placements on the leaderboards. Several people were very focused on their scores during, after and before a round, with the latter being shown by participants calculating if they had enough time left in the session to get a new highscore in Balance Mode. From the Likert statement *I was motivated to try to increase my highscore* (AQ14), only one person did not feel motivated to get a better highscore, while 80% answered *strongly agree* during the first game session. After the second game session, everyone *strongly agreed*. In addition, the leaderboards were found to be a major reason why everyone reported having fun during the game sessions. In contrast, only two people said they had fun during the control session.

However, **when the goals got a bit too challenging to reach, two participants found themselves demotivated**. Saying things like "I don't have anything to compete with against those people" and giving up on that game mode. This indicates that **having only a general leaderboard might make goals unattainable and detract from flow**. A solution to this might be separate leaderboards and personal statistics, as suggested by several participants.

39.7 Immersion

GameFlow's immersion element states that players should be so immersed that they lose track of the real world. Its criteria revolve around being less aware of their surroundings, having an altered sense of time, and feeling emotionally involved in the game.

The altered sense of time experienced by all participants during both game sessions indicates that everyone was immersed in the game. Only the scoring in Balance Mode detracted slightly from this for two participants. An altered scoring method that is not based entirely on seconds might change this. Suggestions from the participants about scaling the score based on objects being juggled or intensity are a way to do this. Similarly, shorter spawn times might prevent what happened to the one participant that was reminded of ordinary time because of the wait. **One can also see how the players got emotionally invested in the game** (another criterion for this element of GameFlow), through their happiness or frustrations based on scores and objects, and through celebrations like throwing their arms in the air and shouting.

Another sign of immersion in the participants was their ability to block out distractions like the loud sounds from the construction site outside the experiment room. Subject-5 even mentioned being in her own world and noticing neither the test facilitators nor the outside world. That 80% thought about exercise during the control session and only one thought about it during the first game session also supports this point. The statement *I thought about being tired several times during the session* (AQ3) from the anonymous questionnaire also supports this, showing how no one thought about being tired in the first game session (only 22% thought about it during the second game session), and 80% thought about being tired during the control session. Additionally, Subject-1 summed up how her concentration and immersion made it easier not to be

distracted: “When I have to think about what I’m doing and focus more, it is easier to not think about other things.”

Through AQ26 about ranking what had the most negative effect during the sessions, it is possible to see what might have disrupted the immersion. A promising sign is that **boredom decreased rapidly from the control session to the game sessions**. Three participants ranked it as number one or two most negative during the control session, while no one placed it in those ranks during either game session. Boredom’s placement in fourth also doubled during the first game session and likely during the second (though there is one missing response). The most disruptive factors during the game sessions were muscle aches/tiredness, stamina, and uncomfortable equipment in that order. It should be noted that five responses for the game sessions answered that none of the options had any impact, and others commented that only the first few options had impact.

39.8 Social Interaction

Social interaction is an element in GameFlow despite being absent from the concept of flow and potentially contributing to disrupting flow. This is because the GameFlow model is meant to measure enjoyment, and social interaction is something a lot of players enjoy and seek out. The criteria state that games should support competition, cooperation, social interaction and social communities. The latter specifically concerns communities both outside of and inside the game.

Although the test facilitators did not reveal any information about the sessions of other participants due to privacy concerns, it was made clear that the participants could choose to talk amongst themselves outside of the experiments if they wanted to. This allowed insight into social interaction between the participants both in and outside the game. The most obvious form of competition happened through the leaderboards, where the participants could test themselves against the anonymous highscores of others (or against scores of their friends for those that compared scores outside of sessions). **Because the leaderboard was the only social feature inside the game, and feedback through scores is seen as helpful for concentration (as discussed above), it was conducive to flow rather than disruptive.**

The community formed outside of the game took the form of players talking about the game between sessions and motivating or taunting each other. This fostered a friendly competition and contributed to memorable and happy moments, like when Subject-7 excitedly interrupted his calming round of Balance Mode to return to Marble Mode and send a screenshot of his new highscore (at the top of the leaderboard) to the group a lot of the participants are a part of.

40 RQ4 Recommended Exercise Amount

RQ4: *Can such an exergame contribute to more people reaching the recommended exercise amount?*

For people to reach the recommended exercise amount discussed in Chapter 9, it is crucial for the game to facilitate players to reach moderate to high intensity, engage them in playing for a more extended period and motivate them to come back to the game often.

40.1 Exercise

The recommendation is for people to engage in moderate to high-intensity exercise. As defined in Chapter 9, moderate intensity includes Zone 2 (60%-70%) and Zone 3 (70%-80%), and high intensity includes Zone 4 (80%-90%) and Zone 5 (90%-100%). Moderate-intensity workouts are suitable for improving endurance, increasing fat-burning and building muscular fitness. High-intensity exercises are suitable for improving speed endurance, increasing lactic acid tolerance and improving the way the body transforms carbohydrates into energy (Polar, 2020).

40.1.1 Heart Rates

During the control session, the average heart rate of the subjects increased gradually from 50% to approximately 88% during the 20 minutes and spent 18 minutes in Zone 2 or higher. 80% of the subjects reported that they got the same or higher exercise benefits as their usual exercise routine during the control session, which shows that the control session accurately represented their regular exercise sessions. The averages from the game sessions primarily stay in Zone 2, taking two minutes to reach Zone 2 in the first game session and one minute in the second. The graph for the first session gradually increases from 60% to 70%, while the second game session stays more consistently around 67%-70%. **This means that while the game makes people reach Zone 2, thereby moderate intensity, it still produces a lower intensity than the control session.** This difference could be because several participants stood during the control sessions, while almost everyone stayed seated during the game. Additionally, as Subject-8 discovered, the game is more challenging to control when standing. This difference in heart rates also matches the answers gained during the interviews, where 60% reported that they felt they got less benefit from the first game session than the control session. However, after the second game session, 70% felt like they got more exercise benefits than during the first session, despite only 50% of the subjects having a higher heart rate during the second game session than the first.

During the first game session, the heart rate of Subject-1, who had the highest average heart rate that session, stayed above 70% for 18 minutes and had the highest peak at approximately 91%. In contrast, Subject-9 reached the max heart rate during the control session and stayed above 90% for the last 9 minutes. **This means that the participant with the highest heart rate during the game sessions stayed almost 10% lower than the participant with the highest heart rate during the control session.** However, this was the period where Subject-9 mentioned that he would not have been able to focus on a game if he had kept the same intensity. The heart rate of Subject-7, who had the lowest average heart rate during the control session, gradually increased from 50% to 78% and spent 14 minutes in Zone 2 or higher. The lowest heart rate from the first session increased from 40% to 66%, and it stayed only 4 minutes in Zone 2, with the rest being in Zone 1 or lower. During the second game session, the participant with the lowest heart rate spent 19 minutes in Zone 1, with a few small spikes into Zone 2. **This shows that the control session did manage to produce almost 15 minutes of moderate intensity in everyone, while the game was not as effective.**

40.1.2 Intensity

However, the player can increase the intensity to reach high-intensity exercise, like Subjects-1 and -2, who spent around 5 minutes each in Zone 4. This variation shows that the player is able to

choose their own intensity, which is suitable for the players who find that inner motivation but bad for the players who lack the ability to get motivated to push themselves. After the first game session, two subjects mentioned that they could have adjusted the resistance more but were too focused on the game to do so. **After the second game session, 40% of the subjects felt they could increase the resistance more because they knew the game better.** This matches the results from the reflection questionnaire, as one can see that 70% *strongly disagreed* with the statement *I changed the resistance often* (AQ20) after the first game session. Only 55% answered the same after the second game session. In contrast, 50% answered *slightly agree* and 40% answered *slightly disagree* after the control session.

40.1.3 Improvements

There are several ways the game could help the player increase intensity. One way is for the game to gradually increase the *equilibrium cadence* during the game. This idea was discussed in Part III but was never implemented due to how inaccurate the sensors got at high velocities. Another way is for the game to change the bike's resistance automatically. However, this was not possible with the prototype bike that was available for this project. Subject-6 suggested that scores could be weighted based on resistance and *equilibrium cadence*, which would incentivise players to keep a higher velocity and resistance. The current prototype bikes cannot read the resistance, but adjusting the scores based on *equilibrium cadence* could be possible. Additionally, Subject-10 suggested that the objects' weight should change the balance point of the board and therefore change the *equilibrium cadence*. This idea was discussed during the early stages of development. However, it was omitted as it might encourage players to place the objects in a way that would decrease the *equilibrium cadence*.

40.2 Replayability

To reach the recommended 300 minutes (or 5 hours) of moderate intensity a week or 150 minutes (2.5 hours) of high intensity (Hansen et al., 2023), it is essential that players are motivated to play for long sessions and that they play the game often.

40.2.1 Session Length

When asked if they wanted to end the session early (AQ4), 70% *strongly disagreed*, and the rest *slightly disagreed* after the first game session. Similar answers were given after the second game session. To compare, after the control session, 10% *strongly agreed*, 30% *slightly disagreed* and 60% *strongly disagreed*. However, when looking at the time spent during sessions, 60% spent the longest time during the second game session, 30% spent it during the first game session, and the remaining 10% spent it during the control session. **That subjects did not want to end the sessions early and wanted to spend more time playing the game than biking with music indicates that they are likely to play the game for longer sessions.** This is also supported by Subject-10 only stopping the second game session after being promised she could continue after the interview.

40.2.2 Limiting Factors

Another indicator of how long people will play is limiting factors like stamina, muscle strength, boredom and equipment. During the interviews, three people reported that their legs limited them during the control session, but that number was reduced to two during the first game session and one during the second game session. Stamina was even less of a limiting factor, with only two during the control session and one during the second game session. One sees a similar trend if one looks at the answers given during the reflection questionnaire. On the question *I felt my stamina was limiting me* (AQ24), the control session had a 50/50 split between disagreeing and agreeing, with only two having strong opinions. On the other hand, everyone disagreed during the first

game session, with most *strongly disagreeing*. The second game session had similar results, with one person *slightly disagreeing*. These answers match the results from the heart rates indicating that the game does not cause as much exertion as the control session. The results from *I felt like my leg strength was limiting me* (AQ24) are similar, with the main difference that there was one *slightly agree* and one *strongly agree* after the first game session. When looking at the answers from *Ranking of the elements that had a negative effect of each session* (AQ26), the most interesting finding was how much *Boredom* fell on the list after the control session, with one rating it as number 1, two rating it as number 2, three rating it as number 3 and four rating it as number 4. After both game sessions, two people rated it as number 3, and the rest rated it as number 4. Another limiting factor could be the equipment, but as none of the subjects used bike shorts with padding and no one answered *strongly agree* to the statement *I felt like the bike was uncomfortable to sit on after a while* (AQ23), this might not be a problem.

40.2.3 Interest

In addition to the game being playable over a long time each session, it is also vital that the game is replayable over an extended amount of time. **After both game sessions, every participant answered that they would want to play the game again.** The answers from the reflection questionnaire support this, as everyone agreed (AQ7). In contrast, only two participants answered that they would want to exercise like the control session again, with the rest either being hesitant or disagreeing. This can be seen more clearly in the reflection questionnaire, where only one answered *strongly agree* to the statement *I would want to exercise like this again* (AQ2), two answered *slightly disagree* and the rest answered *slightly agree*. In contrast, after the first game session, six answered *strongly agree*, three answered *slightly agree*, and the last one answered *slightly disagree* to the same question. **This shows that the game potentially has a higher replayability factor than simply exercising with an exercise bike with music.** As mentioned, people wanted to play the game again, with the *strongly agree* option dropping from 40% to 22.2% after the second session, with the rest of the answers being *slightly agree*. However, the responses to the statement *I would have played the game regularly if I had access to the game and necessary equipment* (AQ15) mainly stayed the same between game sessions, with eight participants agreeing and only one *strongly disagreeing*. As the second game session had one less response than the first, only the first game session had a participant responding with *strongly disagree*. After the second game session, the participants were asked *I had just as much fun this session than during the first game session* (AQ16), and four participants answered *strongly agree* and one answered *strongly disagree*. The remaining four were split equally between *slightly agree* and *slightly disagree*. **This shows that players might lose interest in the game in its current state.** During the interviews, subjects suggested additional features like more levels for marble, additional difficulty levels for Shapes Mode and Balance Mode and leaderboards just between friends, which might delay the loss of interest.

40.2.4 Motivation

Regarding replayability, Subject-2 wanted to return after the experiments were over to increase his score. **During the first game session, 80% found themselves more motivated than during the control session, and the remaining two had the same level of motivation.** The leaderboards seemed to be the primary source of motivation to keep playing and coming back, as 80% mentioned them as a motivating factor. Additionally, three subjects thought that FlipBoard was more fun than their usual exercise routine, and Subject-6 mentioned that he thinks FlipBoard is a fun and easy way to get cardio into his exercise routine. This motivation is promising for the game's longevity and to keep the players regularly playing and pushing themselves.

41 RQ5 Equipment

RQ5:*Does the equipment needed for an exergame deter people from playing exergames?*

Bike exergames are easy to learn because most people know how to bike, meaning players do not have to learn new exercise techniques. In addition, biking is a safe and good way to start exercising. During the control session, two subjects mentioned that using an exercise bike is safer than biking amongst traffic, and another mentioned that biking is gentler on his ankles than running is. **However, there is a huge barrier of entry, as most bike exergames are limited to certain exerbikes, which can be expensive to buy and takes up much space.** Indeed, lack of access to equipment was one of the major reasons given in the general questionnaire for why people did not engage in exergames. In addition, 50% could neither afford nor had enough space for an exerbike such as the PlayPulse bike, and out of the seven people who could both afford it and had space for it, two people commented that they would not invest in such a bike. One person also expressed that 16K was a huge investment for an exerbike they had never heard about or tried. Continuing, they mentioned that such a bike would probably need to be more visible on social media to reach a bigger audience. **During the experiments, 90% answered that they would not have bought a PlayPulse bike because they thought it was too expensive.** On the other hand, only one participant would not use such a bike if it was available at a gym where they had access. However, some mentioned that they would not use it in an open area where people could see them, and one mentioned that he would not buy a gym membership to gain access to such a bike. **All in all, people are interested in using exercise bikes for playing exergames but are unable to because of the large investment needed to buy one.**

42 Experimental Concerns

As described in both Chapter 29 and Section 33.12, there were a few reliability and validity issues, as well as some technical issues and experiment flaws that should be discussed.

42.1 Participants

Both during the general survey and the experiment, the number of participants was lower than recommended. In addition, the non-gamer group in the general survey was too small to make any conclusions about it. **For the experiments, the participants were not ideal for the target audience, as they engage more in physical activity than the ideal target audience.** There was also a missing response to the final anonymous questionnaire, which was a known risk when deciding that the questionnaire should be anonymous. The reasoning behind having an anonymous way to give feedback was to try and minimise the risk of familiarity bias. Unfortunately, there were some signs of the Hawthorne effect (Cook, 1962) affecting how the participants acted. The clearest of these incidents was when Subject-10 commented that she felt like a lab rat during the control session. However, she did comment that she no longer felt like this during the game sessions, as she was too focused on the game.

42.2 Technical Issues

Some technical issues caused annoyance and disrupted flow, which might have affected how the participants viewed the game and the experience. Some of the technical issues were due to bugs in the code, but most were caused by the speed sensors and the incorrect data being sent from the analogue buttons. In addition, the room the experiment was held in had a low airflow and a high temperature. This might have caused some participants to give less or end the session earlier because of discomfort.

42.3 Schedule

Since the time slots for the participants were chosen based on when they were available, some had finished their second game session before others had started their first. This inconsistency meant that **some individuals had an easier time getting onto the leaderboard, as participants got higher scores during the second game session when they were more familiar with the controls**. This might have affected the motivation gained by the leaderboards, both by people getting discouraged as the records were too high and the ones not pushing themselves since the top score was easy to beat. Subject-5's experience is an example of this. She was the first to play the game and found herself quickly reaching the leaderboards. When she started the second game session, she was eager to get more highscores but found that the scores had gotten much higher since she last played and got demotivated.

Another issue is that the experiment period was only two weeks long, and each subject only tested the game twice, so there were difficulties in concluding how the game would perform over a more extended period. **The participants also had life events that might have affected the experiments.** Some subjects had exercised that same week and felt sore, and one was slightly sick, which could have been limiting. Subject-10 had her final game session after an exhausting day at work and used the game as a way to zone out and, therefore, might have given less.

43 Summary of Discussion

This part has discussed the results in the context of the research questions. In addition, some experimental concerns were discussed. Based on the experimental concerns, an updated version of the game with better equipment should be tested with a group of sedentary young adults over a more extended period to ensure that the game concept can help the target audience achieve the recommended exercise amount. The next part will summarise the project by giving conclusions to the different research questions and providing input on what further research could focus on.

Part VIII

Conclusion and Further Work

> "*We have the duty of formulating, of summarizing, and of communicating our conclusions, in intelligible form, in recognition of the right of other free minds to utilize them in making their own decisions.*"
>
> Ronald Fisher (1955)

This part summarises the project by reintroducing the research goal and looking at the answers gained for each research question. It also comes with some suggestions for further work.

44 Conclusion

The research goal for this project was to *develop an exergame prototype that motivates sedentary young adults to reach the recommended amount of physical activity.* The resulting exergame was FlipBoard, a game about balancing a board to achieve various objectives. This prototype game was then used during experiments, in addition to a literature review and a survey to answer the following research questions.

44.1 RQ1 Enjoyed Game Genres

RQ1: *Are there commonly enjoyed game genres, or other gaming preferences, that are not sufficiently represented in the current exergame market?*

The puzzle games genre was the most commonly enjoyed but is lacking from the exergame market. Similarly, the adventure games genre is the second most enjoyed genre (along with puzzle games) for those not physically active. Therefore, it is worth looking into whether or not a more story-driven game could be beneficial as an exergame. Additionally, out of those that prefer either singleplayer or multiplayer, there are more of the former. While most exergames have multiplayer options, a lot still support singleplayer. Therefore, This is not seen as lacking in the market but should still be considered when designing new exergames, especially if the target audience includes sedentary people. In general, most of the respondents were interested in exergames, but few played them regularly. Reasons provided for this range between equipment being too expensive or bulky and lack of awareness and interest in existing exergames. It could be worth looking further into where this discrepancy comes from and how to get more people interested in playing.

44.1.1 RQ1.1 Gender Preferences

RQ1.1: *Does gender affect gaming preferences?*

There were significant differences in genre preferences between the male and female respondents, with the main differences being that women liked puzzle games a lot more often than men and liked action and strategy games a lot less. Additionally, almost half of the female respondents preferred singleplayer, and only 14% preferred multiplayer. Although the reasons for this are out of the scope of this thesis, it would be interesting to find out if factors like harassment and social norms are a cause of this or if it is merely a reflection of which genres they prefer. From the data collected in this project, it is impossible to conclude whether genre preferences cause the singleplayer preference or vice versa. It should also be noted that mobile games were included as video games in this survey and could have affected the results with which genres and other aspects are common in the mobile game market. Regardless, the fact that more female respondents play daily than men substantiates the argument that women's preferences should be considered when designing new games.

44.2 RQ2 Game Design and Exercise Theory

RQ2: *How can existing game design and exercise theory be combined with a new exergame genre into a unique game concept?*

Game design theory principles can be used to ensure that the game is enjoyable enough that players will want to keep playing. Especially, Malone's characteristics for good video games, the concept of flow that describes experiences of enjoyment, the GameFlow model that was designed to measure if games facilitate flow, and the DualFlow model that shows the importance of balancing the extra dimension of physical aspects unique to exergames. Which reward systems to implement are also essential to cater to the different player types. Essentially, a game should include rewards from each of the four categories: Advancement, review, cooperate/compete, and sociability.

44.3 RQ3 Flow

RQ3: *Can such an exergame facilitate a state of flow?*

All participants experienced flow while playing the game. This can be seen by the high level of immersion reached, as made evident by all participants experiencing altered time perception during the game sessions. as well as the positive results in the other elements of GameFlow. The dynamic adjustment of physical challenge through the calibration part prevented the physical aspects of the exergame from disrupting flow. This is something recommended by the DualFlow method that was not present in the other exergames analysed during the literature review. However, there were some other disruptions of flow. Mainly, flow was decreased by the frustration of losing control due to technical issues, side effects of fixes (sensor delay), and design choices of randomisation that were too subtle (randomised rotation angles).

44.4 RQ4 Recommended Exercise Amount

RQ4: *Can such an exergame contribute to more people reaching the recommended exercise amount?*

The exercise recommendation for sedentary adults is 300 minutes of moderate intensity or 150 minutes of high intensity each week. FlipBoard has been shown to facilitate both moderate- and high-intensity exercise, but the intensity level depends on how much the player wants to push themselves. This may make the game an easy entry for people who do not like to engage in exercise, as they can gradually increase the intensity over time, as well as people who exercise frequently and want to start off with higher intensities. However, as the game requires concentration, it is more fitting for longer moderate-intensity sessions which are suitable for improving endurance, increasing fat burning and building muscular fitness. While the game can not replace an existing exercise routine, it can be a beneficial addition to people who already exercise and can be an excellent entry to exercise for people who do not currently exercise. The game in its current state has proven to be more replayable than biking with music. However, that some people found it less interesting after the second game session indicates that players might lose interest in the game over time. For this game to contribute to people reaching the recommended exercise amount over time, more of the suggestions for replayability, such as more levels on marble, more difficulty levels and leaderboards between friends, needs to be implemented.

44.5 RQ5 Equipment

RQ5:*Does the equipment needed for an exergame deter people from playing exergames?*

Many exergames require expensive equipment that takes up a lot of room, which many people neither have the money nor space for. In addition, the obscurity of companies like PlayPulse can deter people from investing, as they either do not know about them or do not trust them. However, most people would use such equipment if it was available in areas they frequent, like a gym. For the latter, some participants clarified that it would have to be in an area of the gym with few people.

45 Further Work

The results of the experiments and the general survey highlighted improvements that could be made to the prototype, along with interesting questions that were outside this thesis' scope. These findings will be summarised in this chapter.

45.1 FlipBoard Improvements

In the case of FlipBoard, the least supported player type is socialisers, as the game has no direct multiplayer features. However, implementing the planned multiplayer mode would provide a good opportunity for cooperation and interaction between players. Furthermore, more reward systems should be implemented to better cover all reward categories. To this end, an achievement system, unlocking mechanism, and personal leaderboards and statistics would be best.

Other functionality should also be implemented or improved to increase replayability and the longevity of the game. The most important of these are more levels in Marble Mode, varied and engaging music, and options to make the game easier or more difficult by, for example, excluding particular objects or scoring Shapes Mode more strictly.

Better equipment would also open up for more advanced tuning of exercise intensity. For example, automatic resistance adjustment could help the player get more out of their workout while allowing them to focus on the game, and better sensors could prevent frustrating sensor delay and interfering data. Technical issues and bugs within the game should, of course, also be fixed. An additional way to improve the efficiency of the exercise is to fine-tune the calibration more and change the equilibrium cadence during rounds as well.

45.2 Further Research

The findings of this thesis would benefit from being verified through testing over a more extended time period with more participants.

Interestingly, most respondents were interested in playing exergames, but few did. It is worth looking into why this is and how to change it, as exergames can significantly benefit a sedentary society. To this end, it would be interesting to investigate whether or not adventure games (story-focused games) would work as exergames, as it was the second most commonly enjoyed genre by not physically active respondents but lacking from the exergame market.

The drastic difference in genre preferences between men and women could also use more research. Specifically, it would be interesting to know if the preferred genres of women are the cause for their increased preference for singleplayer or vice versa. Or if external factors like harassment and social norms are making it more difficult for women to enjoy playing with other players.

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Appendix

A Recruitment form

Vil du delta i forskningsprosjektet “FlipBoard - Unexplored Genres in Exergames”?

Dette er et spørsmål til deg om å delta i et forskningsprosjekt hvor formålet er å undersøke muligheten for andre typer sjangere i exergames (fysisk aktive videospill).

Formål
Formålet med dette forskningsprosjektet er å undersøke om andre sjangere i exergames markedet hadde medført at flere personer blir motiverte til å spille exergames. Ettersom exergames er vist å forbedre mental og fysisk helse, vil det være positivt om de kan glede flere folk.

Dette er en masteroppgave for studenter av Datateknologi ved Institutt for Datateknologi og Informatikk (IDI) hos NTNU.

Hva innebærer det for deg å delta?
Hvis du velger å delta i prosjektet, innebærer det at du deltar i tre eksperimentøkter med trening på en treningssykkel. Hver treningsøkt vil vare i 30 min. Første økt vil bestå av en kontrolløkt, mens andre og tredje økt vil ta i bruk en exergame prototype. Det vil bli tatt pulsmålinger og notater under øktene. Etter hver treningsøkt vil det holdes et kort intervju på ca. 20 minutter, hvor opplevelsen kan forklares mer utfyllende. Det vil bli tatt lydopptak og notater fra intervjuene. Etter hver økt flyller du ut en anonym undersøkelse om opplevelsen. Den vil ta ca. 10 minutter, og fylles ut når det passer deg innen to dager etter økten. Alle testmetodene nevnt over vil foregå i løpet av uke 16 og 17 i 2023.

Det er frivillig å delta
Det er frivillig å delta i prosjektet. Hvis du velger å delta, kan du når som helst trekke samtykket tilbake uten å oppgi noen grunn. Alle dine personopplysninger vil da bli slettet. Det vil ikke ha noen negative konsekvenser for deg hvis du ikke vil delta eller senere velger å trekke deg.

Ditt personvern – hvordan vi oppbevarer og bruker dine opplysninger
Vi vil bare bruke opplysningene om deg til formålene vi har fortalt om i dette skrivet. Vi behandler opplysningene konfidensielt og i samsvar med personvernregelverket. Navn og kontaktopplysninger vil erstattes med en kode som lagres adskilt fra øvrige data. All informasjon vil anonymiseres før publisering av prosjektet.

Under prosjektet vil all innsamlet data lagres kryptert i SharePoint, og vil kun være tilgjengelig for de nevnte masterstudentene og veilederen.

Hva skjer med personopplysningene dine når forskningsprosjektet avsluttes?
Prosjektet vil etter planen avsluttes 15. september. Etter prosjektslutt vil lydopptak, notater og andre personopplysninger slettes eller anonymiseres.

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 på NTNU har Sikt – Kunnskapssektorens tjenesteleverandør vurdert at behandlingen av personopplysninger i dette prosjektet er i samsvar med personvernregelverket.

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

- innsyn i hvilke opplysninger vi behandler om deg, og å få utlevert en kopi av opplysningene
- å få rettet opplysninger om deg som er feil eller misvisende
- å få slettet personopplysninger om deg
- å sende klage til Datatilsynet om behandlingen av dine personopplysninger

1. Navn *

2. Epost *

3. Har du mulighet til brukertester i uke 16 og 17? *

- ◯ Ja
- ◯ Nei

4. Hvilke tider passer ikke?

For å sette opp best mulig tidskjema ønsker vi å vite om det er noen tidspunkt som absolutt ikke passer for deg å ha bruker tester på.

5. Kjønn?

- ◯ Kvinne
- ◯ Mann
- ◯ Ikke-binær
- ◯ Ønsker ikke svare
- ◯ Other

6. Hvor ofte trener du?

Her tenker vi i gjennomsnitt

- ◯ Hver dag
- ◯ 2 eller flere ganger i uka
- ◯ En gang i uka
- ◯ Annenvær uke
- ◯ En gang i måneden
- ◯ Sjeldnere

7. Hvor ofte spiller du video spill?

Her tenker i vi i gjennomsnitt og vi teller alle typer video spill, inkludert mobil spill

- ◯ Hver dag
- ◯ 2 eller flere ganger i uka
- ◯ En gang i uka
- ◯ Annenvær uke
- ◯ En gang i måneden
- ◯ Sjeldnere

8. Hvilke videospill sjangere foretrekker du?

- [ ] Action
- [ ] Adventure
- [ ] Idle
- [ ] Party
- [ ] Platformers
- [ ] Puzzle
- [ ] RPGs
- [ ] Simulation
- [ ] Strategy
- [ ] Other

9. Kommentar

B Consent Form

Vil du delta i forskningsprosjektet

"FlipBoard - Unexplored Genres in Exergames"?

Dette er et spørsmål til deg om å delta i et forskningsprosjekt hvor formålet er å undersøke muligheten for andre typer sjangere i exergames (fysisk aktive videospill). I dette skrivet gir vi deg informasjon om målene for prosjektet og hva deltakelse vil innebære for deg.

Formål
Formålet med dette forskningsprosjektet er å undersøke om andre sjangere i exergames markedet hadde medført at flere personer blir motiverte til å spille exergames. Ettersom exergames er vist å forbedre mental og fysisk helse, vil det være positivt om de kan glede flere folk.

Dette er en masteroppgave for studenter av Datateknologi ved Institutt for Datateknologi og Informatikk (IDI) hos NTNU.

Hvem er ansvarlig for forskningsprosjektet?
Forsøket gjennomføres som del av en masteroppgave ved IDI hos NTNU. Veileder og hovedansvarlig for prosjektet er Alf Inge Wang. Forsøket vil bli gjennomført av masterstudentene Sigrid Greiff Elnan og Vilde Voss Stabell.

Hvorfor får du spørsmål om å delta?
Du er blitt spurt om å delta fordi du er en del av de aktuelle masterstudentenes nettverk. Målgruppen til dette forskningsprosjektet er personer i aldersgruppen 18-30 som ikke vanligvis er motiverte til å trene, og som ikke er interesserte i vanlige exergamessjangere (actionspill, kjøretøybaserte spill etc.).

Hva innebærer det for deg å delta?
Hvis du velger å delta i prosjektet, innebærer det at du deltar i tre eksperimentøkter med trening på en treningssykkel. Hver treningsøkt vil vare i 30 min. Første økt vil bestå av en kontrolløkt, mens andre og tredje økt vil ta i bruk en exergame prototype. Det vil bli tatt pulsmålinger og notater under øktene. Etter hver treningsøkt vil det også holdes et kort intervju på ca. 20 minutter, hvor opplevelsen kan forklares mer utfyllende. Det vil bli tatt lydopptak og notater fra intervjuene. Etter hver økt fyller du ut en anonym undersøkelse om opplevelsen. Den vil ta ca. 10 minutter, og fylles ut når det passer deg innen to dager etter økten. Svarene vil bli registrert elektronisk. Alle testmetodene nevnt over vil foregå i løpet av uke 16 og 17 i 2023.

Det er frivillig å delta
Det er frivillig å delta i prosjektet. Hvis du velger å delta, kan du når som helst trekke samtykket tilbake uten å oppgi noen grunn. Alle dine personopplysninger vil da bli slettet. Det vil ikke ha noen negative konsekvenser for deg hvis du ikke vil delta eller senere velger å trekke deg.

Ditt personvern – hvordan vi oppbevarer og bruker dine opplysninger
Vi vil bare bruke opplysningene om deg til formålene vi har fortalt om i dette skrivet. Vi behandler opplysningene konfidensielt og i samsvar med personvernregelverket. Navn og kontaktopplysninger vil erstattes med en kode som lagres adskilt fra øvrige data. All informasjon vil anonymiseres før publisering av prosjektet.

Under prosjektet vil all innsamlet data lagres kryptert i SharePoint, og vil kun være tilgjengelig for de nevnte masterstudentene og veilederen.

Hva skjer med personopplysningene dine når forskningsprosjektet avsluttes?
Prosjektet vil etter planen avsluttes 15. september. Etter prosjektslutt vil lydopptak, notater og andre personopplysninger slettes eller anonymiseres.

Hva gir oss rett til å behandle personopplysninger om deg?
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Dine rettigheter
Så lenge du kan identifiseres i datamaterialet, har du rett til:

- innsyn i hvilke opplysninger vi behandler om deg, og å få utlevert en kopi av opplysningene
- å få rettet opplysninger om deg som er feil eller misvisende
- å få slettet personopplysninger om deg
- å sende klage til Datatilsynet om behandlingen av dine personopplysninger

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

- Alf Inge Wang - Institutt for datateknologi og informatikk
- alf.inge.wang@ntnu.no
- 73594485

Vårt personvernombud:

- Thomas Helgesen
- thomas.helgesen@ntnu.no
- 93079038

Hvis du har spørsmål knyttet til vurderingen som er gjort av personverntjenestene fra Sikt, kan du ta kontakt via:

- Epost: personverntjenester@sikt.no eller telefon: 73 98 40 40.

Med vennlig hilsen

Alf Inge Wang	*Vilde Voss Stabell*	*Sigrid Greiff Elnan*
(Forsker/veileder)	Masterstudent	Masterstudent

Samtykkeerklæring

Jeg har mottatt og forstått informasjon om prosjektet *FlipBoard - Unexplored Genres in Exergames*, og har fått anledning til å stille spørsmål. Jeg samtykker til:

- □ å delta i tre eksperimentøkter
- □ å delta i tre intervjuer
- □ å svare på tre anonyme refleksjonsskjemaer (én etter hver økt)
- □ at det blir tatt lydopptak under intervjuene
- □ at pulsdata blir samlet inn under eksperimentøktene

Jeg samtykker til at mine opplysninger behandles frem til prosjektet er avsluttet

---

(Signert av prosjektdeltaker, dato)

Sikt

Meldeskjema / FlipBoard - Unexplored Genres in Exergames / Eksport

Meldeskjema

Referansenummer
781989

Hvilke personopplysninger skal du behandle?

- Navn (også ved signatur/samtykke)
- E-postadresse, IP-adresse eller annen nettidentifikator
- Lydopptak av personer
- Bakgrunnsopplysninger som vil kunne identifisere en person

Beskriv hvilke bakgrunnsopplysninger du skal behandle

Alder og kjønn

Prosjektinformasjon

Prosjekttittel

FlipBoard - Unexplored Genres in Exergames

Prosjektbeskrivelse

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.
- Evaluate the game through user experiments

Begrunn hvorfor det er nødvendig å behandle personopplysningene

Epost skal brukes til å kommunisere med testdeltakerene, for blant annet å planlegge testtidspunkt. Navn blir brukt under signering av samtykkeskjema. Det blir tatt lydopptak av intervjuene, for å få en mer nøyaktig oppfatning av det som ble sagt. Bakgrunnsopplysningene, alder og kjønn, blir brukt til å kalkulere makspuls og for å oppdage om det er forskjeller i spillpreferanser basert på kjønn.

Ekstern finansiering
Ikke utfyllt
Type prosjekt
Studentprosjekt, masterstudium

Kontaktinformasjon, student
Vilde Voss Stabell, vildevs@stud.ntnu.no, tlf: 98811394

Behandlingsansvar

Behandlingsansvarlig institusjon
Norges teknisk-naturvitenskapelige universitet / Fakultet for informasjonsteknologi og elektroteknikk (IE) / Institutt for datateknologi og informatikk

Prosjektansvarlig (vitenskapelig ansatt/veileder eller stipendiat)
Alf Inge Wang, alf.inge.wang@ntnu.no, tlf: 73594485

Skal behandlingsansvaret deles med andre institusjoner (felles behandlingsansvarlige)?
Nei

Utvalg 1

Beskriv utvalget

Målgruppen til dette forskningsprosjektet er personer i aldersgruppen 18-30 som ikke vanligvis er motiverte til å trene, og som ikke er interesserte i vanlige exergamessjangere (actionspill, kjøretøybaserte spill etc.)

Beskriv hvordan rekruttering eller trekking av utvalget skjer

Rekruttering vil foregå innenfor nettverket til masterstudentene.

Alder
18 - 30

Personopplysninger for utvalg 1
- Navn (også ved signatur/samtykke)
- E-postadresse, IP-adresse eller annen nettidentifikator
- Lydopptak av personer
- Bakgrunnsopplysninger som vil kunne identifisere en person

Hvordan samler du inn data fra utvalg 1?

Personlig intervju

Vedlegg

Intervjuguide.pdf

Grunnlag for å behandle alminnelige kategorier av personopplysninger
Samtykke (Personvernforordningen art. 6 nr. 1 bokstav a)

Informasjon for utvalg 1

Informerer du utvalget om behandlingen av personopplysningene?
Ja

Hvordan?
Skriftlig informasjon (papir eller elektronisk)

Informasjonsskriv

Infoskriv.docx.pdf

Tredjepersoner

Skal du behandle personopplysninger om tredjepersoner?
Nei

Dokumentasjon

Hvordan dokumenteres samtykkene?
- Manuelt (papir)

Hvordan kan samtykket trekkes tilbake?

Deltakerene kan kontakte masterstudentene eller veileder for å trekke tilbake samtykket. Da vil all informasjon om dem slettes.

Hvordan kan de registrerte få innsyn, rettet eller slettet personopplysninger om seg selv?

Deltakerene kan kontakte masterstudentene eller veileder for å få innsikt, rette eller slette personopplysninger om seg selv.

Totalt antall registrerte i prosjektet
1-99

Tillatelser

Skal du innhente følgende godkjenninger eller tillatelser for prosjektet?
Ikke utfyllt

Behandling

Hvor behandles personopplysningene?
- Ekstern tjeneste eller nettverk (databehandler)
- Maskinvare tilhørende behandlingsansvarlig institusjon

Hvem behandler/har tilgang til personopplysningene?
- Prosjektansvarlig
- Student (studentprosjekt)
- Databehandler

Hvilken databehandler har tilgang til personopplysningene?

Vi vil lagre data på Sharepoint, så det kan antas at databehandlere hos dem har tilgang.

Tilgjengeliggjøres personopplysningene utenfor EU/EØS til en tredjestat eller internasjonal organisasjon?
Nei

Sikkerhet

Oppbevares personopplysningene atskilt fra øvrige data (koblingsnøkkel)?
Ja

Hvilke tekniske og fysiske tiltak sikrer personopplysningene?
- Personopplysningene anonymiseres fortløpende
- Opplysningene krypteres under lagring
- Flerfaktorautentisering
- Adgangsbegrensning
- Endringslogg

Varighet

Prosjektperiode
20.03.2023 - 15.09.2023

Hva skjer med dataene ved prosjektslutt?
Data anonymiseres (sletter/omskriver personopplysningene)

Hvilke anonymiseringstiltak vil bli foretatt?
- Koblingsnøkkelen slettes
- Lyd- eller bildeopptak slettes
- Personidentifiserbare opplysninger fjernes, omskrives eller grovkategoriseres

Vil de registrerte kunne identifiseres (direkte eller indirekte) i oppgave/avhandling/øvrige publikasjoner fra prosjektet?
Nei

Tilleggsopplysninger

Sikt

Meldeskjema / FlipBoard - Unexplored Genres in Exergames / Vurdering

Vurdering av behandling av personopplysninger

Referansenummer	Vurderingstype	Dato
781989	Automatisk	21.01.2023

Prosjekttittel
FlipBoard - Unexplored Genres in Exergames

Behandlingsansvarlig institusjon
Norges teknisk-naturvitenskapelige universitet / Fakultet for informasjonsteknologi og elektroteknikk (IE) / Institutt for datateknologi og informatikk

Prosjektansvarlig
Alf Inge Wang

Student
Vilde Voss Stabell

Prosjektperiode
20.03.2023 - 15.09.2023

Kategorier personopplysninger
Alminnelige

Lovlig grunnlag
Samtykke (Personvernforordningen art. 6 nr. 1 bokstav a)

Behandlingen av personopplysningene er lovlig så fremt den gjennomføres som oppgitt i meldeskjemaet. Det lovlige grunnlaget gjelder til 15.09.2023.

Meldeskjema

Grunnlag for automatisk vurdering
Meldeskjemaet har fått en automatisk vurdering. Det vil si at vurderingen er foretatt maskinelt, basert på informasjonen som er fylt inn i meldeskjemaet. Kun behandling av personopplysninger med lav personvernulempe og risiko får automatisk vurdering. Sentrale kriterier er:

- De registrerte er over 15 år
- Behandlingen omfatter ikke særlige kategorier personopplysninger;
  - Rasemessig eller etnisk opprinnelse
  - Politisk, religiøs eller filosofisk overbevisning
  - Fagforeningsmedlemskap
  - Genetiske data
  - Biometriske data for å entydig identifisere et individ
  - Helseopplysninger
  - Seksuelle forhold eller seksuell orientering
- Behandlingen omfatter ikke opplysninger om straffedommer og lovovertredelser
- Personopplysningene skal ikke behandles utenfor EU/EØS-området, og ingen som befinner seg utenfor EU/EØS skal ha tilgang til personopplysningene
- De registrerte mottar informasjon på forhånd om behandlingen av personopplysningene.

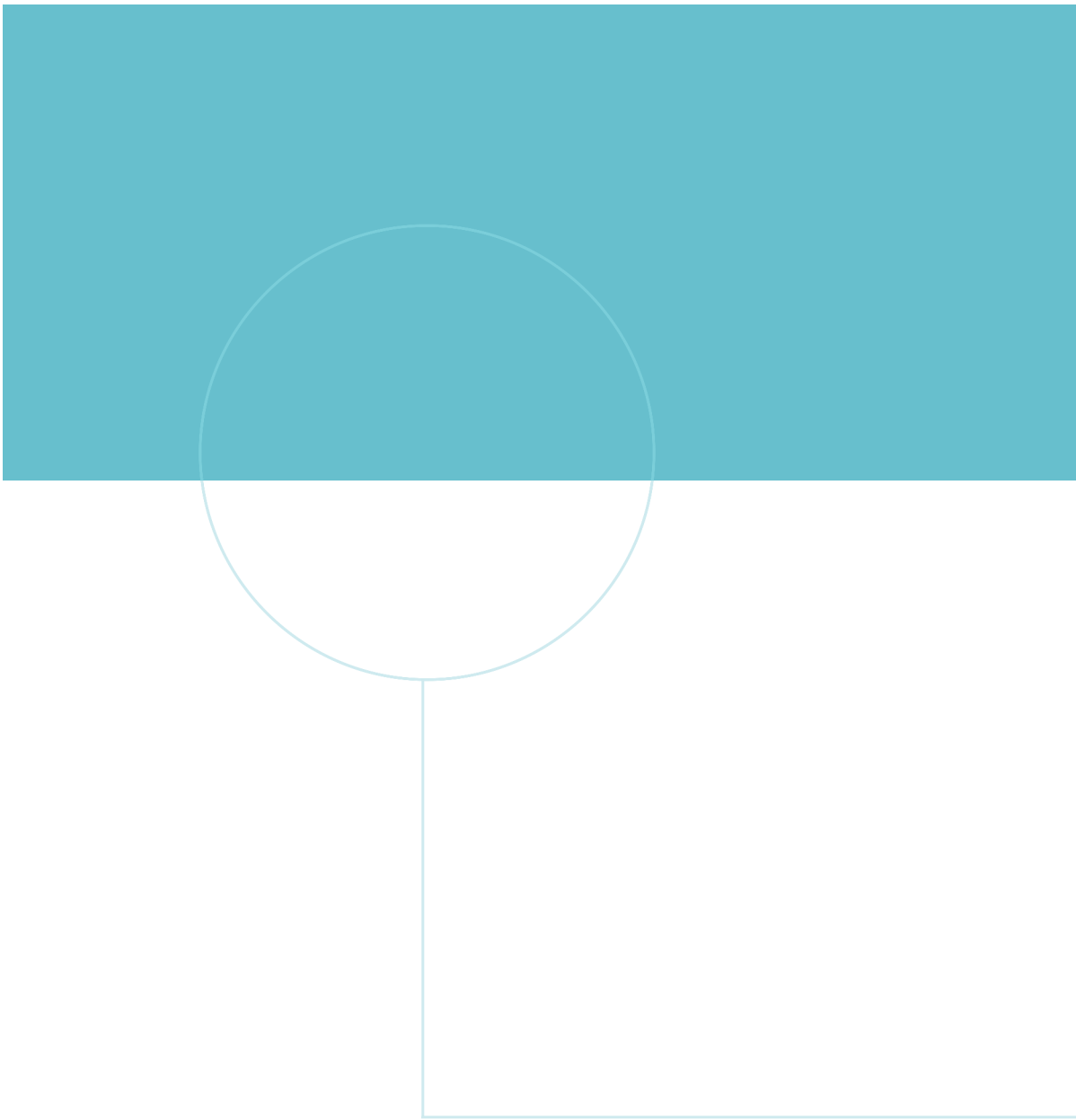
Informasjon til de registrerte (utvalgene) om behandlingen må inneholde

- Den behandlingsansvarliges identitet og kontaktopplysninger
- Kontaktopplysninger til personvernombudet (hvis relevant)
- Formålet med behandlingen av personopplysningene
- Det vitenskapelige formålet (formålet med studien)
- Det lovlige grunnlaget for behandlingen av personopplysningene

- Hvilke personopplysninger som vil bli behandlet, og hvordan de samles inn, eller hvor de hentes fra
- Hvem som vil få tilgang til personopplysningene (kategorier mottakere)
- Hvor lenge personopplysningene vil bli behandlet
- Retten til å trekke samtykket tilbake og øvrige rettigheter

Vi anbefaler å bruke vår mal til informasjonsskriv.

Informasjonssikkerhet
Du må behandle personopplysningene i tråd med retningslinjene for informasjonssikkerhet og lagringsguider ved behandlingsansvarlig institusjon. Institusjonen er ansvarlig for at vilkårene for personvernforordningen artikkel 5.1. d) riktighet, 5. 1. f) integritet og konfidensialitet, og 32 sikkerhet er oppfylt.



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