NTNU
Norwegian University of
Science and Technology

Exermon - Play to Get Strong

Torbjørn Høivik
Gaute Meek Olsen

Master of Science in Computer Science
Submission date: June 2016
Supervisor: Alf Inge Wang, IDI
Co-supervisor: Kristoffer Hagen, IDI

Norwegian University of Science and Technology
Department of Computer and Information Science

Abstract - English

Today humans in modern societies are running higher risks of developing weight-related diseases compared to earlier generations. This is evidenced by a trend of a larger percentage of people being overweight or obese in the western countries. A contributing factor to this increase is our growing use of media and the escalating amount of sedentary workplaces. In order to take advantage of the vast amount of media usage, game developers have started to incorporate body movement or exercise into their games, called exergames. Exergames and the variety of movements in these games, strength training specifically, has still not reached its potential, which is the reason for this study.

In this study, we reviewed existing exergames, video game mechanisms, strength exercise theory, and technology within the exergame field. It is apparent that successful games use game mechanisms such as challenge, fantasy, curiosity, flow, rewards, and social interactions. These findings were then used to design and create a new exergame based on strength training. This new game was then tested on the metrics of motivation, enjoyment, engagement, technology, and physical benefits in order to assess the quality of the game.

Further in the study we detail a description of the exergame that has been tested, a description of the research methodology, our results on the tests, and our discussion and conclusion based on the findings. We found that there are numerous possibilities when creating a game with our premise, and our research show that the game can be motivational, enjoyable, and engaging and at the same time give the players the health benefits that strength training provides. Our method for capturing the movements of the players, however, was far from ideal and further work on this topic is recommended.

Abstract - Norwegian

Mennesker i moderne samfunn har i dag en økt risiko for å utvikle vektrelaterte sykdommer i forhold til tidligere generasjoner. Dette blir understreket av en større andel overvektige, spesielt i vestlig kultur. En medvirkende faktor som spiller inn på dette er vårt økende bruk av media og stigende antall stillesittende jobber. For å utnytte den økende mediebruken har spillutviklere begynt å inkorporere kroppsbevegelse og trening i spillene sine. Mengden spill og utvalgte bevegelser, spesielt styrkeøvelser, har ikke nådd sitt fulle potensialet. Dette er bakgrunnen for denne studien.

I denne studien så vi på eksisterende treningsspill, spillmekanismer, styrketreningsteori og teknologi innen treningsspill feltet. Det er tydelig at spill som har oppnådd suksess, benytter spillelementer som utfordringer, fantasi, nysgjerrighet, flow, belønninger og sosial interaksjon. Disse funnene har dannet grunnlaget til å designe og lage et nytt treningsspill som fokuserer på styrketrening. Dette nye spillet er blitt testet og vurdert etter faktorene motivasjon, moro, engasjement, teknologi og fysiske helsefordeler for å vurdere kvaliteten av spillet.

Videre består studien av en detaljert beskrivelse av treningsspillet som har blitt testet, en detaljert beskrivelse av forskningsmetoden og våre testresultater. Deretter følger diskusjon og konklusjon basert på funnene som ble gjort. Vi har funnet ut at det er mange muligheter for å lage et spill med våre forutsetninger og forskningen viser at spillet kan være motiverende, moro og engasjerende samtidig som det gir spillerne helsegevinst som styrketrening tilbyr. Det som ikke var optimalt med spillet var registreringen av spillerens kroppsbevegelse, videre arbeid på dette området er anbefalt.

Acknowledgements

We would like to extend a huge thank you to our supervisors Professor Alf Inge Wang and PhD Candidate Kristoffer Hagen at the Norwegian University of Science and Technology (NTNU), for the opportunity to work on this exciting project and for their invaluable guidance throughout the process. You gave us the freedom and support to work on something that was ours, but at the same time steering us on the right path when we thought we needed it. Your knowledge, expertise, and the excitement you brought on every meeting have been a tremendous source of inspiration for us.

We would also like to show gratitude to Jens Moser from Netlight Consulting, for the much valued tip of using Fabric in the development process. This provided us with invaluable data and feedback, which gave us a greater understanding of our game.

Our sincerest thanks also go out to all the participants of the testing process. Without you, we would not have been able to conduct this study, and write our thesis. You know who you are.

List of Figures

List of Tables

Contents

Part I

Introduction

Chapter 1

Motivation

Digital media usage has been a steadily growing part of our everyday life. Modern societies use on average more time on media devices such as computers, cell phones, and TVs than any other activity except from sleeping (Foehr et al., 2005; ACSM). We are also living increasingly sedentary lives, especially in the workplace where physical labour have been replaced with a desk job (Lifespan fitness). This change in lifestyle poses a serious threat to a person's health. A sedentary lifestyle gives a person an increased risk of being overweight but also an increased risk of type 2 diabetes (Hu, 2003).

Seeing the importance of this issue, there have been several attempts at rectifying the situation. One of these attempts is a new trend coming out of the game making communities called exergames. These interactive games promote body movement and/or exercise while playing the game, and have seen some success throughout its brief history (Hagen and Weie, 2015; Unnithan et al., 2006). Most of these games have been created with endurance or body movement training in mind, but we could not find a single game created to motivate people for strength training. Strength training, also referred to as resistance training, is training where the goal is to increase one's muscular size and power.

This is why we wanted to create a game which is motivating, enjoyable, and engaging to play, but also provides the health benefits which strength training can provide (Winett and Carpinelli, 2001; Hunter et al., 2004).

Chapter 2

Project and Context

This project is a continuation of a previous project, a specialization project done in the fall of 2015 (Olsen and Høivik, 2015). In the specialization project we did a prestudy of the field of exergaming in general, and a design concept for our own exergame. In this report the text in Part II, except Chapter 5, is included from the previous project. Chapter 10 and Section 14.1, is also included from the specialization project, while Chapter 11, Chapter 12, Section 14.2, and some of Chapter 13 are based on text from the specialization project.

The written assignment for both the specialization project and this master's thesis were as follows:

> **[ExerGames] Play to get fit**
> In this project, the goal is to come up with new game concepts and game technologies for exergames - games where the player carry out physical exercise at the same time. There are several approaches for exergames, and the challenge is to find the balance between something that is fun to play as well as you get a real physical exercise from playing the game.
>
> The first phase of the project will consist of a theoretical study of exergames and mechanisms for how games can be used as a motivator. The second phase focus on implementing a prototype using various technologies. In third and final phase, the prototype will be evaluated and tested.

The first phase was conducted in the specialization project, while phase two and three are work that has been done in this master thesis. The work on this project began by creating our own exergame. We had already made the

concept and rough design during the previous project, so we could begin to work on the exergame quickly. Creating the game took approximately three months with 14 000 lines of code, and an application, server, and database were created.

When the exergame was set up and ready for distribution, the researchers, which is the authors of this thesis, began planning the experiment. This consisted of finding which metrics to test the exergame on, who to test, time period, what types of data to collect, and which data collection methods to use. When this was done, the researchers created the survey to be answered after the testing period along with outlines on how to conduct observations and interviews on the test subjects. The testing period lasted for two weeks. During this time, we as researchers worked on answering questions, fixing problems with the game, and conducting observations and interviews.

The period after the testing phase ended was used to analyse and interpret the results, and write the thesis you are now reading.

Chapter 3

Research Questions and Method

During the specialization project we studied how we could make games motivating, enjoyable, and engaging, as well as providing a good strength workout. We also studied what types of technology are able to track body movement. This project we have used this knowledge in practice to create our own exergame, and see whether the game we created possess the qualities we listed above.

As our main research approach we used the Goal/Question/Metrics (GQM) paradigm (Basili, 1992), where we first define a *project goal*, the conceptual level. Secondly, we define a set of *research questions*, the operational level. Lastly, we describe a set of *metrics* which is going to help us answer our research questions, the quantitative level.

From the written assignment in Chapter 2, and our desire to expand the exergame field in terms of strength training, we came up with the following research goal.

Research goal: Investigate the user perception, physical benefits, and technology capabilities on an exergame that focus on strength training.

By decomposing our research goal, we came up with the following research questions:

> *Research question 1: How is the player's motivation affected by the exergame?*
> This research question studies the player's motivation while playing the exergame. It is important for the player to stay motivated as this

keeps the player playing for a longer period of time.

Research question 2: How is the player's enjoyment affected by the exergame?
This research question studies if the player has fun while playing the exergame. It is very important for the players to enjoy the play sessions, making them feel like they are doing something useful.

Research question 3: How is the player's engagement affected by the exergame?
This research question studies the player's engagement in the game. Having players engaged in the game is important to create a sense of involvement and personal connection to the game.

Research question 4: How is the player's strength affected by the exergame?
This research question studies the player's workout habits and whether the game has helped them improve their physique.

Research question 5: How well does the technology track the player's exercise?
This research question aims to find out if the technology we chose to use in order to track the player's movement was a good one, or if there needs to be an improvement in technology and/or implementation.

In order to answer these research questions, we needed to develop an exergame with its exercise based on strength training. As discussed earlier, we had already laid a foundation for this during the specialization project, and conclusions on how this could be done had been made. See Part II for a detailed description on our *prestudy*. Once this game was developed, we were ready to conduct our research, which would enable us to answer our research questions.

The research contained methodology from both *qualitative and quantitative research* as to get different viewpoints on the exergame and the test subjects. Surveys, observations, interviews, and application usage analysis tool were used in order to adhere to this concept. The number of different data collection methods were also important, as this strengthens our results by

triangulating the data.

The tests were conducted in a two-week period where we asked friends, colleagues, and family to play our game. During the last week of testing we observed and interviewed a select sample of the test population, and at the end of the testing period all the participants answered a survey. We identified that the data we collected were from three different categories, physical, user perception, and technological.

By analysing the results from our tests we could evaluate the quality of our exergame in the categories mentioned above. This was used to answer our research questions, and we found how the game affected the player's motivation, enjoyment, engagement, and strength. In addition, we could answer whether the technology used is viable or not. For a detailed description of the *research methodology* used in this thesis, see Part IV.

Chapter 4

Report Outline

Part II contains the state of the art on exergaming, where we review existing exergames, video game mechanisms, strength exercise theory, and the technology capabilities available.

Part III focuses on our exergame. This part contains the game concept, how we implemented video game mechanisms and exercise in the game, screenshots with descriptions, and development details.

Part IV contains our research methodology. A description of what theories we applied to our research, how we executed the testing, the data collection, and possible weaknesses to our approach.

Part V are the results of the research conducted. The results are presented by methods of data collection used and categorized into three different categories: the results relating to the physical part, the user perception part, and the technological part.

Part VI are our discussions on the results obtained in Part V. We elaborate on what the data means in regards to our research questions.

Part VII is our conclusion on the research and here we also answer the research questions outlined in Chapter 3. It also contains our evaluations on the project and a review of our contribution to the field of exergaming. In addition, we recommend how to further proceed with the findings uncovered in the research.

Part II

Prestudy

This part is to get an understanding about the state of the art of exergaming. We have researched existing exergames, technology capabilities to track physical activity, video game mechanisms, and theory about strength training. Then we have drawn a conclusion about the subjects and what we found important for the rest of our project.

Chapter 5

What is Exergames?

Exergames, also referred to as fitness games or exercise games, is a term used for video games that provide exercise in some form through its gameplay (Sinclair et al., 2007; Read and Shortell, 2011). These games usually rely on technology in order to track the movements and/or reactions of the players, and incorporate them into the game. Exergames are credited with altering the stereotype that gaming is a sedentary activity. More and more people are now seeing different sides of gaming, as it can promote activity and improve fitness levels (Lewis, 2009).

The genre of exergaming can trace its roots to the eighties were several of these games were made. Two big game-making companies at the time, Nintendo and Atari, were making games with movement incorporated in the game (AtariMania; NESguide). The first game really dedicated to exercise, however, was a game called Computrainer (Racermate) which was released on the game system NES (Nintendo Entertainment System) in 1986. This game allowed the player to bicycle through a virtual landscape as well as giving the player input on how he/she is performing physically as they ride along.

The first commercially successful exergame was the dancing game Dance Dance Revolution (DDR). This game sold several million copies, and studies showed that the players of the game had reasonable good exercise as they played it. See Section 6.1 for more information on Dance Dance Revolution.

Today, the two most popular game systems for exergames is the Nintendo Wii and the Xbox Kinect. In Chapter 6 we cover some of the exergames made for these systems. There are also numerous different mobile applications that combine exercise and gaming, such as Ingress and Zombie's Run! (Niantic Labs; Zombiesrungame).

There have been studies on the field of exergaming that has had varying results, depending on the game and the age of the players, this is shown in Chapter 6. It shows that most of these games have a light to moderate intensity level (Unnithan et al., 2006; Lin et al., 2006). Unfortunately, the amount of studies done on these games, and the amount of games themselves are very limited, and the potential for expansion is still great.

Chapter 6

Existing Exergames

This chapter describes existing exergames, and how they combine video game with exercise. We have selected exergames to achieve variety in player movement, and which technologies they use. This gives an overview of the exergame field today, and show that games have succeeded to motivate, thrill, and engage the player as well as giving him/her physical exercise.

6.1 Dance Dance Revolution

Dance Dance Revolution is a game based on rhythm where the player is supposed to step on pressure plates with arrows on them (see Figure 6.1). The plate's arrows coincide with arrows given on the screen, and you get feedback when you time your step at the best possible moment. This experience is accompanied by music which helps the player keep the rhythm. There is a constant stream of arrows on the screen, which keeps the player constantly moving. Konami developed the game and its first release was in Japan, 21. November 1998.

Due to its widespread popularity, scientists in the UK and USA conducted an experiment on DDR to see whether it has potential to get the players into better shape (Unnithan et al., 2006). They found two different test groups, overweight persons and normal weight persons. In the study they tested the person's heart rate and V02 reserve (approximate exercise intensity) during different levels of play in DDR, and then compared the results with the standards set by the American College of Sports Medicine (ACSM) on how much exertion classifies as a workout. Both test groups were above the required heart rate during the hardest levels of DDR, but failed to meet the

requirements on V02 reserves on the same difficulty.

Figure 6.1: *Kids playing Dance Dance Revolution*

6.2 Zombies, Run!

Zombies, run! (Zombiesrungame) is an immersive running or bike application (app) which cast the player into an apocalyptic world with zombies. The concept of the game is to motivate the player through an immersive audio story, where for example you are told to run extra fast in order to outrun some zombies on your tail (see Figure 6.2). This helps the player add speed changes into his/her workout. It can also motivate you for longer workouts as the interactive audio story asks you to do more missions during your run/bike ride.

The player can either run or use a bicycle to play the game. It is also possible to use the stationary equivalent of these at the gym. The game is completely done through audio, and you can even listen to your own music while playing.

The game utilizes the phone's GPS and/or accelerometer in order to track your movement. This means the game will know whether you are actually moving, which gives you a more responsive playing experience.

Figure 6.2: *Zombies, run!*

6.3 Fish'n'Steps

In order to promote an increase in physical activity, the researchers at Siemens Corporate Research created a computer game named Fish'n'steps (Lin et al., 2006). Fish'n'steps is a game based on the player's daily step count. The steps are connected to a fish which grows or shrinks based on the number of steps the player takes (see Figure 6.3). The fish is swimming in an aquarium, which also contains your co-workers fish. This is done to promote competition and cooperation.

The researchers of Fish'n'Steps studied how the game affected the subject's everyday habits. Even though the enthusiasm for the game declined after

the initial two weeks, the participant's routines were already changed for the better, which made them become healthier over the course of the study.

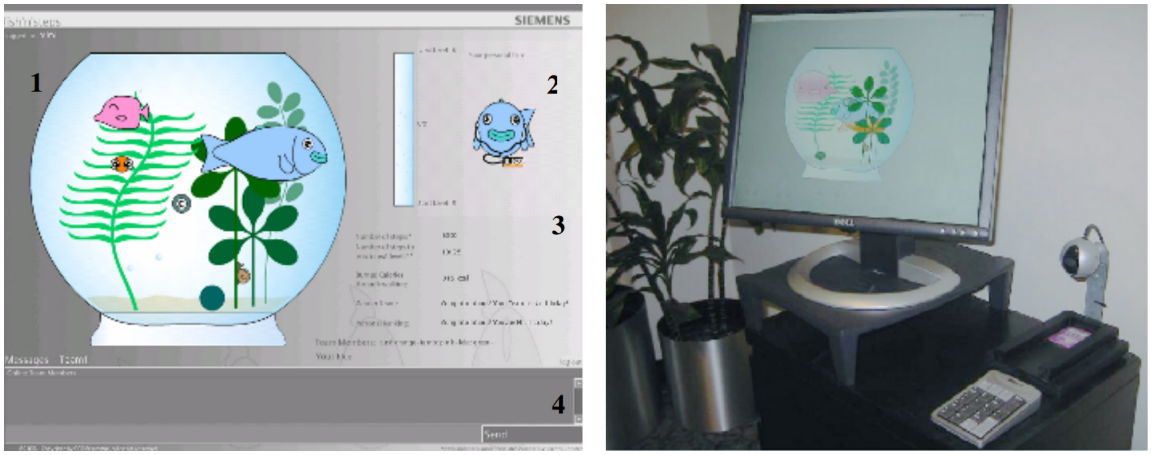

Figure 6.3: *Fish'n'steps (Lin et al., 2006)*

6.4 Nike+ Kinect Training

Nike+ Kinect Training utilizes the Xbox Kinect in order to track the player's movement and visualize it on the screen (Microsoft; Smartwaytofatloss.com). The game also simulates a workout with a personal trainer by having a game avatar work out with you, giving you words of encouragement and advice on how to do the exercises. The Kinect is so precise it will detect lack of form when performing the exercises, and give you hints as to what you are doing wrong. The exercises performed varies from body weight strength exercises such as push-ups or sit-ups to yoga or stand still jogging. Figure 6.4 shows how the game perceives the movement of the player.

The game also has a social aspect to it, as it keeps track of your results and you are able to share them with your Xbox friends. The game has a learning curve, as it will increase its difficulty level based on how well you perform the exercises.

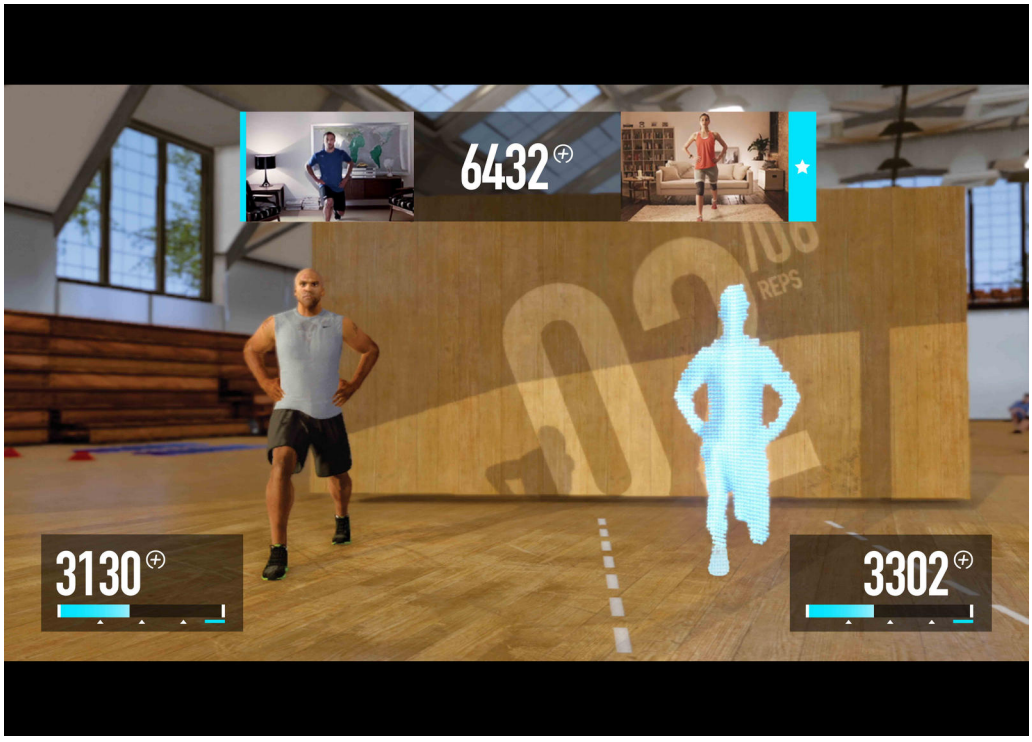

Figure 6.4: *Players using Nike Kinect training*

6.5 Wii Fit

Wii Fit is a collective of games that focus on body movement and physical interactivity. Wii Fit uses a specially built platform, which contains different sensors, called the Wii balance board. The board's main functionality is to track pressure. This enables it to measure a person's centre of gravity and weight (see Figure 6.5). Some of the activities also use the ordinary Wii controller that uses an accelerometer and gyroscope. For example, Wii jogging where you put the controller in your pocket and do stand still jogging. The game will then simulate you taking a jog on the screen, giving you smooth surroundings and avatars to catch up to.

Wii Fit has four different categories in which they create content. These four are Wii balance, Wii aerobic, Wii yoga, and Wii strength. The latter two

categories do not have traditional games made for them, only gamification in the form of coaching sessions, similar to what you find on the Kinect training game. The categories balance and aerobic, however, have various games made to engage players to perform physical movement. A study published in 2010 states that even though Wii Fit does not cost as much physiologically as traditional exercise, it does provide equal or a higher level of enjoyment from its users than traditional video games (Graves et al., 2010).

Figure 6.5: *Wii Fit*

6.6 PedalTanks

PedalTanks (Hagen and Weie, 2015) is an immersive bicycle game, which uses several different game design components such as rewards and immersion in order to engage and motivate the player. The game is a capture the flag third person shooter, where the goal is to defeat the enemy team, by destroying their tanks and bringing their flag to your own base. Every player controls a light, medium, or heavy tank with different sets of abilities. The game is team based as you either play as team blue or team red. The player is sitting

on an ergometer bicycle with a control panel on it, which is connected to a computer. The player's tank moves faster when the player pedals faster. PedalTanks uses current trending games as inspiration and has created a fast-paced multiplayer competitive game with persistent characters. Figure 6.6 shows students at NTNU during a play session.

The researchers of PedalTanks studied how playing the PedalTanks game compare to the recommended amount of activity for an adult, which is 150 minutes per week of moderate activity such as walking (Centers for Disease Control and Prevention). The result was that PedalTanks outperformed moderate walking in form of exertion. The exergame provided sufficient physical activity by playing the game. The test participants clearly enjoyed playing PedalTanks and preferred playing the exergame to going for a walk.

Figure 6.6: *PedalTanks (Hagen and Weie, 2015)*

6.7 PaperDude

PaperDude is a virtual reality cycling game where the player is a newspaper deliveryman (Bolton et al., 2014). The purpose is to throw newspapers into virtual mailboxes. For the player to achieve a good score in the game, he/she needs to hit as many mailboxes as possible and avoid obstacles in the way.

The game focus on immersion as it removes usual game input devices such as gamepads or mouse and keyboard. Instead PaperDude uses a physical bicycle and Microsoft Kinect camera to use physical exercise as input. The player pedals a physical bicycle which controls the newspaper deliveryman's speed, as seen in Figure 6.7. To throw newspapers the player mimics a throwing motion that is captured by a Microsoft Kinect camera. PaperDude uses Oculus Rift VR headset to present the game world the newspaper deliveryman lives in.

Figure 6.7: *PaperDude (Bolton et al., 2014)*

6.8 Summary of Existing Exergames

By looking at several commercial and research exergames, we have seen how they incorporate exercise into the video game, providing the player with physical exercise. Many of these games have been shown to be popular and gives the player a positive health effect.

The trend among these exergames is that they all incorporate endurance training or simple body movement, and a vacuum appears in the link between video games and strength training. Even though some of the games reviewed above incorporate strength training, they are more gamification rather than fully fledged games.

By reviewing these games, we have gotten intricate knowledge on how they use the game genre to motivate and engage the players. We have also seen how they use existing technology in order to capture movement and incorporate it into the game. These key factors helped us making decisions about our own game.

Chapter 7

Technology Capabilities

Exergaming relies on technology to track body movement. The simplest possibility is to make the player tell the game what exercise that he/she has been doing. If you want the game to automatically track the training, there are several possibilities depending on what type of training is to be done.

7.1 Location-Aware Games

If the concept of the game is location based, a GPS can be used. A GPS will tell the player's exact position, within a certain accuracy (Garmin). This can be used to track the distance the player has moved, whether the player is walking, running, or bicycling. Sports as orienteering relies on navigating from point to point, an exergame can be created with GPS to check if the player has visited specific places. In addition, altitude can be monitored if the player needs to incline certain meters during the exercise. GPS receivers are implemented on several devices, like smartphones, certain watches, or small sensors that can be placed in the shoe like Nike+. These GPS receivers can be used to send location information to the game.

7.2 Body Movement

There are devices that contain an accelerometer, like smartphones (Techopedia; GSMArena) and Wii remote (College of Engineering, CSU). These devices can be used in an exergame to track motions, for example if the player is boxing, jumping, or doing squats. Some exercises also require the

player to achieve some specific angles, rotation, or twists, for this a gyroscope can be used. This is implemented in most new mobile phones (Mobilegyros) and Wii remote plus (Caron). The gyroscope can track movements that are simulating sports or exercises, like tennis or doing sit-ups. The accelerometer and the gyroscope can be used together for specific motions or could be used separately.

Body movement tracking of the player can be done through a camera. If the player is in front of the camera, it can monitor the movements of the player, which can be used in the game. Kinect is a motion-sensing camera for Xbox and Windows PCs, which is already used for many exergames like Nike+ Kinect Training (Microsoft). There is also a possibility to use the camera or the proximity sensor of a mobile phone. If the phone is put on the ground and the player is doing push-ups over it, the game will sense the player is coming closer or going further away, counting push-ups.

There exist some strength exercise apps for mobiles, which tracks simple bodyweight exercises. Like Runtastic (Runtastic GmbH) apps where you can exercise push-ups, sit-ups, squats, and pull-ups. Where the push-up app uses the proximity sensor to sense when the chest is close to the mobile that lays on the floor. The sit-up, squat, and pull-up apps use the accelerometer to sense movements to count repetitions. These apps give you an exercise plan and track your exercise, but none of these apps are games.

7.3 Heart Rate Monitoring

For an intensive exercise session, it is important to keep the heart rate up. There are heart rate sensors in watches such as Fitbit (Fitbit), but you can also use a combination of watch and a heart rate band (Polar). Even some cell phones can track your heart rate using a special light in front of the phone (McCann). These could be used to send the heart rate of the player to the game, to ensure the player is keeping the intensity up.

7.4 Exercise Equipment

Another possibility to track exercise is to use training equipment like a spinning bike, rowing machine, or treadmill. The game will receive input from the machine about how fast the player is moving and the distance moved. Other equipment for tracking exercise is pressure surfaces that the player can step on. The dance floor in Dance Dance Revolution and Wii Balance Board are examples where the players are playing a game while stepping on and off these pressure sensors.

7.5 Summary of Technology Capabilities

As seen above, there are several ways of tracking exercise as input to a video game. Which technology to track the exercise will depend on what type of exercise is in the game. Our project that focuses on strength training relies on technology that can track certain body movement, or equipment for strength training, such as free weights. We see that there is a lack of equipment that is able to track strength training with regard to weights. Although there are several possibilities for tracking body movement, which can easily be used for strength exercises. This was taken into consideration when we designed our exergame.

Chapter 8

Video Game Mechanisms

This chapter contains a study of the most common and popular video game mechanisms and characteristics, which are contributing to a game's popularity. We give an overview of what they are, and explain why they are important to make the game successful.

8.1 Challenge, Fantasy, and Curiosity

Challenge is an important aspect to keep the game fun to play (Malone, 1980). To keep the game challenging, the player needs to be presented with *goals*. The goals should be of uncertain outcome so the player does not easily get bored. The game should provide *feedback* to the player, so he/she can tell if they are getting closer to reaching the goal. To get goals with uncertain outcome the difficulty level should be adapted to the player's skill. The uncertain outcome can also be provided with hidden information and randomness. When a player reaches different goals their self-esteem will improve, and the player will likely play it again.

Malone also points out *fantasy* as an essential characteristic for a good computer game (1980). To include fantasy, one needs to present the player with objects or situations that are not actually present. The objects or situations could vary from something that is possible to the impossible. Fantasy can be divided into extrinsic fantasy and intrinsic fantasy. In extrinsic fantasy, the fantasy objects or situations is influenced by the skill used by the player, but not the other way around. This is the easiest way to make the game more interesting by using fantasy elements. In intrinsic fantasy, the fantasy depends on the skill, but the skill also depends on the fantasy (see Figure

8.1). This is often done by presenting the problem with fantasy elements. Games with fantasy are great at triggering the player's emotions and satisfy their needs. Something important to remember with implementing fantasy is that not every fantasy appeal to every player. Therefore, it is important to remember who is going to play the game, and maybe present several types of fantasies in the game.

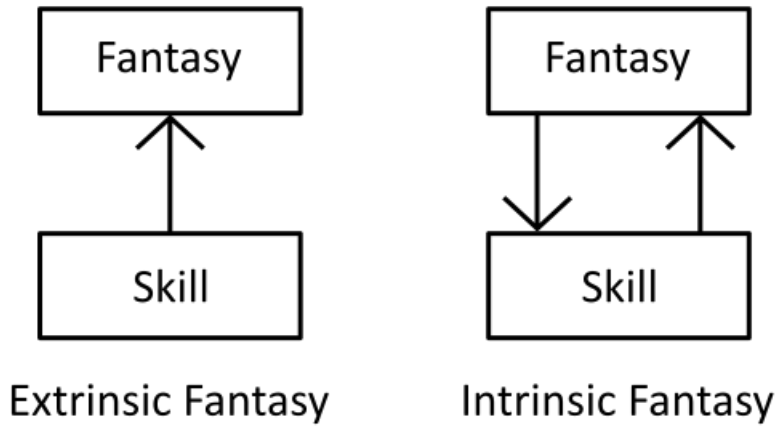

Figure 8.1: *Extrinsic and intrinsic fantasy (Malone, 1980)*

To spark the player's engagement, it is important to spark the player's *curiosity* (Malone, 1980). To do this the game environment should neither be too simple nor too complex. The game environment and situations should be novel and surprising. An optimal game environment will make the player have expectations about what will happen next. Sometimes these expectations are not met, in order to surprise the player. Sensory curiosity is done by keeping the player's attention by changing the visual output or sound. Audio and visual effects could be used as decoration in the game, enhance the fantasy elements, as rewards in the game to applaud good performance, or to represent game information. The cognitive curiosity is the desire for the player to improve their knowledge. This is done by presenting some information in the game, but not all. This engages and motivates the player to play the game to gain all the information to see the whole picture.

8.2 Flow

When a person is fully present in the moment, and enjoying themselves, they are in a state called *flow*. Often expressed as "in the zone". There are two conditions to achieve flow, which is perceived challenges that match the skill level and clear goals with immediate feedback about the process. Figure 8.2 shows how challenge and skill influence how the person feel. When the flow state is reached, the person will have an intense and focused concentration on what he/she is doing, merged action and awareness, loss of self-consciousness, in control of their actions, reduced sense of time, and experiences the activity as rewarding (Nakamura and Csikszentmihalyi, 2002).

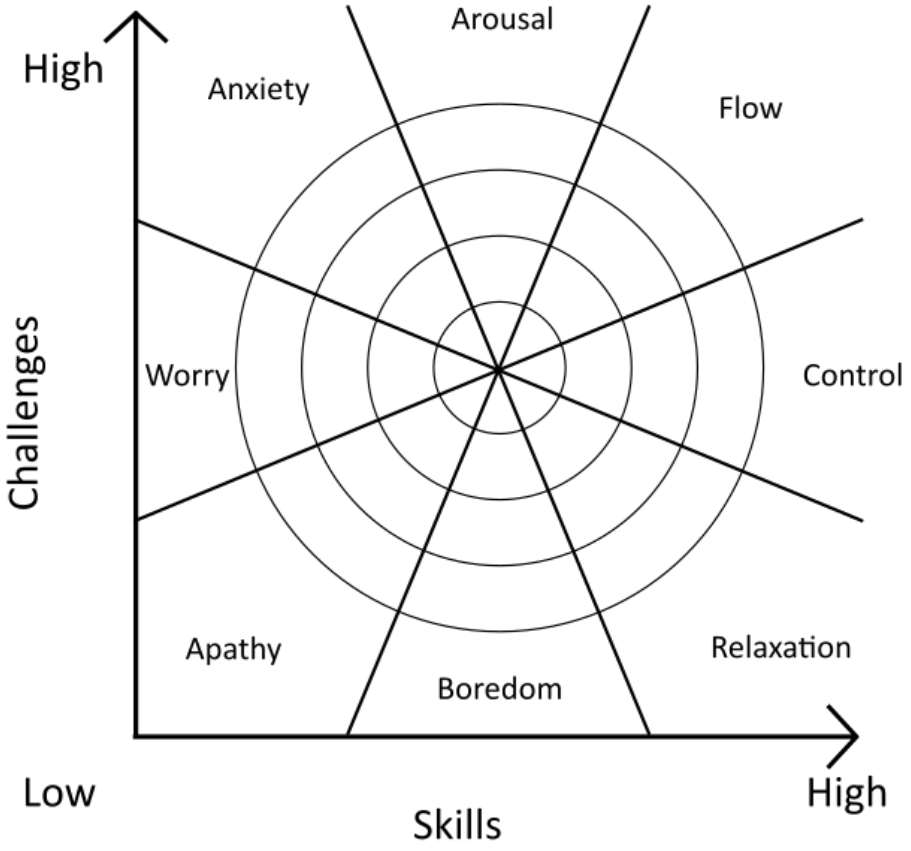

Figure 8.2: *Flow (Nakamura and Csikszentmihalyi, 2002)*

Sweetser and Wyeth used flow as an enjoyment evaluation in games and came up with the gameflow model. Enjoyment is critical for games. If the player is not enjoying the game, he/she will no longer keep playing it. Sweetser and Wyeth point out eight elements to games that increase flow. The game should require *concentration* to play, by quickly grabbing the player's attention and not burden him/her with tasks that feel unnecessary. The player needs to be provided with *challenges*, with appropriate skill level to the player as his/her experience increases through the game. Figure 8.3 shows how the challenges should increase through the game as the player gain better skills to provide flow. When the challenges rise, the game should support *skill development* and mastery to handle the increasing challenges through the game. The player should feel in *control* of their actions in the game and make an impact on the game world. One condition to flow was *clear goals* and immediate *feedback* about the process as stated above. Therefore, it is critical that the game provides the player with clear goals throughout the game. The player should also get feedback about their actions and progressions towards the goals. The game should provide *immersion*, so the player becomes less aware of their surroundings and time, while becoming emotionally involved in the game. At last, the game should support *social interactions*, like competition, cooperation, social communities, and/or interactions between players (Sweetser and Wyeth, 2005).

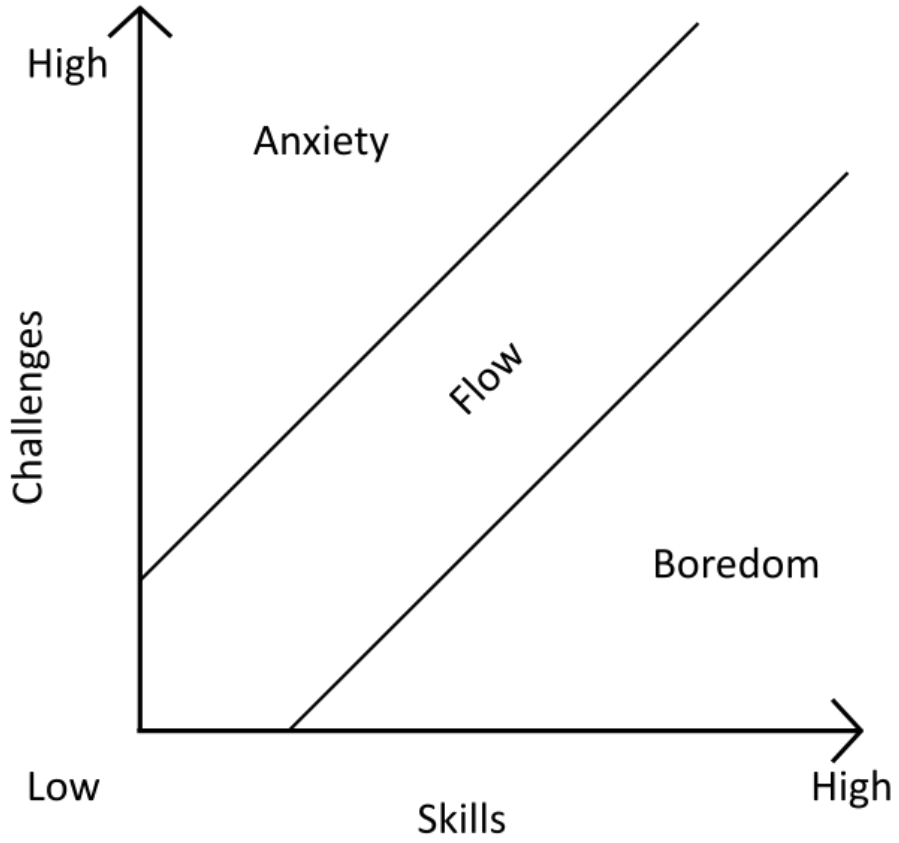

Figure 8.3: *Flow increase (Sweetser and Wyeth, 2005)*

Dual flow is a concept used in relation to exergames. When dual flow state is reached, the player gets an effect from the exercising and finds the game attractive. The difference from gameflow is that the effect of the exercise is also measured. As seen in Figure 8.4, the intensity of the workout needs to match the player's fitness level. Low intensity will result either in no benefit or in deterioration. High intensity for a player that is not fit enough will only result in failure. A match between intensity and fitness will give the player exercise flow. When the player gets in better shape, it is important that the intensity also rises (Sinclair et al., 2010).

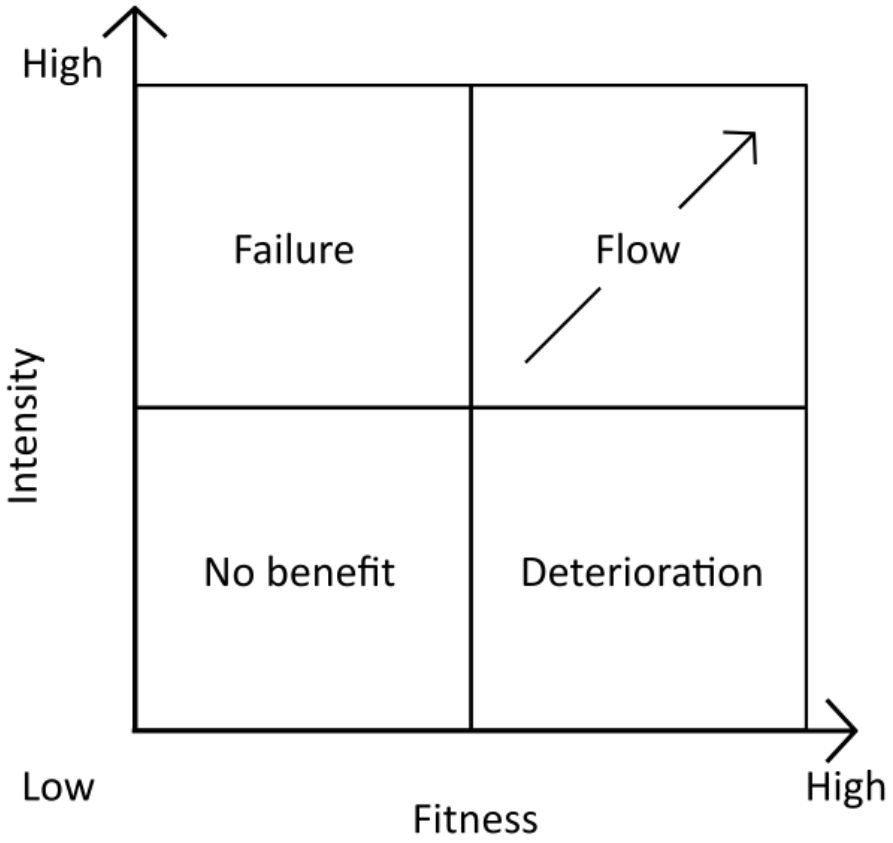

Figure 8.4: *Exercise flow (Sinclair et al., 2010)*

8.3 Rewards

Rewards in general releases dopamine in the brain of the recipient, as the rewards are experienced as "making things better" (Arias-Carrión and Pöppel, 2007).

In their work with role-playing games, Hallford and Hallford (2001) found four main categories of rewards in Massively Multiplayer Online Role Playing Games (MMORPG). These rewards are rewards of glory, rewards of sustenance, rewards of access, and rewards of facility, which can also cross over to

other gaming genres (Salen and Zimmerman, 2004).

Rewards of glory is a type of reward that does not directly give the player any advantages in the game, but is perceived as a reward anyway. This can be for example a scoreboard or an achievement board at the end of the game session (see Figure 8.5). These types of reward are often subject to discussions amongst the players, and people often find themselves making new goals in the game in order to earn these rewards. These goals may not directly be the same as the main goal of the game.

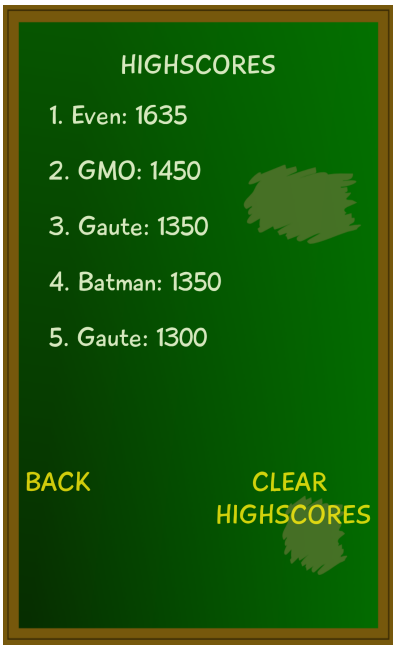

Figure 8.5: *Highscore table*

Rewards of sustenance is a type of reward that allows the player to continue playing the game (Gazzard, 2011). For example, in the game Super Mario where you can get extra lives, or the popular arcade game Flipper where you get extra time and balls in the game if you do well. Another example is from the Tamagotchi game, where your pet could die if you did not give it attention (see Figure 8.6).

Figure 8.6: *A dead tamagotchi*

Rewards of access is typically rewards that open a new area of space or a new challenge to the player. For example, in Half-life 2 the player is introduced to a room where the only exit is a window up high. The only way to reach the window is to stack the boxes in the room to form a provisional stair. The game gives no hints that this is a possibility so the player needs to figure it out on his/her own. The reward for making this stair is to be able to progress to the next area of the game. Rewards of access can be both mandatory rewards where the player needs to achieve them, but they can also be optional, such as access to areas that give the character a considerable boost or access to a secret level.

Rewards of facility is a reward that enables the player to do something he/she could not previously do. This could be new abilities or new items, but could also be a steady increase in the player's already acquired abilities. In the big MMORPG World of Warcraft, they use all three through their levelling

system. Progressing through the game gives experience points which count towards the characters next level. When a character levels up it gets an increase in all his/her main attributes such as strength and agility but also may get new abilities such as spells or attacks. Levelling also enables the character to use better equipment, which in turn boost the character's stats and abilities. Figure 8.7 shows a talent tree from a class in World of Warcraft. As you reach higher and higher levels, you can choose more and more abilities.

Figure 8.7: *World of Warcraft talent tree*

Rewards can be several of the given categories at the same time. For example, in the Nintendo Gameboy series Pokémon, where the pokémon can learn new skills which unlock new areas of the map. This will be both a reward of facility and reward of access.

Rewards are hugely important in video games, as they support *dopamine learning*. Dopamine learning allows the player to recognise the patterns that

lead to a positive outcome faster (Arias-Carrión and Pöppel, 2007). Rewards are also important because it provides *incentive* and *motivation* for the player (Hagen and Weie, 2015).

8.4 Social Interactions

Social interactions (see Figure 8.8) is a common reason for people being physically active (Allender et al., 2006). Therefore, implementing social aspects to the exergame can provide huge motivation for the players to keep playing the game and perform better. This can be done with a multiplayer game or by providing a network between the players to create a community where they can connect with each other. Social interactions in the exergame could be such as feedback between players and that their actions might affect each other. Hamari and Koivisto point out several important benefits from implementing a social aspect to gamification and persuasive technology (Hamari and Koivisto, 2013). The importance of having a community where people are committed to the same goals is essential to motivate the players to keep working on reaching those goals. The network will create meaningful interaction for the players and it allows reciprocal activity, increasing the perceived benefits of the game for the players. This is because players are exposed to attitudes of others and receive feedback, which can positively influence their opinion towards the game. When players share and being exposed to activities of other users, it is likely to promote goal commitments towards challenges. All this indicates that for an exergame to reach its full potential, the game should be implemented with some sort of social activity.

Figure 8.8: *Two sims hugging*

8.5 Summary of Video Game Mechanisms

By reviewing video game mechanisms, we have gained important insight into what type of elements should be in a video game in general. We have learned how to effectively motivate and engage the players, meanwhile as they enjoy playing. These takeaways have been invaluable while designing our exergame.

We have seen that in order for a game to *motivate* the player for continuous play, we need to incorporate *rewards* and *social interactions* in the game. These mechanisms and characteristics play a crucial role in a player's motivation as the player will strive for the sense of achievement through self-realization or social status.

The game mechanism of *flow* is a factor in order for games to be *enjoyable*. If the player manages to experience flow during a game session, he/she will be thoroughly enjoying the experience. Human beings will do an activity just to experience this state, no other external motivation is necessary.

Engaging the player can be accomplished through using appropriate *challenge*, *fantasy*, and *curiosity* in the game. If the game is too easy and there is no uncertainty about the player's success through the game, the player will feel a sense of apathy to the lack of challenge. It is therefore important to make the game challenging, but not impossible. We could further engage the player's emotions during a game session through the use of *fantasy*, as relatable characters, places, or situations brings the player closer to the story. Engagement can also be achieved by appealing to the player's sensory and cognitive curiosity.

It is important to note that most of the game mechanisms and characteristics discussed in this chapter are usually intertwined, and feature together in most games.

Chapter 9

Strength Exercise Theory

In this chapter, we will review some of the basics of strength training, and what studies say about the subject. We will also examine two different types of strength training, and weigh the pros and cons of each type.

9.1 General Strength Training

The decision to make an exergame based upon strength training came from the void in the market, but there are many benefits linked with strength training. These include reduced risk of injuries, reduced pain in muscles and joints, better body posture, increased muscular endurance, and increased muscular power (Winett and Carpinelli, 2001; Hunter et al., 2004).

Strength exercise is done by doing a controlled movement to the degree such that micro tears are made in the muscle tissue. These tears are then continuously repaired by the muscle fibres, which expands to cover the gap, this in turn makes the muscle larger and able to exert more power (Nerd Fitness; Sports Fitness Advisor). Compound exercises are best for improving strength because it targets several major and minor muscle groups at the same time (bodybuilding.com).

The American College of Sports Medicine recommends exercising strength training at least two times per week, doing ten to twelve repetitions of eight to ten different exercises, which covers all major muscle groups (ACSM). Feigenbaum found that a repetition number between four and ten will progress a person's strength, and a number between twelve and twenty will work on the muscles endurance (Feigenbaum and Pollock, 1999). The topic of the

number of sets recommended is a controversial one. It is common practice to recommend doing three sets of each exercise, but most studies show that there is no significant difference between workout schedules with one and three sets (Feigenbaum and Pollock, 1999). Only one of the studies reviewed by Feigenbaum and Pollock found a statistical difference between doing one, two, or three sets of an exercise.

9.2 Bodyweight Training

There are numerous ways of doing strength training, and one of the most acknowledged ways is bodyweight training. This is when a person uses his/her own body as resistance by countering the force that gravity exerts on it. Bodyweight training allows for several compound exercises such as push-ups (see Figure 9.1), hang-ups, and squats. It is widely acknowledged as a benchmark for strength, as it is used by many militaries as part of their recruitment process (Forsvaret; Smith).

The learning curve for these sorts of exercises is also minimal, as this is usually learned during physical education in schools. Given that you only use yourself as weight, you can also reduce the risk of injuries. There is still though a risk of overtraining because of unfamiliar stress to the muscles (Kraemer and Ratamess, 2004).

Figure 9.1: *Bodyweight training*

9.3 Free Weight Training

Traditional free weight training is exercise where a person uses weight such as dumbbells, barbells, and kettlebells as resistance. You can find weights that fit your own fitness level, which makes it an alternative for anyone, especially for people who are recovering from muscle injuries. This type of strength training is probably the best source for compound exercises as the addition of barbells and dumbbells enables the performance of, "The three greats", bench press (see Figure 9.2), deadlifts, and squats (bodybuilding.com).

One of the issues with traditional weight training is that the learning curve for the inexperienced is very steep. One requires a decent amount of expertise and insight in order to perform the exercises correctly. As with bodyweight training, there is also a risk of overtraining the muscles.

Figure 9.2: *Free weight training*

9.4 Summary of Strength Exercise Theory

The theory of strength training had great importance on the design of our exergame. We have seen that it is important to use the correct exercises as to reinforce and develop the player's fitness level. It is also important to give the players a varied exercise palette since full body workouts are the recommended plan of action.

The risk of injuries and overtraining can be remedied by a less steep learning curve or restrictions on the amount of resistance, but also through extensive information on how to perform the exercises.

Part III

Exermon

To expand the field of exergames, we have created a new game called "Exermon". The game is designed and created with important aspects from the prestudy. This part will go into detail about the concept, gameplay, and how physical exercise and game is combined. We will also describe the developmental details of the game. The exergame is an Android application, where the Android smartphone tracks the strength exercises.

Chapter 10

Game Concept

The name of our exergame is Exermon, a combination of the words exercise and monster. The player of the game chooses a personal monster to train, called an "exermon". The appearance of the exermon depends on the player doing body weight exercise to grow and keep being alive. When the player is exercising, the exermon will gain stats based on exercise and repetitions. The player will see the monster get stronger by raising the stats and will risk death to the monster with lack of exercise over a period. Think of the handheld game from 1996 Tamagotchi (Tamagotchi Wikia) where the player needs to take care of their digital alien pet (see Figure 10.1), by feeding them and entertaining them by playing minigames, the digital pets will keep alive and healthy.

Figure 10.1: *A Tamagotchi game*

The exermon lives on an island where it can fight other monsters in an arena or fight bosses. The player can connect with friends to compare their monsters and fight them. Also on the island, the player can collect badges and buy items in a store. To get a monster that fights well, the player needs to keep exercising to boost the monster's health points, power, and speed.

Chapter 11

Game Design

The game design chapter contains a description on how the exergame is structured and a thorough description of how we have implemented all the mechanisms defined in the video game mechanisms chapter.

11.1 Gameplay

Strength training demands great concentration and focus on the exercise that is going to be performed, so the person exercising will not be able to interact with the game during that time. This naturally made us design the game in a three-part structure. These parts are training, fighting, and planning. The physical activity will occur in *the training part* of the game. This part gives motivation in the form of sounds and graphics, but is mostly about recording the exercise being done, as this will accumulate to rewards later on. The game is designed such that the player will know that this behaviour will grant rewards, and the player needs to see "the bigger picture" in this part.

The fighting part is where the player interacts more actively with the game and gets to see the results of the training done in the previous part. The fighting is a first-person boxing style game where you are boxing a computer generated opponent. The player fights by swiping on the screen trying to hit the opponent's avatar, which is continuously moving. Fighting against the computer-generated opponents can be done in three different modes. One of these is the arena, where the player is given a ranking, which goes up and down according to how well the player is fighting. The player will meet harder and harder opponents as he/she climbs the rankings, where the goal

is to reach the number one spot. The second mode is the boss fight. This is where the player faces an extremely hard opponent with lots of health points, power, and speed. This boss grants bigger rewards than the arena, and can only be killed once a week. At the beginning of each week, the boss is generated according to the player's stats, such that it is possible to exercise through the week in order to conquer it. The third mode is where you can fight your friends' exermon. The exermon is controlled by the computer, but take on the characteristics of the exermon of your friend. The more development your friend has achieved on his/her exermon, the harder it is to defeat in the fight since it will have higher stats.

The planning part of the game is where the player gets an overview and status of the game, and how he/she is doing in it. The player is presented with the actions that are available to him/her, an overview of accomplishments, and an overview of the player's social network. This part is the most recurring in the game, as this is the first part the player reaches after starting the game, and is a constant while the two other parts are optional to the player.

11.2 Challenge, Fantasy, and Curiosity

In the fighting part, the player is able to fight in an arena full of different exermons where each player will try to improve their position and reach the top in the arena. There is also a weekly boss, where the player needs to improve their exermon to be able to beat it. This gives the player *clear goals*, and he/she always has a purpose in the game. The player can also challenge his/her friend's exermons to battle, as this can spark *discussion* and *competitiveness* amongst the players.

To make the game more interesting and affect the player's emotions, fantasy is a central element to Exermon. The *fantasy* in the game is that there exists an island full of monsters. The monsters called exermons, train to improve their attributes and battle each other. The game uses both *extrinsic* and *intrinsic* fantasy. The training phase uses extrinsic fantasy, as the player is exercising without depending on the fantasy. When the player is finished training, the training skills influence the fantasy as the monster improves and grows. The fighting phase uses intrinsic fantasy, as the player aims at a

fantasy monster. The opponent is then influenced by being hit by the player. This way the skill affects the fantasy and the skill depends on the fantasy. The fantasy involves monsters, and might not appeal to all players. To solve this, we are letting the player choose between several monsters, some that are muscular, while other are cuter. This is what Pokémon has done. Figure 11.1 shows how the pokémons varies in looks.

Figure 11.1: *Pokémon characters*

To keep the player *curious* while playing the game, we try to present a game world that is comprehensible for the player, but not too simple. When the player is in the fighting part, audio and visual effects are used when the player swipes a hit on the opponent, to spark the player's sensory curiosity. To spark the player's cognitive curiosity, the player will not know when the exermon improves their appearance or how much gold that is rewarded for defeating an opponent.

11.3 Flow

The fighting part requires *concentration* to play because the player needs to aim their hits. As the player's exermon improves, the fighting *challenges* will also increase, by playing tougher bosses and improving their position in the arena to meet better opponents. These steps are done to make sure the challenge matches the player's skill.

The player gets immediate *feedback* throughout the fighting part, by receiving information about hits, the health of his/her exermon, the health of the opponents exermon, and if he/she won or lost. The planning part gives information about their position in the arena and his/her progression in the collection of badges. Under the training part, the game makes sounds ensuring the player when repetitions are done. The player is always in *control* of his/her actions while playing, as the player decides what to do next in the game. The player might not understand how to attack the opponent in a fight at first, making the player feel a lack of control to impact the game. But when the player learns how to swipe to attack, he/she will be in full control of the fighting as well.

11.4 Rewards

Rewards of glory are rewards, which does not directly give the player an advantage in the game, but can be a source of discussion by the players after a game session. Exermon has several of these rewards to motivate for further play, and create envy amongst other players. The exermon will become larger or smaller based on the stats that it has, which reflects the amount of exercise the player has done. Figure 11.2 shows an example of how one of the exermons develop throughout the game, based on the stats gained by the player. Another source for glory rewards in Exermon is the reward badges. When a player does something in the game, he/she can obtain these badges. The badges are used as reinforcement of right behaviour, a source of discussion, and commemoration of big gaming and fitness achievements.

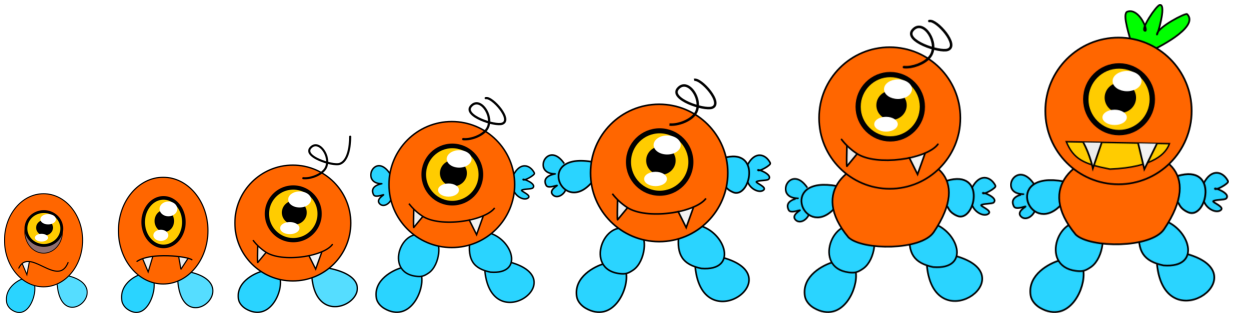

Figure 11.2: *Exermon avatars' growth*

As an effective *reward of sustenance*, the people that created Tamagotchi added the possibility that the pocket animal would die if you neglected it (Tamagotchi Wikia). This gave the players extra motivation to play, as they had an emotional connection to their pocket animal. We implemented this mechanic into Exermon by adding the possibility that the exermon can die, if it does not work out. This is done by slowly decrementing the stats of the exermon over time. If one of the stats ever reaches zero, the exermon will die, and the player will have to start over with a new one.

Rewards of access, as we described it earlier, opens up new area or challenge for the player. In Exermon, this is facilitated through unlocking new exercises and new fights as the player learns and hones his/her skills.

In order for the player to feel progression through the game, we reward the players with an exermon with better stats, new and harder exercises, and items, which makes the exermon stronger. So called *rewards of facility*. These rewards are tightly connected to the rewards mentioned in the paragraph above, and some of them fall into both categories.

As a way to make people learn the game and the right action patterns, we reward the player for doing the correct moves. This is done throughout the game, which means that new exercises will be unlocked faster, fights are easier to win, and the character is faster developed in the beginning. We also accompany this with reward badges, to further accentuate the feeling of early accomplishment. These badges are initially easy to obtain and scale as the player progress through the game. We do this to stimulate *dopamine learning*, which makes the player learn faster and motivates for continued

play (Arias-Carrión and Pöppel, 2007).

11.5 Social Interactions

Hagen and Weie write that the majority of the most played games on Steam (online game platform) have some sort of social aspect to them (2015). Seeing social interaction and community building as an important aspect of games, we made a social aspect to Exermon as well. As described in Section 11.1, this is a place where the player can connect with their friends, compare their exermon, and fight. This can spark discussions between the players as they can see the results the other players are getting. It can also provide extra motivation as they get more competitive. The community can also form common goals to reach, which makes the player base more committed to the game.

Chapter 12

Exercise Design

The game focuses on body weight training, since it is easily monitored by a smartphone. This is in contrast to free weight training, which is a strength exercise area that is hard to monitor and implement into a game with today's technology. Exermon allows the player to carry out various physical exercises. To ease the player into body weight training and reduce the risk of injuries the player starts the game with only push-ups, sit-ups, and squats unlocked, but as the player advances in the game, he/she can also unlock other exercises. Exercises to be unlocked: hang-ups, table-ups, dips, bulgarian squats, glute bridge, hanging leg-raises, pistol squats, and handstand push-ups. For a detailed description of the exercises, see Appendix A. The majority of the exercises mentioned above are compound exercises, which allows the player to target multiple large muscle groups at the same time. In addition, there are exercises that isolate the smaller muscle groups in order to complete a full body workout.

To encourage players to do different exercises there is a point system where each exercise awards different points for each repetition. The harder exercises will be more attractive to do as they grant more points. Each exercise varies in what type of point the player's avatar gets. For example, doing push-ups grants a total of nine points per repetition, these are split into two points of health, four points of power, and three points of speed, while a repetition of glute bridge grants three points of health, one point of power, and two points of speed. All this put together will reward the player with a balanced character, by doing several exercises to work out the whole body.

How many repetitions and different exercises done, will eventually be up to each player. However, for a balanced monster that keeps improving the stats, one has to do several exercises at least two times per week. The game facilitates *dual flow*, by unlocking new and harder exercises, but also because

the player can endure longer sessions with more repetitions in each exercise. This will gradually happen as the player gets more and more fit.

Chapter 13

Game Description

This chapter describes and shows the exergame Exermon. Images and descriptions will be used to explain its content.

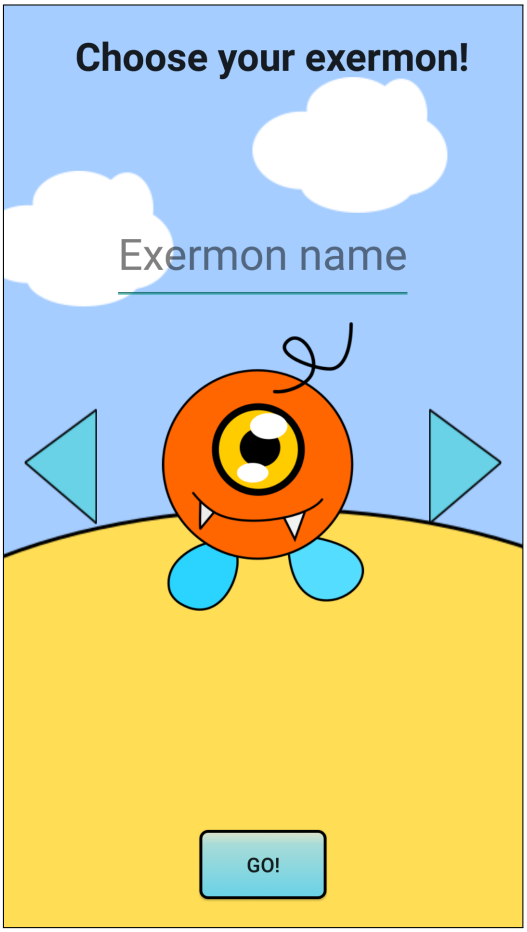

Figure 13.1: *New exermon*

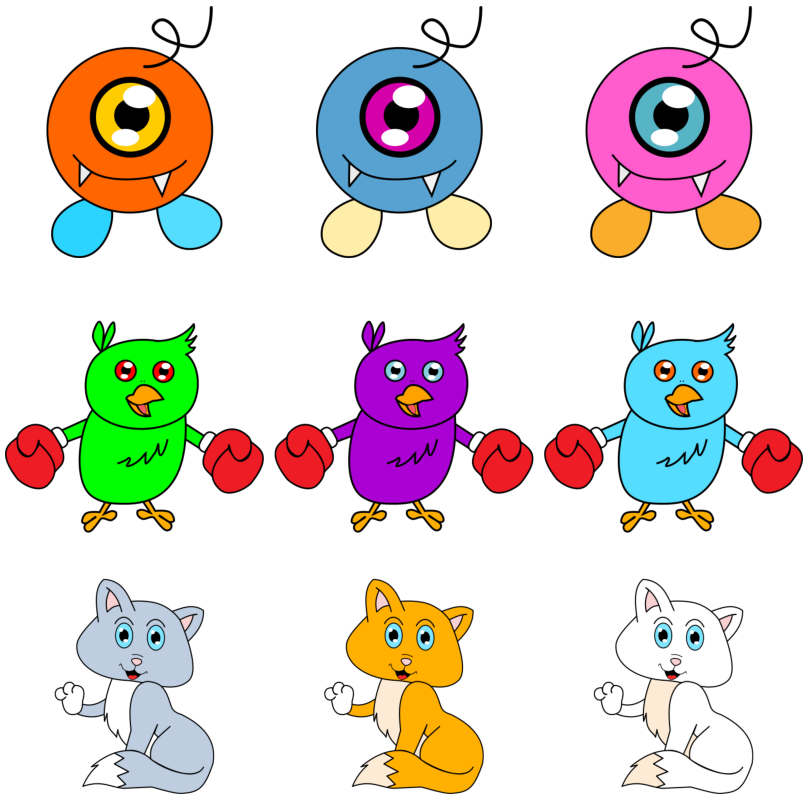

Figure 13.2: *Available exermons*

When the player opens the app for the first time, he/she will be greeted with a welcome message. Then the player needs to choose an exermon. Figure 13.1 shows how the player can choose their exermon avatar and give it a name. This page will, for the most part, be only one-way interaction as the player customizes his/her own avatar. The player can use the blue arrows in order to change the type of exermon he/she wants, finding a monster that appeals to the player's *fantasy* preference. The player can choose between nine avatars, shown in Figure 13.2. At this stage, the goal is to establish an emotional connection between the player and his/her avatar. When the player is able to customize his/her own avatar he/she is more likely to care for it on a deeper level, and wants to see it thrive.

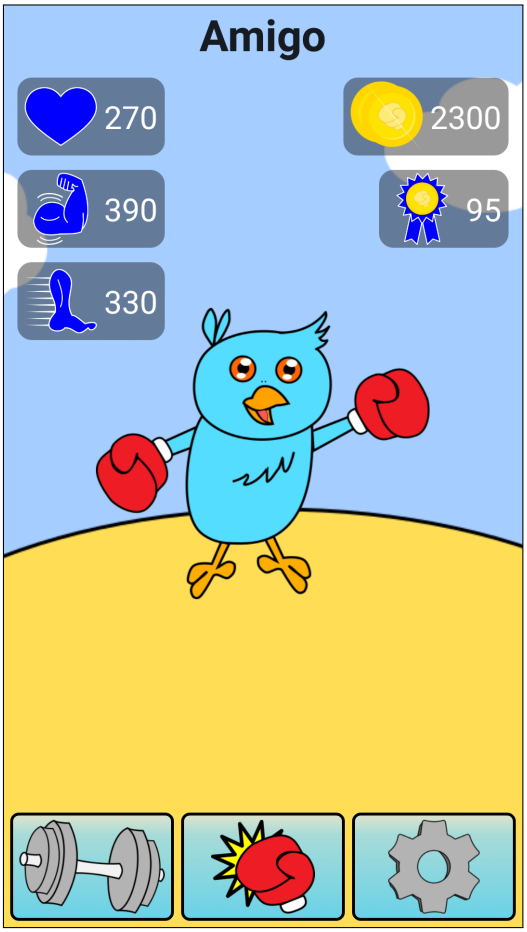

Figure 13.3: *Exermon overview*

Figure 13.3 shows the overview screen. This is the place where players get a visual image of his/her exermon in addition to how developed it is through the stats. The exermon stats are shown in the upper left area, where health points are represented by a heart symbol, power is represented by an arm symbol, and speed is represented by a leg symbol. In the upper right area, the coins represent the gold the player has won and the ribbon represent the arena rank. At the bottom, there are three buttons the player can click on to go to the exercise menu (see Figure 13.4), fighting island (see Figure 13.7), or game settings (see Figure 13.15). This screen is designed so that the player gets a status update on where he/she stands in the game. It will serve as *feedback* to whether the workouts and fights are going in the right direction,

as well as being a source for *social interaction*, as they can show the screen to the friends around them. It is similar to the Opponent screen (see Figure 13.9), in order for the player to more easily compare his/her own exermon to the opponent's exermon in the game.

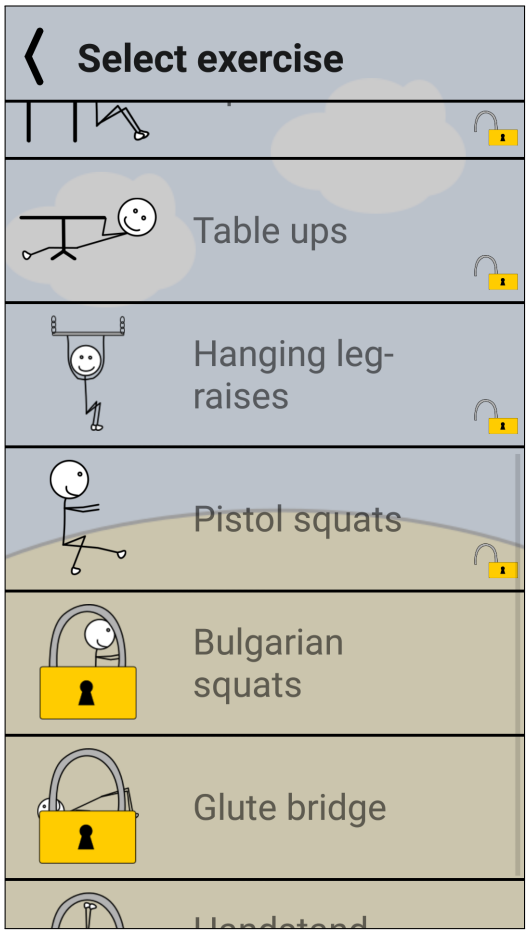

Figure 13.4: *Select exercise*

Figure 13.4 shows the exercise menu, where the player can choose what exercise he/she wants to perform. The graphic of each exercise helps the player to get an understanding of what movement is required, and smooths the transition from stagnant to moving. Hopefully, this will keep the player in the *flow* state as they do not have to spend considerable time having to learn what each exercise is about. Some of the more difficult exercises will be locked at

the start of the game, so the exercise intensity matches the player fitness to ensure *dual flow*. On this screen, the player can click on the locked exercises, and be asked by the application if the player wants to unlock it, but only if the player has enough gold. The player will earn gold by defeating opponents in a fight.

Figure 13.5: *Exercise*

Figure 13.5 shows the exercise window, with push-up as example. This is the view when the player is working out, each repetition is tracked and a counter is displayed in the centre. Above the counter, the player will see how much stats this exercise session has produced and a display of an exercise boost item if the player has bought this from the shop. Since the player will

not always see the screen while exercising, he/she will receive audio feedback after each repetition is taken. On exercises that require the player to be within a certain range of the cell phone there will also be a mid-repetition audio *feedback* as the player reaches this range. This feedback will be helpful to maintain the player's focus on the game, even though they are physically exercising. The audio feedback is there to motivate and engage the player, but are short to avoid disrupting or distracting him/her.

Figure 13.6: *Exercise info*

The player can click the done button when he/she is finished training, to exit the exercise window and achieve the stats gained. The info button will open a popup window shown in Figure 13.6 that explains how to do the exercise

and what to do with the phone so it can track the movements. At the bottom of the popup window, there is an image visualising which sensor in the phone the exercise is using and how it tracks movement.

Figure 13.7: *Fighting island*

Figure 13.7 shows the fighting island, where the player can choose the arena, the boss head skull, or the friends hut to fight opponents. The trophy symbol sends the player to the badge overview (see Figure 13.12), where the player can see his/her progress in the game. The player can also go to the shop (see Figure 13.13) from the island, to buy items that give the player advantages in the game. This island named "Swole Island" is a big part of the *fantasy* element of the game as it gives the player the feeling that this is a real place.

This is also enhanced by having a night theme on the app in the evening and night (see Figure 13.8). The player's exermon is living, training, fighting, and earning accolades on this island. This affects the player's emotional connection to the game. The player will be in full *control* of his/her actions, and be the one deciding what will happen next in the game. By clicking the back button in the upper left corner the player is sent to the overview screen (see Figure 13.3).

Figure 13.8: *Night theme*

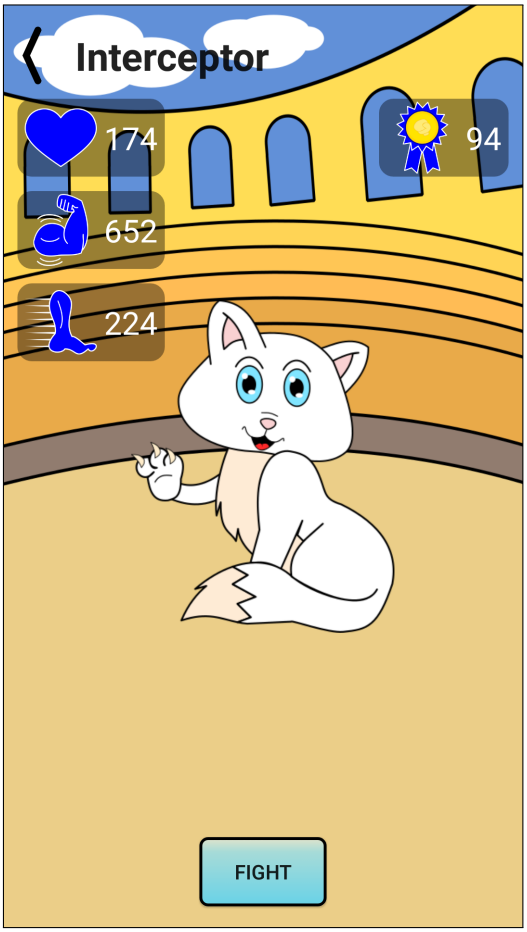

Figure 13.9: *Opponent*

Figure 13.9 show the opponent screen. Here the player will see their selected opponent's stats and can choose to initiate fight or chicken out. By clicking the fight-button the player will be sent to the fighting screen (see Figure 13.11). As stated earlier, it is a place to compare exermons but this screen also challenges the player to analyse and size up his opponent before a fight. The player gets a visual representation of his/her opponent before the fight where the player can visually determine whether he/she is able to beat it or not. The more advanced players can also analyse the stats of the opponent, and formulate a fight- or workout strategy in order to beat it. For example, if the opponent has lots of speed and power but has low health points, it might be prudent to finish the fight fast with precision strikes, or work out to gain

more health as to withstand the opponent's hits. The screen will present the player with a *clear goal*, with what he/she has to defeat.

When facing a boss, the background changes to a dark cave (see Figure 13.10). This combined with a scarier fight music, sets the player in a nervous mood making the achievement bigger when defeating the boss.

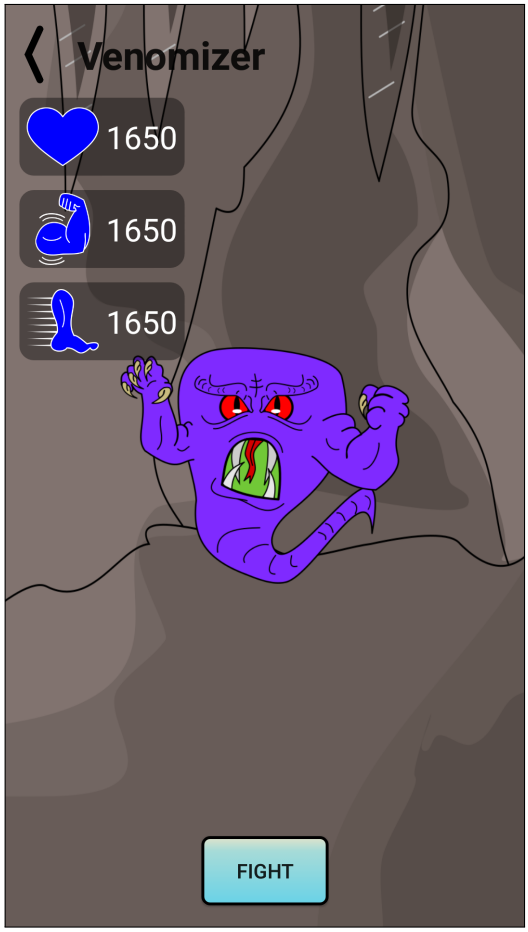

Figure 13.10: *Boss*

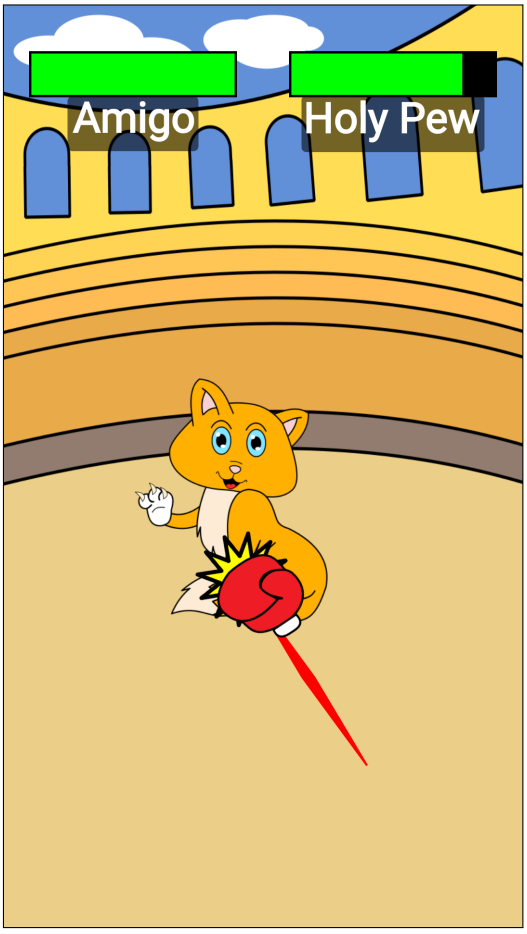

Figure 13.11: *Fight*

The fighting screen shown in Figure 13.11 is where the player will swipe towards the opponent to give damage. The player needs to tap the screen and hold to start charging the hit, the longer he/she holds, the more damage the hit will deal. Then the player is able to swipe towards the opponent to try to land the hit. The opponent will move in all directions to dodge the attacks, as well as attacking back, requiring *concentration* from the player to not miss on attacks and win the fight. This is one crucial part of the game, as this is where the player can see the fruits of his/her labour in action. Fighting the same opponent twice with workouts in between gives the player direct *feedback* on how much the training has helped him/her in the game. The player's exermon and the opponent stats lays the foundation

for how difficult the fight will be. Health points decide how much damage the exermon can take, power decides how much damage the attacks give, and speed how fast the opponent move and how often the player's exermon dodges the opponent's attack.

Feedback is a huge part of the fighting as it is important that the player feels in *control* of the situation and are given the information needed to succeed. The green bars in the top area displays how much health the player's exermon and the opponent have left. Visual and audio feedback are given as the player swipes, hits, or is hit. The player is also able to immediately see when the opponent moves as to promote skill and precision, instead of randomly swiping the screen trying to get a hit. Background music is played during the fight as to further enhance the fighting experience.

The fight will be a *challenge* for the player, and defeating an opponent will increase the player's self-esteem. If a player has been training a lot, without fighting in the arena, the fights will initially be easier. This reinforces the player that the workouts are not a waste of time for progression in the game.

Figure 13.12: *Badges*

Figure 13.12 shows the badge overview, where the player can see what badges he/she has earned. By clicking on badges, the player will be presented with information about the badge. It contains information on what to do in order to obtain the badge, and gives *feedback* on the progression. These are *rewards of glory* in order to motivate the player for further play. It promotes new gameplay as it can give the players side goals. In the upper right corner, the player can see how many badges he/she has achieved of the total 75 badges.

Whenever the player earns a badge the game gives him/her a cool visual effect triggering *sensory curiosity* to promote the obtaining of these accolades. In addition, this can reinforce the good playing patterns of the player and

stimulate dopamine learning.

Figure 13.13: *Shop*

The shop is shown in Figure 13.13, where the player can buy exercise boost that gives double amount of stats gained from exercising. The player can choose between exercise boosts that last for one, five, or ten exercise sessions or one, three, or seven days. There are also stat boosters in the shop, which gives the player 100 health points, power, or speed stats. But these boosters are expensive and are not sustainable in the long run. This shop enables the player to spend the gold he/she has won from battling opponents on *rewards of facility*, since the items increase the player's abilities.

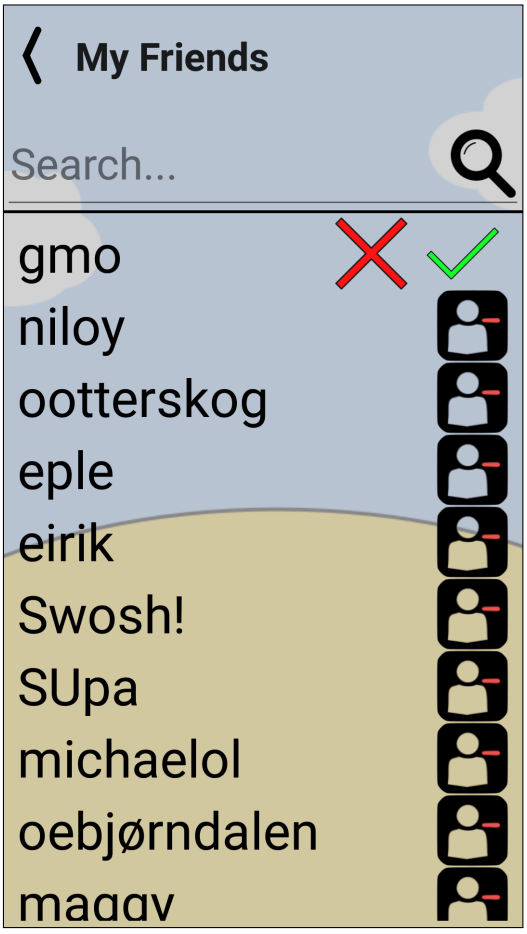

Figure 13.14: *Friends*

Figure 13.14 shows how players can connect with each other. The friends list contains all added friends and players that have sent a friend request. The search bar allows players to search in their own friend list or search for friends they have not added yet, so they can send a friend request. By clicking on a friend's name, the player will be sent to the opponent screen (see Figure 13.9). This is how Exermon provides a social network for the players that allows for *social interactions*.

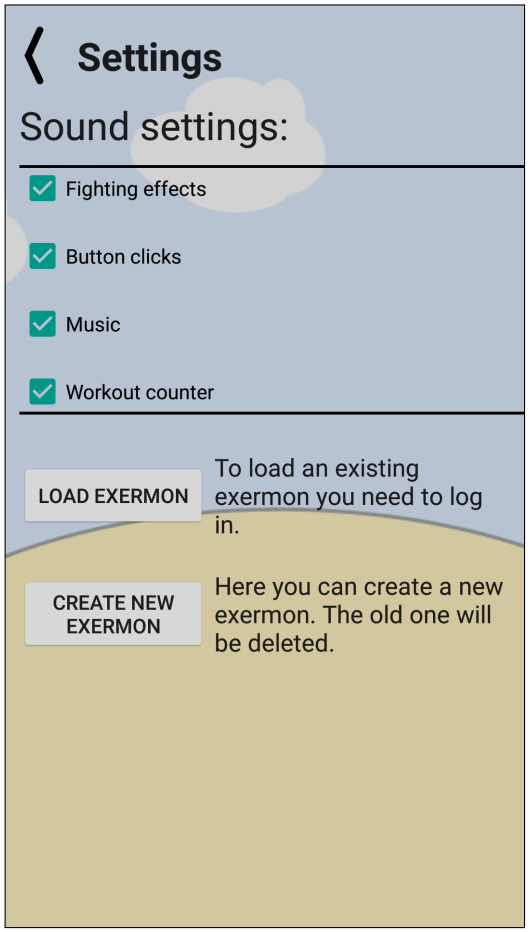

Figure 13.15: *Settings*

The settings screen shown in Figure 13.15 allows the player to customize the app by choosing which sound to mute by his/her own preference. By clicking the "Create new exermon" button the player can start over with a new exermon by sending the player to the new exermon screen (see Figure 13.1). The "Load exermon" button allows the player to load an exermon into the phone from the server. This can be useful if a player changes their phone and do not want to lose their exermon and progress in the game.

Chapter 14

Technologies

This chapter will dive into the technical aspect of the Exermon application. Discussing why we went for the mobile platform and decided to develop for Android. In addition, we describe how we implemented the mobile phone sensors to track body movement.

14.1 Platform

The game will focus on body weight exercise, therefore we decided to use the accelerometer and the proximity sensor for the exercises, since they are well suited for body weight movement tracking, and give the players more mobility than the other technologies reviewed in Chapter 7. These sensors are in smartphones, which a huge part of the potential users own. The exergame is a mobile application, so users always have the game available and can play when they feel like it. *Android* and *iOS* owns 96.7 % of the market of smartphones in April, May, and June in 2015. Android takes most of the market with 82.8 %, while iOS has 13.9 %, and *Windows Phone* got 2.6 % (International Data Corporation). When deciding which platform to develop for, there were several choices. A native app is when the application is developed only for a single mobile operating system. By doing this we could focus on a single operating system or develop the app for each wanted operating system separately. We could also have chosen to develop a cross platform application, which in most cases could be built to Android, iOS, and Windows Phone application simultaneously.

Developing a cross platform application is a good idea, in order to target almost all smartphone users, but there are pros and cons with this. There exist

many tools, which helps you develop cross platform applications. Frameworks like *Titanium* (Appcelerator), *PhoneGap* (PhoneGap), and *Sencha* (Sencha) uses HTML, Javascript, and CSS to create apps, which is not suited for game development and therefore were not suited for our needs. Then there are cross platform tools like *Xamarin* (Xamarin), *RoboVM* (RoboVM), and *RubyMotion* (Rubymotion) which could have suited our needs very well. Both Xamarin and RoboVM have a subscription fee, therefore we did not consider using them. RubyMotion is a cross platform tool where you develop in the programming language Ruby, which we do not have experience with and therefore decided not to use.

Game engines were also a good choice because they are used to create and develop video games, and support game elements like visual rendering, collision detection, animation, and playing sounds. *Cocos2d* (Cocos2d), *Unity* (Unity3D), and *Corona* (Corona labs) are some good choices for game engines that build to Android and iOS. Cocos2d is a family of frameworks, where you could choose what cross platform tool you like based on preferred programming language. Cocos2d-xna uses C# and seemed like a great choice, but there is a huge lack of documentation around this cross platform tool. This flaw could have led to problems later in the project if problems were occurring and we could not have found any solutions to them. Unity might have been a good choice since it can be used for 2D games, but it is a huge framework with a lot to learn before you can make good games. Due to the low complexity of the game compared to professional games, we found it unnecessary to use time and effort to learn something that potentially would not save us any time in the long run, so we did not choose to use Unity for this project. Corona lets you make games fast by supporting different game features. In our game, the exercises rely on the accelerometer and proximity sensor. Corona supports accelerometer, but does not support the proximity sensor, unless you got the paid version that lets you use native libraries to access the proximity sensor to the Android and iOS, which means neither Corona suited our needs.

If we would have wanted the exergame to support both the Android and iOS platform we were left with developing the app twice, once for Android and once for iOS. This could have led to much work, by not doing this we had better time to develop a better game and better testing. Choosing only one platform were good enough for the prototyping, but if we want the

game to achieve commercial success, the game should be supported by both Android and iOS. For our prototype and testing phase, we focused on an app for Android. We both have experience with Android development and felt confident the exergame development would go well without being stuck at many unforeseen problems. With Android native development, the code is written in Java and has a tried and tested toolkit with good performance. All resources and latest APIs can be accessed. By choosing Android, we focused on a huge part of the mobile market, and had many possible participants for the test phase.

14.2 Sensors

To track the players exercising, the proximity sensor and accelerometer sensor are used. Counting repetitions for push-ups and handstand push-ups are done through the proximity sensor. On the Android smartphones, the proximity sensor measure distance in centimetres. This is done by placing the phone on the floor, the player lowers the chest or head towards the phone, this will trigger a change in the proximity sensor. These values are used to count how many times the chest or head have been close to the phone, which is the number of push-ups or handstand push-ups taken by the player. There are some phone differences from different Android phones, the range varies a few centimetres from phone to phone. This is not a problem, just that some phones will not be as strict with requiring the deep push-ups.

For sit-ups, squats, hang-ups, dips, table-ups, bulgarian squats, glute bridge, hanging leg-raises, and pistol squats the player's moving motion is captured by the accelerometer. The accelerometer captures acceleration on all three physical axes (x, y, and z), see Figure 14.1. Depending on the exercise, the phone will listen for a movement on a specific axis. If the sensor output value exceeds the threshold in one direction the app knows the player is halfway through in a repetition and waits for a movement in the other direction on that axis, to know the player has fulfilled one repetition. The accelerometer varies from phone to phone, therefore some players will exceed the threshold with smaller movements than other. This could result in players that receive fewer or more repetition than actually done.

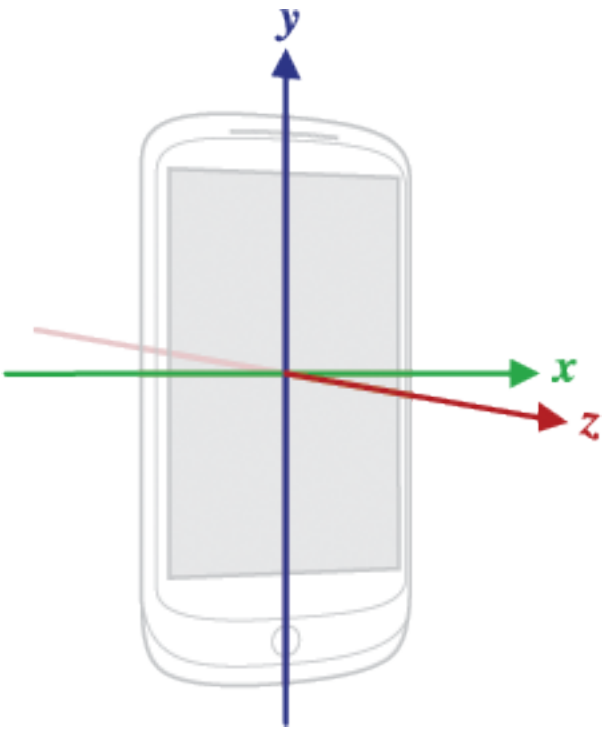

Figure 14.1: *Accelerometer axis on Android*

The sensors will only be tracking the correct movement patterns, and not if the movement is actually executed correctly by the player. This makes the sensor implementation vulnerable to cheating as players can simulate the correct movement with the mobile phone in their hand, instead of actually doing the exercise. Both the sensors discussed above are susceptible to this and have no way of differentiating if a person is actually doing the movement, and if a person is cheating.

Chapter 15

Requirements

When we designed our exergame, we had many functional requirements. These requirements are inspired by our findings during the prestudy. The functional requirements (FR) are fulfilled and described through the content in Chapter 11, Chapter 12, and Chapter 13. Table 15.1 summarize these FRs.

FR #	Functional requirement
FR1	The game shall allow the player to create their own exermon, choosing between several monsters, and naming it
FR2	The game shall provide the player with an overview with a visual of their exermon together with the exermon's stats, arena rank, items, and how much gold the player has
FR3	The game shall decrease the exermon's stats over time, when the player is not exercising
FR4	The game shall increase the exermon's stats for each repetition of an exercise with a set number of points, depending on the exercise
FR5	The game shall allow the player to do the following exercises: push-ups, squats, sit-ups, hang-ups, dips, hanging leg-raises, pistol squats, bulgarian squats, glute bridge, and handstand push-ups
FR6	The game shall allow the player to unlock exercises with gold
FR7	The game shall play a sound when the player does a repetition, and on half-repetitions for push-ups and handstand push-ups
FR8	The game shall provide information on how to do the exercises, this will include what to do with the phone in order to track correctly
FR9	The game shall provide the player with the opportunity to play boss fights, arena fights, and friend fights
FR10	The game shall reward the player with gold after winning a fight, the amount of gold depends on the opponent
FR11	The game shall respawn a new boss every Monday
FR12	The game shall rank up the player in the arena when beating an opponent and rank down one spot every day
FR13	The game shall allow the player to attack in fights, by swiping towards the opponent

FR #	Functional requirement
FR14	The game shall make the opponent move and attack the player's exermon in fights
FR15	The game shall manage friends, allowing the player to search for, add, and remove other players in the game
FR16	The game shall allow the player to view friends' exermon, and have the opportunity to fight it
FR17	The game shall play music and fight sounds when the player is fighting in the game
FR18	The game shall allow the player to buy items with gold, which boosts the exermon's stats or amount of points gained per repetition
FR19	The game shall give the player badges by obtaining the badge demand
FR20	The game shall display all badges obtained and not yet obtained with information about the progress on the badge demand
FR21	The game shall turn the background to a night theme between 20.00 to 07.00
FR22	The game shall allow the player to load an exermon saved in the database

Table 15.1: Functional requirements

We also had several non-functional requirements (NFR) while creating the exergame. The International Organization for Standardization (ISO) links non-functional requirements to *quality in use* (ISO/IEC, 2001). They categorize quality in use into six different main categories, functionality, reliability, usability, efficiency, maintainability, and portability. We used this standard as inspiration when creating our NFRs. Our NFRs in this project is shown in Table 15.2

NFR #	Category	Non-functional requirement
NFR1	Functionality	The system should give the correct amount of exercise repetitions 90 - 100 % of the time
NFR2	Reliability	The application should continue to work normally in the event of a server crash
NFR3	Usability	It should not take longer than 30 minutes to learn how to use the system
NFR4	Efficiency	It should not take longer than two seconds to get results from server calls
NFR5	Maintainability	During one hour of play the number of system crashes should not exceed one
NFR6	Portability	The system should support 90 - 100 % of all Android mobile phones

Table 15.2: Non-functional requirements

In order to make sure our game was within the boundaries set by these requirements, we had to do testing. In Chapter 18 about requirement and development testing we describe how we tested our game, and answer how the exergame performed in terms of the requirements above.

Chapter 16

Software Architecture

This chapter will show the architecture of the exergame in the form of a part structure diagram and a package diagram.

16.1 Part Structure Diagram

Figure 16.1 shows an overview of the communication between the player, client, and server. The server and database are only used to handle information storage and communication between friends.

The client side of the system contains the Android application. This is where the interaction between system and player happens, and it is the most extensive part. The application contains the game logic and all the images, layouts, and animations to display to the player, as well as sounds to play. The application has a communication module, to receive and send data to the server. The application can also be used independent of the server, if the player has no connection to the internet. This is because all the game data is saved locally on the phone as well, the only thing the player is then missing is interaction with friends.

The server side of the system has a representational state transfer (REST) application programming interface (API), which the client can send requests to. These requests is handled by the server, which communicates with the database through data access objects (DAO). The database contains data about all the exermon created, user accounts, and friend connections.

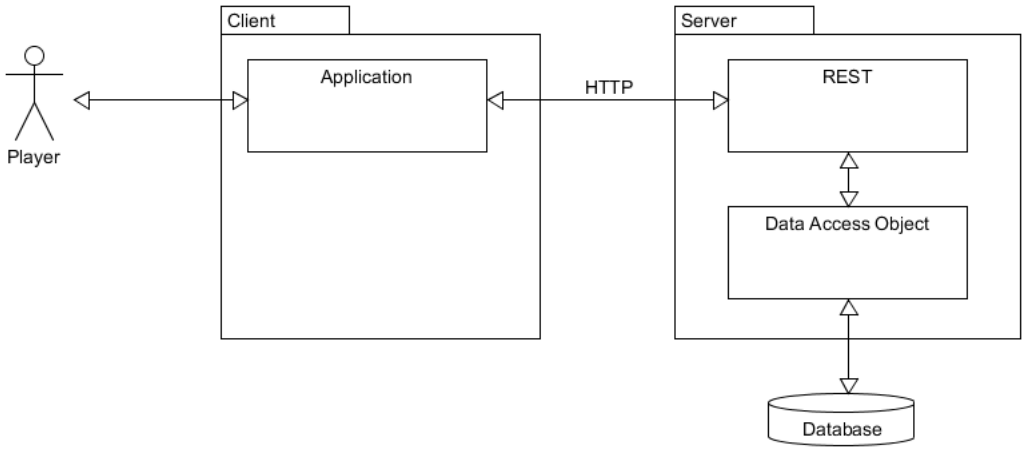

Figure 16.1: *Part structure diagram*

16.2 Package Diagram

The package diagram shown in Figure 16.2 explains how we have split Exermon into different layers. The package diagram gives an overview of each package in the different layers and which parts that communicate. The *view layer* is in charge of presenting the game to the user in form of visualization and audio, as well as receiving user input. Activities and fragments are Android's way of handling views by using layouts, images, and animations from Resources. The sound player is in charge of playing sounds and music, it uses audio files from Resources. We have used custom views when we needed to personally customize the views provided by Android. The custom views, along with all the other graphical design in Images, were created by the developers of Exermon. The development team consisted of the authors of this thesis.

In the *module layer*, there are four packages, where each part is in charge of a specific area. Game logic is in charge of handling all objects in the game and how they communicate. The sensor package handles the sensor values and calculates when a repetition has been made. The local storage package is in charge of saving and retrieving all game data, that needs to be remembered

to next game session. The server communication package sends a request to the server when the game needs to access data stored in the database or save data to the database.

The *server* part is split into two different logical units. The REST module handles the communication, and take requests from the different clients. The DAO-unit is accessing the database, retrieving and storing information that the client needs.

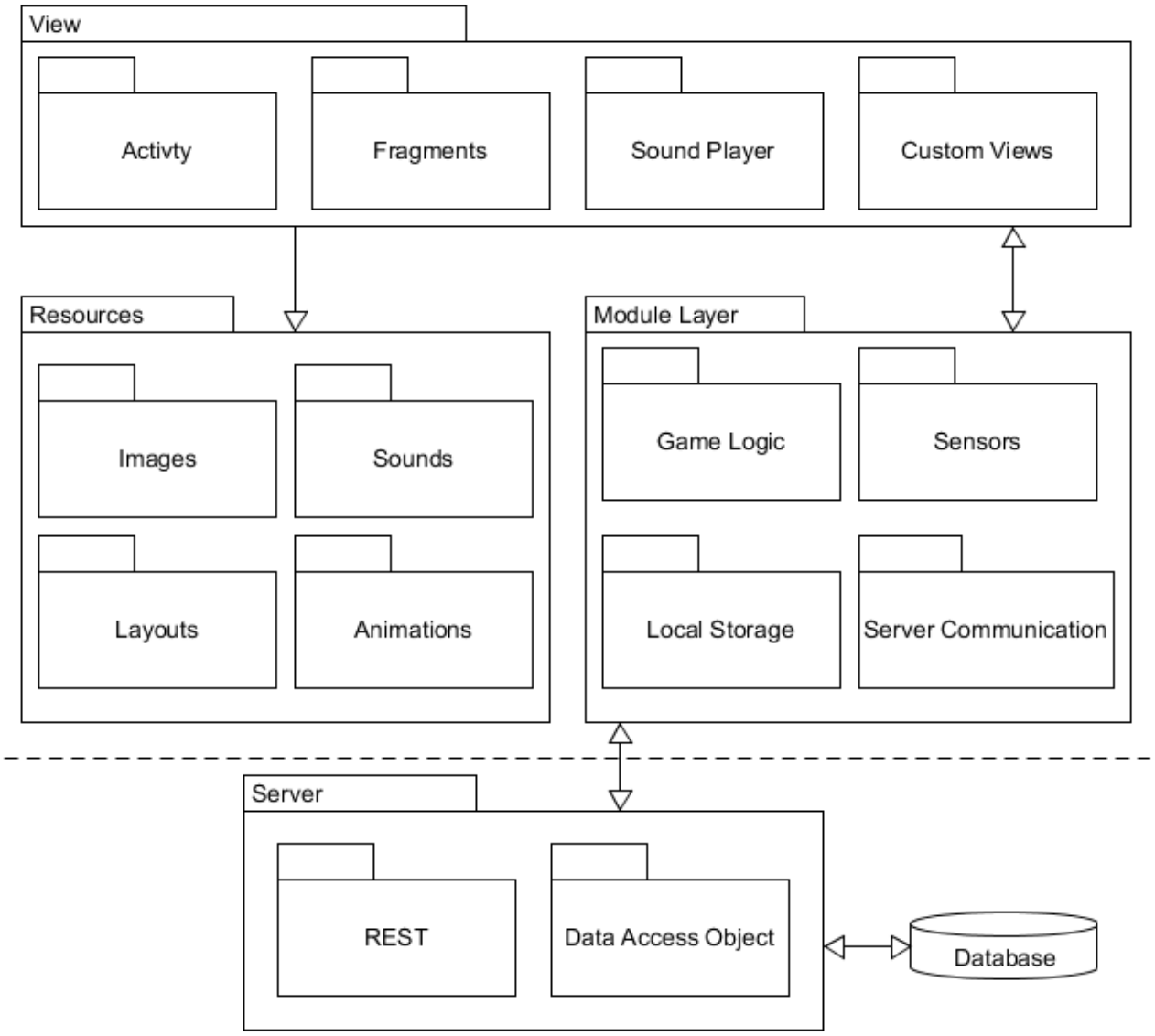

Figure 16.2: *Package diagram*

Chapter 17

Software Design

This chapter shows how we designed and created Exermon, in form of which classes the application are made of and a model of the database.

17.1 Class Overview Diagram

The class overview diagram, in Figure 17.1, shows which Java classes we have developed to make the full application. The diagram displays the packages from Section 16.2 and give more insight to what they contain.

The *MainActivity* class is the most important in Exermon, as it handles the initial start up of the application and the changing of fragments. It also communicates with the *SoundPoolPlayer* in order to play the correct music or sound at the correct moment. It communicates with *BadgeSaver*, *SharedPreferenceSaver*, and *ExermonSaver* in order to save the correct information about the players progress in the game. The latter class being used to save the progress to the server.

The classes in the *Fragments* package handles its own view, which is what the user sees on the screen. It also communicates with the various different *Game Logic* classes in order to calculate and show the correct data to the user. For example, the *Fight* fragment class uses all the classes in the *Fighting* package in order to move the opponent exermon correctly, give the right amount of damage, show the right textures at the right time, and announce the correct winner at the end of the fight. Some of the fragments also use the *ServerCommunication* class in order to store or retrieve data from the server. For example, *FriendList* uses the server in order to get the player's

friends, search for friends, add new friends, or delete old friends.

The sensor classes handle motion detection in the game. The *SensorAbstract* contains standard methods which both of the other classes uses. The *AccelerometerChange* uses the accelerometer in the phone in order to track movement. When the class is created, it is told which exercise is going to be done, and is able to adjust its tracking accordingly. *ProximitySensor* uses the proximity sensor in the phone in order to track push-ups and handstand push-ups.

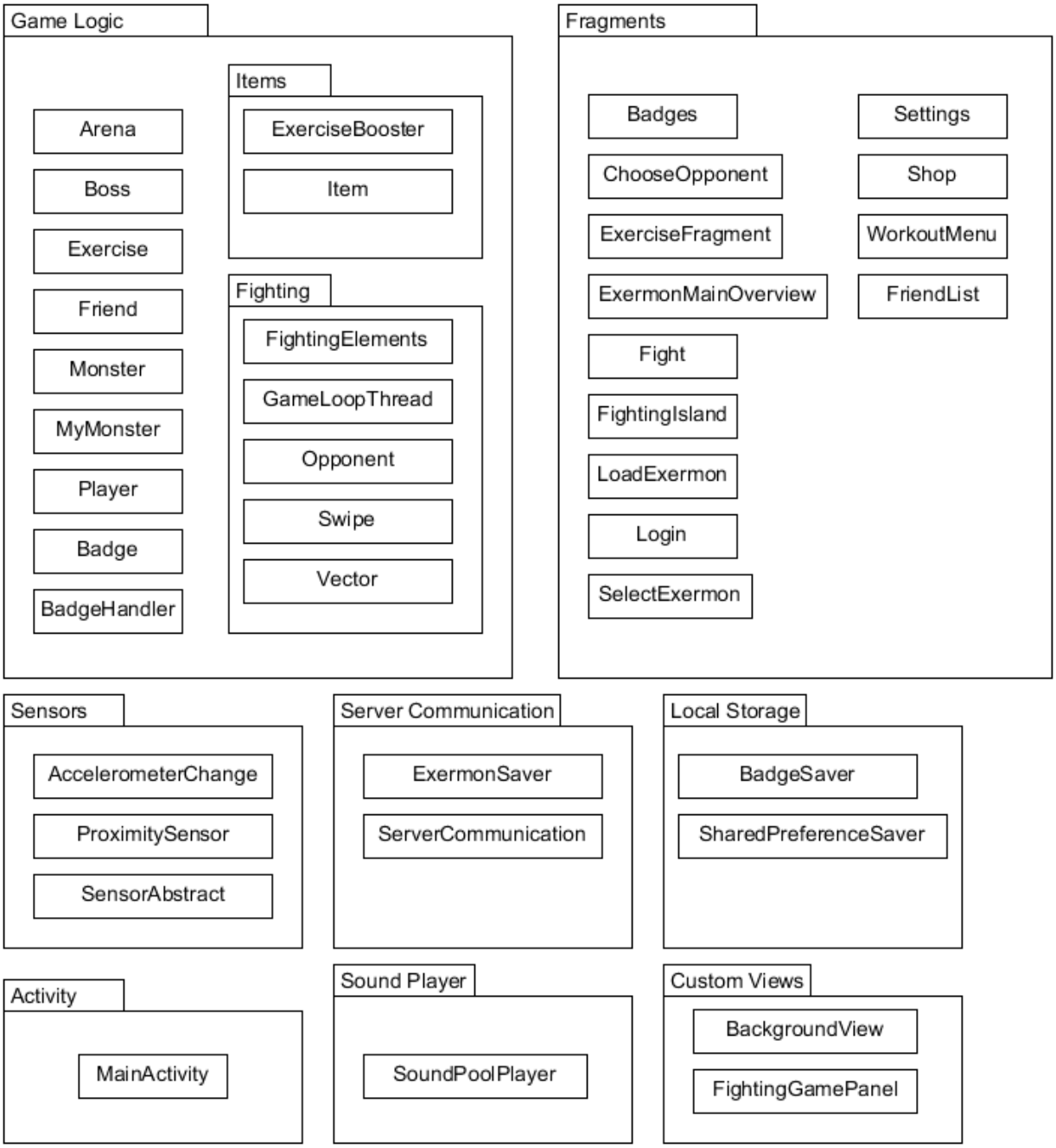

Figure 17.1: *Class overview diagram*

17.2 Database Model

When the mobile application communicates with the server, the server retrieves and stores data from the database. The database is used to save data about each exermon, user account, and friend communication. The database content and couplings are displayed by an enhanced entity–relationship model, shown in Figure 17.2.

The *Exermon* and *Account* entities are the most important ones in the database. The Exermon entity keeps track of the players' exermon, including their name, stats, and arena rank. In addition, it keeps track of the last time either the stats or arena rank changed, in order to properly decrement this if the player loads his exermon on a different phone. The Account entity has a one-to-one relationship with Exermon, and stores all the information bound to the account of each player. It also keeps track of how much gold the player has earned.

In order for a player to keep track of their friends, the *Friend* entity stores the account ID of both accounts. The account IDs are only stored here if both players agree to become friends. The *PendingFriends* entity is similar to the Friend entity as it stores the account ID of the potential friends. The server uses the ordering of the account ID to determine which account added the other. For example, if Karl added Hillary in Exermon, Karl's account ID would be stored in the first column and Hillary's in the second.

When the player unlocks an exercise in the game, the database will store a link between the account and the exercise that the player unlocked. The *ExerciseAccount* stores the account ID and exercise ID in order for the player to be able to do the exercises he/she has unlocked, even with a new phone. The *Exercise* entity stores all the exercises made available in the game.

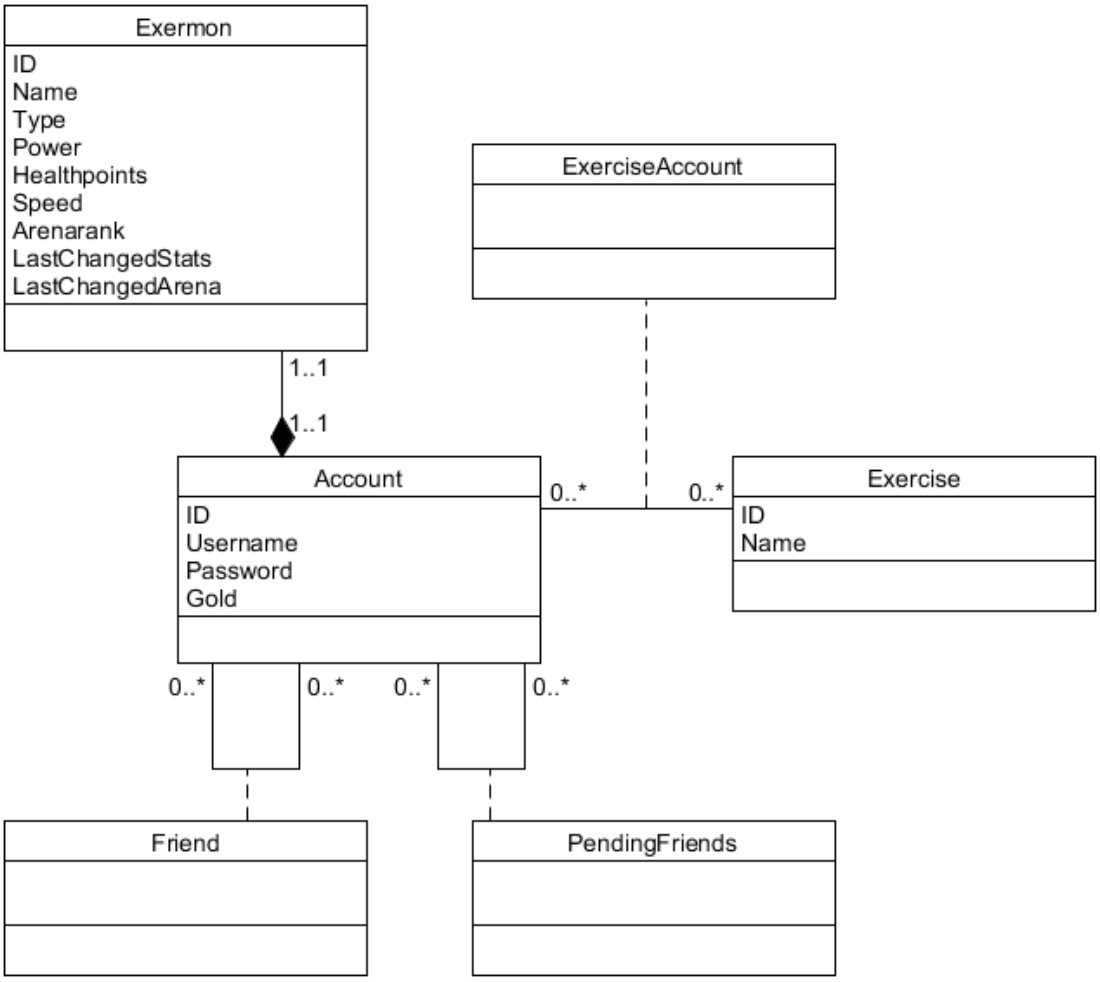

Figure 17.2: *Database model*

Chapter 18

Requirement and Development Testing

In this chapter, we describe how we conducted the testing of Exermon during the development phase. We detail the general testing approach while developing the game, as well as a description of some of the specific testing processes we went through. Lastly, we conclude whether our FRs and NFRs were met or not.

18.1 General Testing Approach

During the development process, we always tested new tasks after they were implemented in the game. This was first done by the person implementing the task, and then later on it was redone by the other person in the development team. By using a Kanban board we could easily track the state of every task in the system whether they were done, needed quality assurance, under development, or not started. When tasks were moved from under development to quality assurance, only the other developer of the team could move it to the done state. Using this system we could assure that all functionality in the game would be tested twice, by two different people.

When testing new tasks we went through the typical "happy"-path where we used expected input and user patterns. If the game handled this well, we went on to try to break it by using unexpected input and user behaviour. We also used different paths in and out of the functionality in question in order to see how the game handled interruptions and special paths through the code.

18.2 Alpha Testing

When the development of the game was over, the development team set aside a week of time where we played and used the game, emulating the usage of an ordinary player. Our main focus on this stage was on how well the sensors performed, and how they needed tweaking in order to become as accurate as possible. We also looked at how often the system crashed, as tracking the frequency of this was important to our NFRs.

When doing exercises in the game, we registered how many repetitions we received correctly from the game and how many we received when not doing the actual exercise. We continuously tweaked our algorithm for recording the exercises during this time, until the number of correct and incorrect recorded repetitions were steady and within the limit we set in NFR 1. It is important to note during this time we were only using two different Android mobile phones, and the data obtained from the requirement and development testing were from these.

18.3 Beta Testing

We realized it was prudent to get more feedback from users not directly linked to the development process as well. This made us go through another testing phase where we recruited volunteers from Netlight Consulting to play Exermon. The volunteers were experienced with development and technology which made them suitable to give us more insightful feedback than we might have otherwise gotten. During a period of one week we had four testers using our game, giving us feedback on what they thought could be better, or more understandable. We established a base for communication where everyone could easily post their thoughts about the game, and we would respond as often as we could.

In addition to feedback, we got to see on a larger scale how the application performed in terms of response time and crashes. For example, we uncovered that the application was sometimes using up the phone's memory by not correctly dumping the unused views. This caused a system crash on the

phones with memory on the lower end of the spectrum.

18.4 Functional Requirement Validation

The general testing approach helped us massively towards meeting our functional requirements. By using the Kanban board, and writing tasks in accordance to our functional requirements, we could easily see whether they were fulfilled or not (see Figure 18.1). By using a quality assurance list, each FR was validated by both developers, before marking it fulfilled. We can conclude that our functional requirements, FR1 - FR22, are fulfilled in Exermon.

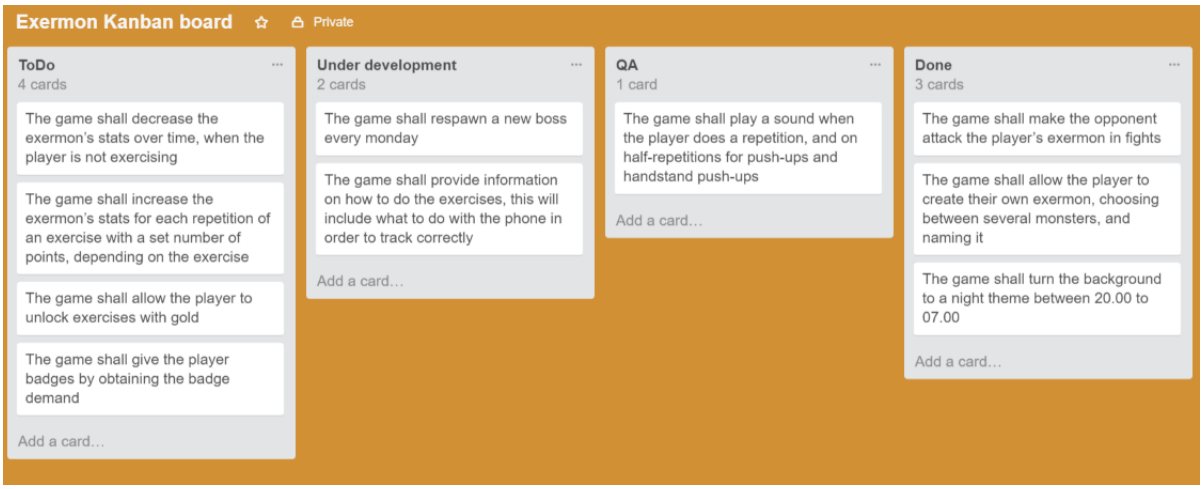

Figure 18.1: *Example of Kanban board*

18.5 Quality in Use

In Chapter 15 we talked about how non-functional requirements determined the quality in use of a system. We detailed a set of NFRs which were going to ensure that our exergame had the quality in use we desired. Through testing, we were able to draw conclusions on the quality of Exermon.

NFR 1: The system should give the correct amount of exercise repetitions 90 - 100 % of the time
Through the alpha tests, we were able to tweak our algorithm to give us a more accurate repetition count. In the latter stages of this testing phase, we experienced that the game would correctly track and record our repetitions within the limits set in this NFR. This is further accentuated by the fact that no one from the beta tester group had any complaints or feedback on the exercise tracking.

NFR 2: The application should continue to work normally in the event of a server crash
During both alpha testing and the development process, the developers tested what would happen in the event of a server crash, foreseeing this as a possible issue in the future. We simulated server crashes by shutting down the server during different stages and seeing whether the application crashed. We determined that Exermon handled this excellently, even giving correct feedback to the user.

NFR 3: It should not take longer than 30 minutes to learn how to use the system
To answer this NFR we had to rely on our beta tests, because we as developers cannot be seen as impartial in the matter. Although we did receive feedback that a couple of the testers struggled initially to understand some parts of the game, the general consensus was that the game was easy to learn and use. Excerpt from feedback by a tester: "I liked the app as well! I didn't understand what to do in the beginning but I think if you for example let a popup message display the first time you enter an exercise it would make it a little easier at least."

NFR 4: It should not take longer than two seconds to get results from server calls
To answer this we mainly used results from the development process and the alpha test. The server and database were deployed on student versions of Microsoft Azure and ClearDB respectively. The student version of ClearDB had a function which made the database go into hibernate mode if there were no communication with it for a couple of minutes. Once the database was in this mode, it took anywhere from

5 - 20 seconds to get it to an active mode again. Due to this issue, the server would sometimes go above our given time limit to respond to requests. However when the database was in active mode, the server was fast, responding well within the given time limit.

NFR 5: During one hour of play the number of system crashes should not exceed one
Taking data from both the alpha and beta test, we could see that the amount of crashes on the application were minimal. Most of the crashes happened during the alpha test, as the game were at an earlier stage in the testing and most of the bugs were fixed when the beta testing began. During the beta test we only uncovered one new bug, which happened twice. When this bug was fixed, the game was stable and we could tentatively conclude that this requirement was met.

NFR 6: The system should support 90 - 100 % of all Android mobile phones
We decided ourselves which API our application could be built for. By selecting minimum API 15, our exergame is supported for Android 4.0.3 and above. Android Studio uses Google Play Store to get an overview over which versions of Android all the Android devices uses. You can then get an overview over how many of these devices will be able to run your application. Using this tool we were able to determine that our application could be run by approximately 97.4 % of the devices on Google Play (see Figure 18.2), which is well within our set limit.

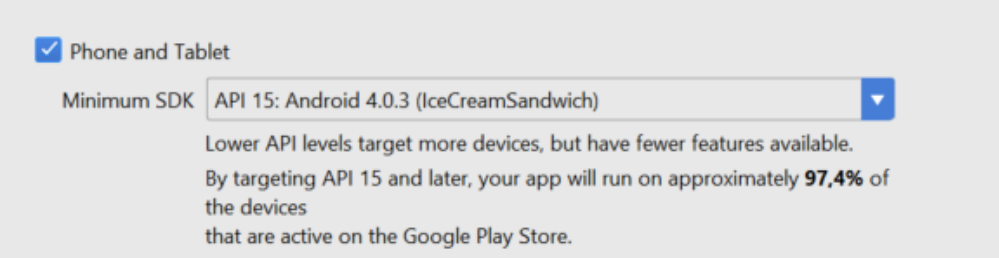

Figure 18.2: *Overview of supported devices*

By having these set of NFRs and doing the testing that we did, we were able

to assure a high quality in use in Exermon. This made for a better playing experience as the system feels more stable and robust. However, we realize that more tests and testing approaches would be beneficial to determine the validity and quality of the results.

Part IV

Research Methodology

The nature of this project makes it suitable as an empirical research. Even though the theories discussed in the prestudy chapter may guide us upon a path, they cannot give us a definite indication to the quality of the product. In order to answer the research questions described in Chapter 3, people needed to play our game, and data needed to be collected throughout these sessions. In this part, we will describe what theories we used while planning our testing, together with a description of how the actual testing was conducted.

Chapter 19

Research Theory

Here we go through accepted research methodology and theories that we used while designing and executing our testing.

19.1 Triangulation

Denzin is an advocate of using triangulation, the combination of methodologies in the study of the same phenomenon, during any research (Denzin, 1973). Research which uses only a single method, observer or theory may be subject to weaknesses or intrinsic bias. To counter this, it is important to gather data through several methods. We used four different methods of gathering data, which helps us reduce the risk of any weaknesses that can influence the results.

19.2 Qualitative and Quantitative Research

In order to get different viewpoints and a better understanding of the users and the exergame (Olsen, 2004), we applied a multi-methodological approach to our research. We combined aspects from both quantitative- and qualitative methodology in order to gather a broader spectrum of data (Olsen, 2004). We used surveys and an application usage analysis tool to gather quantitative information about Exermon. For the qualitative information, we conducted interviews and observations. This gave us both quantitative and qualitative information about the game.

Chapter 20

Execution

This chapter gives a description of how we gathered our test subjects, how we sampled them, and how we distributed the game to our users. We will also present how we conducted the experiment.

20.1 Distribution and Sampling

Volunteers for the research were gathered through different types of social media and social events. The researchers used Facebook and Slack (Facebook Inc.; Slack technologies) in order to get friends and acquaintances to volunteer. The recruitment message contained information about what the research was for, how we planned to execute it, and what was expected of the volunteer. The researchers saved each volunteer's contact information in order to distribute the exergame at the start of the testing phase.

Distribution of the exergame was done through the Google Play Store. The Play Store is Android's application platform which allows the users to download the application at the location of their own choosing. The application was distributed to 37 volunteers out of which 33 people downloaded it.

For observation and interviews, the researchers used stratified sampling in order to get their sample pool. This is sampling where you define your samples (strata) based on population characteristics such as age or gender. The strata need to be mutually exclusive such that no person is in two stratas at the same time. The strata defined were young adults between the ages of eighteen and twenty-five of both genders. The researchers used convenience sampling to identify 4 men and 4 women to interview and conduct

observations on.

20.2 The Experiment

The experiment was carried out in a two-week period where we allowed our test subjects to play as much as they wanted, on their own initiative. The timespan of the testing was chosen because we wanted to find out if people felt stronger after playing our game, and building strength usually takes time (Tipton and Wolfe, 2001). We instructed the subjects to play it at least once in order to get a feel for the game and be able to form an opinion based on the experience. The training sessions were initially done without any observations by the researchers. During this period the researchers worked on fixing system crashes, helping subjects having trouble with the game, and answering questions.

During the second week of the testing, appointments for observations and interviews were set up with a selected group from the testing population. These individuals were scheduled at a location of their convenience, where they brought their mobile phone. During the observation, the test subject was instructed to do certain things in the game, such as working out, playing in the arena, and adding friends.

After the observation sessions, the test subject and the researchers sat down to conduct an interview. The interviewee was instructed to be as honest as possible, and to express himself/herself freely. The interviewer noted down the answers while sometimes asking follow-up questions to a particular answer if the meaning was unclear.

Twelve days after distributing the game, every test subject were contacted and asked to answer a survey. In the survey, we asked for complete candour in order to get as valid feedback as possible. The survey took approximately ten minutes to complete, except when the test subject did not feel like he/she had played it enough to form a proper opinion about the game. Then the survey took considerably less time as he/she could skip most of it. This way we could record answers from everyone that received the game, even when they did not play it for some reason or another.

Chapter 21

Data Collection

In this chapter we will discuss which types of data we collected during the experiment, and what methods we used in order to collect it.

21.1 Types of Data

We wanted to see whether Exermon has quality in three different categories. We categorized them in the following sections: The physical, the user perception, and the technological.

21.1.1 The Physical Part of the Game

We wanted data that told us something about the quality and frequency of the exercises being done in the game, but most importantly if they got stronger by using the game. In addition, we wanted to see whether the game catered to dual flow. This data coincides with our research question: *How is the player's strength affected by the exergame?*

21.1.2 The User Perception Part of the Game

Data from the user perception part tells us something about the attitude of the players towards the game during, before, and after play. This is closely related to three of our research questions:

1. *How is the player's motivation affected by the exergame?*

2. *How is the player's enjoyment affected by the exergame?*

3. *How is the player's engagement affected by the exergame?*

21.1.3 The Technological Part of the Game

Here we can determine whether our technological choices were optimal, and whether or not it worked for everyone. Data from this part will help us answer our research question: *How well does the technology track the player's exercise?*

Due to the lack of constrictions on cheating in the game we also wanted to see how frequently, if ever, people cheated the exercises. By cheating, we mean tricking the sensors into giving you repetitions when you did not actually perform one. This can be done by, for example, shaking the phone while having the squat screen open in the game. This says something about the quality of the technology used in the game.

21.2 Survey

We designed the survey to give us data from all three categories discussed in Section 21.1. The questions and statements in the survey were drawn from the game mechanics, technology, and strength exercise chapters discussed in the prestudy.

For the game mechanics questions about flow, we drew inspiration from Susan A. Jackson who writes about the flow state scale (Jackson et al., 1996). For the rest of the game mechanics, we found several different statements that could give us information about each specific mechanic, and used the process of elimination to find the most fitting one. We also added statements about the general categories motivation, enjoyment, and engagement to see whether these matched up to the underlying statements. In the sur-

vey the test subjects could answer the statements with "strongly disagree", "disagree", "agree", or "strongly agree".

To achieve data on how *motivated* the test subjects were, we presented them with six different statements on motivation. One about motivation in general. The other statements focus on *rewards of glory*, *rewards of sustenance*, *rewards of access*, *rewards of facility*, and *social interactions*. This is because we concluded in the prestudy that rewards and social interactions contribute to the player's motivation. The statements related to motivation are shown in Table 21.1.

ID	Statement
S1	I was motivated to play the game before each session
S2	My character's appearance inspired me to work out more
S3	Knowing that my character would die, made me work out harder
S4	I wanted to play more in order to unlock all the exercises
S5	Beating an opponent that previously appeared unbeatable, gave me great motivation to work out
S6	Being able to compare my exermon with my friends', motivated me to improve

Table 21.1: Motivational statements in survey

To find out how the player's *enjoyment* was affected by the game, the players was presented with seven statements related to this. One general statement about enjoyment of the game. The rest of the statements are about elements in *flow*, because these elements are necessary to achieve flow or increases flow. We categorize the flow statements under enjoyment, because in the prestudy we concluded that the player needed to experience flow to fully enjoy the game. Table 21.2 show the statements about enjoyment and flow, presented in the survey.

ID	Statement
S7	I enjoyed playing the game
S8	I was completely focused on the tasks I was doing
S9	I felt better at the game, the more I played
S10	I felt in control of what I was doing in the game
S11	It was clear that I was making progress in the game
S12	I was presented with clear tasks to accomplish
S13	I was so engaged in the game, that I became less aware of my surroundings

Table 21.2: Enjoyment statements in survey

To collect data on the player's *engagement*, we presented the players with one general engagement statement and three other statements related to *challenge*, *fantasy*, and *curiosity*. From the prestudy, we concluded that these three elements play a huge factor in engaging the player. The statements related to engagement are shown in Table 21.3

ID	Statement
S14	I felt engaged in the game
S15	The game was challenging, but it was appropriate to my skill level
S16	I found the fantasy world in the game appealing to me
S17	I was curious on how my exermon would evolve

Table 21.3: Engagement statements in survey

In order to capture the information about the *physical* part, we identified

what data we wanted and made questions and statements covering each part. We made questions asking for exercise frequency, and statements for improvements in strength and whether the game matched the individual's fitness level. Table 21.4 shows the questions and statements related to exercise and strength.

ID	Question/statement
Q1	How often did you work out BEFORE the testing period?
Q2	How often did you work out DURING the testing period?
S18	I feel that I have improved my strength, because of the game
S19	I felt that the exercises I did, matched my fitness level

Table 21.4: Physical questions and statements in survey

For the *technological* part of the survey, we were interested in looking at two different subjects. First we wanted to see how well the mobile phone tracked and counted the repetitions when an individual were actually doing the exercises. And secondly we wanted to see how many, if any, used the technology to cheat. Table 21.5 shows the questions related to the technological part.

ID	Question
Q3	How well do you feel the phone tracked your movements?
Q4	Did you cheat by not doing the correct physical exercises in the game?

Table 21.5: Technological questions in survey

The survey also contains one statement about the *user satisfaction* of the whole game and one question about *frequency of play*. This is to find out if the overall impression of the game was good. Table 21.6 shows the overall statement and question. See Appendix B for the full survey.

ID	Question/statement
S20	Overall I really liked the game
Q5	How often did you play Exermon?

Table 21.6: Overall statement and question in survey

21.3 Observations

The observations were designed to be overt systematic observations (Oates, 2005). Overt observations are observations of subjects that are aware that they are being observed. Our test subjects were informed beforehand of the observation, and could see the observers throughout the process. Our observations were systematic in the way that we planned on looking for certain things and having the subject do certain things during the sessions. We did not however strive for strictness in the execution of the observations, which made the atmosphere more casual and hopefully making the subject feel more at ease.

Figure 21.1: *Re-enactment of test subject working out in the game*

The subject under observation was asked to first do at least two exercises of his/her own choosing (see Figure 21.1). Thereafter he/she was asked to play the game sitting next to the observer so that the observer could see what was being done in the game (see Figure 21.2). While playing, the observer would suggest that the subject could do different things in the game that the subject might not have noticed, or just skipped. This was done in order to see the subject use the system in its entirety, not just some parts.

During the observation, the observer was constantly looking at how the subject interacted with the game. We looked at how easily the subject navigated through the game, how his/her thought process was during different stages of the game, and different emotional cues expressed by the test subject. These could be, for example, joy, concentration, elation, frustration, and anger. In addition, we also looked on how the test subject was performing the exercises, and how many repetitions that were taken. After each exercise, we observed how many repetitions the game counted in order to get data on how well the technology performed.

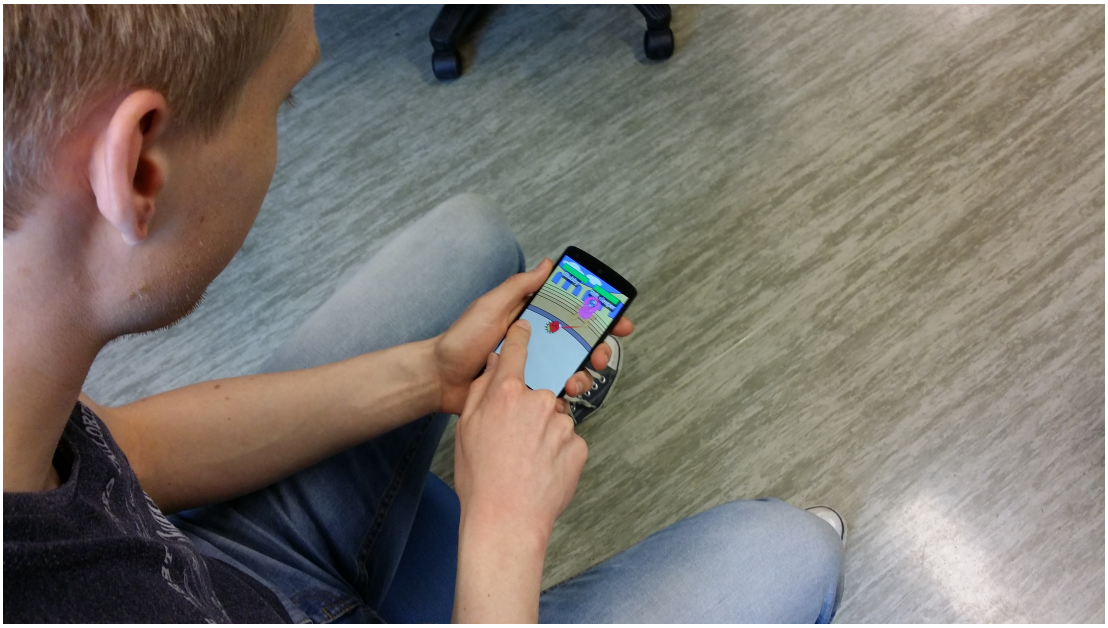

Figure 21.2: *Re-enactment of test subject playing the game*

21.4 Interviews

Together with the observations the researchers used a semi-structured interview (Oates, 2005) to gather more qualitative data (see Figure 21.3). The topic and themes of the interview were predefined before the interviews took place but the questions were not, to enable the interviewer to redirect the interview based on the observations done beforehand. For example, if someone clearly struggled with something the observers could ask: "We saw you struggled a bit with the fighting in the arena, could you tell us what you thought were not intuitive enough?"

The topic of the interview was Exermon, and the themes, based on our research questions, were motivation, enjoyment, engagement, improved strength, and technology. During the interview, the interviewer would ask questions based on each of the themes mentioned. For example, we could ask: "Did you enjoy fighting in the arena?" or even more general: "Did you have fun playing the game?" We also asked the interviewee about their general opin-

ion about the game, in order to get perspectives we might have otherwise missed.

Figure 21.3: *Re-enactment of interview*

21.5 Application Usage Analysis

In addition to the data collection mentioned above, we used a technology called Fabric (Twitter Inc.). The technology is installed in the software, to keep track of useful data such as the number of daily users, the number of new users, session lengths, and information on the devices each user has. We could also define numerous different events that would trigger when a user entered a certain part of the system. This way we could track when people were working out, fighting, buying items, or viewing friends. Fabric also provided us with information about system crashes, making it easier for us to remedy any and all problems that might have inhibited the testing.

Chapter 22

Reliability and Validity

In this chapter, we discuss what factors that may impact the results of our research.

22.1 The Hawthorne Effect

Gale writes in his work that the behaviour of individuals will change as they become aware that they, or their actions, are under observation. The Hawthorne effect (Gale, 2004) were discovered by researchers that wanted to check whether certain lighting conditions would increase productivity. They soon realized that the mere act of telling the workers that they were observing this phenomenon increased productivity, independent of the actual lighting conditions.

We did overt observations which meant that the test subjects were aware of our observations and the Hawthorne effect might have influenced our results, giving us more positive feedback and data than we might otherwise have gotten.

22.2 Familiarity Bias

As the participants of the test were recruited from the researchers' social circuits of friends, relatives, and acquaintances, the results might have been influenced by familiarity bias. Due to the fact that the participants knew who made the system under testing, they might be inclined to answer favourably

towards it.

To counter this, we asked the participants to be as honest as possible, stating that this was an objective test and that it would only hurt our results if they gave false answers to our questions. Even though these measures were taken, one could argue that you might obtain different results if the test subjects did not know the creators personally.

Part V

Results

This part will present our results from testing the exergame Exermon. The results are provided from the survey, observations, interviews, and the mobile analytic tool Fabric. In this part the results will only be presented, discussion about the findings will follow in the next part.

Chapter 23

Test Population

Originally there were 37 test participants. But someone got lost in the test process, by either not downloading the exergame or not answering the survey. In the survey, we asked "How Many times did you play Exermon?", one of the possible answers were "I did not play the game enough to form an opinion". They explained this with reasons like not having enough time, I was injured and could not exercise, and I could not download the app. Five test participants answered this, and will not be a part of the result.

The final subjects with usable data consisted of 24 people where 7 of these were women, as seen in Figure 23.1. 88 % of the test population were young adults in the age at 21 to 30 years old. While the rest of the 12 % was evenly spread out in the age groups of 15 to 20 years old, 31 to 50 years old, and 51 to 70 years old (see Figure 23.2).

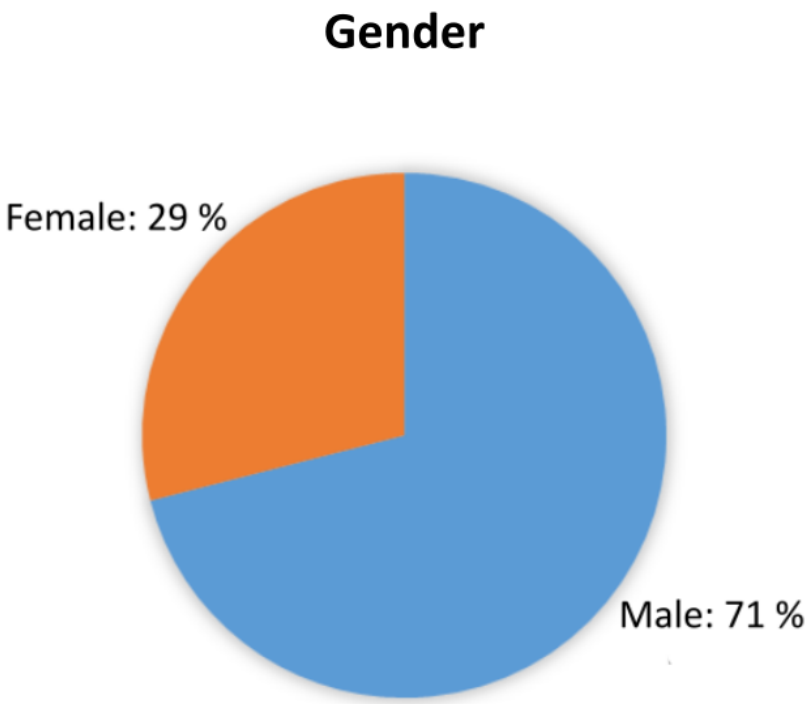

Figure 23.1: *Distribution of gender*

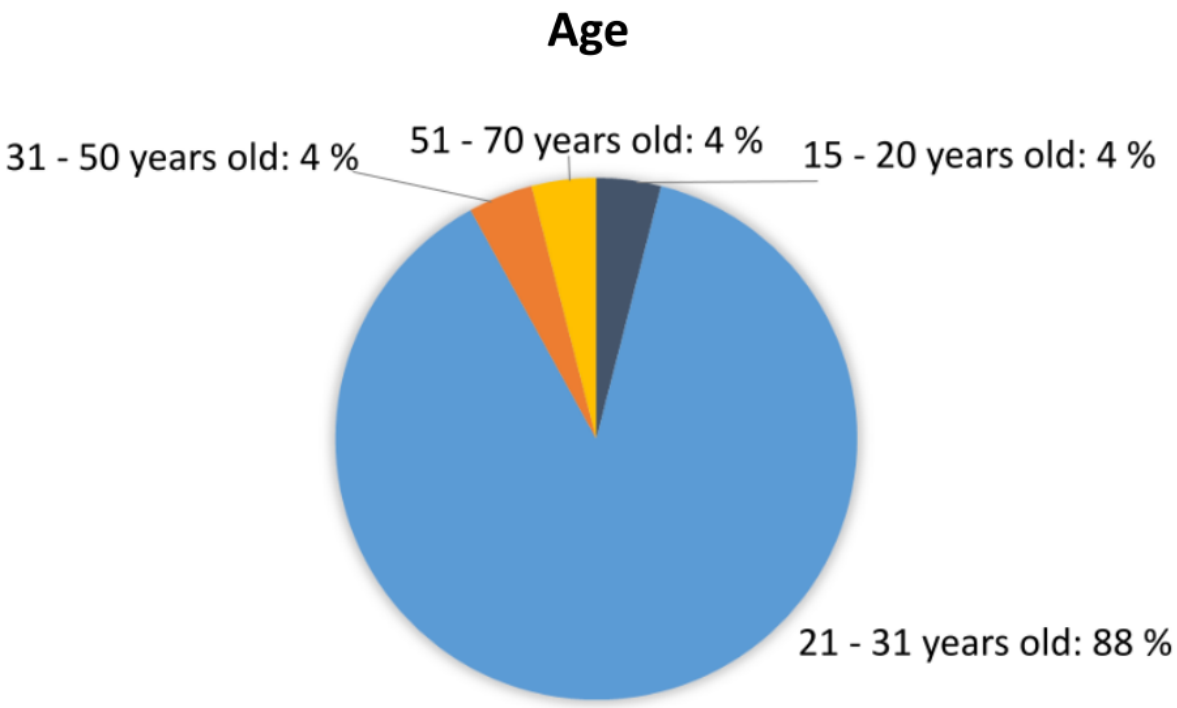

Figure 23.2: *Age groups of the test population*

Out of the 24 test participants, we selected 4 females and 4 males in the age group of 18 to 25 years old, to observe playing the game and interview afterwards.

Chapter 24

Physical Part

This chapter presents the results that are related to the physical part of the game. Which means the results focus on how often the participants exercised, how the exercises suited them, and if they experienced any changes in perceived strength. The results in this chapter are from the survey, observations, interviews, and fabric.

24.1 Survey

The test subjects were asked how often they worked out before testing the game and how often they exercised during the test period. During the test period, 41.7 % of the test subjects had an increase in how often they exercised weekly, as shown in Figure 24.1. Figure 24.2 and Figure 24.3 shows how often the test subjects exercised before and during the test period.

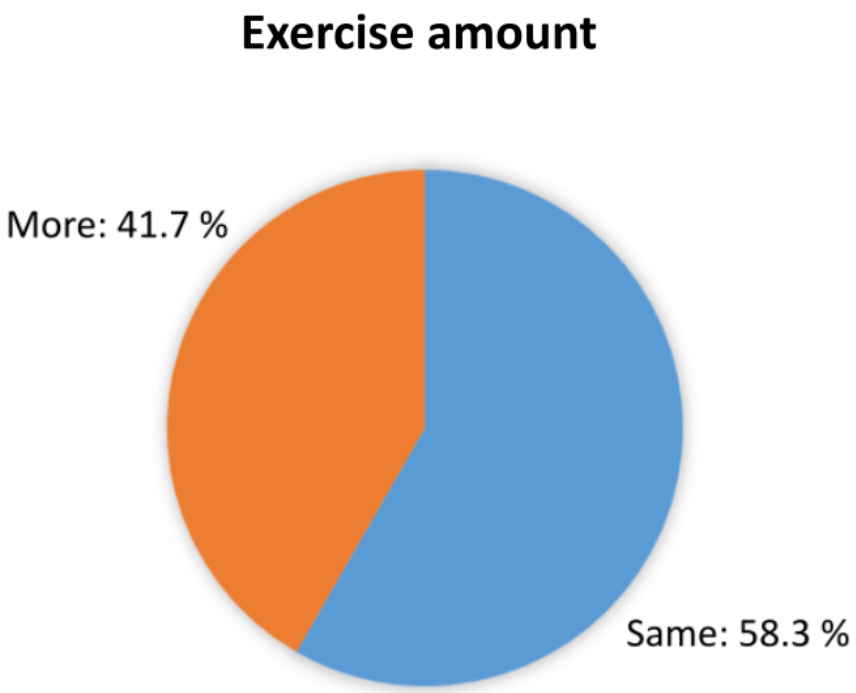

Figure 24.1: *Change in weekly exercise*

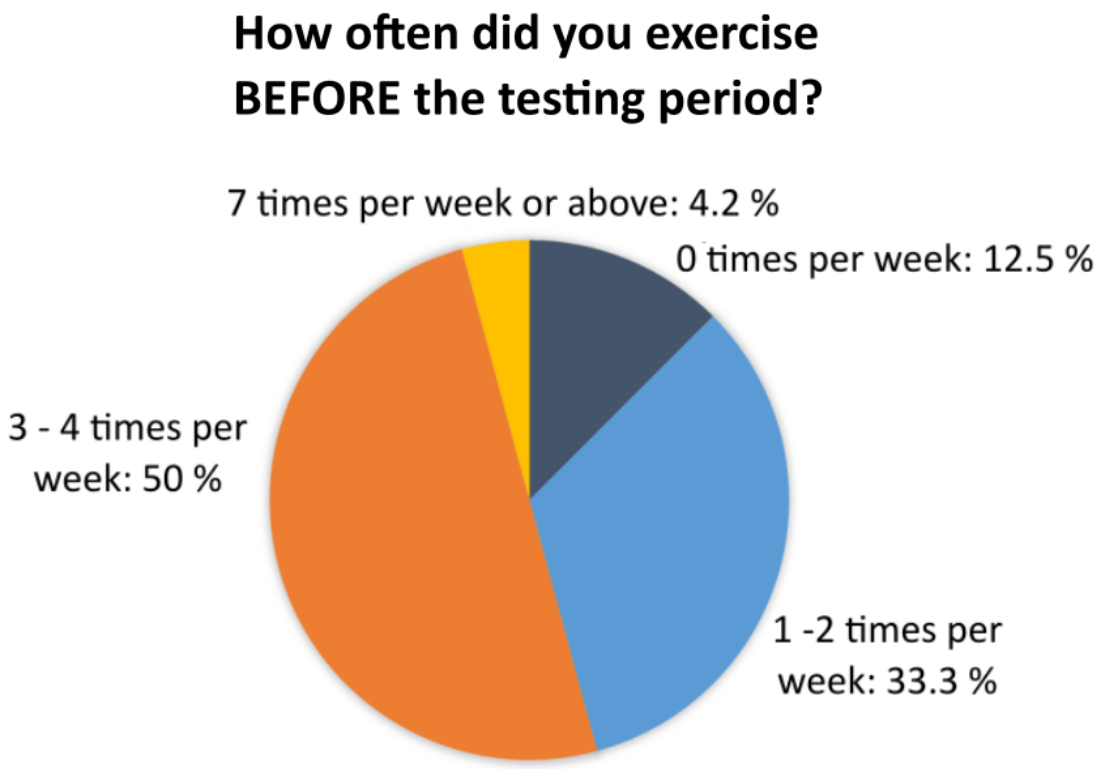

Figure 24.2: *Q1 - Exercise habits before the testing period*

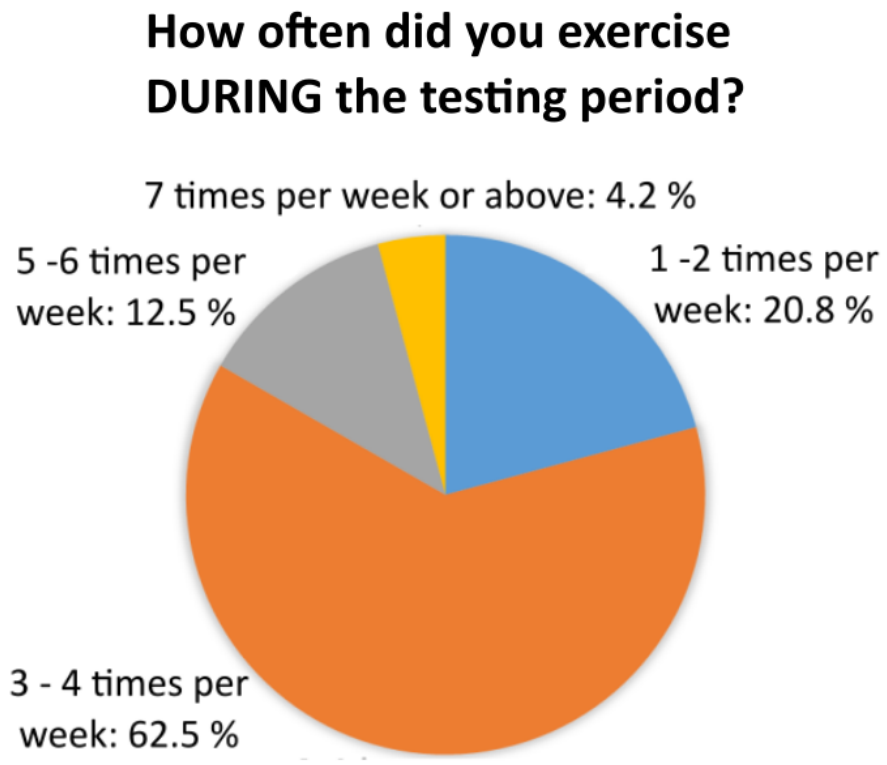

Figure 24.3: *Q2 - Exercise habits during the testing period*

In the survey the test participants were faced with 20 statements, where they could choose between “Strongly disagree”, “Disagree”, “Agree”, and “Strongly agree”. To make the results more distinct we have combined ”Strongly disagree” and ”Disagree” into one category called disagree. The same has been done to ”Strongly agree” and ”Agree”. We present our results in terms of how many percent answered either the disagree or agree category. Two of these statements is under the physical aspect, and are seen in Table 24.1.

ID	Statement	Disagree	Agree
S18	I feel that I have improved my strength, because of the game	62.5 %	37.5 %
S19	I felt that the exercises I did, matched my fitness level	16.7 %	83.3 %

Table 24.1: Results of physical statements

24.2 Observations

By observing the eight test participants, we can see that they did the exercises correctly. By correctly we mean that they performed the exercises to the best of their abilities, not cheating or only doing it half-way. Every person did either two or three different exercises. The majority pushed themselves to take as many repetitions as possible. We could see that the exercises were clearly physically straining on the subjects, evidenced by heavy breathing or verbal confirmation that they were tired. The exercises matched the test subjects own physical fitness because each person chose exercises themselves. They felt their choice were hard enough to pose a challenge, but not too hard as to be impossible, or cause injury. Exercises that the participants chose were pistol squats, push-ups, squats, sit-ups, dips, and glute bridge.

24.3 Interviews

By interviewing eight players, four of them stated that they had increased the amount of exercising because of the exergame. One of these players elaborated "I have exercised more because of the game, I like this kind of training".

Three of the players that had increased the exercise amount said that they have gotten stronger by being able to do more repetitions of the exercises. Three others explained how they already exercise a lot, because of this they

did not feel that the exergame had contributed to improved strength, even though one of them did work out more during the test phase. Two of the interview subjects had not exercised more because of Exermon.

24.4 Application Usage Analysis

Using Fabric, we recorded every time someone finished an exercise in the exergame. Figure 24.4 shows how many exercise events that occurred in the 14 days of testing. By events, we mean the number of separate times an exercise was performed.

The most exercise events happened at the very start of the testing period (first 4 days). During this period is also where the peak is reached at 150 events on one day (day 2). The event count then stabilizes at around the 25 - 50 mark before it spikes again at day 12. The lowest count during the testing period is at day 10, where we registered 9 counts of exercise events. The average event count for exercises were at 65.2 per day.

Figure 24.4: *Exercise events registered*

We also tracked how many different users carried out these exercises. Figure 24.5 shows the number of unique test subjects which performed one or more exercises on the given day.

The peak of users happens on the same day as the peak of exercise events seen above. We can also see that the number of users is highest in the beginning of the test period, which also coincides with the number of exercise events. It is interesting to note that on day 12, where we registered 147 cases of exercise events, there are only 8 unique users performing them. This is in contrast to day 2 were 17 different users performed 150 exercises. The average amount of unique users per day were at 8.1.

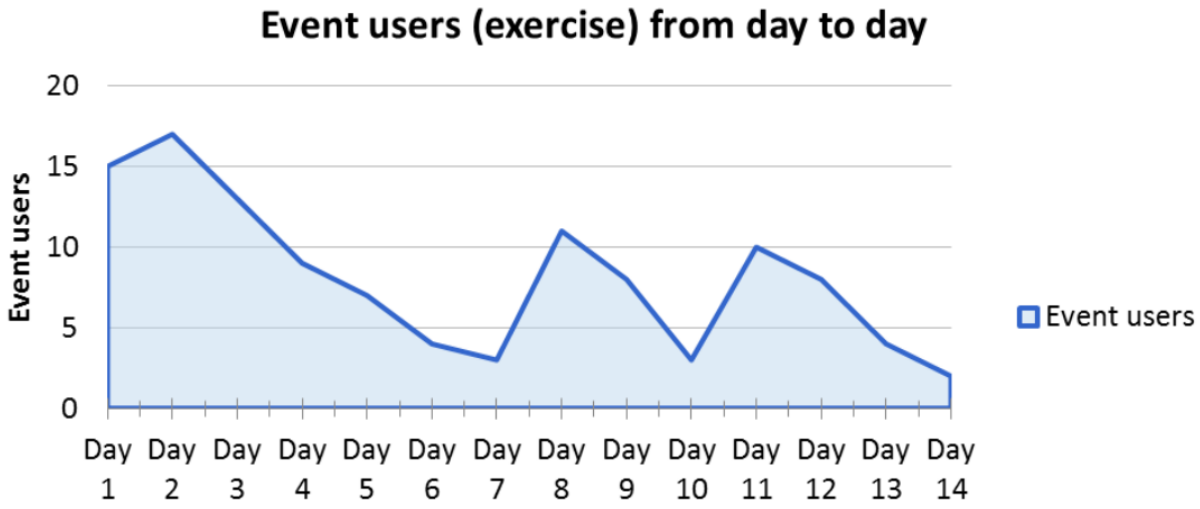

Figure 24.5: *Unique users exercising*

Chapter 25

User Perception Part

The user perception part present results that focus on the player's motivation, enjoyment, and engagement. The results in this chapter are from the survey, observations, interviews, and fabric.

25.1 Survey

As discussed in the Research Methodology part, we categorized our questions in terms of what they could tell us about our research questions. We also asked one general question about each overarching theme. Table 25.1 shows what percentage of people answered disagree or agree with the statements we presented on the players' motivation, where the first statement is the general one.

ID	Statement	Disagree	Agree
S1	I was motivated to play the game before each session	8.3 %	91.7 %
S2	My character's appearance inspired me to work out more	58.3 %	41.7 %
S3	Knowing that my character could die, made me work out harder	62.5 %	37.5 %
S4	I wanted to play more in order to unlock all the exercises	29.2 %	70.8 %
S5	Beating an opponent that previously appeared unbeatable, gave me great motivation to work out	16.7 %	83.3 %
S6	Being able to compare my exermon with my friends', motivated me to improve	37.5 %	62.5 %

Table 25.1: Results of motivational statements

Table 25.2 shows what percentage of people answered disagree or agree in the enjoyment theme of our survey. The first statement is a general statement about enjoyment.

ID	Statement	Disagree	Agree
S7	I enjoyed playing the game	0 %	100 %
S8	I was completely focused on the tasks I was doing	20.8 %	79.2 %
S9	I felt better at the game, the more I played	8.3 %	91.7 %
S10	I felt in control of my what I was doing in the game	20.8 %	79.2 %
S11	It was clear that I was making progress in the game	16.7 %	83.3 %
S12	I was presented with clear tasks to accomplish	33.3 %	66.7 %
S13	I was so engaged in the game, that I became less aware of my surroundings	75 %	25 %

Table 25.2: Results of enjoyment statements

Table 25.3 is what percentage of people answered disagree or agree on each statement from the engagement theme. The first statement is a general statement about engagement.

ID	Statement	Disagree	Agree
S14	I felt engaged in the game	8.3 %	91.7 %
S15	The game was challenging, but it was appropriate to my skill level	29.2 %	70.8 %
S16	I found the fantasy world in the game appealing to me	20.8 %	79.2 %
S17	I was curious on how my exermon would evolve	16.7 %	83.3 %

Table 25.3: Results of engagement statements

25.2 Observations

The observations show that beating friends motivate to improve the exermon's stats, to be able to fight better. One of the test subjects lost a lot of motivation when his friends did not manage to follow his development and therefore it was too easy to defeat them. After the participants had exercised, some hurried back to the image of their exermon, to see if it had improved its visual appearance. Being able to obtain badges clearly motivated two of the females to exercise more to get the next badge. One of the test participants had bought an exercise boost item, before the observation. Because of this, she really tried to maximize the amount of repetitions she could do, to gain the most possible stats.

"It is fun to fight" one of the test subjects says out loud while playing in the arena. The majority of the people who were observed concentrated while playing the game, to do the best they could. We observed that they understood that they made progress in the game, by viewing their rank and stats. When we told the test subjects to play the game, the people were divided in two. Some knew right away what they wanted to do, and went in the arena or found friends to battle with no further explanation. The others felt a little bit insecure about what to do, and needed more instructions on what their next step was going to be. We could see that the players smiled and enjoyed different parts of the game.

From the observations, we saw that everyone we observed had challenges that matched their skill level. This was because they started by working out to improve their stats, and stepped up to the opponent's level. When the players fight, there is background music playing. A few had muted this music, while others moved to the music and enjoyed it. One of the test subjects celebrated his victories, and after defeating a friend shouted out to the friend that was nearby "Hah, I beat you!".

25.3 Interviews

When the eight players told us what was motivating, they focused on different elements in the game. Six of eight was clearly motivated, while two of them had some lack in motivation. Some told us that the rivalry against friends was a huge motivating factor. For others, it was the appearance and development of their exermon and keeping it alive.

Every interview participant said they enjoyed playing the game. Especially the fighting part of the game seen in Figure 13.11. "I was excited" a participant said about the fighting in the game. Two participants said that the exercising got more exciting because you could see the repetitions, increase in stats, and a sound played at every repetition. Although every player had enjoyed playing, three players pointed out that the game gets a little boring in the long term, because of lack of features and monotonous fighting.

The engagement in the game varied a lot. A few felt really engaged in the beginning, but lost it after a while. While some were really engaged in the game, relating to their exermon and trying to achieve the best result possible. "I was really focused while fighting, because I really wanted to win" was the response from a participant. Two of the players said they were lacking in engagement in the game.

25.4 Application Usage Analysis

For the psychological part, we tracked two events to gather data from, fight events and friend view events.

25.4.1 Fights

Figure 25.1 shows how many fight events that were registered from day to day. We can see from the results that there are three main spikes of activity on the fighting. Most fighting activity is also around the first days of the

testing period, but we can also see spikes of activity both around day 8-9 and day 12. The average number of fights per day were at 129.3.

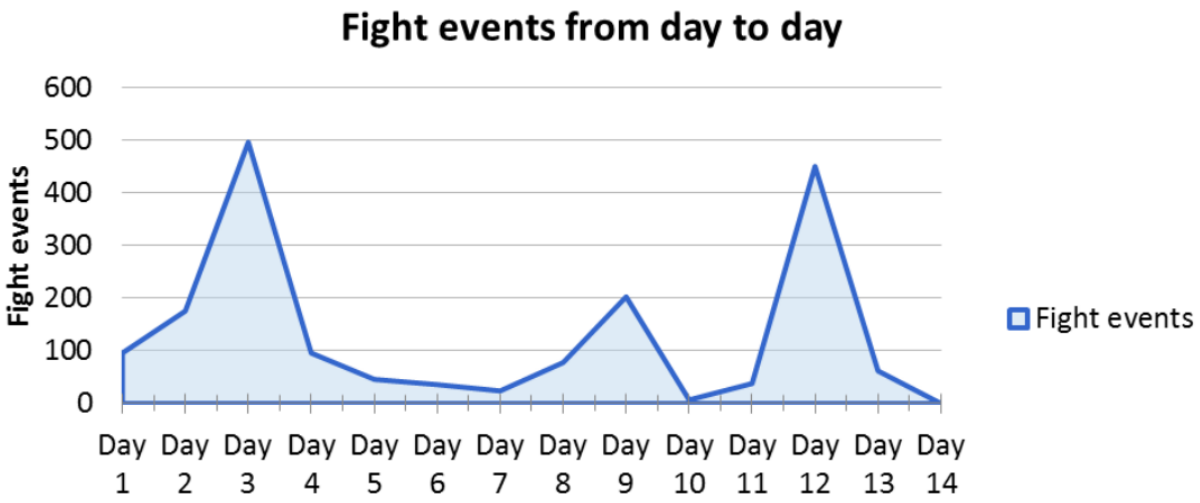

Figure 25.1: *Fight events*

The fight events were categorized into three different categories: Arena fights, friend fights, and boss fights. Figure 25.2 shows what percentage of the fights were in each category.

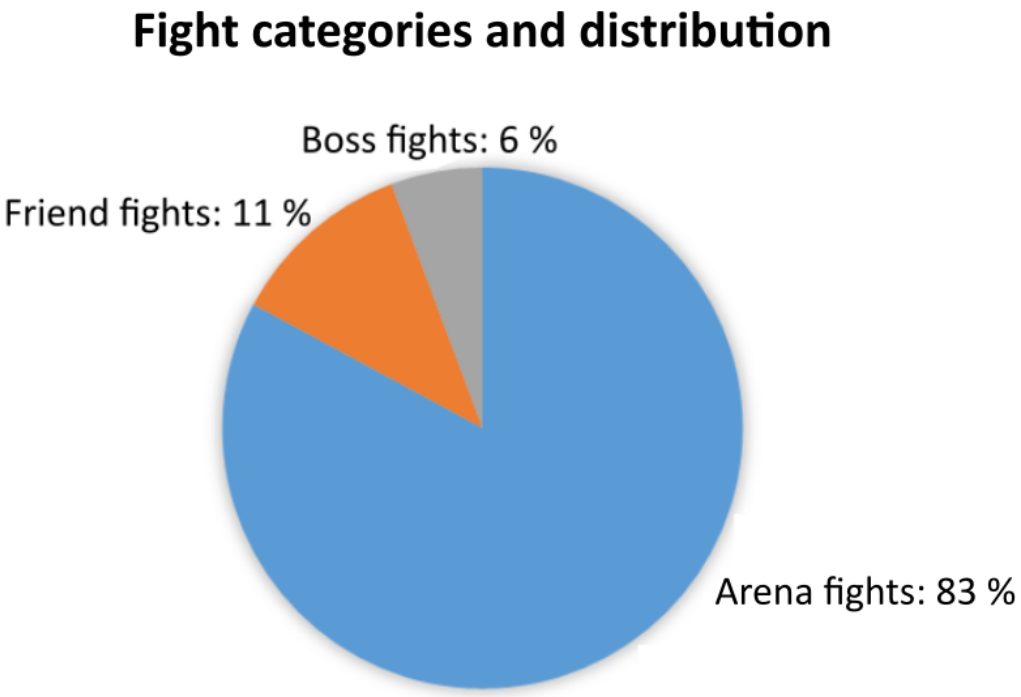

Figure 25.2: *Fight categories*

In addition, we also tracked the number of unique users triggering the fight events, as we did with the exercise events. Figure 25.3 shows the number of unique users triggering at least one event on the given days. We see that the number of users coincides with the number of fights on the given days. What is interesting to note here is that the number of unique users on day 12 is 7, and the number of fight events on this day is at 451. Which means that 7 users managed to play almost the same amount of fights as the 16 users registered on day 2.

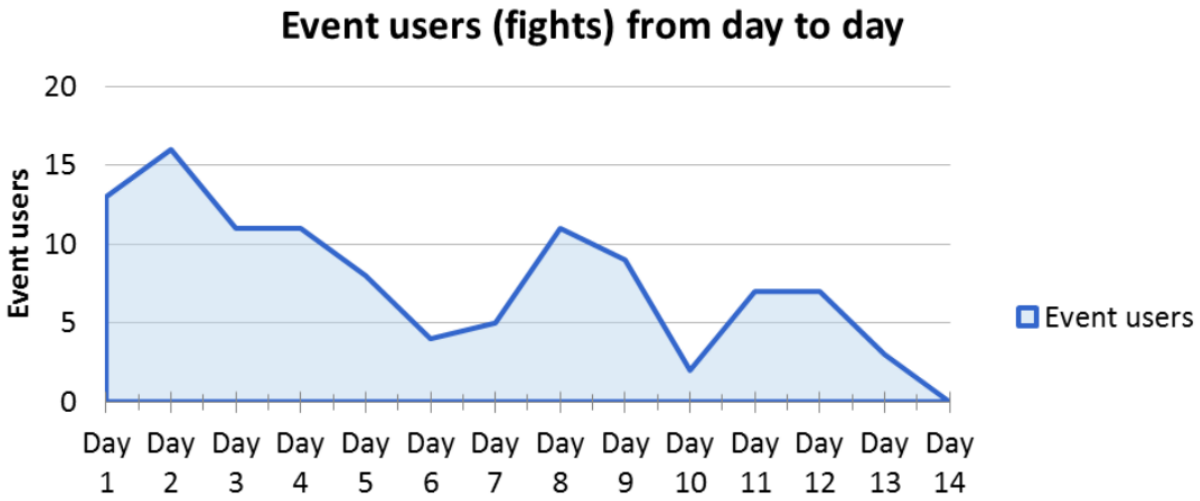

Figure 25.3: *Unique users fighting*

25.4.2 Friend View

To see how many were using the social functionalities in the game, we tracked the number of friend view events that were done throughout the testing period. Figure 25.4 shows the amount of friend views from day to day. The average amount of friend views per day were at 38.7.

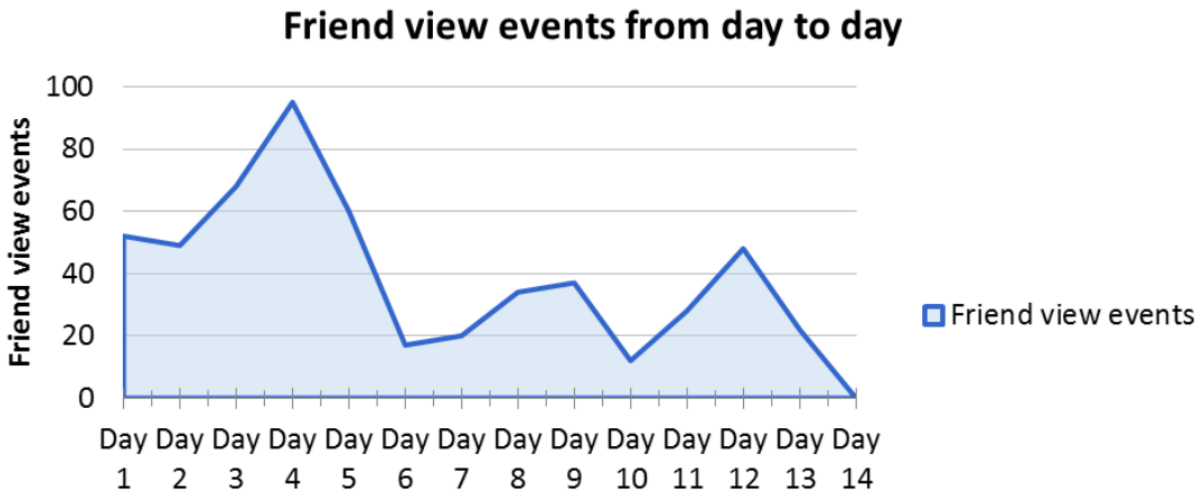

Figure 25.4: *Friend view events*

Figure 25.5 shows how many unique users were doing the friend views. The amount of users is significantly lower than the amount of friend views, and the average event user viewed 9.2 friends per day.

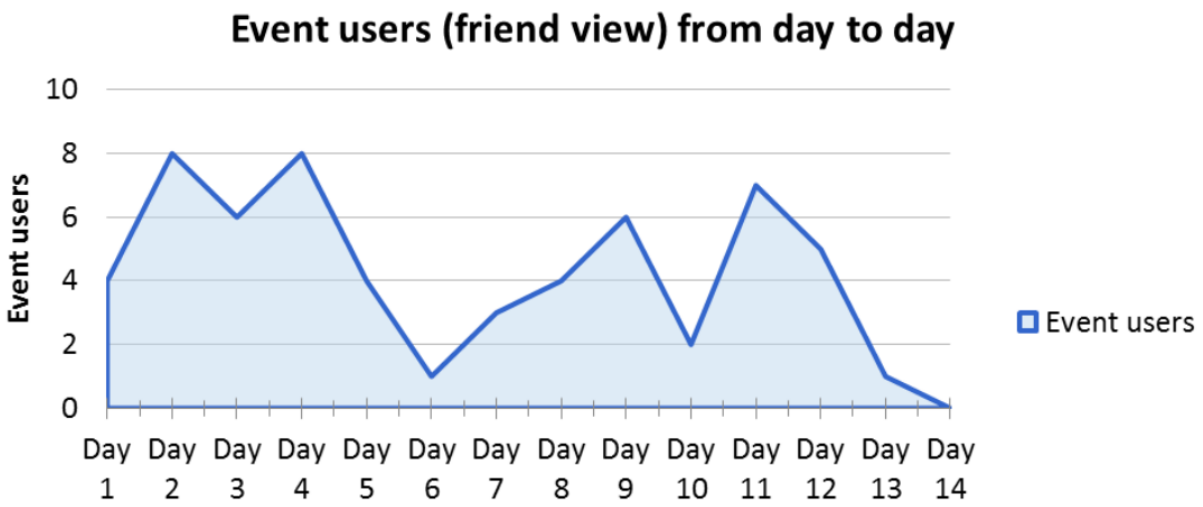

Figure 25.5: *Unique users viewing friends*

Chapter 26

Technological Part

This chapter focuses on how well the users thought the tracking of exercise was. But also if they exploited the possibility to make the game think they are working out, when they are actually cheating instead. The results in this chapter are from the survey, observations, and interviews.

26.1 Survey

In the survey we asked "How well do you feel the phone tracked your movements?", where 37.5 % of the test subjects felt they got about the same number of repetitions as they actually did. While 62.5 % had trouble getting the phone to count the correct number of repetitions when exercising, as seen in Figure 26.1.

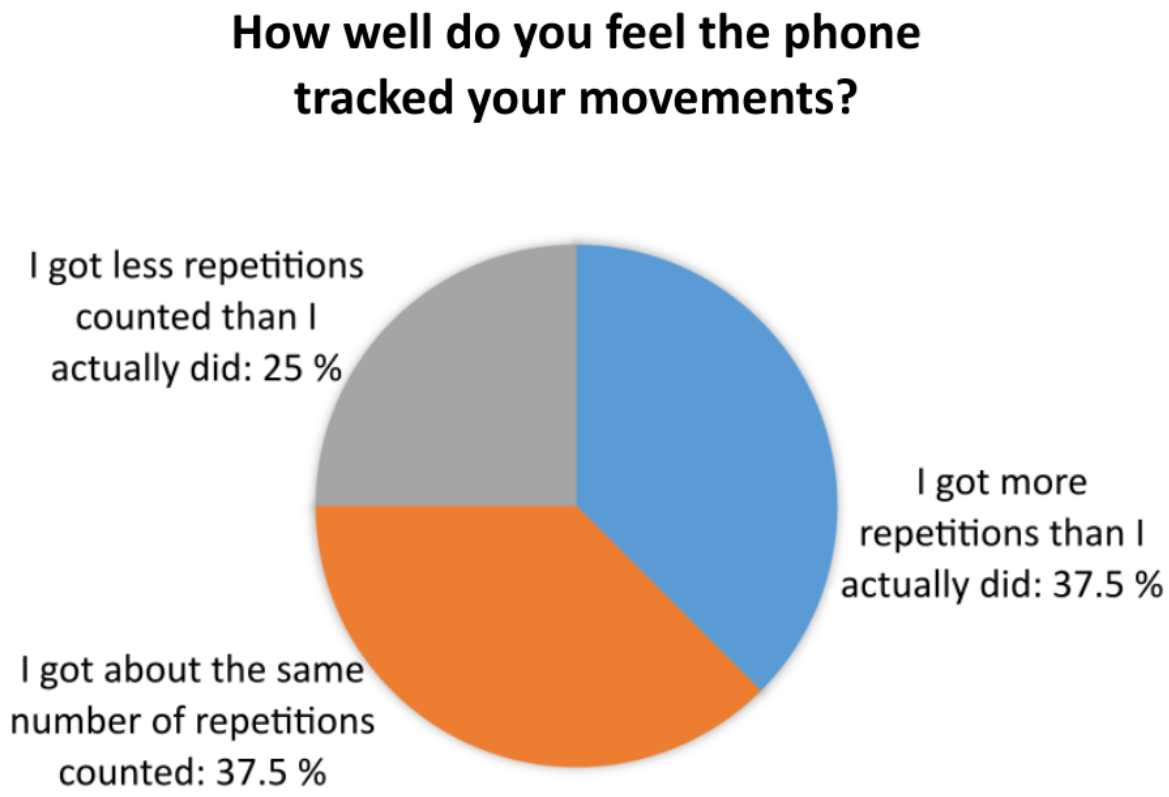

Figure 26.1: *Q3 - How the users thought the phone tracked their movements*

In the game it is easy to cheat, by not doing the exercises correctly. Instead a player could fake the exercises by either shaking the phone or waving their hand in front of the phone. The test participants were asked if they cheated. 70.9 % cheated only a few times or never cheated, while 29.1 % cheated many or all times, as seen in Figure 26.2.

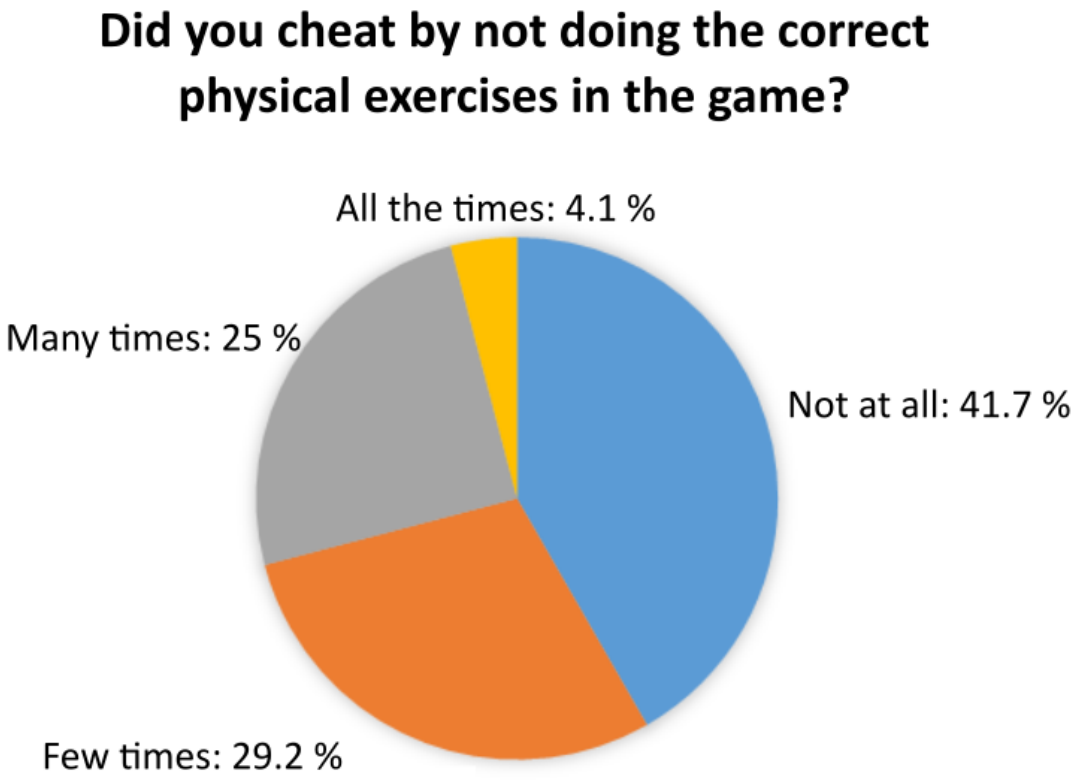

Figure 26.2: *Q4 - Users cheating habits in Exermon*

The persons who cheated had a text field where they could explain the reason for cheating. People that only cheated a few times, had reasons like that they wanted to test which motions on the phone counted the repetitions, to avoid that the exermon died, or the phone had counted the wrong number of repetitions done, so they "cheated" some repetitions to get the correct number. The persons that cheated many times or all the times, had reasons like they wanted to gain stats to beat opponents in the arena, the boss, and friends or they did not want to do a lot of exercising.

26.2 Observations

By observing the players, we saw some variations in how well the phone tracked the repetitions. The majority got exactly correct or had a few repetitions too many or too few. Except for two participants that had problems with the exercise dips, where it counted several repetitions while getting into position and none when actually doing the repetitions. In addition, one person did not receive any repetitions while doing the exercise glute bridge. One had a lower tier phone that was missing the proximity sensor, and therefore did not get any repetitions counted when doing push ups. One of the persons we observed decided to do the exercises without the phone, and afterwards simulated the repetitions by shaking the phone.

26.3 Interviews

Two interview subjects felt that the exercises got tracked really bad. “I lost focus on doing the exercise physically correct, because I was more focused on getting the phone to count the number of repetitions correctly.” was the response from a participant. The six other interview subjects were either happy or almost happy with the exercise tracking. “I feel that the phone tracks my exercises about 80 % correct. I wish an adjust button existed, so I could correct it afterwards.” was said during an interview. Some experienced that for some exercises the phone tracked perfectly, but had more problems with a few other exercises. One of the participants had problems with the phone counting repetitions when getting in and out of exercise position.

Chapter 27

Overall

The participants were asked how often they played Exermon. The majority played the game 1 to 4 times per week, with 87.5 % as seen in Figure 27.1.

Figure 27.1: *Q5 - How often test users played the exergame*

One of the 20 statements took the whole game in consideration (see Table 27.1).

ID	Statement	Disagree	Agree
S20	Overall I really liked the game	0 %	100 %

Table 27.1: Results from the overall statement

Part VI

Discussion

This chapter contains our discussion around our design phase, our exergame, and the results we got through the testing period.

Chapter 28

Designing the Exergame

Due to the limited amount of previous work related to our system, there may be several weaknesses connected to our design process and the game in itself. First and foremost is the lack of documentation and research on the field of exergaming as a whole, as it is a relatively new concept and the games are not yet refined. This may have made our design process lacking in key insight, not yet discovered.

In addition, strength training and technology is also a relatively unknown field, as there are only a couple of systems that record these types of exercises. These systems are also closed for review which makes us blind to the key take-aways that may have been apparent if we could see the source code or data obtained.

Chapter 29

Evaluating Physical Benefits

In Chapter 9 we stated that the recommended weekly exercise schedule consisted of ten to twelve repetitions of eight to ten different exercises, twice a week (ACSM). In Exermon, we made eleven exercises available to be used by the player. Some of these exercises were made available right away, and some were made to be unlocked after a while in order to adhere to dual flow. From the results of the testing, we could see that before the testing period started, 12.5 % of the test subjects did not meet the recommended amount of strength exercise as they did not work out at all. We could also see that 33.3 % were at the line or slightly below if we assume that all of their exercise were strength exercise. We also have to assume here that they did the recommended amount of different exercises. During the testing, the test subjects worked out considerably more than they did previously. All the test subjects did at least work out 1 - 2 times a week which puts them within the recommended amount, or slightly below. Our observations tell us when the players were exercising in Exermon, they were pushing themselves quite hard as they got out of breath, or even telling us that they were tired. Using Fabric, we saw that the average user was doing around 8 different exercises every time he/she exercised in the game. We could also see by the number of unique event users that each test subject worked out at least 2 times per week, which coincides with the data from the survey.

We asked the test subjects whether they felt they improved their strength, because of the game. 37.5 % of our players agreed with this statement. Our interviews also reveal a similar score, as 3 out of 8 said that they got stronger because of the game. There is a close link between the 41.7 % that increased their exercise amount, as seen in Figure 24.1, and the percent of people that feel that they have increased their strength. An argument can be made that this increase in exercise caused the increase in strength. There might also be several other reasons, besides not increasing the amount of exercise, that the

test participants did not feel that the game improved their strength.

Firstly, the testing period only lasted two weeks. This might not be enough time for people to feel that they have significantly improved their strength as this takes time, especially if they only worked out 1 - 2 times a week (20.8 % of the test subjects).

Secondly, the exercises in the game might have been too easy for some of our test subjects seeing that 50 % of them worked out 3-4 times a week or more before the testing started. The interviews also reveal this, as 3 out 8 said they already work out a lot and that the game did not increase their strength. An argument can be made that this was not such a big factor as we asked the test subject whether they felt the exercises in the game matched their fitness level. 83.3 % of the players agreed to this statement.

Lastly, the majority of the exercises were locked in order for the players to progress physically as they played the game more. Seeing that most of our test subjects already worked out a lot, this might only have been hindering them in developing their strength further as the hardest exercises were unavailable until the player had collected enough gold to unlock them. In the comment section of the survey we got feedback relating to this, as some stated that they wanted all the exercises unlocked at once.

Chapter 30

Evaluating User Perception

As per our method, we decided to evaluate the game based on our three overarching user perception themes: Motivation, enjoyment, and engagement.

30.1 Motivation

In the survey, motivation scored reasonably high, as 60 % or more people answered agree to 3 out of 5 of the statements. Two of the questions did not however score as good. 41.7 % of people agreed with the statement *"My character's appearance inspired me to work out more"*, and shows us that the appearance of the character does not necessarily make people want to work out more. The character and its appearance were important to the players however, as many stated that they were curious as to how the exermon would evolve. Through observations, we also got the impression that choosing the right appearance on the exermon were important to the players. One of the observation subjects even said "You guys should make a cuddle mode, where you can get points by cuddling the exermon". The interviews also revealed that they found motivation through development of the appearance of the exermon.

The statement: *"Knowing that my character could die, made me work out harder"* also had a lower agree percentage than the other statements in the theme. This could be due to the fact that we did not inform the test subjects that the exermon would die if one of their stats reached the zero mark. In fact, some of the observation subjects stated that they got really sad when they noticed that their exermon had died, and wished they knew that this could happen if they did not work out. One even suggested giving the users

a push notification a couple of minutes before the death of the character so they could hurry and take a couple of repetitions of an exercise. They also stated that they got more motivated to exercise on their next exermon as to prevent this from happening again.

Beating hard opponents, we found, was a big motivating factor for many of our test subjects. This came through beating the stat development of a friend, or beating a really tough opponent in the arena. For example, we received many requests for a high score table, where one could compare each other's progress and get a more formal type of competition. From Fabric, we could also see that the players continuously tracked their friends' exermon, as to get a status update on their progress.

30.2 Enjoyment

It is very clear that the test population enjoyed playing the game. Every single respondent answered "Agree" or "Strongly agree" on the statement *"I enjoyed playing the game"*. In the prestudy chapter we concluded that flow was a large contributor in making games enjoyable, and it is flow that we used as an indicator on how enjoyable our game was to play. The results from the survey tell us that most of our test subjects experienced some degree of flow while playing the game. This is also backed up by our observations which revealed that our subjects were showing great concentration while fighting in the game, even tensing up if the fight was close. We also saw them celebrating after victory, or looking disappointed after a loss. "I will beat this guy!", one of our test subjects exclaimed after losing several fights in a row. She managed to beat the arena opponent after five tries.

Some felt that the game was unclear when it came to what to do, and how to do it. For example, many struggled with how the combat system worked in the fighting, and did not understand how to hit the opponent. The researchers foresaw this as an issue, and gave a detailed description on how to execute a fight in a user manual when they first distributed the game. One can argue that in order for the players to achieve a better flow state, we should have made the fighting system clearer in the game itself, maybe giving hints or tips on how to do things on the screen, as many will not bother to

read a user manual before jumping into the game.

The survey also told us that not many felt that they became less aware of their surroundings while playing. Due to the fact that the game is played on a mobile phone, with limited screen size and sound quality, it might be harder for people to feel like they are getting sucked into the game and experience immersion. It might also be because the test subjects need to work out after a while and this requires coordination with the world outside of the game.

30.3 Engagement

On the engagement, we had mixed results. From both the survey and the observation, we could clearly see that the players were engaged in the game. The players were moving to the music, commenting on their exermon appearance, and competing with each other to get the highest stats. The interviews, however, revealed that some were not really engaged in the game at all, and some got disengaged after a while as the game became too monotonous.

Because it is an early version of the game, the amount of gameplay is still limited. This might have been why people felt disengaged after a while, as they had played and tested all the different aspects of the game. A more developed game could maybe have prevented this apathy amongst the players. One of the test subjects said that they thought the game had loads of potential, and he was really excited to play the first days of testing, but felt the gameplay was a bit one-sided and that there were too few exercises.

Chapter 31

Evaluating Technology

An important aspect to exergames is the quality of monitoring the exercising. Bad exercise-tracking might ruin the game for the player or make it unplayable. In our exergame, the strength exercises are tracked by the proximity sensor to determine how close the player is, and the accelerometer sensor to sense the player's movement. In the survey only 37.5 % feels that they got about the same number of repetitions counted. The problem is that the rest, 62.5 %, is almost evenly split between getting too many repetitions, or too few. This makes it hard to adjust the sensors for a better fit, because every player does the repetitions a little bit different and has different Android phones with sensor variations. One mistake in the survey might have been asking one question about phone tracking that includes every exercise. Because the observations and interviews reveal that the correctness of the player's phone tracking varies from exercise to exercise. People that took sit-ups often got correct or too many repetitions counted. While observing a test subject take glute bridges, we saw that he got fewer repetitions than he actually did. This might affect the question in the survey, as the players could have had different exercises in mind when answering. Some participants suggested that an extra adjust button could be implemented, that lets the player increase or decrease the repetition count afterwards without doing any movement. This could remove some frustration, as the player could always get the correct amount of repetitions. A side effect might be that the players stop using the phone to track the exercising. This could be a positive thing, since one player said that getting the phone to track the exercise made him lose focus to the correct physical movement.

Tracking the exercises, the way we did, easily allowed the players to cheat by not doing the correct physical movement. Since keeping the game enjoyable and engaging over time relies on the player steering away from cheating, we hope the game has a kind of gentleman's agreement to play the game

honestly. This is especially important when fighting against friends, to not make the game unfair. From the survey we saw that there were some players that really wanted a fast progression in the game, who resorted to cheating because of this. Almost 30 % cheated a lot or all the time, which means that the game probably always will have cheaters. But 7 out of 10 will play the game honest, which is the majority of players.

Part VII

Conclusion and Project Summary

This part will contain our conclusions based on the discussions done in Part VI. We will also summarize our project, by evaluating our work, what we contribute to the exergame field, and our recommendations for further work to be done.

Chapter 32

Conclusion

In the specialization project, we studied existing exergames. We have researched how exergames can use today's technology in order to track body movement. We have also studied video game mechanisms, to find elements for creating a game that is enjoyable to play, engaging, and motivate the players to keep playing the game. Last in the literature study, we looked upon exercise theory, with focus on strength exercise. We used this acquired knowledge in this project, in order to create our own exergame called Exermon, where the goal was to create a motivating, enjoyable, and engaging game with strength training as the form of exercise. In order to measure the quality of the game, we ran tests from various different angles. These tests enabled us to uncover where people found fault with our game, and what they thought was best about our game. These tests gave us answers in accordance to our research questions.

In *research question 1* we wanted to see whether the player was motivated to use the exergame. We discussed theoretically how we could do this in the prestudy part. The theory suggests that this can be done by utilizing rewards and social interactions in the game, as this gave the player motivation for achievement and status amongst his/her friends. In Exermon we implemented this through badges, avatar improvements, and a friend's hut. The tests revealed that the players were reasonably motivated by playing the game. Different players found different aspects of the game motivating.

Research question 2 asked how the player's enjoyment was affected by the exergame. We discovered flow had a very large influence in whether a game was enjoyable or not and we implemented the elements of flow throughout our game, especially while fighting. Our players enjoyed playing our game to a large degree. Every single player found our game enjoyable, even though some of them did not find every game mechanic, related to flow, equally

enthralling.

Research question 3 asked how the player's engagement was affected by the exergame. Challenge, fantasy, and curiosity, we discovered, had an effect in engaging the players in the game. We utilized this in our game by providing players a platform to fight opponents, audio and visual effects, and a vast fantasy world to explore with your very own personalized exermon. Our results show us that people were split when it comes to being engaged in Exermon. Some of our test subjects were really engaged in the game, while others felt apathy towards it.

Research question 4 asked how the player's strength was affected by the exergame. We identified two different training types that could be used to improve strength. We incorporated one of them, bodyweight training, into Exermon. The tests showed us that the rate of exercise had improved on almost half our test participants while playing our game, and the recommended frequency, length, and variety of exercises were met during the two weeks of testing. In spite of this, more then half of the test subjects felt that they had not gotten stronger because of the game.

Research question 5 asked about the quality of the technology and its capabilities on tracking body movement. We identified several tried-and-tested technologies that are capable of tracking body movements. We created Exermon as an Android game as it gave us the proximity and accelerometer sensors. The results on our choice of technology are mixed, as only about one-third of our test participants got the right amount of repetitions counted. The remaining participants got either too few repetitions counted, or too many. The fact that the technology also made it easy to cheat, did not heavily affect the majority of our users as less than a third of the participants cheated a lot.

This project has shown that it is possible to create an exergame with strength training as its exercise component and that the game is amusing. Every test subject agreed that they liked Exermon. The game has huge potential, and with adding and redoing functionalities in the game, we believe it can become even better. We have achieved relative success with implementing the game mechanisms in order to make the game motivating, enjoyable, and engaging, even though the implementation of the technology might have to

be reviewed. In addition, the game leads people to work out more, which gives them numerous health benefits.

Chapter 33

Project Evaluation

The prestudy is an important part of almost any research, and we believe this is the case in this one as well. Especially the part of the prestudy that focused on the state of the art on exergames, and how they succeeded. This gave us invaluable knowledge about what has been done, what has not been done, and what can be done in the field. This sprung us into the idea about making the player able to work on his/her strength while he/she is playing. We also grasped the key aspects on how to make games motivating, enjoyable, and engaging during the prestudy, which helped us a lot and gave us a flying start into this project.

During the development phase we used an online tool called Trello (Trello, Inc.), which helped us monitor the status of the development tasks more easily. We could get an overview of what had been done, what needed quality assurance, what was being worked on, and what was open to start working on. This enabled us to keep a steady pace throughout development and finish up our tasks without delay.

In the exercise part of the game, the mobile phone is using the accelerometer in order to capture the movement of the player. In order for this to work, we had to create an algorithm which recognized the movement pattern of the particular exercise and counted repetitions based on this. This algorithm was hard to implement, as we wanted the players to be able to have the phone in their pocket in whichever direction they wanted. A general algorithm independent of direction of acceleration was desirable. Unfortunately, we were not able to create this, as it became too imprecise and would either count too many repetitions, or too few. Using a direction specific algorithm instead, we were able to get it to an acceptable level of accuracy on all of the exercises, on the researches mobile phones. However, the results from the tests show that the algorithm was too imprecise for the majority of the test

subjects.

The relationship between the researchers and the supervisors have been very positive. With bi-weekly meetings, we managed to quickly get started with development and it kept us on track during the course of the project. They have also provided us with great counselling to all questions we had. The collaboration between the authors has also been impeccable. We have known each other for numerous years and worked on several other projects beforehand, which made the start of the project seamless and without distraction.

Chapter 34

Contribution

To expand the exergaming field, we have designed and created a new exergame called Exermon, whose goal it is to be a motivating, enjoyable, and engaging game which also provide the player with strength training. Exermon shows numerous different ways of incorporating the video game mechanisms discussed in the prestudy part, and shows how we can use mobile technology in order to track body weight strength exercises.

We have tested and evaluated the feasibility of the exergame. We have uncovered strengths and weaknesses with the game, and the technology it is based upon. Most importantly we have shown that it is possible to create a *motivating*, *enjoyable*, and *engaging* game with *strength exercise* as the form of movement in the exergame.

Chapter 35

Further Work

The next natural step for the game is to first re-evaluate whether the mobile platform is the optimal choice of technology in order to track body movement. If this is not the case, steps to port the game over to another platform should be taken, as to remedy the problems with cheating and wrong number of repetitions done. If the mobile platform still is the best option, one should take steps to improve upon the movement tracking to minimize the wrong repetition count or the amount of cheating in the game. We also want to include the iOS users, by developing an iOS application as well. One could also perhaps make extra equipment that can track exercises that the phone is not able to.

When the technology is at an acceptable level we would like to expand the game with more features and better gameplay. Features and improvements currently in the planning stage:

- Add more game items in the shop
- Better/more fighting mechanics
- Implement jogging and rope skipping as an exercise in the game
- Encryption on sensitive data on the server
- Better account management features
- More mini-games for the exermon to compete in
- Real-time multiplayer while fighting friends

- More sounds and better graphics
- Score tracking on friend fights

This list is extensive, and it should take a considerable amount of time to implement, but we believe that they are crucial in order to achieve commercial success. After sensor improvements and these elements are implemented into the exergame, we would like to run another round with testing with a larger test population. This will provide us with new results, about the user satisfaction on the exercise tracking and how well the new features fit into the game. A study with focus on muscle growth and improvement of fitness level during play of Exermon would also be recommended, as we can then say definitely that physical improvements are made through play of the game.

To achieve revenue from the game, we will provide the players with in-app purchases of some items in the shop as well as new exermon characters to buy. To increase the revenue, we also consider implementing ads into the game, but then it is important that they are not intrusive and causes users to uninstall the application. When all of this is implemented and is at a satisfactory level, we will publish Exermon for all to download. In addition to the features and work mentioned above, we will spend resources on marketing, in order to fight the difficulties in being visible for the users in the huge game market that you find today.

References

ACSM. Exergaming. https://www.acsm.org/docs/brochures/exergaming.pdf. Accessed: 2015-11-20.

S. Allender, G. Cowburn, and C. Foster. Understanding participation in sport and physical activity among children and adults: a review of qualitative studies. *Health education research*, 21(6):826–835, 2006.

Appcelerator. Appcelerator main page. http://www.appcelerator.org/. Accessed: 2015-11-20.

Ó. Arias-Carrión and E. Pöppel. Dopamine, learning, and reward-seeking behavior. *Acta neurobiologiae experimentalis*, 2007.

AtariMania. Overview of different foot craz games. http://www.atarimania.com/list_games_atari-2600-vcs-foot-craz_control_16_2_G.html. Accessed: 2016-06-25.

V. R. Basili. Software modeling and measurement: the goal/question/metric paradigm. 1992.

bodybuilding.com. What is the best all compound workout? http://www.bodybuilding.com/fun/wotw46.htm. Accessed: 2015-11-20.

J. Bolton, M. Lambert, D. Lirette, and B. Unsworth. Paperdude: a virtual reality cycling exergame. In *CHI'14 Extended Abstracts on Human Factors in Computing Systems*, pages 475–478. ACM, 2014.

F. Caron. Of gyroscopes and gaming: the tech behind the wii motionplus. http://arstechnica.com/gaming/2008/08/wii-motion-sensor/. Accessed: 2015-11-20.

Centers for Disease Control and Prevention. How much physical activity do you need? http://www.cdc.gov/physicalactivity/everyone/guidelines/. Accessed: 2015-12-11.

Cocos2d. Cocos2d main page. http://cocos2d.org/. Accessed: 2015-11-20.

College of Engineering, CSU. Wiimote lab. http://projects-web.engr.colostate.edu/ece-sr-design/AY08/SKIES/Wiimote\%20Lab\%20revised2.pdf. Accessed: 2015-11-20.

Corona labs. Corona main page. https://coronalabs.com/. Accessed: 2015-11-20.

N. K. Denzin. *The research act: A theoretical introduction to sociological methods*. Transaction publishers, 1973.

Facebook Inc. Facebook social network. http://www.facebook.com. Accessed: 2016-04-27.

M. S. Feigenbaum and M. L. Pollock. Prescription of resistance training for health and disease. *Medicine and Science in Sports and Exercise*, 31:38–45, 1999.

Fitbit. Fitbit surge. https://www.fitbit.com/no/surge. Accessed: 2015-11-20.

U. G. Foehr, V. Rideout, and D. F. Roberts. Generation m: Media in the lives of 8-18 year-olds. *The Henry J. Kaiser Family Foundation*, 2005.

Forsvaret. Fysiske krav. https://forsvaret.no/karriere/krav/fysiske-krav. Accessed: 2015-11-20.

E. Gale. The hawthorne studies—a fable for our times? *QJM*, 97(7):439–449, 2004. ISSN 1460-2725. doi: 10.1093/qjmed/hch070. URL http://qjmed.oxfordjournals.org/content/97/7/439.

Garmin. What is gps? http://www8.garmin.com/aboutGPS/. Accessed: 2015-11-20.

A. Gazzard. Unlocking the gameworld: The rewards of space and time in videogames. *Game Studies*, 11(1), 2011.

L. E. Graves, N. D. Ridgers, K. Williams, G. Stratton, and G. T. Atkinson. The physiological cost and enjoyment of wii fit in adolescents, young adults, and older adults. *Journal of physical activity & health*, 7(3):393–401, 2010.

GSMArena. Samsung galaxy s6. http://www.gsmarena.com/samsung_galaxy_s6-6849.php. Accessed: 2015-11-20.

K. Hagen and S. Weie. Creating an effective exergame with lasting entertainment value. *Norwegian University of Science and Technology, Department of Computer and Information Science*, 2015.

N. Hallford, J. Hallford, and A. LaMothe. *Swords and Circuitry: A Designer's Guide to Computer Role-Playing Games*. Premier Press, Incorporated, 2001.

J. Hamari and J. Koivisto. Social motivations to use gamification: An empirical study of gamifying exercise. In *ECIS*, page 105, 2013.

F. B. Hu. Sedentary lifestyle and risk of obesity and type 2 diabetes. *Lipids*, 38(2):103–108, 2003.

G. R. Hunter, J. P. McCarthy, and M. M. Bamman. Effects of resistance training on older adults. *Sports medicine*, 34(5):329–348, 2004.

International Data Corporation. Smartphone os market share, 2015 q2. `http://www.idc.com/prodserv/smartphone-os-market-share.jsp`. Accessed: 2015-11-20.

ISO/IEC. *ISO/IEC 9126. Software engineering – Product quality*. ISO/IEC, 2001.

S. A. Jackson, H. W. Marsh, et al. Development and validation of a scale to measure optimal experience: The flow state scale. *Journal of sport and exercise psychology*, 18:17–35, 1996.

W. J. Kraemer and N. A. Ratamess. Fundamentals of resistance training: progression and exercise prescription. *Medicine and science in sports and exercise*, 36(4):674–688, 2004.

N. Lewis. 'exergaming'may combat kids' sedentary lifestyles. *Calgary Herald*, 2009.

Lifespan fitness. Health risks of a sedentary lifestyle. `http://www.lifespanfitness.com/uk/workplace/resources/articles/health-risks-of-a-sedentary-lifestyle`. Accessed: 2015-11-20.

J. J. Lin, L. Mamykina, S. Lindtner, G. Delajoux, and H. B. Strub. Fish'n'steps: Encouraging physical activity with an interactive computer game. In *UbiComp 2006: Ubiquitous Computing*, pages 261–278. Springer, 2006.

T. W. Malone. What makes things fun to learn? heuristics for designing instructional computer games. In *Proceedings of the 3rd ACM SIGSMALL symposium and the first SIGPC symposium on Small systems*, pages 162–169. ACM, 1980.

J. McCann. Samsung galaxy edge review. `http://www.techradar.com/reviews/phones/mobile-phones/samsung-galaxy-s6-edge-1286088/review/3`. Accessed: 2015-11-20.

Microsoft. Nike+ kinect training overview page. `http://marketplace.xbox.com/en-US/Product/Nike-Kinect-Training/66acd000-77fe-1000-9115-d8024d53090f`. Accessed: 2015-11-20.

Mobilegyros. Gyroscope in mobiles and tablets. `http://mobilegyros.blogspot.no/`. Accessed: 2015-11-20.

J. Nakamura and M. Csikszentmihalyi. The concept of flow. *Handbook of positive psychology*, pages 89–105, 2002.

Nerd Fitness. Strength training 101. `http://www.nerdfitness.com/blog/2013/02/28/strength-training-101/`. Accessed: 2015-11-20.

NESguide. Overview of different power pad games. `http://nesguide.com/genre/powerpad`. Accessed: 2016-06-25.

Niantic Labs. Ingress main page. `https://www.ingress.com/`. Accessed: 2016-05-25.

B. J. Oates. *Researching information systems and computing*. Sage, 2005.

G. M. Olsen and T. Høivik. Exergame - play to get fit. Technical report, Norwegian University of Science and Technology, Department of Computer and Information Science, 2015. TDT4501, Specialization Project.

W. Olsen. Triangulation in social research: qualitative and quantitative methods can really be mixed. *Developments in sociology*, 20:103–118, 2004.

PhoneGap. Phonegap main page. `http://phonegap.com/`. Accessed: 2015-11-20.

Polar. Polar v800 product page. `http://www.polar.com/nb/produkter/maksimer\_ytelsen/loping/v800`. Accessed: 2015-11-20.

Racermate. Racermater's computrainer page. https://www.racermateinc.com/computrainer/. Accessed: 2016-05-25.

J. L. Read and S. M. Shortell. Interactive games to promote behavior change in prevention and treatment. *Jama*, 305(16):1704–1705, 2011.

RoboVM. Robovm main page. https://robovm.com/. Accessed: 2015-11-20.

Rubymotion. Rubymotion main page. http://www.rubymotion.com/. Accessed: 2015-11-20.

Runtastic GmbH. Push-ups, sit-ups, squats, pull-ups – how our fitness apps work. https://www.runtastic.com/blog/en/technology/pushup-situp-squat-pullup-fitness-apps-work/. Accessed: 2015-11-20.

K. Salen and E. Zimmerman. Rules of play: Game design fundamentals massachusetts, 2004.

Sencha. Sencha main page. https://www.sencha.com/. Accessed: 2015-11-20.

J. Sinclair, P. Hingston, and M. Masek. Considerations for the design of exergames. In *Proceedings of the 5th international conference on Computer graphics and interactive techniques in Australia and Southeast Asia*, pages 289–295. ACM, 2007.

J. Sinclair, P. Hingston, M. Masek, and K. Nosaka. Testing an exergame for effectiveness and attractiveness. In *Games Innovations Conference (ICE-GIC), 2010 International IEEE Consumer Electronics Society's*, pages 1–8. IEEE, 2010.

Slack technologies. Slack. https://slack.com. Accessed: 2016-04-27.

Smartwaytofatloss.com. Nike+ kinect training review. http://smartwaytofatloss.com/nike-kinect-training-review/. Accessed: 2015-11-20.

S. Smith. Army basic training pft. http://www.military.com/military-fitness/army-fitness-requirements/army-basic-training-pft. Accessed: 2015-11-20.

Sports Fitness Advisor. Muscle anatomy & structure. http://www.sport-fitness-advisor.com/muscle-anatomy.html. Accessed: 2015-11-20.

P. Sweetser and P. Wyeth. Gameflow: a model for evaluating player enjoyment in games. *Computers in Entertainment (CIE)*, 3(3), 2005.

Tamagotchi Wikia. Tamagotchi wikia. http://tamagotchi.wikia.com/wiki/Main_Page. Accessed: 2015-11-20.

Techopedia. Accelerometer. https://www.techopedia.com/definition/24430/accelerometer. Accessed: 2015-11-20.

K. Tipton and R. R. Wolfe. Exercise, protein metabolism, and muscle growth. 2001.

Trello, Inc. Trello. https://trello.com/. Accessed: 2016-06-10.

Twitter Inc. Fabric. https://fabric.io. Accessed: 2016-04-27.

Unity3D. Unity3d main page. https://unity3d.com/. Accessed: 2015-11-20.

V. B. Unnithan, W. Houser, and B. Fernhall. Evaluation of the energy cost of playing a dance simulation video game in overweight and non-overweight children and adolescents. *International journal of sports medicine*, 27(10): 804–809, 2006.

R. A. Winett and R. N. Carpinelli. Potential health-related benefits of resistance training. *Preventive medicine*, 33(5):503–513, 2001.

Xamarin. Xamarin main page. https://xamarin.com/. Accessed: 2015-11-20.

Zombiesrungame. Zombie's run main page. https://zombiesrungame.com/. Accessed: 2015-11-20.

Appendices

Appendix A

Exercises

Here we will go through, step by step, how to perform the exercises mentioned in the research and included in Exermon.

A.1 Push-ups

1. Be in plank position with your hands directly below your shoulders (see Figure A.1).

Figure A.1: *Push-up starting position*

2. Lower your body, by bending your elbows, until your torso and legs are aligned (see Figure A.2).

Figure A.2: *Push-up end position*

3. Push yourself to the starting position by straightening your elbows. Keep a straight back, with your head looking towards the ground. Imagine pushing the ground away from you.

A.2 Hang-ups

1. Hang with your arms straight from the bar, palms facing away from you, as you grip it (see 1. in Figure A.3).

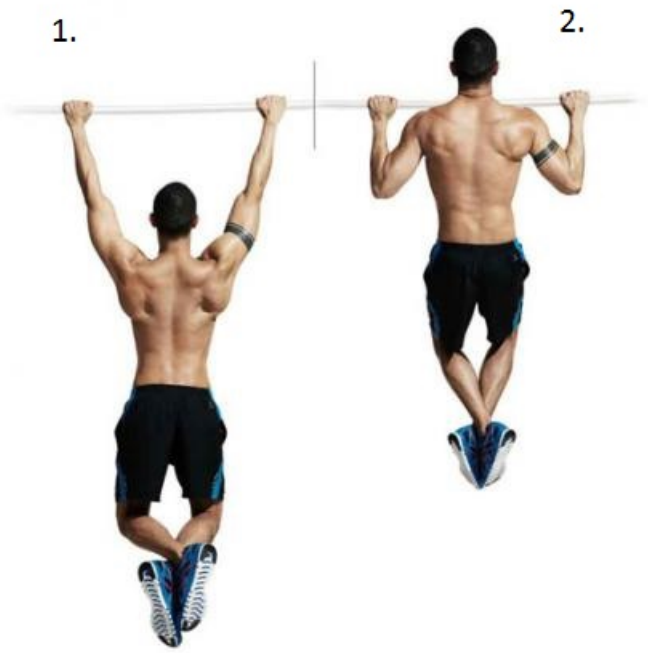

Figure A.3: *Hang-up*

2. In one controlled movement, raise your body up. Your chin should be above your hands (see 2. in Figure A.3).

3. Slowly lower yourself back to the starting position.

A.3 Squats

1. Begin standing up looking straight forward. Your legs should be slightly wider than hip-width, toes turned out slightly (see Figure A.4).

Figure A.4: *Squat starting position*

2. While still looking forward, heels firmly on the ground, and keeping a straight back, bend your knees until your thighs are aligned with your knees. Your head should be aligned with your feet in a straight line perpendicular to the floor (see Figure A.5).

Figure A.5: *Squat end position*

3. While keeping the gaze straight forward, a straight back, and heels on the ground, push yourself up to the starting position.

A.4 Sit-ups

1. Begin by laying on the floor, arms crossed across your chest, legs bent so the soles of your feet touch the ground (see 1. in Figure A.6).

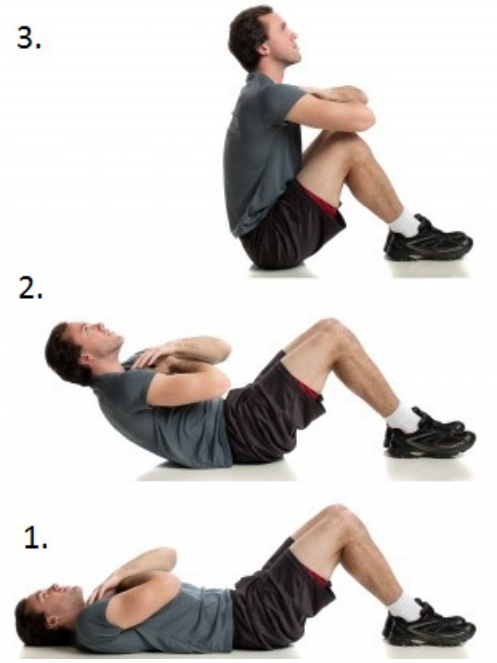

Figure A.6: *Sit-up*

2. Keep your back and neck straight as you raise your torso towards your knees. If you want to do a crunch, stop just before your lower back stop touching the ground (see 2. in Figure A.6).

3. Stop as your back is perpendicular to the floor (see 3. in Figure A.6).

4. Lower yourself back to the starting position.

A.5 Table-ups

1. Start by laying under a table. You should be able to reach the top of the table by stretching out your arms. Position yourself so you have a slight angle from your shoulders to the top of the table. Grab the sides of the table and straighten your back.

2. In one controlled motion, raise your body so your upper chest is at the table (see Figure A.7).

Figure A.7: *Table-up*

3. Lower your body back to the starting position.

A.6 Dips

1. Start by hanging with arms straight from the dip bars (see 1. in A.8).

Figure A.8: *Dips*

2. Lower your body by bending your elbows. Stop when your chest is at the level of your hands (see 2. in Figure A.8).

3. Keeping your body as straight as possible, raise your body up to the starting position.

* If you do not have the equipment you can do the exercise as shown in Figure A.9.

Figure A.9: *Dips alternative*

A.7 Bulgarian Squats

1. Begin by standing straight up with one leg resting on an elevated surface behind you (see 1. in Figure A.10).

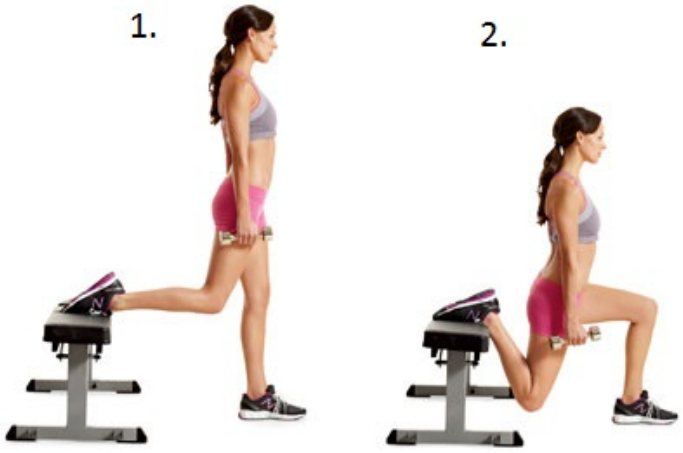

Figure A.10: *Bulgarian squat*

2. Bend the knee of the foot on the floor until your knee and thigh are aligned (see 2. in Figure A.10).

3. Raise yourself up to the starting position.

A.8 Glute Bridge

1. Begin by laying on the ground with knees bent as the soles of your feet are touching the ground (see 1. in Figure A.11).

Figure A.11: *Glute bridge*

2. Raise your torso and feet by pushing your feet towards the ground. Stop when your knees form a straight line to your chest (see 2. in Figure A.11).

3. Lower yourself to the starting position.

A.9 Hanging Leg-raises

1. Begin by hanging with your arms straight from a bar (see 1. in Figure A.12).

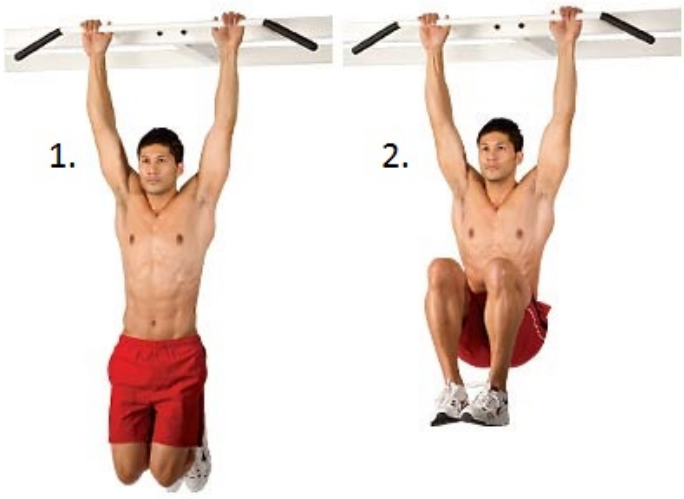

Figure A.12: *Hanging leg-raise*

2. Raise your legs, with or without bent knees, until your knees are ninety degrees on your torso (see 2. in Figure A.12).

3. Lower your legs back to the starting position.

A.10 Pistol Squats

1. Begin by standing on one leg, having the other leg slightly bent in front of you. For balance, it is recommended that you also have your arms straight in front of you (see 1. in Figure A.13).

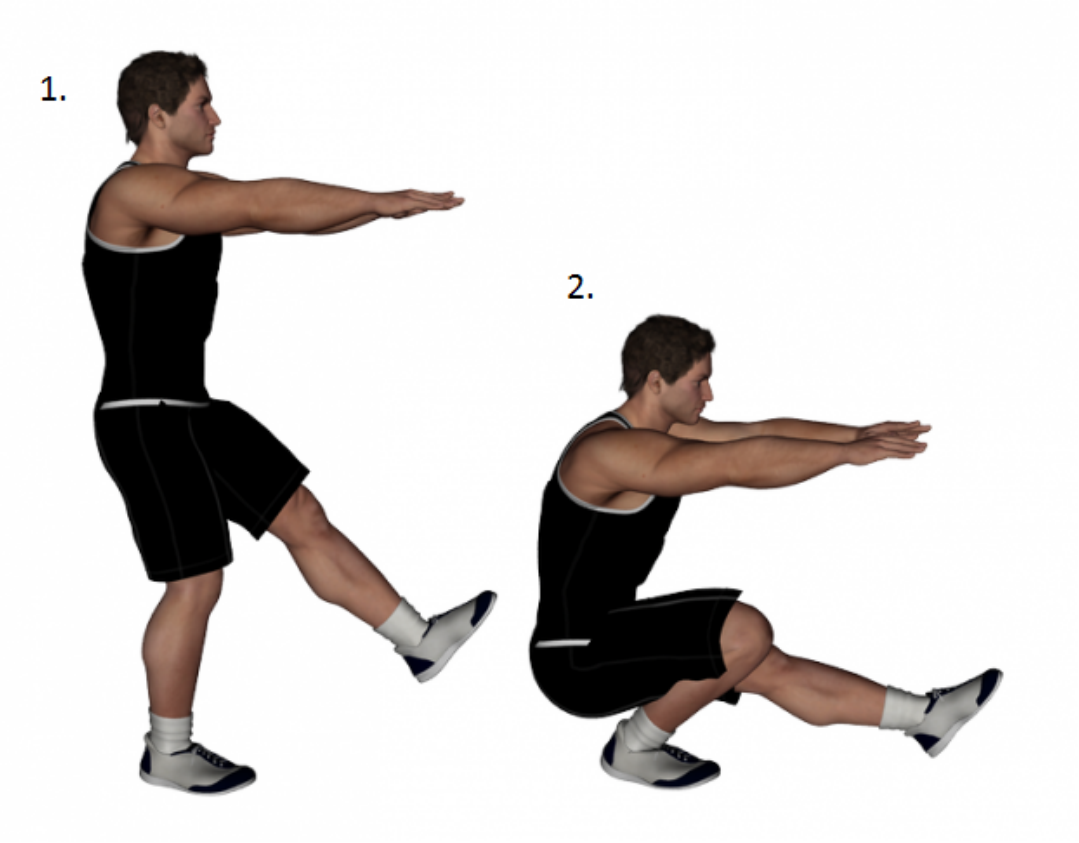

Figure A.13: *Pistol squat*

2. In one controlled movement, lower your body by bending your knees. Your heel should always touch the ground. Keep your forward foot above the ground at all times, and straighten it forward as you lower yourself. Stop when your thighs slightly surpass your knees (see 2. in Figure A.13).

3. Push yourself up to the starting position. Remember to keep a straight back throughout the exercise.

A.11 Handstand Push-ups

1. Begin by standing on your hands, if you need to, use a wall to help yourself keep balanced. Your hands should be slightly wider than shoulder-width apart (see 1. in Figure A.14).

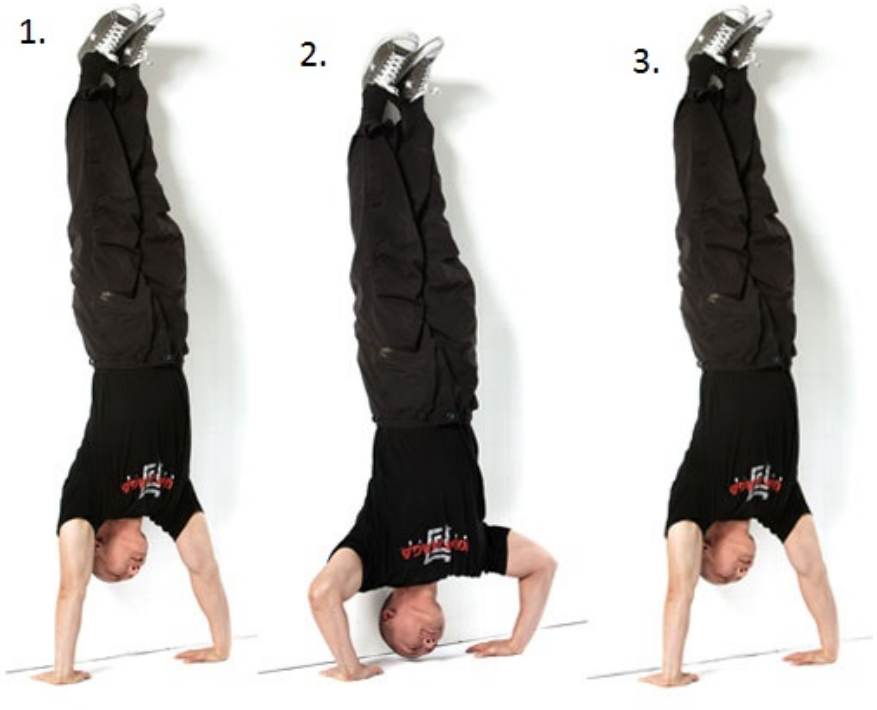

Figure A.14: *Handstand push-up*

2. Lower your body by bending your elbows. Stop when your head touches the ground (see 2. in Figure A.14). You can also stop slightly above the floor as you progress with this exercise.

3. Push yourself up to the starting position (see 3. in Figure A.14). Think that you are pushing the ground away from you.

Appendix B

Exermon Questionnaire

Exermon questionnaire - English

* Required

1. **Gender** *
   Mark only one oval.
   - ◯ Male
   - ◯ Female

2. **Age** *
   Mark only one oval.
   - ◯ Below 15 years old
   - ◯ 15 - 20 years old
   - ◯ 21 - 30 years old
   - ◯ 31 - 50 years old
   - ◯ 51 - 70 years old
   - ◯ Above 70 years old

Frequency of play

By play we mean how often you opened the app, doing something in the game.

3. **How often did you play Exermon?** *
   Mark only one oval.
   - ◯ I did not play the game enough to form an opinion *Skip to question 11.*
   - ◯ 1 - 4 times per week
   - ◯ 5 - 8 times per week
   - ◯ 9 - 12 times per week
   - ◯ 13 times per week or above

Frequency of workouts

4. **How often did you work out BEFORE the testing period?** *
   Mark only one oval.
   - ◯ 0 times per week
   - ◯ 1 - 2 times per week
   - ◯ 3 - 4 times per week
   - ◯ 5 - 6 times per week
   - ◯ 7 times per week or above

5. **How often did you work out DURING the testing period?** *
Mark only one oval.

- 0 times per week
- 1 - 2 times per week
- 3 - 4 times per week
- 5 - 6 times per week
- 7 times per week or above

6. **Answer these statements based on your own experience** *
Mark only one oval per row.

	Strongly disagree	Disagree	Agree	Strongly agree
I was motivated to play the game before each session				
My character's appearance inspired me to work out more				
Knowing that my character could die, made me work out harder				
I wanted to play more in order to unlock all the exercises				
Beating an opponent that previously appeared unbeatable, gave me great motivation to work out				
Being able to compare my exermon with my friends', motivated me to improve				
I enjoyed playing the game				
I was completely focused on the tasks I was doing				
I felt better at the game, the more I played				
I felt in control of what I was doing in the game				
It was clear that I was making progress in the game				
I was presented with clear tasks to accomplish				
I was so engaged in the game, that I became less aware of my surroundings				
I felt engaged in the game				
The game was challenging, but it was appropriate to my skill level				
I found the fantasy world in the game appealing to me				
I was curious on how my exermon would evolve				
I feel that I have improved my strength, because of the game				
I felt that the exercises I did, matched my fitness level				
Overall I really liked the game				

Legitimacy of workout

7. **How well do you feel the phone tracked your movements?** *
   Mark only one oval.

   - ◯ I got less repetitions counted than I actually did
   - ◯ I got about the same number of repetitions counted
   - ◯ I got more repetitions counted than I actually did

8. **Did you cheat by not doing the correct physical exercises in the game?** *
   Mark only one oval.

   - ◯ Not at all
   - ◯ Few times
   - ◯ Many times
   - ◯ All the times

9. **If you cheated, what was the reason?**

Feedback

We are interested in what you thought about the game, and how we can improve it.

10. **Feedback**

Stop filling out this form.

Reasons for not playing enough

11. **What was the reason you did not play enough Exermon?** *
    Check all that apply.

    - ☐ The game did not work on my phone
    - ☐ I did not understand what I was supposed to do
    - ☐ Other reason

12. **Please elaborate the reason**

.....

.....

.....

.....

.....
