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Creating and evaluating an application for motivation through collective exercise

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Abstract

Many systems have been developed over the years with aim to motivate physical activity and behavioural change. The process is complex, and is often necessary to implement several strategies. Integrating the user's social context could increase motivation, and is a common approach for adding an extra incentive to exercise. This thesis investigates how theories about social interaction has enforced systems for motivating exercises.

A recurring feature for social applications, are some variation of collective exercise. Collective exercise in real life yields many advantages compared to exercising alone, and could therefore be an important asset. Most systems with a collective exercise approach, is mainly based on the activity being performed alone. It was identified a technology gap, and was the motivation for the application created in this thesis.

For this purpose, it was created an application based on two friends performing an activity together. The app is suppose to motivate during an exercise and runs partly on smart-phone and smart-watch. The concept is based on social comparison, social learning and social facilitation. The app creates a virtual running environment by visualising the user and his friend, and motivates through the feeling of collective exercise.

The results of this work is a review over previous attempts for motivating physical activity in relation to social interaction, a description of the app created, an open source code base available for reuse and an evaluation of the app with users. It was identified a general lack of longitudinal studies on behaviour change systems, and this also applies to this study. Further work should focus on testing the app in a more controlled setting during a longer period of time.

Sammendrag

Mange systemer har blitt utviklet med formål å motivere til fysisk aktivitet og atferdsendring. Denne prosessen er kompleks, og det er ofte nødvendig for å kombinere flere strategier. Integrering av brukerens sosiale kontekst en vanlig tilnærming for å øke motivasjon tilknyttet fysisk aktivitet. Denne oppgaven undersøker hvordan teorier om sosial interaksjon har blitt implementert i systemer for å motivere fysisk aktivitet.

Å skape følelsen av å trene sammen med en venn, er en gjennomgående motiveringsstrategi. Kollektiv trening kan gi mange fordeler sammenlignet med å trene alene, og kan derfor være en viktig ressurs. De fleste systemer med en kollektiv trening tilnærmelse er hovedsakelig basert på at aktivitetet utføres individuelt. Dette har blitt identifisert som et teknologigap og har vært motivasjonen for utviklingen av systemet i denne oppgaven.

For dette formålet, ble det utviklet en app basert på at to venner utfører en aktivitet sammen. Systemet er laget for å motivere under trening og kjører delvis på smart-telefon og smart-klokke. Konseptet er basert på sosial sammenligning, sosial læring og sosial tilrettelegging. Appen skaper et virtuelt løpemiljø ved å visualisere brukeren og vennen hans gjennom hele treningsøkten.

Resultatet er en vurdering av tidligere forsøk på å motivere fysisk aktivitet ved bruk av sosial interaksjon, en beskrivelse av appen utviklet, en åpen kildekode tilgjengelig for gjenbruk og en evaluering av appen med brukere. Det ble identifisert en generell mangel på langtvarende studier på atferdsendrings systemer, og dette gjelder også for denne studien. Videre arbeid bør fokusere på å teste appen i et mer kontrollert miljø og i løpet av en lengre periode.

Preface

This thesis completes my master's degree in informatics at the Department of Computer and Information Science at the Norwegian University of Science and Technology. This project was conducted from January 2016 until December 2016.

I want to thank my supervisor Professor Konstantinos Chorianopoulos from the Department of Informatics at the Ionian University in Corfu, Greece, for providing me with an exciting master thesis project and giving me valuable guidance throughout the year. Thank you for continue helping during autumn 2016.

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I also want to thank all the participants for being part of the experiment and give me valuable feedback.

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Chapter 1

Introduction

1.1 Lack of exercise: a public health challenge

Insufficient physical activity is a global health problem, and according to WHO this applies to 80 % of the world's adolescent population [1]. Obesity is one of the world's most prevalent health issues, with 600 millions adults suffering from obesity in 2014 [2]. Staying healthy is not only about the absence of sickness, as WHO defines it, "health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" [3].

Obesity increases the risk for type 2 diabetes, coronary heart disease and different types of cancer and can be curbed through physical activity [4] [5]. Motivation is a determinating factor in the exercise habits of an individual and can be strongly influenced by new technologies as shown in a growing body of evidence [**?**]. Motivating physical activity and behavioural change is a complex process, and often requires a combination of techniques.

1.2 Motivation to exercise through technology

Technology for promoting physical activity has evolved the last couple of years, and developers try to find new and exciting ways of motivating. Smart-devices with sensor technology are becoming cheaper and better, and enable new ways of promoting physical activity. According to Medie Norge, own 81 % of all Norwegians a smart-phone [6]. There are a variety of apps and devices targeting physical activity on the market and the sensors can monitor more and more of our physical performance [7] [8] [9]. Social interaction is a common approach in motivating physical activity, and technology enables the possibility to virtually exercise together. This could increase motivation and performance and will be a focus area in this research [10] [11].

1.3 Motivation to exercise through collective exercise

Many people enjoy exercising together and benefit from social learning [12] and team spirit. Gockley et al. did a study on women aged 18 - 45 on how social influence has an impact on health, and found out that 83 % would prefer to exercise with a friend and 76 % would share progress and goal with another person [13]. Being nudged to exercise by friends or having an exercise buddy are important motivational factors [14].

Exercising together is important for motivation and performance [15] [16] [17] [18] [19] [20]. Social facilitation theory suggests that people increase their performance in the presence of others [15]. The impact social is complex and depends on the level of competition, task complexity and the intensity of the interactions. Studies show that competition leads to increased performance and motivation [16] [17].

People do want to exercise with friends and family, but planning and coordination may be challenging. According to the Norwegian Directorate of Health, four out of ten do not want their exercise routines to be constricted to certain days or points in time. [14]. Technology should focus on enabling whats impossible in real-life, virtually possible, for instance actualising past events. This will be another focus area in this research.

1.4 Research questions and report outline

This thesis is divided in three main analyses with their own sub research questions.

1.4.1 Research questions

Behavioural change research suggests that technologies developed with strong ties to theory have larger outcome effects than those without it[21]. A recurring challenge, including for commercial apps promoting physical activity, is the lack of use of available research[22] [23] [24]. When constructing prototypes of apps aiming at increasing motivation to exercise, it is important to bear in mind the successes and failures of previous attempts. The first part of this thesis will therefore include a review of relevant literature (Chapter 2) and practical applications (Chapter 3). The aim is to answer the following research question:

1. Which theories and practical applications have used **social interaction** and

technology to increase users' **motivation** to exercise? What are their limitations?

The second part of this thesis will describe an attempt to create an application that uses social interaction to increase motivation to exercise. Developing the prototype implies design choices linked to the interface and the features (Chapter 4) and the building of technical architecture (Chapter 5). The aim is to answer the following research question:

1. How can **collective exercise** be implemented in an app aiming at increasing **motivation** to exercise?

The third and final part of the thesis focuses on the results of the prototype evaluated in an experiment. The methodology for the evaluation is presented (Chapter 6) before introducing both qualitative and quantitative results (Chapter 7). How the app effected motivation will be discussed (Chapter 8). The aim is to answer the following research question:

1. How can the app be **evaluated** with regards to its effect on **enjoyment**, **performance** and **motivation**?

The last chapter will be a reflection over the work done in this thesis, and indications for further work.

1.4.2 Relevant definitions

Social interaction refers to "particular forms of externalities, in which the actions of a reference group affect an individual's preferences. The reference group depends on the context and is typically an individual's family, neighbors, friends or peers" [25]. Social interaction is ingrained in the user's social context.

Social context, will in this thesis be referred to as the user's social network of friends, family and acquaintances.

Collective exercise, will in this thesis in general be referred to as virtual collective exercise.

Motivation is defined as "the hypothetical construct used to describe internal and/or external forces that produce invitation, direction, intensity and persistence behaviour" [26]

Evaluation is defined as "to judge or determine the significance, worth or quality of"[27] and will used the following variables:

- **Enjoyment**, is defined as "the possession, use, or occupancy of anything with satisfaction or pleasure" [28].
- **Performance**, is defined as "the manner in which or the efficiency with which something reacts or fulfills its intended purpose." [29].
- **Motivation**

1.4.3 Scope

This thesis only focuses on the social aspects on how apps are affecting motivation for exercise. Concerns related to aesthetics and user-friendliness are outside of the scope of this analysis. These elements are considered secondary when studying the link between social interaction and exercise, and are therefore not included. They are however relevant for further research. The app being a prototype means that challenges linked to large scale implementation such as privacy, releasing or integration to social media are not taken into account. The prototype was only functional on one smart-phone and smart-watch, and lacked the features necessary for broad download and use by several users.

1.5 Research design and methods

This thesis is designed as exploratory research, meaning the aim of the research has been to gather attitudes and thoughts about a new concept [30]. An exploratory research design was chosen in order to not exclude or ignore any interesting findings. Both qualitative and quantitative research methods has been used during this research, and will be elaborated in chapter 6.

Chapter 2

Literature Review

2.1 Review methodology

The initial project chosen was "Design for behaviour change with emphasis on wellbeing in relation to physical activity". The chosen area was social interaction, and this chapter will elaborate different techniques and theories in relation to that.

The literature study began by searching databases for relevant articles and theories, the search terms were among others "social interaction", "exergame", "physical activity and technology", "personal informatics", "wearables", "behaviour change system", "motivation". From these search words, 100 articles were chosen to investigate further, a selection of these will be presented in the section below.

2.2 Motivation theory

Motivation is described as being the key for an individual to be persistent with a task or regime, and is hence important for getting people to exercise [26]. It is often described as the key for an individual to be persistent with a task or a regime and is the drive behind why an individual chooses to repeat a certain action.

There are two types of motivation; extrinsic and intrinsic. Extrinsic motivation is performing an activity because the reward or consequence that follows after, and not for the activity in itself. For instance, exercise because of the health benefits that follows, and not because it is pleasurable or fun. Intrinsic motivation is when an individual choose to behave a certain way because the action is rewarding in itself, for instance playing a sport because it's fun.

An important theory in relation to intrinsic motivation is the self-determination theory [31]. This theory states that motivation, integrity and human development is grounded in the individuals relatedness, autonomy and competence towards an action. "People are inherently motivated to feel connected to others within a so-

PRINCIPLE	NEED
Relatedness	Connect to personal goals
	Connect to a meaningful community of interest
	Create a meaningful story
	Beware of social context meanings
Competence	Provide interesting challenges
	Provide clear, visual and well structured goals
	Provide juicy feedback
	Beware of unintended behaviors
Autonomy	Play is voluntary
	Beware of losing autonomy
	Beware of devaluating activity

Table 2.1: The self-determination theories principle of intrinsic motivation [1]

cial milieu [relatedness], to function effectively in that milieu [competence], and to feel a sense of personal initiative while doing so [autonomy]". Creating intrinsic motivation in technologies for promoting physical activity is thus important. Behavioural change techniques is different ways to implement theories with aim to explain why individuals change behaviour [32].

Almost all the systems and techniques described in this review, is a combination of several approaches. Motivation and behaviour change are a complex process and it requires a combination of many approaches to successfully motivate. This review will describe the main concept in the different categories.

2.3 Social interaction

Evidence suggests that integrating social interaction in technologies has an impact on motivation. The terms highlighted below are different social motivational strategies or theories proven to motivate physical activity.

Bandura's **social cognitive theory** states that people through observing others are influenced to behaviour change [12]. When observing others, people remember the sequence of events and can choose to replicate the action. This is related to social learning, people learn behaviour through observation.

Social influence could lead to **social pressure**. Social pressure could motivate in relation to team **cooperation** and **competition** [33] [10]. Being on a team with others could lead to pressure to perform. Studies has showed that compe-

[1] table inspired by https://daim.idi.ntnu.no/masteroppgaver/010/10903/masteroppgave.pdf p.18

tition tends to leads to increased performance and motivation [16] [17]. Malone and Lepper on their work on intrinsic motivation, suggest that social competition and cooperation are powerful motivational factors [34]. Triplet suggest that the competitive aspect in relation to the sights of another performing the same activity lead to a "greater concentration of energy" [16].

Social comparison is a common approach, and **social comparison theory** predicts individuals to gravitate behaviour to others they are around [20]. This theory was confirmed in a study done by Thomas Plante et al. The participants performance was increased when exercising with someone in better shape [35]. Luszczynska et al. argue that behaviour change can occur when observing others, due to an individual's need to act socially acceptable [36]. The findings of the study was that perceiving friends eat healthy and exercise, leads to increased exercising and healthy eating. Other studies suggest that engaging in the same physical activity as others, increases the likelihood of joining and staying motivated during the exercise [18] [19].

Social facilitation theory states that people can increase their performance when others are present [15]. The impact social presence have is complicated and affected by evaluation context, task complexity and the amount and type of presence.

The **social-ecological model** focus on how the social, physical and the political environment must constitute and support behaviour change [37]. The individual himself has most influence on his own behaviour, whereas the social environment is the next most important determinant of behavioural change. American Horsepower challenge is a system based on this model [38]. 15 schools and 577 students competed against each other to win a virtual race. The schools earned points based on the students step count. The whole school environment was supporting the competition, and teachers facilitated and helped the students in incorporating more walking. The study concluded with reduced effectiveness over time, but managed to provide insights on how environmental factors could plays a role in an individuals physical activity level. **Social support** is another approach that has been proven to motivate physical activity [39]. Social support is based on friends and family tracking or viewing one's exercise, and provide motivational feedback. This approach is very common for commercial applications [40] [7] [41].

Social context and intrinsic motivation are closely related, and could create more meaning to a system. Friends and family are meaningful to most people, and if implemented properly the system can become something more than just a system. It can become something to discuss and talk to friends about. This is based on the "relatedness" principle of intrinsic motivation. Motivating though social context is something this research will focus on.

2.4 Gamification

Gamification aims at motivating exercise through making an activity more fun and engaging. It requires introducing game design elements in non-game contexts [42]. The main objective of gamification is to make activities that are not very engaging more fun and compelling by introducing game elements.

When searching for "Exergame", this approach was naturally used in the articles retrieved and has been proven to motivate exercise [43] [44] [45]. Exergame are a mixture of an exercise and a game. There are variations of exergame applications with different levels of gamificatiom from console based with a physical interface to only a few game-elements [46] [10].

In a review of gamification approaches for encouraging daily physical activity, they had a minimum of two game-elements and maximum of nine. The most common game-elements was rewards and competition [47].

Adding social interaction could enhance the experience by making it more meaningful and add additional incentive to earn points and badges [10] [43] [48]. In the game StepCity, the goal is to compete against friends on building a crime free city [44] . The users earn currency based on the step count each day to buy buildings. The study concluded with increased physical activity for the participants.

Reviews on gamification applications has concluded with many systems ignore interpersonal differences with users [47] [49]. This especially applies to to competition and cooperation. Some users are demotivated by competition, and finds it unnecessary, while others are find it motivating [50] [10]. Developers are being encourage to implement more choices in this regard.

2.5 Personal informatics

Personal informatics is an approach for reflection over own personal information captured by technology [51]. This approach is popular for encouraging behaviour change, and can be used in areas ranging from physical activity, health and conserving energy [52] [53] [54]. Personal informatics is related to the cognitive dissonance Theory, which is mainly about how people strive for internal consistency. Some people may have contradictory beliefs, which could lead to dissonance [55]. This is linked to how people wish to be more physically active, and through reflection and awareness can "strive for internal consistency". Studies shows that minimal logging of exercises has positive effect on physical activity [52].

Social interaction in combination with personal informatics has been proven to have powerful motivational effect [56] [33]. In a study about the system "Houston", the participants were asked to log their steps every day and share the results with

friends. The sharing aspects added a social incentive to increase physical activity and was appreciated by the participants. Combining personal informatics and social interaction is a common approach. Sharing of exercise data, goals and progress adds another reason for becoming "internal consistent".

ChickClique aims at motivating "cliques" of girls by having them share their daily step count with each other [33]. A study showed that group performance was the most motivating element for users. This is an example on how one can take advantage of the users existing social context in combination with personal informatics. Sharing of exercises leads to awareness over others physical activity, and can influence and inspire to behavioral change [12].

The goal setting theory in combination with personal informatics is another common approach [57]. This theory focusing on the importance in setting a goal when it come to performance. A goal is defined by what a user want to achieve or trying to do consciously and has been proven to have powerful motivation effect related to physical activity [56].

Commercial mobile apps often rely on this type of feature. For example iPhone's Health app can capture all kinds of health-related data [**?**]. Both from the iPhone's built in sensor and external sensors one can connect with bluetooth. The data can be displayed for the user to analyse, and even be incorporated into a person's electronic health record.

2.6 Persuasive technology

Technology with aim to change behaviour or attitudes with persuasion and influence, is called persuasive technology [58]. Persuasive technology is said to be design with intent, because so many design patterns for persuading behavior is developed [59]. Almost all systems described in this chapter is a persuasive system.

According to Fogg's behaviour model, must three elements be present for behavioural change through persuasive technology, as displayed on 2.2 [60].

The three types of motivation is according to Fogg what drives individuals to behaviour. For instance, fear of being unhealthy could motivate to better eating habits. Several types of ability, or simplicity factors must be present or not a limitation. This relates to how *simple* it is for an individual to choose to change behaviour. This varies for individuals and context. For some people time could be a general limitation, for others time could be a limitation one week. The goal is to find out what is simple/the ability for the target users in a system. The last element, trigger, is used to ask an individual to perform an behaviour. Spark is related to in-situ motivation and real-time feedback. Facilitator is how to make the performance of the behaviour easier, for instance automated activity recognition. Signal function as reminder. This could for instance be a reminder on progress

ELEMENT	COMPONENT
Motivation	Pleasure/Pain
	Hope/Fear
	Social Acceptance/Rejection
Ability/Simplicity	Time
	Money
	Physical Effort
	Beware of unintended behaviors
	Brain Cycles
	Social Deviance
	Non-Routine
Trigger	Spark
	Facilitator
	Signal

Table 2.2: Fogg's three elements of persuasive technology [2]

towards goal.

Health coach approaches are examples on technology that implements Fogg's model. This could be as simple as providing the user with information about progress towards a goal, "Google Fit", is a smart-phone app with this function [61]. The user can state a step count goal each day, and the app provides information on progress towards that goal throughout the day. The user can decide a goal himself, which relates to the ability element, and the feedback about progress towards goal is the trigger.

Another health coach approach is the system GymSkill. The system monitors and assess the user's performance by using a smart-phone and a balance board [62]. The handheld device captures data from the balance board, and provides the user with feedback on performance. This is an interesting approach on giving professional, personalised and automated feedback and guidance by using persuasive technology.

Kukkonen highlights the importance of social commitment and social influence for persuasion to happend [58]. Social commitments are important for staying cognitive dissonance. Persuasive Systems should implement an easy way of communicating this to friends and family. Based on Fogg's principle's on mobility and connectivity, he suggests several principles for designing social support, these are social learning, social comparison, normative influence, social facilitation, cooperation, competition and recognition [63]. These are similar to as those mentioned

[2]table inspired by https://daim.idi.ntnu.no/masteroppgaver/010/10903/masteroppgave.pdf p.20

in section 2.3. Recognition is referred to as giving rewards.

2.7 Feedback mechanism

Feedback is very important for systems encouraging behaviour change according to DiClemente et al. [53]. In their article they differ between three types of feedback, **generic**, **targeted** and **personalised**.

Generic feedback provides an individual with general information relevant for the entire population it belongs to. For instance information about health benefits connected to physical activity.

Targeted feedback is rather general, but more individual that generic. This could be feedback based on clothing size or gender. This feedback is based on the targeted population, and not the individual.

Personalised feedback is the most individual type. This type of feedback involves assessment of the individual. Systems for motivating physical activity often relies on actively providing motivation, hence personalised feedback is preferable.

Different types of health coach systems as described in section 2.6 are based on personalised feedback. Feedback on scores or status was the most common mechanism in the gamification systems review in [47]. Feedback on status related to goal-setting was also common. According to Groh is juicy feedback important for intrinsic motivation in gamification applications. This is in relation to the self-determination principle of competence [64] [34].

Live or real-time feedback is necessary for providing motivational cues during an exercise and has been proven to increase performance, enjoyment and fun [45], [11]. Live or real-time feedback could be visual, audio or in form of vibration. Live feedback is often necessary in exergames, where status on score and progress are important for play.

Visualisation of performance during an exercise is a real-time feedback approach commonly used in commercial exercise applications. This has been used for encouraging users to achieve exercise goals [65]. In an analysis done of the top free fourteen running applications on the market in 2013, had all applications visual feedback [65]. Providing the user with distance, time, calories burned and pace. The apps also provided map visualisation.

There are however some drawbacks related to visualisation. It could distract users from the running environment, and has been stated as a safety concern in several studies [45], [11]. An approach for avoiding this, is audio feedback. Voice messages from friends and familiy is another common approach for commercial applications [7] [41]. Music has also been suggested to have motivational qualities [66] [67].

ONTRACK is a study on how to use audio as navigation. The system takes

advantages of the listener's own desired to listen to music in order to navigate. It manipulates the music the user is playing for indicating the direction and distance to location. The study concluded that the system could effectively navigate people through complicated routes [68].

2.8 Summary

This review has described many different approaches for motivating physical activity and behaviour change. There are advantages with all the approaches described, and it is often necessary to use a combination of several techniques. The aim with this review has been to get familiar with the topic, and identify interesting aspects to bring further in this research.

Chapter 3

Practical applications

The following chapter will present and investigate seven research prototypes and six commercial applications in regards to their implementation of social interaction. The last sections will identify recurring features and shortcomings with the presented systems. The chapter will end with implications for a prototype.

3.1 Research Prototypes

This section will present seven research prototypes.

3.1.1 Fish'n'Steps

Fish'n'Steps is a persuasive application with aim to increase daily physical activity[50]. The application is a web interface connected to a pedometer. The interface consist of a fish in a tank, and the goal is to keep the fish healthy and tank clean by walking enough steps. Each participant has a personalized goal each day and the closer to the goal, the happier and healthier are the fish. Two versions was created for experimental purposes, an individual and a collaborative. In the collaborative version, teams up to four members share a fish tank. They "walk" together towards a clean and healthy fish tank. Each participant can identify the least healthy fishes from participants who haven't walked enough steps. The participants were however anonymous, only nicknames were used.

This application was a catalyst in its field and provided a fun and original mapping of physical activity to a fish tank. The participants thought the game was encouraging and fun at the beginning, but after some time the excitement about the game decreased as the game was repetitive. The game is influenced by several social motivation strategies such as comparison, influence, cooperation and competition. The participants however felt the competition aspect was in-

compatible with the theme. The participants were anonymous and the socialness in the game, occurs after the activity is over, which could make the social motivation questionable. The system do have chat implemented, but this feature wasn't popular.

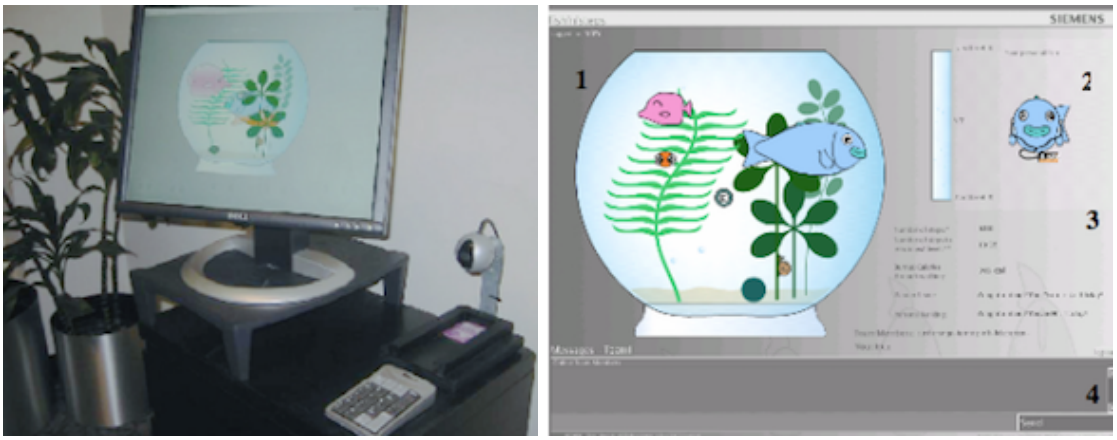


Figure 3.1: Fish'n'Steps

3.1.2 Into

Into is a persuasive mobile phone application allowing to walk virtually from one location to another [43]. The user creates a challenge, for instance "travel from Helsinki to Tampere" and can either travel alone, or invite friends to collaborate with. All team members progress combined are displayed on the map as a vitrual trip. Information about each team member's progress is also displayed in a list, available for all team members to see. Depending on how fast the team is walking, they have an animal representing them. When they reached the destination they are rewarded with a badge.

The concept is similar to Fish'N'Steps, but differs in how the data is presented and contextualized. The game is influenced by several social motivation strategies such as comparison, influence, cooperation and competition. Team cooperation and competition aims to create a feeling of exercising together towards a common goal. As with Fish'n'Steps, the application is only social after the activity is done, live social interaction is absent, which may decrease the motivational effect.

Figure 3.2: Into

3.1.3 HealthyTogether

HealthyTogether is a mobile application that compares social incentives in a gamification setting [10]. The goal of the application is to increase the user's daily physical activity level. The application has three modes, competition, cooperation and hybrid. Pairs of users operates together in all modes, these pairs are called "dyads". The goal of the game is to earn badges, which they get from a collection of karma points. They earn karma points based on their step count, distance traveled and floors climbed. In cooperation mode they earn badges together, in competition mode they earn them on their own. The hybrid mode combines the two.

The application has a similar approach as the two previously presented. The step count is visualized and based on the social mode and the goal is to cooperate or compete. The motivation aspect comes from witnessing other users' physical activity and exchanging messages, which was highly associated with increased step count. Even though the activity is performed individually, provides the application some kind of social support through the message exchange which the user appreciated.

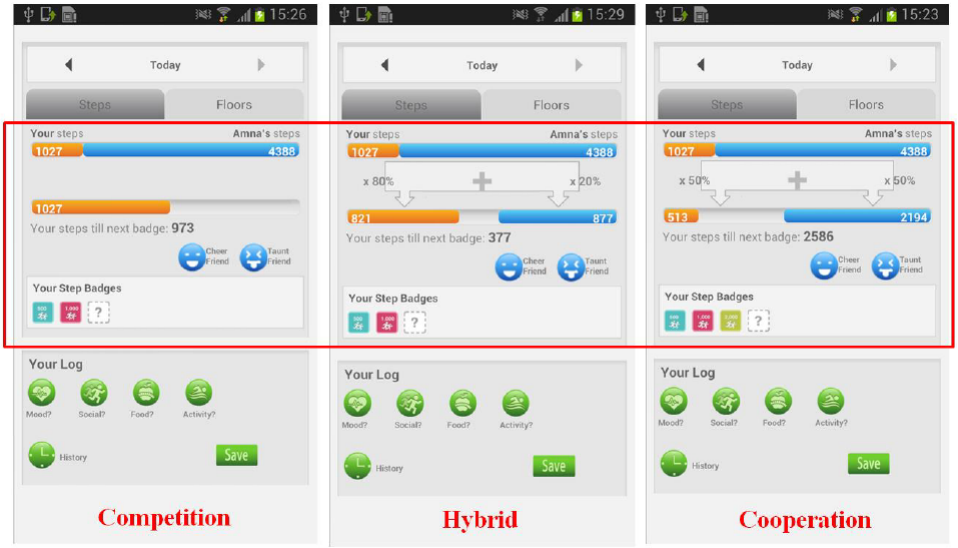


Figure 3.3: HealthyTogether

3.1.4 Swan Boat

Swan Boat is a race game where team collaborate to control the direction and speed of a boat using an interactive treadmill with a screen and wearable sensors, to win against other teams [45]. The team members are in charge of a direction each, so for steering in one direction the user in charge has to either slow down or increase the speed on the treadmill. The wearables consist in a sensor bracelet and a Player Space Director, which can be used to attack the opponent boats. The game has support for playing together or play distributed over the internet.

This system aims at increasing motivation during structured exercise, which is different from the three systems already mentioned. It is an original way of mapping between treadmill and gameplay. The aim of the system is to provide a fun way to do structured exercise, and it relies on live social feedback throughout the activity.

Figure 3.4: Swan Boat

3.1.5 Jogging over a distance between Europe to Australia

"Jogging over a distance" (Jogging) makes it possible for two geographically separate users to virtually run together [11]. The system consist of headphones, a microphone and a heart rate monitor. The headphones and microphone enable communication between two users during a run. The heart rate monitor measures the user's exertion, which is used for knowing each others location. The users states a preferred heart rate before using the system, which is used as a baseline. The sound in the headphones is then adjusted based on the heart rate. This system, as with Swan Boat, aims at increasing motivation during exercise, and has social real-time feedback throughout the activity. The system focus on physical effort rather than performance, making it possible for two users with different physical shape to exercise together. The system is influenced by social motivation strategies such as comparison and social influence.

Figure 3.5: Jogging the distance

3.1.6 Social Fabric Fitness

Social Fabric Fitness (SFF) isa wearable e-textile display for in-situation motivation of runners in a group environment [69]. The display is connected to a smart-phone that transmit tracking data from the run and to the display, the runners also wear a heart rate monitor on their chest. The display is mounted on a runner's back during the run, and shifting between displaying the runner's pace, duration and heart rate, so all other runners can see it. The aim of the study was to investigate how the runners feel about displaying this information to the other runners, and how the others runners are affected by seeing the information.

Motivation comes from the social pressure to keep up with the other runners. The system aims to take advantages of the user's social context and desire for running with other people. It focuses on awareness within a group, compared to Jogging that focuses on the relationship between two geographically separate runners. The authors mentioned that the display does expose information about the users to everybody, that could be sensitive, for instance heart rate. The system is also influenced by social motivation strategies such as comparison and social facilitation.

Figure 3.6: Social Fabric Fitness

3.1.7 RUFUS

RUFUS is a bit different from the other technologies [39]. This system has aim to support long distance runners during their race, through communication from supporters. The supporters can send three types of cheers through a web interface. The web interface sends the signal to an android phone connected to a wearable bracelet. The wearable bracelet has three different colored LEDs lights and a vibrator. The type of LED that lights depends on the feedback sent by the supporter.

The wearable device has one button that the runner can use to communicate back to the supporter, when he for instance wants more cheering.

The system provides real-time feedback from friends and family, and allows social interaction during the activity. Motivation comes from social support and is original because it focuses on supporter-runner relationship rather than runner-runner like the two mentioned above.

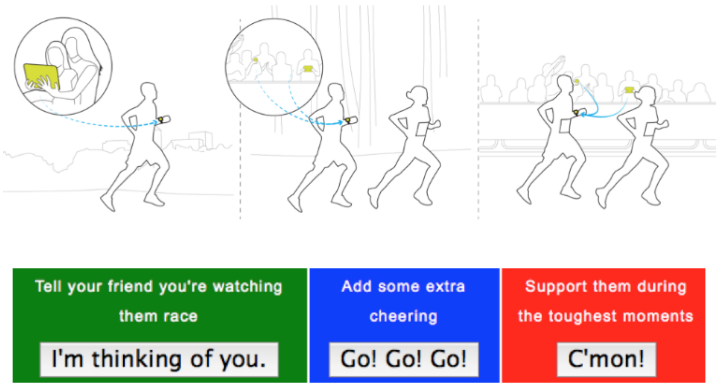


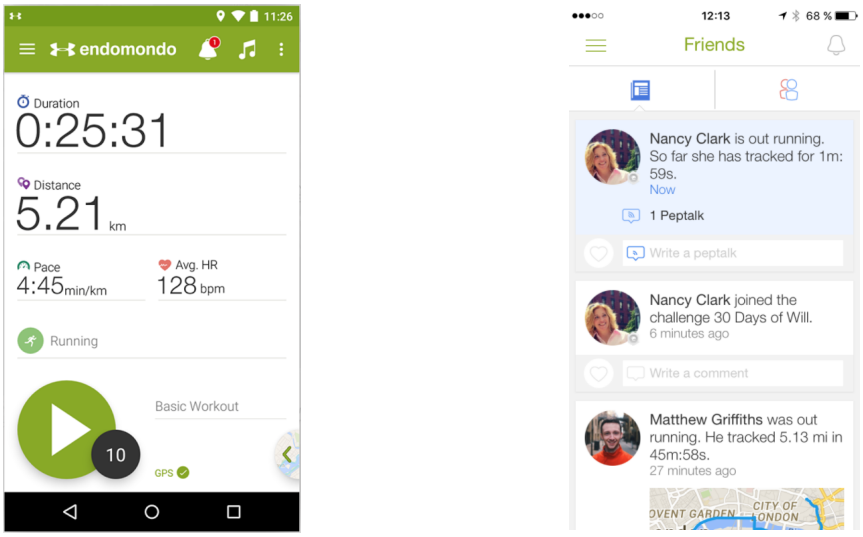
Figure 3.7: RUFUS

3.2 Commercial applications

Commercial apps that encourage exercise have also relied on using social context and collective exercise. This will be review in the sections below.

3.2.1 Endomondo

Endomondo is a popular app for motivating and tracking a broad range of physical activities [7]. The app is first and foremost a running application for tracking calories, distance and pace. The user can choose between different feedback during the activity like map visualisation, distance, calories, or a combination. Social aspects like sharing results on social media, newsfeeds and challenge and compete with friends are integrated as seen on figure **??**. The app have a "Pep Talk" feature, that enables the possibility for friends to send live voice messages to those exercising. This require the user to share their workout on Endomondo's website. Endomondo is available for smart-phones and smart-watches.



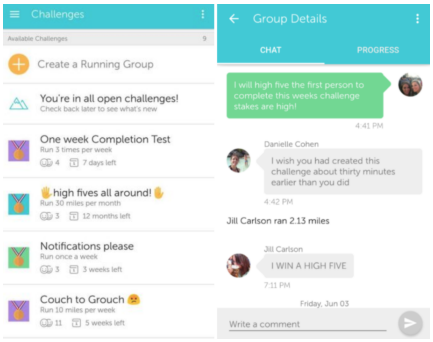
(a) Running screen

(b) Friends news and peptalk

Figure 3.8: Endomondo

3.2.2 Runkeeper

RunKeeper is another app aiming mainly at tracking runs [40]. The app has many of the same features as Endomondo including challenges and sharing on social network such as Facebook. The user can chose between different types of feedback, for instance map visualisation, distance and pace. Runkeeper has a group running challenge feature, as displayed on figure **??**. This feature is based on a group of friend joining a challenge to run a certain distance or frequency in a time span. They can chat and encourage each other. The run itself is individual, the user has to upload the run when it is finished. Runkeeper also has another interesting feature which is Runkeeper Live. When this feature is activated, friends and family can go to the users public profile and locate the user during the whole run. Runkeeper is available for smart-phones and smart-watches.



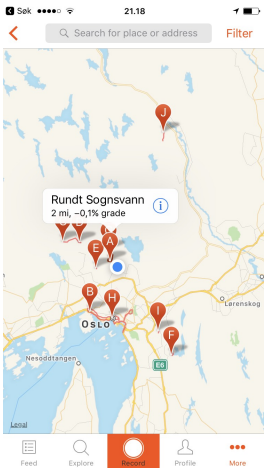
(a) Challenges and running group

(b) Smart-watch interface

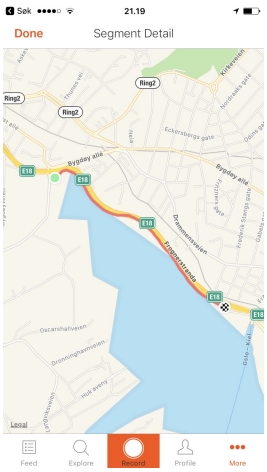
Figure 3.9: Runkeeper

3.2.3 Strava

A popular app called Strava is also about tracking runs, and has the same tracking functions as the two already mentioned with map visualisation, pace and distance [8]. What separates Strava from the other approaches is the possibility to search the a massive database for routes to run. The routes are divided in segments and each segment has a leaderboard. Figure 3.10a, displays segments in the Oslo area. Figure 3.11b displays details about the segment. The segments are uploaded by users all around the world. The motivational aspect is to compete against the leaders or friends and family. It is also possible to upload your own routes and segments, so other can run it. The segments has leaderboards for each week, month, year and overall. Strava is available for smart-phones and smart-watches.



(a) Available segments nearby

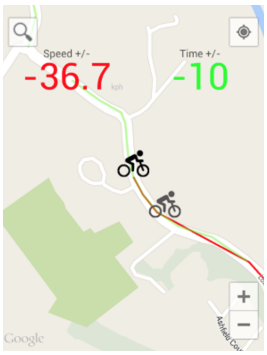


(b) Segment details

Figure 3.10: Strava

3.2.4 GhostRacer

GhostRacer is another running and cycling app based on tracking and saving routes [9]. The main function is to compete against yourself and beat your own record. It has real-time feedback based on previously recorded routes. The user will see himself as a "ghost" running or cycling on the map. The ghost will function as a pacemaker as seen on figure . Additionally it has real-time voice feedback about time and distance. It has social features like leaderboards and challenges.



(a) Displaying the ghost on the map

(b) Displaying comparison data

Figure 3.11: GhostRacer

3.2.5 Nike+ run club

Nike + run club is a tracking app with main focus on tracking, coaching and running together, hence the name "club" [41]. It claims to have motivated millions of runners. The "run together" element is based on comparing and competing with friends and with leaderboards. The run in itself is not social though, it is based on the user running a route, then sends a challenge to its friends to beat the time. It has one live feedback feature called "Cheers". Before a user head's out running, he can share it on Facebook. Each time a friend "likes" the post, the runner will hear a cheer. As seen on figure 3.12, are the concept based on performing together and being part of something together. The visual interface is very similar to the other apps mentioned, with possibility to see map, distance and pace.

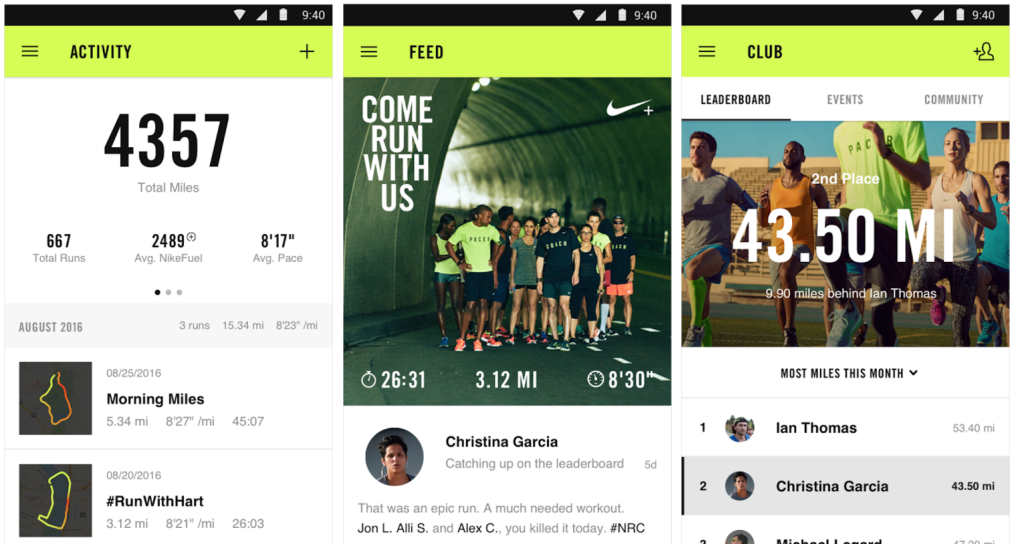


Figure 3.12: Nike + Run Club

3.3 Recurring features

Different social aspect and features has recurring and is presented in the sections below.

3.3.1 Social context

The above mentioned systems and applications all rely on social context as a powerful motivational factor. This can create more meaning in a system according to

the self-determination principle of relatedness, and is important for intrinsic motivation [31]. This is reinforced when participants know each other. In Fish'n'Steps for instance, the anonymity of the game curbed the users interest for social interactions. Participants often identify the use of social context as more motivating [10] [39] [11].

All of the commercial apps rely on social context as an additional incentive through social media. This will automatically integrate the user's social network. Sharing of workouts, challenging friends, leaderboards etc. are features that take advantage of the user's social context. Runkeeper and Nike+ Run Club have "running together" features, based on the user's commitment to reach goals together with friends and family. SFF takes advantage of already established running groups and created a system to enhance that experience. Jogging, is based on friends desire to run together and creates an opportunity for users who are geographically separated.

Social interaction could imply variations of outcome and content. Strava for instance, depends on users sharing jogging routes to function properly. In this way there are always new routes to run. Variations and gameplay opportunities are important for a system to be motivating in the long run. Many apps have newsfeed based on friends sharing their workout or similar, this will often have new content. Sharing of workout could be inspiring for others.

3.3.2 Feedback

All of the systems described have social feedback to a different degree. Social feedback stems from input from the user's friend. The social feedback in Fish'n'Steps, Into and HealthyTogether is an overview over their teams progress, as seen on 3.2 and 3.3. This is presented after they have walked a certain amount of steps. Both Fish'n'Steps and HealthyTogether has additionally chat possibility. The participants in Fish'n'Steps thought it was awkward to use due the anonymity, while it was associated with increased step count in HealthyTogether.

The social feedback provided from the "running together" activities in Runkeeper, GhostRacer, Endomono and Nike + Run Club [1] is provided to the user after the activity is over. This is for instance group chat about challenges or news feed displaying their friends results. This can be seen on the figures 3.9a, 3.8a. During the activity, the feedback is mainly based on individual performance. This implies motivation from the social feedback is limited during the physical activities and there are no feedback related to both (or more) performing the activity together. In all the commercial apps can the user chose between map visualisation, distance travelled, calories burned or a mixture. In GhostRacer are the user additionally

[1] except for the special live features

exposed for a pacemaker based on previously performance as seen on 3.11a.

The possibility to share exercises on social media is a common approach for all of the apps, and can receive social support from like on posts. As described above, many apps have live social feedback based on social support. RUFUS and SFF use the Runkeeper Live feature. RUFUS use this feature for supporting the runners and send cheer signals. SFF used it to track the runners pace, duration and distance.

SFF, Swan Boat and Jogging have live social feedback, based on a friend performing the same activity. The feedback in SFF, is the runner information displayed. In Swan Boat, the game is dependent on live response from the other players to function properly. The feedback provided in Jogging are sound from the headphones, which is based on the runners talking in microphones to each other.

3.3.3 Collective exercise and social support

In the systems described are social interaction mainly based on two concepts, virtual collective exercise and social support. Collective exercise implies performing the activity together or enhancing the feeling of doing it together. Social support is based on friends and family tracking or viewing one's exercise, and provide motivational feedback. Technology enables the possibility to provide social interaction when being geographically separate, this section will discuss how the systems have manage to implement this.

Collective exercise is a recurring feature in all technologies described in this chapter, but integrated to a different extent. Fish'n'Steps, Into and HealthyTogether requires the participants to walk enough steps to complete a challenge or goal together. Endomondo, Strava and GhostRacer have a compete-with-friends or challenge-friends feature. Both Runkeeper and Nike+ Run Club have a feature called "Running together". Actual exercise performed individually is common for these systems. This implies the activity to be only social before or after, not during. For the systems described in this chapter, this is in correlation to social live feedback.

The systems that actually have live feedback based on an activity performed together are SFF, Swan Boat and Jogging. How much collective exercise feeling Swan Boat yields could be questionable. Swan Boat is the type of exergame described in chapter 2, dependent on a physical interface. This type of systems is more focused on motivating through gaming rather than exercising together. SFF is dependent on the users running together in real life. Jogging is the only system with aim to motivate during an exercise based on both performing the same activity, at different locations.

Endomondo (Pep Talk), Runkeeper (Live), Nike+ Run Club (Cheers) and RUFUS have social live feedback based on a friend and is social during the activity.

The feedback is however based on social support and not collective exercise.

Many systems with collective exercise have the actually activity performed individually, other systems have social support during the activity. For those systems with the actual exercise performed together, live feedback is in correlations to this. This implies both (or more) of the users being present at the same time.

3.3.4 Autonomy

People do want to exercise together, but collective exercise requires planning and research suggest that four out of ten do not want to plan their exercises [14]. This is related to loss of autonomy. Autonomy is referred to as independence of freedom, and is also a principle in the self-determination theory about intrinsic motivation. Loss of autonomy could lead to demotivation [31]. This was mentioned as problematic in Jogging, since the participants were at different timezones. Collective exercise do require both participant being present at the same time, but technology should focus on making what is impossible in real life, virtually possible.

3.4 Motivation from collective exercise

It is not incidental that collective exercise and social support is important. Theories and studies concludes it could increase performance and motivation. In HealthyTogether, the participants wanted to be more physically active because their buddy was present. In SFF felt many runners pressure to perform better since others could see their personal information. One participant in Jogging claimed he ran further than he would otherwise. Sharing exercises or challenge friends approaches are created for increase performance and motivation.

There are however different motivation provided from social support and collective exercise. Social support is based on getting feedback based on individual performance. Collective exercise is based on doing it together and could increase performance and motivation from competition, social comparison, social facilitation, social influence and social learning [15] [16] [17] [18] [19] [20] [36]. These are strategies proven by evidence to facilitate motivation, and is not induced by social support

The participants in Jogging and HealthyTogether mentioned how they were motivated by the fact that they were in it together, they were going through the same thing. By having both performing the activity, the user can relate to each other, and perhaps feel more a togetherness or team spirit. The message exchange in HealthyTogether made the participants feel a sense of presence and was associated with increased step count. Observing their friends increasing daily step count influenced the participants in HealthyTogether and Into to walk more

steps. Sharing workouts on social media is based on the same concept. Being aware over others physical activity induce social comparison and social influence, which again leads to behavioural change [20] [12]. In jogging, the participants appreciated the sense of social presence, and they felt it was good to exercise virtually together with a friend.

As described, many advantages arise from collective exercise. The level of social presence will naturally enhance the collective exercise experience. Some motivational aspects of collective exercise will not yield if the level of social presence is limited, this is for instance motivation given from feedback during an exercise. The sight of another performing the same activity could lead to a "greater concentration of energy"[16]. This approach is called pacemaking and was mentioned by the participants in SFF to positively increase performance, and is also a part in GhostRacer. One goal should therefore be to provide feedback based on both performing the activity, during the activity.

3.5 Limitations

Some limitation has been identified with the described systems, regards to their evaluation and how the collected exercise is implemented. This section will elaborate this

3.5.1 Validity concerns

As seen on table 3.1, there are clearly a lack of longitudinal studies. Fish'n'Steps is the only study that lasted more than two weeks, with a total duration of 14 weeks, 4 weeks pre-intervention 6 weeks intervention and 4 weeks post-intervention. HealthyTogether had three different groups and it lasted for two weeks, one control week and one intervention week. Swan Boat had one group tested and lasted for two weeks, one control week and one intervention week. Fish'n'Steps, HealthyTogether and Swan Boat are the only studies done in a controlled setting.

The lack of control trials result in nothing to compare use of the system with. This applies to Into, Jogging , SFF and RUFUS. For instance in Into, the lack of a control week makes it impossible to know if the system increased step count or not. Due to the short duration, could not any significant conclusion be drawn, but it could provide indications for further work.

The fact that all studies is relatively short term or only have had one trial with the system, can imply novelty effect. A novelty effect is when users are motivated because of new and exciting technology, and not the functions and features the

[1]Two participants ran twice

Name	Participants	Type of study	Duration/Trials
Fish'n'Steps	19 (11 female)	field study, 3-phase	14 weeks
Jogging	17 (7 female)	field study	1 trial per participant [1]
Into	37 (31 female)	field study	1 week
HealthyTogether	36 (21 female)	field study, 2-phase	2 weeks
Swan Boat	17	lab study, 2-phase	2 weeks
Jogging	17 (7 female)	field study	1 trial per participant
SFF	52 (35 female) + 4	case study	1 trial per participant
RUFUS	18 (9 female)	field study	1 trial per participant

Table 3.1: Study evaluation

artifact offers [70]. This could have been avoid or reduced with longer studies and/or more trials per participant.

Most of these studies are feasibility studies. Feasibility studies are usable for testing a concept, but the ultimate goal with all of these systems are behaviour change. If a system leads to behaviour change, is not possible to evaluate with a feasibility study. According to Prochaska, it may take several years for a behaviour change to be maintained [71]. It is not incidental that many of these studies are feasibility studies. There are a general lack of large clinical trials and long-term studies in a controlled setting for system with aim to encourage physical activity [47].

3.5.2 The absent category

The systems described in this chapter can be divided into three categories as shown in table 3.5.2

Activity performed	Social feedback	Live social feedback
Individual	Fish'n'Steps Into RunKeeper Strava GhostRacer Nike+ Run Club Endomondo	HealthyTogether RUFUS Endomondo(Pep Talk) RunKeeper(Live) Nike+ Run Club(Cheers)
Multiplayer		Swan Boat Jogging the distance SFF
Loss of autonomy?	No	Yes

- **Cell 1:** These systems have social feedback (not live), and the activity is performed individually. The users do not lose autonomy.
- **Cell 2:** These systems have live social feedback, but the exercise is performed individually (social support). Live feedback indicates loss of autonomy.
- **Cell 3:** The systems belonging here are those with social feedback, multiplayer and not losing autonomy for the users.
- **Cell 4:** These systems have multiplayer and live social feedback. The users lose autonomy.

Loss of autonomy was found to have an impact on motivation towards exercising together versus alone [14], and was therefore added as an extra aspect to consider in this thesis.

The fact that all systems described (except for RUFUS), relies on the collective exercise concept, implies its importance for motivating exercising. But as described, the integration of this aspect has some shortcomings. As seen in the table, there is an absent category. There are no technologies that integrates collective exercise with the actual activity performed together, without losing autonomy.

Technology should focus on making possible what is impossible in reality, like being together / social without loss of autonomy.

3.6 Implications for prototype

The three elements that has never been combined will be the implications for the prototype created in this thesis, and is:

- Collective exercise

- Feedback based on both performing the activity
- Avoid loss of autonomy

Chapter 4

Application Design

This chapter will elaborate all details about the application design. The chapter starts by explaining the concept, the physical activity chosen and the equipment. It will continue by providing an description of the features. The next section will present a short prototype test. The chapter will end by explaining the final design of the application.

4.1 Concept

The concept is virtual collective exercise with a friend, and is called **RunTogether**. It is influenced by GhostRacer, Strava and Jogging the distance [9] [8][11]. Instead of running with a ghost like GhostRacer, the user run with a friend. The user can create a new route and upload it to the app, like a segment in Strava. The route will be available for his friends to run later. The virtual running approach is adapted from Jogging, but the participants do not need to run simultaneously.

Running is the exercise chosen to focus on because it is a fairly monotone activity with little variations, and it does not require much from the user. This makes it possible for the user to focus on other aspects during a run, for instance feedback from a system.

It will run partly on smart-phone and partly on smart-watch. Wearables has many advantages when it comes to promoting physical activity. The device is mounted to the user and it is continuously connected to the user's skin. Since it is worn on the body, the user does not need to hold the device to interact with it. The location of the device, is often known in advance by the system, for instance smart watch on the wrist. This makes it possible to provide feedback during the exercise, with limited distraction.

4.2 Features

The aim is to combine the three elements identified in chapter 3, which is social feedback throughout the activity, collective exercise and avoiding loss of autonomy.

4.2.1 Feedback element

By choosing similar pacemaker approach as GhostRacer, map visualisation a suitable choice. Map visualisation is common for commercial running application, and research suggests it could have an impact on motivation and performance [72]. Map visualisation with a polyline over the route to run, is a good way to navigate the user in the correct direction, and is thus chosen as one feedback type. Map visualisation is a popular approach for smart-watch applications, and all the apps described in chapter 3 has it [65]. The feedback is given throughout the activity, as it would have been during an actually collective exercise.

Vibration is another type of feedback RunTogether has implemented. Vibration is a way of notifying the user with limited distraction. This is implemented for enhancing the feedback on the map. Vibration functions could function as a trigger to run faster or to keep going. Different vibrations could indicate where the user is compared to his friend.

Both visual and vibration feedback was evaluated in a small prototype test. This will be explained in section 4.3.

4.2.2 Collective exercise element

The concept is based on motivation through collective exercise, and how this could be reinforced by social context. Meaning people are more motivated by exercising together with a friend than an unknown person. This is accomplished by having both users displayed on the watch together, running next to each other. The performance of the users on the map (the user and his friend), corresponds to their actual performance. This realistic representation is to enhance the collective exercise feeling. The user can anytime look at the watch and compare his performance with his friend's. According to social comparison theory and social facilitation theory, this could lead to increased performance and motivation [20] [15]. These motivational aspects would not have been provided from social support or if the feedback were given after the activity was over. The idea is to go further with the pacemaking approach from GhostRacer, and add another incentive through friendly competition/comparison.

4.2.3 Autonomy

Avoiding loss of autonomy has some design implications. Being obligated to exercise certain days and at a certain time is for many linked to losing autonomy. In real life are collective exercise and losing autonomy unavoidable. There is however one way of providing doing this virtually, and that is recording the exercise. All data related to the exercise can be saved and retrieved for later use. The user will be showed a list of available routes, and can choose to run at, together with his friend. The only precondition is that one friend has to upload a route first.

4.3 Prototype testing

A prototype test was conducted. The goal was to get inputs from a small amount of users on how the final design should be. Four people participated, and some changes was made after each test. The main goal was to test how the users perceived the feedback.

4.3.1 User 1

The first test was five minutes long and consisted of one run. The participant tested visual feedback with markers and vibration feedback consisted of three long if ahead and three short if behind.

The visual interface consisted of map visualisation and four markers. Yellow indicating the participant, purple indicating the friend, green indicating the start position and for red the stop position. The map also had a red polyline displaying where the user should run. The purple markers movement on the polyline corresponds to that friends run, which was previously recorded. The yellow moves according to the users location.

Figure 4.1: Visual feedback 1

Results: The participant mentioned she didn't feel any connection to the markers, it didn't mean anything to her. She came with a suggestion to change the marker to the first character of the names of the users instead, to make it more personal.

She also tried vibration feedback together with the visual. She didn't like the vibration and thought it was confusing.

After the first test, some adjustment to the user interface was made, changing the markers to the first characters of the participant's name.

4.3.2 User 2

This test consisted of two runs on 5 minutes each. Two different visual feedback types was tested as well as the same vibration feedback as test 1. Below is pictures of both visual feedback tested. For the second run, the user interface was changed according to the participant in test 1 suggestion.

Figure 4.2: Visual feedback 1 and 2

Results: She liked the character visual feedback best, but suggested adding pictures of the user instead, for more a personalised feeling. She also found the vibration confusing, and suggested decreasing the amount of vibrations.

4.3.3 User 3 and 4

This test had two participants. Two different types of visual feedback was tested as seen on figure 4.3. The user interface was changed according to the participant in test 2. The vibration feedback was also changed to three short vibration if par-

ticipant was behind his friend. Both participants tried the different feedback types.

Figure 4.3: Visual feedback 2 and 3

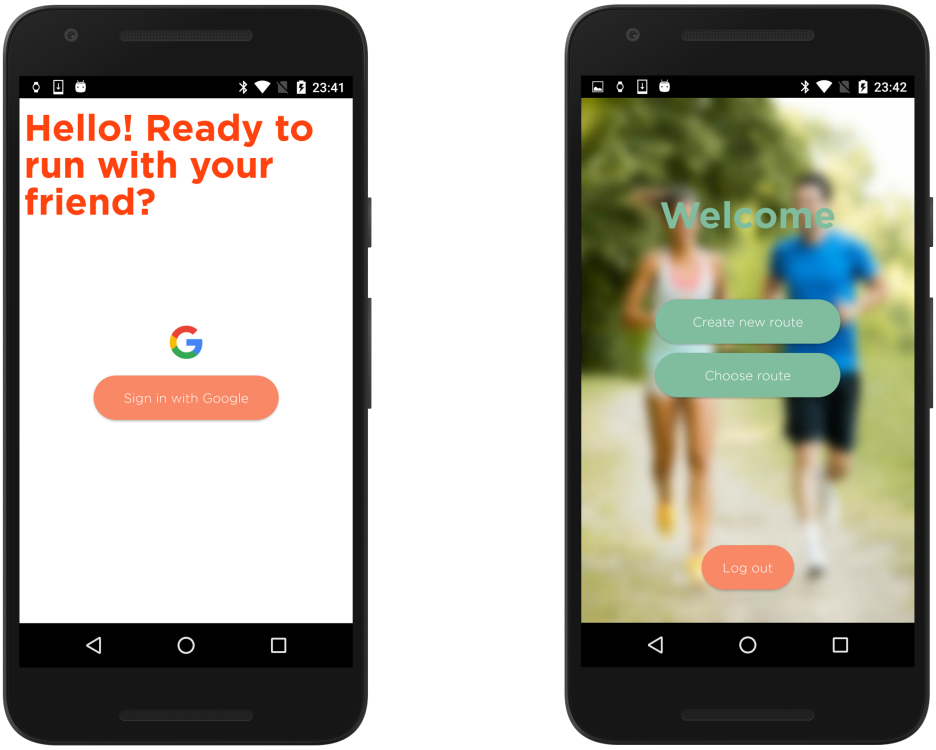
Results: They both liked the feedback type with pictures best, and suggested removing the vibration.

4.3.4 Prototype test summary

The participants in general though the concept was exciting. It was clearly that changing the user interface changed the experience, and made it more personal. One of the participant said it was "cosy" and fun to see pictures of her and her friend. Another said it made her feel a connectedness to her friend and that made the run more enjoyable. This gave a clear indication that this user interface could enhance the sense of social presence, and was therefore chosen as the only feedback.

4.4 Final design

This section will present the final design of the application, both the smart-phone and smart-watch app. Figure 4.4a is the starting point of the handheld application. The user is asked to sign in with google. After authentication the user is redirected to the welcome screen displayed in figure 4.4b. The user can choose between creating a new route or chose an existing route. The latter is the run with friend option, and will be explained first.

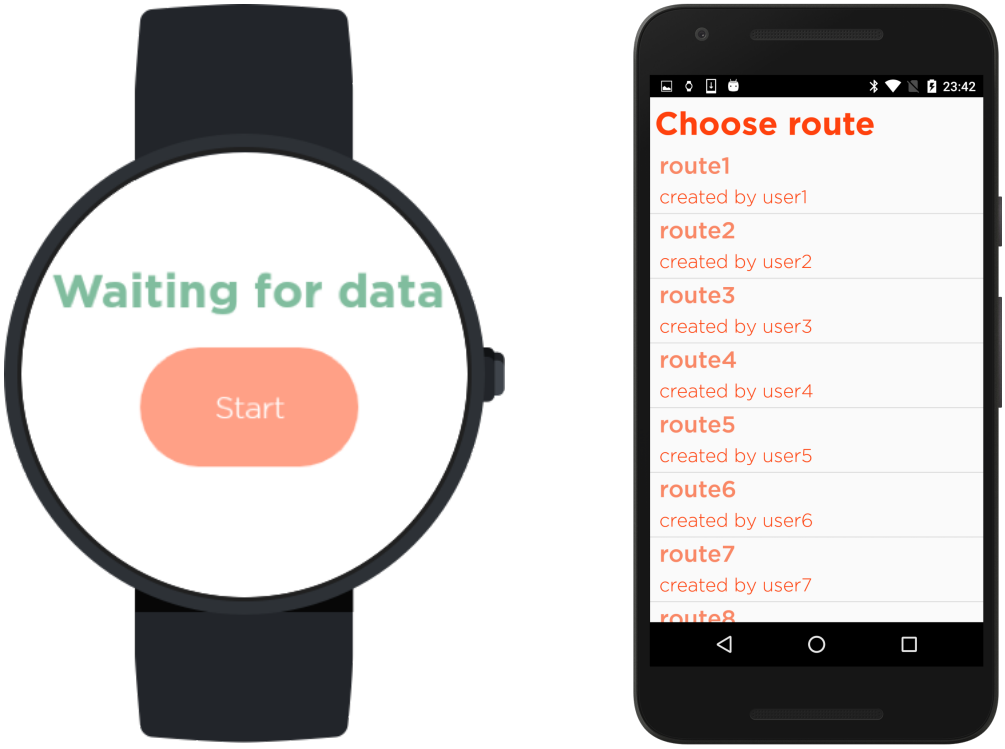


(a) Sign in screen (b) Welcome screen

Figure 4.4: Starting point

4.4.1 Run with friend

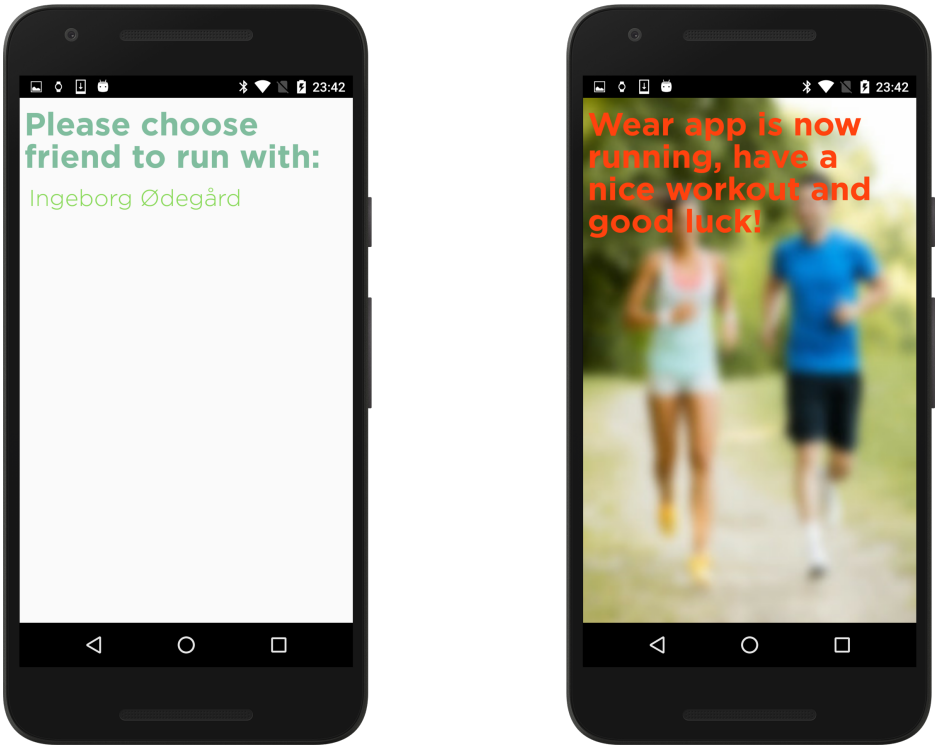
If the user chooses to run an existing route, the app will automatically be launched on the wearable if the two devices are paired. The handheld will display a list of routes as figure 4.5b shows. The smart-watch will wait until it receives route data from the handheld.



(a) Smart watch waiting for data

(b) List of routes

Figure 4.5: Run with friend choice



(a) List of friends (b) Data sent to wear app

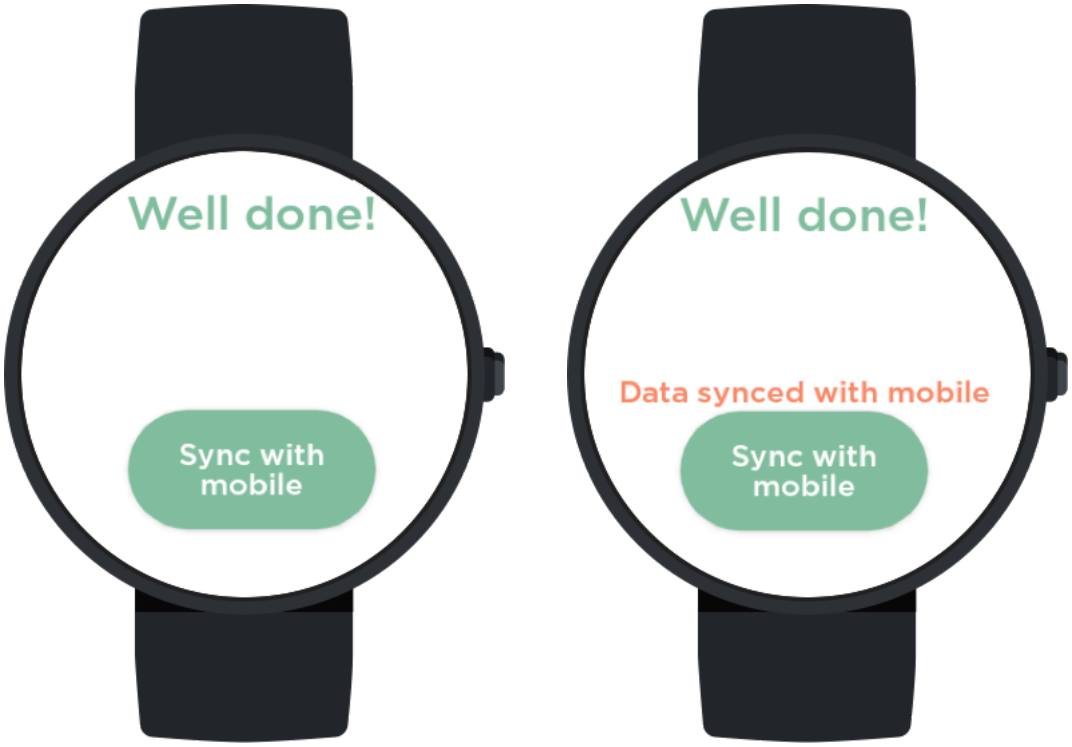
Figure 4.6: Run with friend choice

After choosing a route, a list of friend's that has run that route is displayed. In figure 4.6a, only one user has run the selected route. The idea is that several friends can run with each other and use the same routes. After the friend choice, the route data is sent from the handheld to the wearable.

(a) Wear app is ready (b) Running interface

Figure 4.7: Run with friend choice

As seen in figure 4.7a, the button is enabled when the wearable receives data from the handheld. When pressing the start button, the user is redirected to the visual interface and can begin the collective exercise with his friend.



(a) Run is finish (b) Data is synced

Figure 4.8: Syncing data

When the route is finish, the user has to tap and hold on the map. The user will then be asked to sync data with the handheld, as displayed in figure 4.8a, after the synchronisation is complete figure 4.8b is displayed.

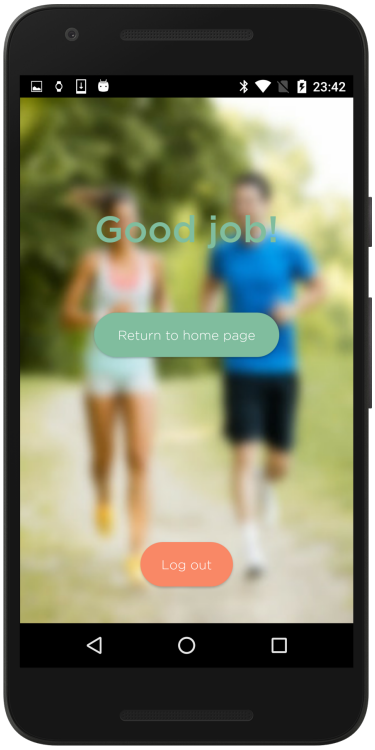
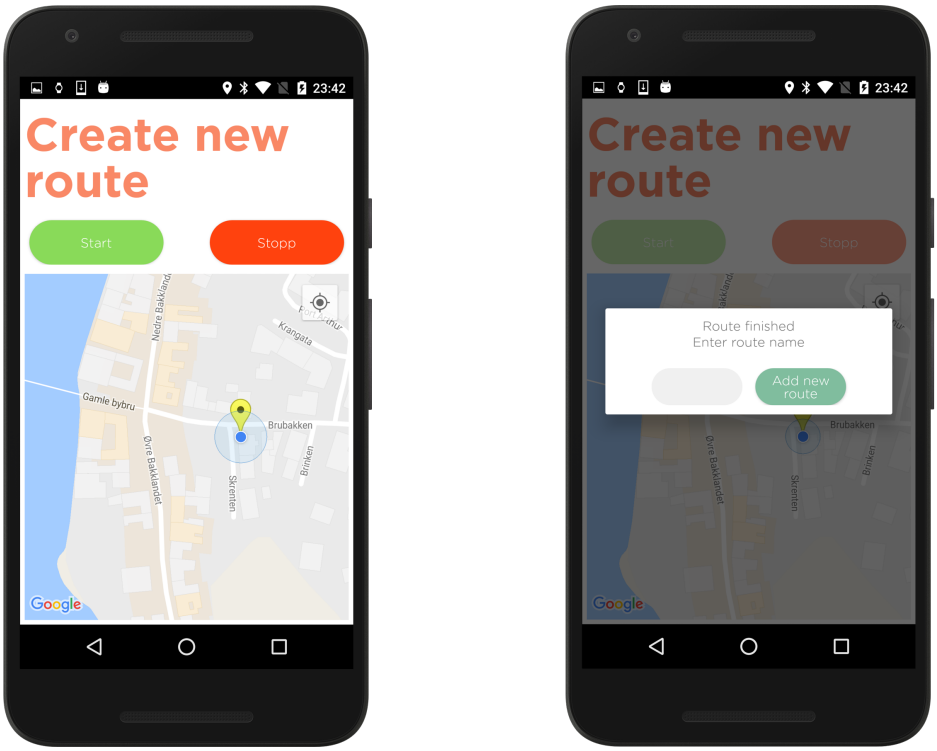


Figure 4.9: Good job screen

4.4.2 Create new route

The user start to record the route by pressing start and ends it by pressing stop. After pressing stop button the user has to enter a route name and save it. The user is then redirected to the welcome screen.



(a) Create new route (b) Add new route

Figure 4.10: Create new route choice

Chapter 5

Architecture and Implementation

The following chapter will present the system architecture and implementation details. The first sections will cover the application modules and how they communicate. The last sections will present the backend solution.

5.1 System architecture

The system consist of two apps. One handheld and one wearable app. The handheld app is created in native Android, and the wearable app is created in native Android Wear [73] [74]. The app use Firebase as backend solution to save and retrieve data [75]. The wearable app is connected to the handheld app, and the handheld is connected with Firebase. Firebase is a backend as a service. Both apps has its own module in Android Studio.

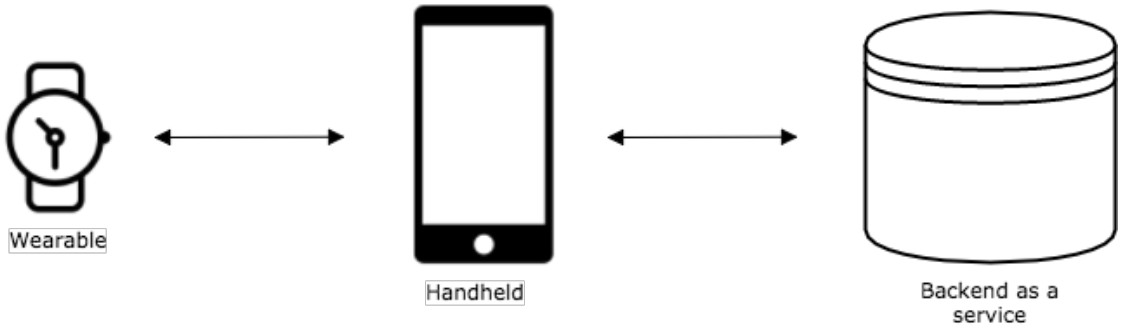


Figure 5.1: System architecture

5.2 Android

Android is Google's mobile operating system based on the Linux kernel [73]. Android's main application components are Activities, Services, Local Broadcasters and Content providers. These are essential building blocks and is loosely coupled with the AndroidManifest.xml file. The manifest file consist of a description of each component and how they interact. It also includes the required permissions, declares the minimum API level for the app and lists the libraries the application must be connected to.

This application consist of several activities, one service and one local broadcaster. The activity displays the view and handles interaction with it. The view consist of an xml layout file and the activity is a java class. The activities are coupled to each other, and an activity starts another activity usually. It's normal to bundle the data sent between the activities in Intents. An intent is "an abstract description of an operation to be done". [76].

5.3 Android Wear

The wearable app is created in Android Wear [74]. Wear apps run directly on the device, which makes it possible for the developer to access low level hardware such as GPU and sensors. They use the same Android SDK as other android devices, but differ in usability, design and functionality.

5.3.1 Wearable Data Layer API

Communication between the wearable and handheld is accomplished through bluetooth or Wi-Fi [77]. For achieving this connection, the apps have to implement the Wearable Data Layer API. The API consist of several data object and is a part of Google Play Services. The data objects are The MessageApi, DataApi and the ChannelApi. The MessageApi is suitable for doing remote procedure calls like sending messages or starting an intent on the wearable from the handheld. For sending larger pieces of data, one can use the DataApi or the ChannelApi. The DataApi is for sending Data Items. A data item is used for synchronizing data between the handheld and wearable.

Below is a diagram explaining the communication between a handheld and a wearable when using the DataApi. The data is sent down the stack on the handheld side, through the bluetooth link, and up the stack at the wearable side.

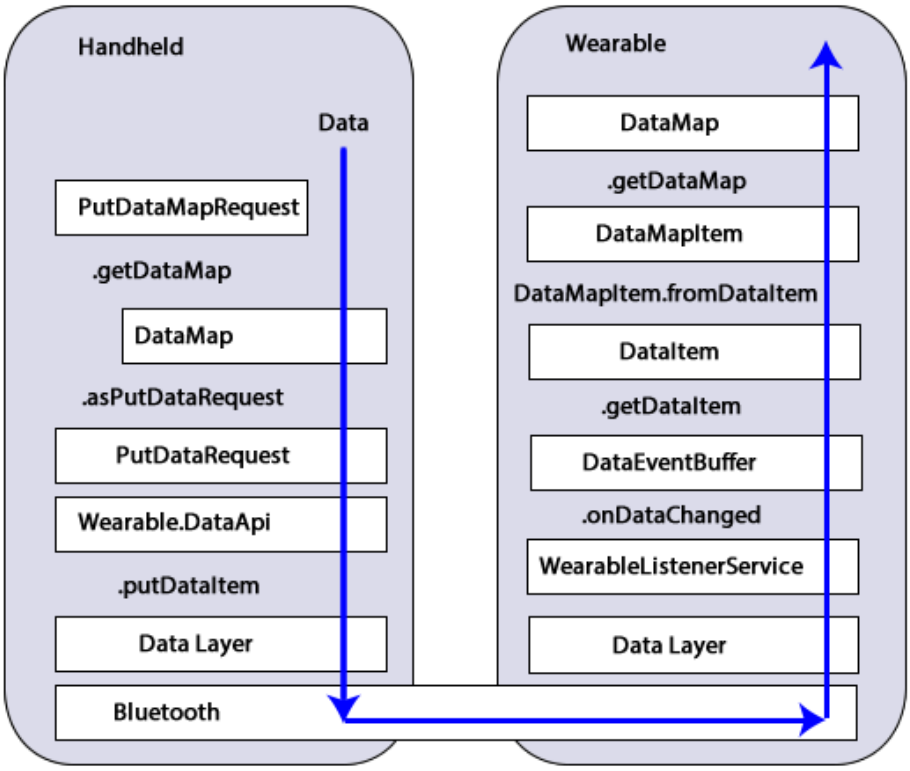


Figure 5.2: Communication between handheld and wearable [1]

- First is a PutDataMapRequest made on the handheld side. DataMap, DataItem and PutDataRequest are objects needed for sending data, and PutDataMapRequest simplifies the creation of these.

- The WearableListenerService on the wearable side receives the data and a buffer of DataEvents are returned.

- The DataItem is in the buffer, and are converted to a DataMapItem, which is converted to a DataMap. The DataMap contains the original handheld data, and is now synced with the wearable app.

The app created use both the MessageApi and the DataApi for communication between the two devices. It use the MessageApi for sending an intent to start the wearable when the user chose to run with a friend, and the DataApi for syncing data between the two devices.

[1] figure borrowed from http://android-wear-docs.readthedocs.io/en/latest/data.html

Wearable apps are smaller and thus has less functionality than handheld apps. When possible, the handheld app should take care of operations and transfer the results to the wearable. Communication with Firebase is thus taken care of by the handheld app. All information about the user and the routes are saved in Firebase. Saved data are retrieved from Firebase by the handheld, and sent through the DataApi to the wearable. The figure 5.3 describes the flow in the system when the user chose to run with a friend.

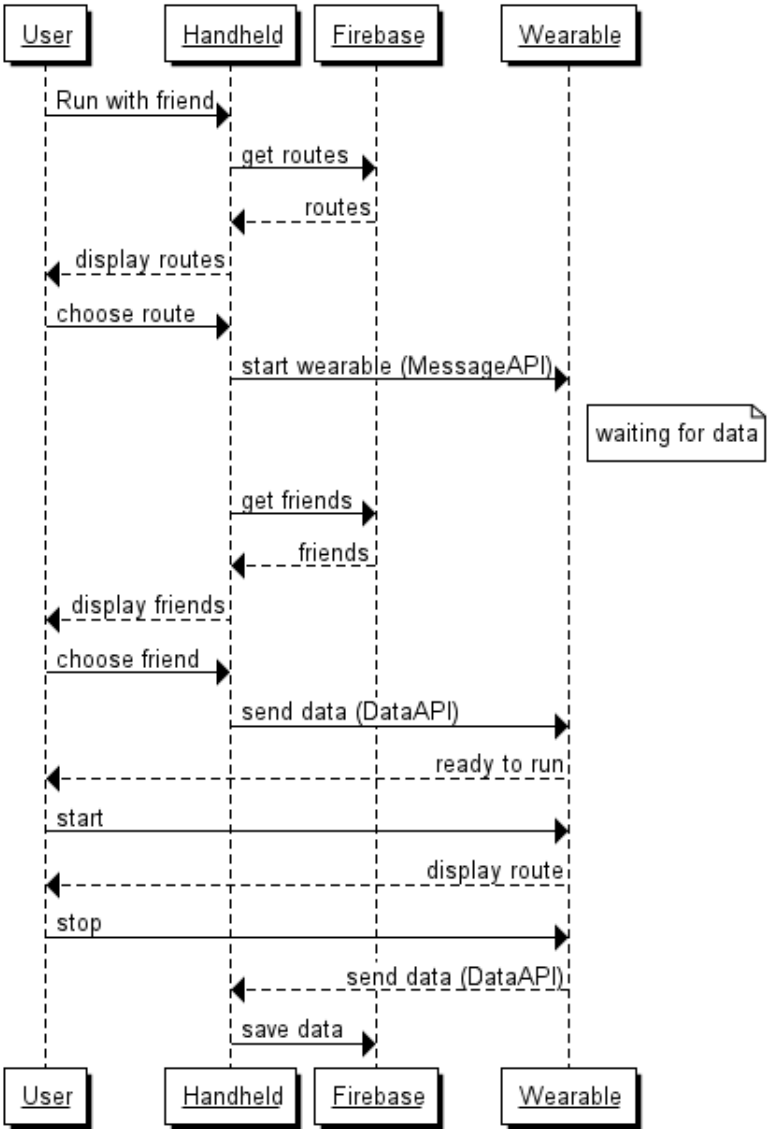


Figure 5.3: System flow

5.4 Backend

The application use Firebase as backend solution, which is a "backend as a service" (BaaS), to save and retrieve data [75] [78]. BaaS is a model for mobile and web applications to link their database to a backend cloud storage. Firebases client-server solution is based on two-tier architecture, which is direct communication between client layer and data source. Firebase data synchronization is based on an observer pattern. Each time data changes, all connected clients are synchronized in real-time. Firebase has an API one can use to read and write data.

5.4.1 NoSql database / Data model

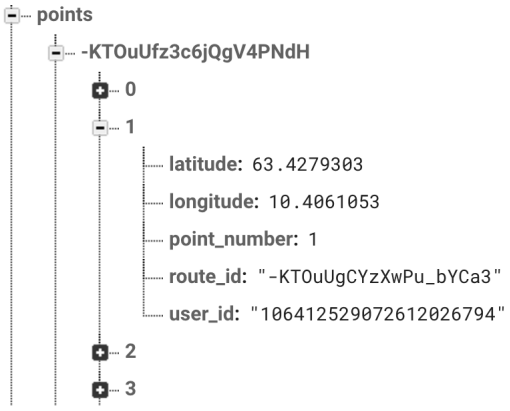
The data is stored as a JSON tree in a NoSQL database, which is required by Firebase [79] [75]. Each new data added is a node in the tree, with a corresponding key. Firebase has support for saving Java objects directly, but it requires defining an empty constructor. A reference to the Firebase database has to be established in the code for using the API. For basic write operations one can use the java method setValue() on the object, for read operations one can use onDataChanged() on the Firebase reference.

RunTogether's database consist of five nodes, as displayed on figure 5.4a. Each node is a collection of the data model objects. These are Java objects, and consist of History, Point, UserRouteRelation, Route and User. For instance, the points table consist of a collection of Point objects.

The collection have a point collection id, which is referenced in the route object and saved in the routes node.

(a) All nodes in database

(b) Route node and children



(c) Points node and children

Figure 5.4: Firebase database

Displaying a list of routes is important in the app. In a NOSql database, all children to the node that's been queried are retrieved. Avoiding nesting data was therefore important, otherwise all points to all routes would been retrieved from the firebase to the app, which would have been demanding for the processor. This is called denormalizing data [80].

5.5 Google Play Services

Google has many different services and APIs available for use [81]. Google play services APK (Android Application Package) is a background service that runs on Android devices, representing the individual service. The google play service

client library, contains the API and is the communication tool with the APK. The services and APIs available includes Location, Google+, Maps, Drive, Cast, Ads, Wallet and more. The service carries out the actions you specify with API calls.

This application is dependent on using several of the services. For displaying the map, the application use Google Maps API. For getting location the application use Fused Location Provider. As mentioned above, it use Wearable Data Layer API for communication with the wearable device.

5.6 Application code

The application code is available at https://github.com/ingebooo/RunTogether/

Chapter 6

Evaluation Methodology

The following chapter will present the evaluation of the app. The first section will cover the methodologies used. The next section will present the different data collection methods, and how they were used in this research. It will continue by describing the sample, inclusion criteria and display the participants demography. The next sections will cover the variables and the experiment performed. The last section will present the methodological limitations.

6.1 Methodology

The methods used in this research have been both qualitative and quantitative. Qualitative research methods have aim to study cultural and social phenomena [82]. Qualitative research is based on people's ability to talk about how they feel about certain aspects. The goal is to understand the social and cultural context of the user, and find out what the user really feel about a situation or artifact.

Quantitative research is methods for investigating observable phenomena that can be verified using statistical, mathematical or computational techniques. This type of research is often associated with being more scientific and objective than qualitative research [82]. Quantitative data can be defined as "Data which can be expressed numerically or classified by some numerical value". [83]. The data collected is often called units, and what to measure is called variables. A variable is a specific property or a characteristic with the unit [84].

A field experiment was performed to evaluate the app created. A field experiment is suitable when the goal is to evaluate an intervention in the participant's natural environment [85]. This is in contrast to a laboratory experiment which setting is controlled and artificial.

Two different activities were tested within-groups in order to compare the runs against each other [86]. Within-group design implies the participants being

exposed for all conditions during an experiment. This makes comparison easier and is suitable when time is limited. This design implies a risk for carryover effect, which occur when the first activity in an experiment has an impact on the subsequent activity, some choices elaborated in subsection 6.2 were made to avoid this [86].

6.1.1 Data collection

A semi-structured interview was performed after the run with the app. Semi-structured interviews are formal and includes an interview guide created in advance, but the researcher can choose to delve into topics that are not covered by the guide [83]. This type of interview yields the opportunity to go in depth on aspect that is relevant and interesting for the research, and also to identify new ideas. It was a suitable choice for exploring the concept, and resulted in new and relevant topics be discussed. The interview questions are provided in Appendix A.

The participants were given a questionnaire after both experimental conditions. Questionnaires is a quantitative data collection method and consist of a set predefined questions in a particular order [82]. Questionnaires is a good way of collecting quantitative data that's not measurable in its nature, for instance in what degree something is perceived negatively or positively. It is thus important to have specific questions in a logical order, so they are interpreted correctly and in the same way by all the participants. The questionnaire is provided in Appendix B.

Data was additionally recorded by the handheld device or the wearable device during both experimental conditions.

6.1.2 Sample

The inclusion criteria for the participants was being aged between 20 - 29 years. Research suggests that age group to most likely to be motivated by collective exercise [14]. Since the app is based on motivating during a run, was it also important that the participants enjoy running. Some variations in the participants preferences towards running alone or together was important, and additionally to test both female and male. Table 6.1 presents the different participants, their preferences and related experience.

Prior the experiment was participants sampled and background information gathered to make sure the inclusion criteria were met. The preparation questions is provided in Appendix A. It was important to ask the participants how far they usually run and/or if they have a running route they prefer. The reason is that the runs in this experiment was suppose to be the length of the participants regular running distance. A general round based on the regular distance was created. The

ID	gender	age	avg. runs per week	prefer: run alone	prefer: run together	ran with	Exp.
1	female	25	1-2	✓		2	1
2	female	25	1-2	✓	✓	1	3
3	female	22	2-3	✓	✓	2	3
4	male	23	1-2	✓		5	1
5	male	24	1-2	✓	✓	4	0
6	female	25	2-3		✓	7	4
7	female	25	2-3		✓	6	2

Table 6.1: Participant demography

route was simple without many curves, so the focus would be on the run, and not where to run.

The last column "Exp." provides information about their experience with related technology. The numbers indicate the degree of experience. 0 indicates none experience, and 4 indicates experience with smart-watch and running apps.

An overview over participant preferences are also displayed on the table. Two of the participants answered they would prefer to run alone, but they like to run with a friend sometimes. Three of the participants couldn't decide what they preferred. Two of the participants said they prefer to run with a friend, but sometimes they prefer to run alone. The participants had different opinions on when they preferred one over the other, and it wasn't mutually exclusive for anyone.

6.1.3 Variables

Dependent variables are what being measured and independent variables are those affecting the dependent. Independent variables are unchangeable during the experiment, and determines the dependent variables value in the different conditions [84]. The goal is to see if the independent variables changes the dependent variables. The dependent variable in this experiment are:

- Time and average pace
- Enjoyment
- Exertion
- Motivation

The independent variable to effect the dependent are **run Y**, explained in subsection 6.2.3.

6.2 Carrying out the experiment

The experiment consisted of two separate activities run X and run Y. Each participants ran twice, so the experiment in total consisted of 14 runs. Seven seven without the app and seven with the app. All runs were performed in Trondheim autumn 2016. The length varied from approximately 3 km - 5 km. To avoid the subject being fatigue from the first run, it was a minimum of two days between the runs.

The experiment procedure can be divided in three parts, before the run, the run and after the run. How this went down is explained in the subsections below.

6.2.1 Before the run

A short interview was conducted before the first run. This was to gather some information about knowledge about running apps and smart-watches, in order to get an overview of a possible novelty effect.

A thoroughly explanation of the concept was then provided. The participant and the researcher went together through the whole app, both the handheld and the smart-watch part. After the walk-through, the participant was presented with a map over the route to run. The participant got as much time as needed to explore and to get familiar with the route.

The participant was not told about the research questions nor what kind of data was collected until after the last run was finished. The aim was to not affect the participant to run faster or slower in either conditions, but rather do what was natural.

6.2.2 Run X (without the app)

The purpose of this run, was to collect data from the participants regular run. It was therefore necessary to not put pressure on the participant to run fast or slow, but rather ask the participant to try to ignore the experiment.

The participant were given an Android smart-phone to record the latitude and longitude coordinates, time, distance and average speed. The participant were asked to press start when the run began, and to push stop when the run was finished. The phone was placed in the pocket during the run, and the participant was told not to think about it. The researcher followed the participant to the start location and met the participant at the stop location when the run was finished.

6.2.3 Run Y (with the app)

The purpose of this run was to collect data from running with the created app. The researcher tried to get the participant in the correct context by telling that a friend had been out running and uploaded a route to run for the participant.

The participant were given instructions on what to do during the run and how to start and stop the app. The participant were asked to be aware of the watch, but not be too distracted from the road. The researcher followed the participant to the start location and met the participant at the stop location when the run was finished. The smart-watch used during the experiment was Moto Sport 360. The watch recorded time, distance and average speed, to compare with data from run X. The participants were given the same short questionnaire as run X, and a semi-structured interview was conducted when the run was finish.

6.2.4 After the run

The participant were given a short questionnaire to fill out after the run, asking the participant to rate the run from 1 - 5 about perceived enjoyment, exertion and motivation. This was for getting some additionally numerical values to compare with the performance- and interview data. For instance to see if the perceived exertion is in coherence with the actual performance.

After run Y (with the app), was a semi-structured interview additionally conducted. The interview questions are listed in Appendix A.

6.3 Methodological limitations

Empirical data has three main concern, reliability, validity and external validity. Reliability refers to which data is used, how it is collected and how it is analysed, and is critical for quantitative data. Reliability is often not a concern for qualitative data, due its unstructured nature [84]. For quantitative methods, validity refers to what extent the method study the planned phenomena. For qualitative methods it is how well the collected data reflects the goal of the study and how well it represents reality. External validity refers to how well the results can be generalized to other phenomena. How this study has been affected by these concerns, will be discussed in chapter 8.

There are some practical issues that can occur in this process. When dealing with new technology that has limited documentation and resources, the implementation could be more time consuming than estimated. Android Wear, which is the operating system the app is programmed for, is relatively new and could therefore

yield some problems not documented. Bugs related to hardware is also something to be aware of.

Chapter 7

Results

The following chapter will present all the results. The chapter starts by presenting information regarding the data analysis. It continues by displaying the quantitative data results and the effect on the dependent variables. The next sections will cover the interview results, user preferences and some limitations regarding the study. The chapter will end with a short summary.

7.1 Data analysis

After collection of empirical data is collected, a data analysis is necessary. Qualitative data analysis is based on the researcher's ability to detect patterns, categories and themes from the data. This has to represent the reality and be relevant for the study [82].

The qualitative data analysis in this research began by going through all the interview transcriptions. The data materials was read through several times, coded and categorized deductively[82]. This means the codes and categories were derived from theory or previous research. One category was for instance "collective exercise", and another was "competition", related codes could be "motivation", "fun", "distraction" etc.

In quantitative analysis, coding is also useful technique. This applies especially for data that are not in numerical form, for instance from questionnaires. This is enables quick and easy data analysis [82]. After the coding is done, the analysis involves representing the data in tables and graphs, making it possible to explore and detect patterns. The quantitative data in this thesis are presented in table **??** and 7.2, the questionnaire results are presented in a table in Appendix B.

7.2 Data records

On the table 7.1 are the results from run Y, which was the run with the app. The "Partner time" column indicates the time the participant ran with/against. Each run with the app, required a run already be recorded by a friend. As seen on the table 7.1, ran five out of seven fastest with the app.

On the table 7.2, are the results from run X, which was the control run. Two out of seven ran faster in this run.

Runner	**Partner**	**Distance**	**Avg. speed**	**Time**	**Partner time**	**Faster than X?**
1	2	2.70 km	9.62 kmh	16:50	17:03	Yes
2	1	2.70 km	8.93 kmh	18:08	18:11	No
3	2	2.70 km	9.56 kmh	16:56	17:03	Yes
4	5	5.01 km	11.09 kmh	27:05	28:06	Yes
5	4	5.01 km	10.48 kmh	28:40	27:22	No
6	7	3.16 km	9.89 kmh	19:10	19:49	Yes
7	6	3.16 km	9.72 kmh	19:30	19:42	Yes

Table 7.1: Run Y

Runner	**Distance**	**Avg. speed**	**Time**
1	2.70 km	9.39 kmh	18:11
2	2.70 km	9.50 kmh	17:30
3	2.70 km	9.45 kmh	17:08
4	5.01 km	10.98 kmh	27:22
5	5.01 km	10.69 kmh	28:06
6	3.16 km	9.62 kmh	19:42
7	3.16 km	9.56 kmh	19:49

Table 7.2: Run X

7.3 Dependent variables

The dependent variables in this experiment are time, average speed, enjoyment, exertion, motivation to run faster and motivation not to stop. These was measured with a questionnaire, these results can be found at Appendix B.

How the independent variables (run Y) affected these, will be explained below.

7.3.1 Performance

- Five out of seven ran fastest with the app. This was participants 1, 3, 4, 6 and 7.

7.3.2 Enjoyment

- Participant 1, 3, 5 and 7 enjoyed run Y most.
- Participant 2 and 4 enjoyed run X most.
- Participant 6 felt as much enjoyment in run Y as run X.
- Participant 4, 5 and 7 felt more exerted after run Y (with app).
- Participant 1 and 2 felt more exerted after run X (without app).
- Participant 3 and 6 felt as much exerted in run Y as run X.

Five participants ran faster with the app. Four out of these, felt less or as much exertion and at the same time ran faster. This gives an indication that the app provided the participant with distraction from tiredness and provided enjoyment.

7.3.3 Motivation

- Participant 1, 2, 3, 5 and 6 felt most motivated to run faster in run Y. Of these, ran 1, 3 and 6 of the participants fastest in run Y.
- Participant 4 felt as much motivated by both.

Participant 2 was more motivated to run fast in run Y, but ran faster in run X. This indicates that the app provided the participants with motivation, even though they did not perform better.

- Participant 3, 4, 5 and 6 felt more motivated to not stop in run Y.
- Participant 1, 2 and 7 felt as much motivated in both runs.

7.4 Interview results

The app had several effects on the participant's motivation. This has been divided into three categories explained below.

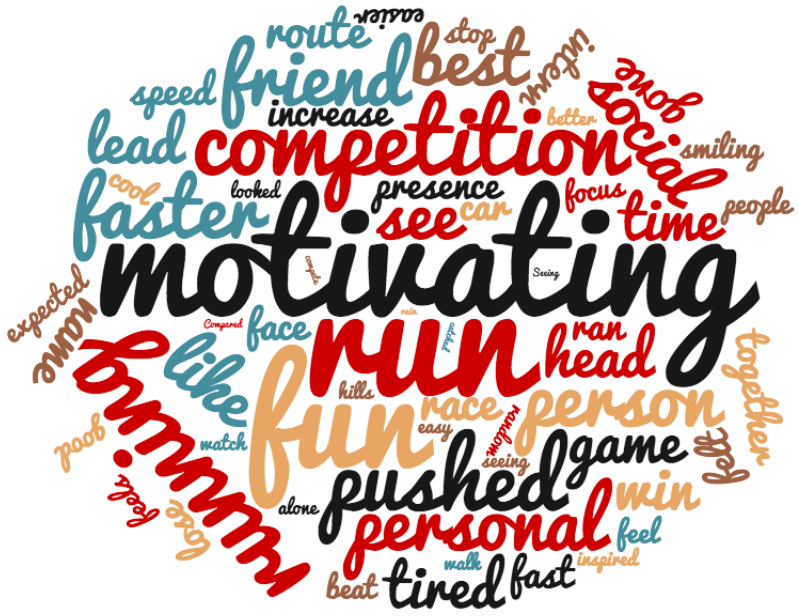


Figure 7.1: Wordcloud from attitudes towards app

7.4.1 Motivated by observing others

Many participants mentioned the effect of seeing their friend's image on the smartwatch as a motivation to run faster and not stop. The pacemaker approach received positively, as one participant mentioned that she was provided with something to compare herself against, which was motivating. Another participant mentioned how the app made her run faster and commented *"In the beginning X and I was running next to each other, then I didn't look at the watch for a couple of minutes. When I looked at it again X was in front of me and then I increased the speed"*. As one participant commented *"I usually don't run fast, I run slow. But when I used the app I didn't want to run as slow as I normally do, it was something inside me that wanted to keep track with my friend and not loose her out of sight"*.

Several of the participant mentioned how the feedback provided them with motivation to not stop and walk during the run, which can easily be done when running without the app. One participants commented, *"I have a tendency to walk up the hills when I run alone, I did not want to walk up the hills when using the app because I didn't want X to run from me."* Another participant commented

"I definitely pushed myself more when I ran with the app".

Many mentioned how the feedback enhanced the collective exercise-feeling. One commented *"The best part was at the beginning when we ran together and switched between being in front and behind. It almost felt like she was there with me"*. The participants liked that they could see their friend on the map, the pictures made it more fun and realistic.They especially enjoyed that it was not random how the friend moved on the map, but it was actual recorded data from the friend's route. Another commented *"I like the fact that how X moves on the map, is corresponding to the time and pace she actually had. The picture of us on the watch could be us in real life when we run together, she always is a bit faster than me"*. Another participant mentioned that *"It wouldn't be the same if it was markers or dots as representation"*.

7.4.2 Motivated by competing with others

The competition aspect was clearly an important motivational cue. Many of the participants mentioned how it motivated them to run faster. They wanted to lead and win. One participant mentioned that when she took the lead, it made her feel like she had the upper hand, which she enjoyed. One of the participants was surprised how much she enjoyed leading. *"Competition is usually not that motivating for me, but the app awoke my competitive instinct. Being in front made me feel good, it was more fun and felt better than I thought"*. It was also mentioned that it was exciting to see if their friend could catch up.

The participants in general did not like the feeling of being behind. Most of them said it was more motivating than tedious. *"I was really motivated to regain the lead"*. The general assumption was that the participants did not want to stop because they did not want their friend to run away from them.

Competition was related to fun and enjoyment. *"This was much more fun than I expected"* said three of the participants unsolicited right after they ran with the app. Several of the participants said that the app reminded them of a game, as one of them commented *"Running with the app feels like a car race game, its was fun!"*, another one mentioned *"It would have been fun to have many friends running the same route at the same time, then all my friends heads would compete in a race game"*.

7.4.3 Motivated through social context

Is seemed like the app facilitated motivation from the user's social context. Many participants were motivated by the competition, but for some it was not the competition itself that made it motivating. The competition aspect appear to be closely related to the social context. Many of the participants said they cared more about

the competition because they knew the person they were competing against. Another participant mentioned how the picture representation contributed to the competitiveness.

One participants mentioned that the app gave her personal motivation, which is according to her *"when you are affected by the outcome of the event, after the event"*. She referred to the fact that she planned on texting the friend she ran with to say that she ran faster than her. Another participant said *"It was motivating because I know him, competing against someone you know becomes an internal competition"*. This again relates to how the social context makes it more meaningful in addition to the activity itself.

Another participant said *"It was fun to see her smiling behind me"*. It was fun that her friend was smiling so much, even though she was behind her. Another participants said, *"It was fun to see my friend running the wrong way on the map, it was motivating because then I knew I could catch up. I think it was a bit fun to see that she took the wrong way twice, especially because it was her"*. This suggest the participants enjoyed the social context and the face on the watch provided something to relate to.

One of the participants ran faster than his friend the whole route, and was limited exposed to the pacemaker and motivational cues. He was even though motivated to run fast, as he commented *"I was motivated because I was faster. It is motivating to have a fast run which is difficult for my friend to beat.* This indicates he was motivated by the social context around the app, something outside the app itself.

7.5 Different user preferences

The participants had different thoughts and preferences whether to run with a friend and alone. This yields also for running with the app. What some participants find negative with running with another participant, is something another participant finds positive with running alone. For instance being able to listen to music instead of talking.

Many participants mentioned that when running with another person, they get motivated to run faster and further. This was found more difficult when running alone. There are no one to push you when you get tired, no pressure on continuing when you want to stop. There are not that much to motivate you, other than your own will. The app provided them with the motivation they get from running with another person, and was highly appreciated.

Most of the benefits from running with a friend is appreciated by many of the participants, for instance getting motivated to run faster and not stop. But some drawbacks causes them prefer to run alone instead. For instance having to

plan, Some of the participant mentioned that running with another person requires planning, and the threshold is thus higher. Planning implies some loss of control over when to exercise, and could be demotivating. They appreciated the fact that they can run whenever with the app, and mentioned it was motivating. This indicates the app has autonomy, which was one of the goals. Being able to listen to music when running with the app was also appreciated as one commented about using the "I can get motivated by seeing my friend and still be able to listen to music.".

When the participants were asked if they would rather run with the app than alone, many of the participants said yes and some of them said it depends on what kind of run they were after. Some of them mentioned that if the goal of the exercise is to take is easy, and not push oneself, they would rather run alone. But if the goal of the exercise is to run fast and push oneself, the app is preferred.

When it comes to running with another person versus alone versus the app. The participants had different opinions. It would seem like the app has some different usage scenarios and can be used in a variety of ways. For the participants that prefer to run alone, the app will provide them with motivation they otherwise wouldn't have gotten. The experience is something both the participants that enjoy running alone and running together can enjoy, to a different extent. Something to highlight is the autonomy the app provided.

Six participants said they rather would run with the app than run alone, one said it depends. Two participants said they would rather run with the app than with a friend, one said depends and one said don't know.

7.6 Suggestions on improvements

One participant came with a suggestion that the camera would zoom out automatically, so both pictures (runners) would be in the view of the camera at all times. Another suggestion was the ability to pause the run.

Many of the participated suggested that the app should provide some more information during the run. One suggested displaying how much time and how many meters separated him and his friend, as well as best time on the route. The same participant mentioned how he was demotivated by not knowing how far he was behind. Another of the participants wanted to see some basic information about the run, distance covered, time and heart rate.

Another participant suggested having sounds and vibrations, indicating where the two runners are compared to each other.

7.7 Limitations

There are always some validity concern related to qualitative data. The participants could be affected by the researcher to answer a certain way. The interview was held after the run with the app. The fact that some had run both runs before the interview could have affected the answers in some way. Due the nature of this master thesis, the participants could feel pressure to not say anything negatively towards the app. This was however tried to be avoided, hence the researcher explained all feedback is good feedback in relation to research.

On the second run, the participant were a little more familiar with the route than on the first run, meaning it could be easier to run faster. Participants 1, 2, 3, 4, 6 and 7 (all but one) had better results on the second run. Five of these ran fastest with the app, participants 1, 3, 4, 6 and 7. Only participant 7 ran with the app first, and had fastest time with the app. Participant 2 ran the wrong way when using the app, and therefore "lost" her friend early. The same participant ran fastest when not using the app. This could imply that knowledge of the route may have affected the results.

This participant also stated she ran fast because she was cold, and just wanted to be finish with the run as fast as possible. Participant 5 ran also fastest when not using the app. He stated that he slipped and fell during the run, and it affected the rest of the run. This could also explain the results.

Since both of the participants lost their pacer, they was not exposed for the independent variable during big parts of the run, which could affected the dependent variables (time and average speed).

The pacemaker for all the participant in this experiment, was the run their friend did without the app. This implies that for the app to increase the performance (from pacemaking), the friend has to run slightly faster [16]. This will also mean that the if the runners follow the pacer/friend the whole time, the runners in the worst shape (compared to their friend) will increase their performance, and the runners in best shape will decrease their performance.

This is something that was clear when looking at table 5.2.1. Participant 1 ran the first run without the app, and had time 18:11. Participant 2 ran with the app, with participant 1 as pacer. Participant 2 followed participant 1 the whole way, and "won". But when participant 2 ran without the app, she ran one minute faster. Participant 2 also claimed she ran fast because she was cold and wanted to be quickly finished with the run.

Something different happened with participant 4 and 5. Participant 4 ran significantly faster than participant 5 on both the runs. But participant 4 ran faster with the app even though he hadn't participant 5 as pacer in most part of the run. As mentioned in [] he was really motivated by being in the "lead", and claimed that it made him wanting to run even faster.

7.8 Summary

The participant liked and was motivated by the app. The pacemaking aspect was positively received, and motivated them to run faster and not stop. Five out of seven of the participant ran faster with the app. There was however some convoying variables that could have affected these results. The answers from the questionnaires did shows that most of the participants enjoyed running with the app more than without it. The also felt less exerted, even though the ran faster with the app. This confirms the qualitative data that states the participant used the watch as distraction from exertion. The participant felt motivated to run faster with the app, even though some of the didnt run faster with the app, which also confirms the qualitative data about motivation.

Chapter 8

Discussion

8.1 Research question 1

*Which theories and practical applications have used **social interaction** and technology to increase users' **motivation** to exercise? What are their limitations?*

Several social theories and practical applications were identified in chapter 2 and chapter 3. **Social comparison** (social comparison theory) was integrated in several of the system. Fish'n'Steps, Into, HealthyTogether, SFF and all the commercial apps have implemented it in a different way [20]. **Social facilitation** (social facilitation theory) is closely related to social comparison, and was stated as being a motivational factor in SFF [15]. **Social influence** (social cognitive theory) was used as a motivational strategy in all the commercial apps, including Fish'n'Steps, Into and HealthyTogether [12]. RUFUS and all the commercial apps are based on some kind of **social support** (social ecological model). **Competition** and **cooperation** is implemented in Fish'n'Steps, Into and HealthyTogether, and the same applies for all the commercial apps with challenges and group challenges [37].

Social interaction is a common term for these systems. Motivation from social interaction is mainly based on collective exercise or social support. Social context has been used to increase motivation from social interaction in many systems described in this thesis.

In Fish'n'Steps, they used competition and comparison as social motivation strategies [50]. The participants social context were however not implemented. In HealthyTogether and Into, the social context facilitated an additional incentive for earning badges and rewards [10] [43]. The same applies for the commercial apps. Integration with social media adds other dimensions related to for instance competition, collaboration and challenges.

Some limitations regarding the collective exercise approach were identified in chapter 3. In Runkeeper and Nike+ they have virtual running groups, but no feedback related to this is provided. Strava and GhostRacer have an approach that supports challenges and competition with friends, but no social feedback during the activity. Fish'n'Steps and Into are mainly based on counting steps together. The collective exercise was implemented by providing social feedback before or after the activity, and not during. In-situation motivation from the feedback aspect is therefore lacking in these approaches.

In Endomondo (PepTalk), Nike+ Run Club (Cheers), Runkeeper Live and RUFUS the feedback is social and live throughout the activity, but is not based on collective exercise. Many advantages related to performing an activity together is therefore not present.

SFF, Swan Boat and Jogging, were identified as systems with social live feedback. A multiplayer approach with social real-time feedback is implemented in SFF, Swan Boat and Jogging. SFF is based on the participants exercising physically together, and requires the participants being limited by time and place. In Jogging and Swan the participants can exercise virtually together. But they are still limited by time. This is a drawback with multiplayer approaches, and have been a focus area with RunTogether.

8.2 Research question 2

How can collective exercise be implemented in an app aiming at increasing motivation to exercise?

Three elements are important for such technology to have the intended effect: Collective exercise, social feedback and avoiding loss of autonomy.

8.2.1 Feedback element

Feedback has been identified as an important factor for enhancing virtual collective exercise. In chapter 3, several ways of providing social feedback based on collective exercise was presented.

Feedback related to two users (or more) performing an activity together was identified as limited in the systems described in chapter 3. This was therefore implemented in RunTogether. The feedback from RunTogether is given throughout the activity. Both users are visualized on the map and are supposed to simulate co-running, and corresponds to the performance of the friend. Providing feedback based on both performing the same activity was important in RunTogether. The

exercise data was displayed with the user's social context in mind. The picture representation was suppose to make the experience more personal and fun.

As identified in chapter 2, could feedback distract from tiredness and increase performance, enjoyment and motivation. The questionnaire results indicates the feedback in RunTogether had similar effect. Some participants mentioned how they looked at the watch when they got tired to be distracted. This is also reflected in results of the questionnaire about perceived exertion. Four out of five participants ran faster when using RunTogether, and felt less exerted.

Some distraction concerns were also mentioned in chapter 2. RunTogether provided visual feedback, and is based on the user looking at the watch for getting feedback. Some safety concerns in relation to this was thus present. Vibration feedback was tested, but removed in the pilot study. Considering the time limitation for this thesis, feedback to navigate other than visually was not prioritised. None of the participants mentioned safety concerns.

8.2.2 Collective exercise element

To a certain extent all systems described in chapter 3 claims to have a collective exercise approach, but many systems are in fact mainly supporting individual exercise. Collective exercise has been identified as a source of motivation throughout this thesis.

Several theories about the benefits of collective exercise were elaborated in chapter 2, and were integrated in RunTogether. Social comparison theory was implemented by enabling continuously comparison by looking at the watch. Social facilitation theory states that the amount and level of social presence, have an impact on motivation and performance [15]. Displaying pictures of the user and his friend was an approach to increase social presence. This approach was based on the prototype test described in chapter 4. The performance of the friend, corresponded to the actual performance, which was suppose to enhance the social presence and collective experience.

Engaging in the same physical activity as others, increased the likelihood of joining and staying motivated during the exercise [16] [36] [18] [19]. This was implemented in form of a pacemaker in RunTogether. Having a pacemaker increased performance, especially in relation to competition. All the participants felt they were competing, even though it was not the intention. Motivation from competition is exclusively provided from collective exercise, not social support.

8.2.3 Autonomy element

Autonomy was also identified as important for motivation. Avoiding loss of autonomy was accomplished by providing present feedback based on past events and

essentially actualising it and make it feel like its happening again. The physical data was recorded and saved for later use.

The participants in this study confirmed previous research and mentioned how running with a friend requires planning, and it could be demotivating. They appreciated the fact that RunTogether can be used anytime.

8.3 Research question 3

*How can the app be **evaluated** with regards to its effect on **enjoyment**, **performance** and **motivation**?*

An evaluation was performed by an experiments to measure physical data, enjoyment and motivation.

8.3.1 Effect on motivation

Three topics related to how the participants were effected by the motivation aspects evolved from the interviews. This was motivated by observation, competition and social context. Motivation by observation is related to social comparison theory, social facilitation theory and social cognitive theory [20] [15] [12]. The participants used the watch to compare their own performance with their friends, and it lead to running when they otherwise would have stopped, for instance when the route was uphill. Observing others has been proven to motivate in the past, and managed to motivate the participants in RunTogether [36] [18] [19].

Motivated by competing with others are related to social competition and social facilitation. All of the participants liked the competitive aspect and felt motivated by being in front and being behind. As mentioned in chapter 2, section 2.4, interpersonal differences in relation to how individuals are affected by competition and cooperation is important to take into account [47] [49]. The initial idea was that the participants could choose whether they wanted to compete or to run together, but when asked, all felt they were competing. Some of the participants were surprised how much they were affected and enjoyed the competitive aspect, as well as their desire to win and lead.

For some people is jogging a social activity since they can talk during the run. For many the ability to talk during a run is why it is motivating to run together [11]. RunTogether does not provide any communication channel, hence it is not possible to talk to the person you run with. Not being able to talk, was appreciated by the participants that prefer running alone. For those, being able to listen to music are more motivating. This gives an indication that for some was

not communication necessary for providing motivation. Perhaps a communication channel could increase the feeling of exercising together.

Motivated by social context is related to (nearly) all social motivation theories and especially social ecological theory, that states the environment around is (after the individual himself) most capable of influence behavioural change. Most of the participants were motivated by the competitive aspect because it was in a social context. The app provided the participants with relatedness by the social context, which created a more meaningful experience.

The competitive aspect was motivating because the participants knew who they were competing against. *"Personal motivation"* was mentioned by one of the participants, and was related to how it would be natural to talk about the experience later. This shows the motivating impact of the social context in RunTogether. Several participants additionally mentioned how the social context contributed enjoyment and fun.

The questionnaire results confirms these motivation effects. Five out of seven participants felt more motivated to run faster when running with the app. Four out of seven participants felt more motivated to not stop during the run with the app.

There was one demotivating effect of the app. This was related to "losing" their friend. If their friend on the watch was quicker and disappeared from the screen, there was no way of knowing their distance apart.

Social context was also identified as having positive effect concerning variations and possibilities in a system. Strava was mentioned as being continuously updated with new segments for the users to run. This was an aspect implemented in RunTogether. One participant mentioned how she sometimes is uninspired to run because she does not know any engaging running routes. She considered RunTogether as inspiring by offering new routes to run.

8.3.2 Effect on performance

Data was collected and saved during the experiment to compare performance. Perceived exertion was additionally asked about in the questionnaire, to see if they corresponded to the performance data.

Five out of seven participants ran faster with the app, which is very good results.

Some convoying variables could have affected these results, as elaborated in chapter 7. For instance familiarity with the route, the cold weather, slippery road and "losing" the pacemaker during the run. The fact that the pacemaker and runner had to be in similar physical shape for it to increase the performance could also be something that could explain the results.

Social comparison theory states that one gravitates to the performance of the person one exercising with [20]. This did affect the performance of one of the participants during the experiment. The pacemaker was the run their friend did without the app. This implies that for the app to increase the performance (from pacemaking), the friend has to run slightly faster [16]. This will also mean that the if the runners follow the pacer/friend the whole time, the runners in the worst shape (compared to their friend) will increase their performance, and the runners in best shape will decrease their performance. This happen to one of the participants as stated in chapter 7, section 7.7, but was different for another participant which was really motivated by being in the "lead", and claimed that it made him wanting to run even faster.

8.3.3 Effect on enjoyment

Perceived enjoyment was another variable measured during the experiment. Four out of seven participant enjoyed the run with the app most. Many participants mentioned how they thought the app was fun, and reminded them of a game.

The fact that the participants used the app as distraction from tiredness also confirms this. Four out if five that ran fastest with the app, felt less exerted when running with the app. This gives a good indication that the app distracted from tiredness and was enjoyable. Fun and enjoyment was also mentioned throughout the interview by all of the participants, and was clearly related to the social context.

8.3.4 Limitations

The experiment was performed with seven participants. This small amount of participants is a limitation to the study regarding drawing significant conclusions from the quantitative data. The sample population was additionally rather similar, which could have had an impact on the results. All the participants was between 22 and 25 years, and all are pursuing or have a higher degree at university level. In Norway, higher education is correlated with increased physical activity and better health [87]. The sample population should have been larger and more variations in the participants background and age.

As identified in chapter 8, some convoying variables could have affected the quantitative data results. The qualitative data could have been affected by the researcher and by the experiment situation to run faster, or answer a certain way during the interview. This was avoided as much as possible.

As many of the systems described in chapter 3, this study had some novelty effect concerns, which could be a threat to external validity. Only one of the participants had run with a smart-watch before. The motivation and enjoyment from running with the app, could be based on excitement from using new technology.

This could been avoided by having the participants run several times with the app, but was not feasible due time limitations.

As identified in chapter 3, few studies has been conducted in a controlled setting. This study had the participant run twice, in two different conditions. This gave quantitative data for performance comparison and qualitative data for attitudes towards the concept. Having the participants only run once in both conditions is insufficient to draw any significant conclusions outside the sample population, but it managed to provide some indications for further research.

This study did have some technical issues. Time limitation affected the study most, as well as the small amount of participants. This is interrelated. The technical issues that occurred was related to a Google Play Services update on the watch connected to the Google Maps API. This update lead to Google Maps wasn't working on the watch, this problem resulted in one week delay.

Chapter 9

Reflection and Further work

This chapter will present some sum up the thesis and provide some reflections about the results. The last section will present further work suggestions.

9.1 Reflection

This study began by reviewing many different approaches on motivation and behaviour change in relation to technology and social interaction. Behavioural change and motivation is complex and there are no straightforward solution. Systems often relies on multiple theories and techniques. Social interaction and context has been a theme in this thesis, due it's natural way of creating meaning to a system.

Many different systems with a social aspect was identified in chapter 3. When reflecting over all systems, it was identified almost all had some kind of collective exercise approach. This feature was implemented differently in all the systems. A system with feedback based on collective exercise without loss of autonomy was identified as absent. Many advantages arise from collective exercise, but the planning part is a limitation and leads to loss of autonomy. This results in many chose to exercise alone, and miss out on valuable motivation.

Social context was identified as important for motivation and was implementation of by having the participants run virtually with a friend. The social context arise from the fact that the users know each other, and the visual feedback displaying the pictures of both of them. Visualising on the watch, contributed to a feeling of collective exercise. The route was recorded, and resulted in the possibility to run together without losing autonomy.

The qualitative results shows the participants felt motivated and enjoyment and the quantitative results shows the participants increased their performance . Five out of seven participants ran faster when running with the app. The app provided the participants with motivation to perform better, and enjoy the exercise

more at the same time. The participants appreciated the fact that running with the app do not require planning.

9.2 RunTogether fills the technology gap

A technology gap was identified, and is the combination of collective exercise, social feedback and avoiding loss of autonomy. RunTogether gives present feedback based on past event, essentially actualising past events and making it feel like its happening again.

Activity performed	Social feedback	Social real-time feedback
Individual	Fish'n'Steps Into RunKeeper Strava GhostRacer Nike+ Run Club Endomondo	HealthyTogether RUFUS Endomondo(voice msg) RunKeeper(live) Nike+ Run Club(voice msg)
Multiplayer	RunTogether	Swan Boat Jogging the distance SFF
Loss of autonomy?	No	Yes

9.3 RunTogether enhances users' experience

The participants had different thoughts and preferences for when they prefer to run with a friend and alone and when they would prefer to run with the app, as mentioned in chapter Table 9.1 displays the different advantages with the conditions. As one can see, RunTogether has advantages from both running with a friend and running alone. This implies RunTogether enhances users' experience, and can satisfy a broad range of users.

RunTogether can provide similar motivation as collective exercise provides in real life. It cant replace running with a real person, but can be a powerful replacement and provide motivational cues not received when running alone. For those preferring to run alone, it can enhance the experience during every run.

Advtantage	**With friend**	**Alone**	**With app**
run faster	✓		✓
not stop	✓		✓
social context	✓		✓
talk	✓		
music		✓	✓
autonomy		✓	✓

Table 9.1: Advantages with the different conditions

ID	**Run with app vs alone**	**Run with app vs friend**
1	Yes	Yes
2	Yes	Don't know
3	Yes, if similar shape	No
4	Yes	Depends
5	Yes	Yes
6	Yes	No
7	Depends	No

Table 9.2: Users preferences

(Almost) all the participants stated they would rather run with RunTogether than run alone. This table gives clear indications that RunTogether enhances users' experience versus running alone.

9.4 Further work

All further work should include an extended research experiment in order to support the findings in this thesis. The experiment in this thesis has been limited with regard to a number of factors. A further study could increase the number of participants and make some changes regarding:

- socioeconomic status

- age
- physical shape
- training history
- interest and experience with wearable technologies

A new study could also include testing and comparing with the systems mentioned in chapter 3.

A further study could focus on develop more and new features in the RunTogether app. An approach could be introducing users in the beginning, from for instance focus groups that could indicate desirable features. This could evaluate features like:

- heart rate
- pause possibilities
- multiple users (faces)
- positive cues for increased performance
- personal training assistance
- other sports than running

These new features would in any case require an extended experiment to be significant.

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Bibliography

[1] World Health Organization. Physical activity. http://www.who.int/mediacentre/factsheets/fs385/en/, 2016.

[2] World Health Organization. Obesity and overweight. http://www.who.int/mediacentre/factsheets/fs311/en/, 2016.

[3] World Health Organization. Who definition of health. http://www.who.int/about/definition/en/print.html, 2003.

[4] 3rd Kohl, H. W., C. L. Craig, E. V. Lambert, S. Inoue, J. R. Alkandari, G. Leetongin, and S. Kahlmeier. The pandemic of physical inactivity: global action for public health. *Lancet*, 380(9838):294–305, 2012.

[5] Shrioma EJ. Lobelo F. et al Lee, IM. Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. *British Dental Journal*, 213(7):359–359, 2012.

[6] Medie Norge. Andel som har smarttelefon. http://www.medienorge.uib.no/statistikk/medium/ikt/379, 2016.

[7] Unknown. Endomondo application. https://www.endomondo.com, 2016.

[8] Unknown. Strava application. https://www.strava.com/, 2016.

[9] Unknown. Ghostrcer application. http://bravetheskies.com/ghostracer/, 2016.

[10] Yu Chen and Pearl Pu. Healthytogether: exploring social incentives for mobile fitness applications. In *Proceedings of the Second International Symposium of Chinese CHI*, pages 25–34. ACM.

[11] Florian Mueller, Frank Vetere, Martin R. Gibbs, Darren Edge, Stefan Agamanolis, and Jennifer G. Sheridan. Jogging over a distance between europe and australia. In *Proceedings of the 23nd annual ACM symposium on User interface software and technology*, pages 189–198. ACM.

[12] Albert Bandura. Social foundations of thought and action: A social cognitive theory. 1986.

[13] Rachel Gockley, Michael Marotta, Carin Rogoff, and Adrian Tang. Aviva: a health and fitness monitor for young women. In *CHI '06 Extended Abstracts on Human Factors in Computing Systems*, pages 1819–1824. ACM.

[14] Yngvar Ommundsen and Anita A. Aadland. Hvem er inaktive - og hva motivere til økt fysisk aktivietet? *Fysisk inaktive voksne i Norge*, 2009.

[15] John R. Aiello and Elisabeth A. Douthitt. Social facilitation from triplett to electronic performance monitoring. *Group Dynamics Theory Research and Practice*, pages 163–180, 2001.

[16] Norman Triplett. The dynamogenic factors in pacemaking and competition. *The American Journal of Psychology*, 9(4):507–544, 1898.

[17] Elmer Spreitzer and Eldon E. Snyder. Correlates of participation in adult recreational sports. *Journal of Leisure Research*, 15(1):27–38, 1983.

[18] James Faulkner. The rating of perceived exertion during competitive running scales with time. *Psychophysiology*, 45(6):977–985, 2008.

[19] Debra A. Laverie. Motivations for ongoing participation in a fitness activity. *Leisure Sciences*, 20(4):277–302, 1998.

[20] Leon Festinger. A theory of social comparison processes. *Human Relations*, 1954.

[21] Ross Shegog. Application of behavioral theory in computer game design for health behavior change. 2010.

[22] C. Lister, J. H. West, B. Cannon, T. Sax, and D. Brodegard. Just a fad? gamification in health and fitness apps. *JMIR Serious Games*, 2(2):e9, 2014.

[23] David E. Conroy, Chih-Hsiang Yang, and Jaclyn P. Maher. Behavior change techniques in top-ranked mobile apps for physical activity. *American Journal of Preventive Medicine*, page 649–652, 2014.

[24] C. H. Yang, J. P. Maher, and D. E. Conroy. Implementation of behavior change techniques in mobile applications for physical activity. *Am J Prev Med*, 48(4):452–5, 2015. 1873-2607.

[25] Jose A. Schenkman. Social interactions. *The New Palgrave Dictionary of Economics*, 2008.

[26] Robert J. Vallerand. Intrinsic and extrinsic motivation in sport and physical activity: A review and a look at the future. pages 59–83, 2012.

[27] Definition dictionary. Evaluation. http://www.dictionary.com/browse/evaluate.

[28] Definition dictionary. Enjoyment. http://www.dictionary.com/browse/enjoyment?s=t.

[29] Definition dictionary. Performance. http://www.dictionary.com/browse/evaluate.

[30] Kultar Singh. *Quantitative Social Research Methods*. SAGE Publications Pvt. Ltd, 2007.

[31] R. M. Ryan and E. L. Deci. Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemp Educ Psychol*, 25(1):54–67, 2000.

[32] Dr. Susan Michie, University College London, s.michie@ucl.ac.uk, Dr. Marie Johnston, and University of Aberdeen. Behavior change techniques. pages 182–187, 2016.

[33] Tammy Toscos, Anne Faber, Shunying An, and Mona Praful Gandhi. Chick clique: persuasive technology to motivate teenage girls to exercise. In *CHI '06 Extended Abstracts on Human Factors in Computing Systems*, pages 1873–1878. ACM.

[34] Thomas W. Malon and Lepper Mark R. Making learning fun: A taxonomy of intrinsic motivations for learning. *Aptitute, Learning and Instruction: III. Conative and affective process analyses*, 1987.

[35] Thomas G. Plante, Santa Clara University, Meghan Madden, Sonia Mann, and Grace Lee. Effects of perceived fitness level of exercise partner on intensity of exertion. 2010.

[36] Aleksandra Luszczynska, Frederick X. Gibbons, Bettina F. Piko, and Mert Tekozel. Self-regulatory cognitions, social comparison, and perceived peers' behaviors as predictors of nutrition and physical activity: a comparison among adolescents in hungary, poland, turkey, and usa. 2007.

[37] K. R. McLeroy, D. Bibeau, A. Steckler, and K. Glanz. An ecological perspective on health promotion programs. *Health Educ Q*, 15(4):351–77, 1988.

[38] Yan Xu, Erika Shehan Poole, Andrew D. Miller, Elsa Eiriksdottir, Richard Catrambone, and Elizabeth D. Mynatt. Designing pervasive health games for sustainability, adaptability and sociability. In *Proceedings of the International Conference on the Foundations of Digital Games*, pages 49–56. ACM.

[39] Pawel Wozniak, Kristina Knaving, Staffan Björk, and Morten Fjeld. Rufus: Remote supporter feedback for long-distance runners. In *Proceedings of the 17th International Conference on Human-Computer Interaction with Mobile Devices and Services*, pages 115–124. ACM.

[40] Unknown. Runkeeper application. https://runkeeper.com/index, 2016.

[41] Unknown. Nike+ run club application. http://www.nike.com/no/no$_n$o/c/$running/nike - run - club$, 2016.

[42] Sebastian Deterding, Rilla Khaled, Lennart Nacke, and Dan Dixon. Gamification: Toward a definition. In *CHI 2011 Gamification Workshop Proceedings*.

[43] Aino Ahtinen, Pertti Huuskonen, and Jonna Häkkilä. Let's all get up and walk to the north pole: design and evaluation of a mobile wellness application. In *Proceedings of the 6th Nordic Conference on Human-Computer Interaction: Extending Boundaries*, pages 3–12. ACM.

[44] Greg Walsh and Jennifer Golbeck. Stepcity: a preliminary investigation of a personal informatics-based social game on behavior change. In *CHI '14 Extended Abstracts on Human Factors in Computing Systems*, pages 2371–2376. ACM.

[45] Miru Ahn, Sungjun Kwon, Byunglim Park, Kyungmin Cho, Sungwon Peter Choe, Inseok Hwang, Hyukjae Jang, Jaesang Park, Yunseok Rhee, and Junehwa Song. Running or gaming. In *Proceedings of the International Conference on Advances in Computer Enterntainment Technology*, pages 345–348. ACM.

[46] Jeffrey Yim and T. C. Nicholas Graham. Using games to increase exercise motivation. In *Proceedings of the 2007 conference on Future Play*, pages 166–173. ACM.

[47] M. Tabak, M. Dekker-van Weering, H. van Dijk, and M. Vollenbroek-Hutten. Promoting daily physical activity by means of mobile gaming: A review of the state of the art. *Games Health J*, 4(6):460–9, 2015.

[48] Yuichi Fujiki, Konstantinos Kazakos, Colin Puri, Pradeep Buddharaju, Ioannis Pavlidis, and James Levine. Neat-o-games: blending physical activity and fun in the daily routine. *Computers in Entertainment (CIE)*, 6(2):21, 2008.

[49] T. Alahaivala and H. Oinas-Kukkonen. Understanding persuasion contexts in health gamification: A systematic analysis of gamified health behavior change support systems literature. *Int J Med Inform*, 96:62–70, 2016.

[50] James J. Lin, Lena Mamykina, Silvia Lindtner, Gregory Delajoux, and Henry B. Strub. Fish'n'steps: encouraging physical activity with an interactive computer game. In *Proceedings of the 8th international conference on Ubiquitous Computing*, pages 261–278. Springer-Verlag.

[51] Ian Li, Anind Dey, and Jodi Forlizzi. A stage-based model of personal informatics systems. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 557–566. ACM.

[52] B. J. Speck and S. W. Looney. Effects of a minimal intervention to increase physical activity in women: daily activity records. *Nurs Res*, 50(6):374–8, 2001.

[53] C. C. DiClemente, A. S. Marinilli, M. Singh, and L. E. Bellino. The role of feedback in the process of health behavior change. *Am J Health Behav*, 25(3):217–27, 2001.

[54] Clive Seligman and John M. Darley. Feedback as a means of decreasing residential energy consumption. *Journal of Applied Psychology*, 62(4):363, 1977.

[55] Leon Festninger. *A Theory of Cognitive Dissonance*. Stanford University Press, 1957.

[56] Ian Smith James A. L Sunny Consolvo, Katherine Everitt. Design requirements for technologies that encourage physical activity. In *Proceedings of the Conference on Human Factors and Computing Systems: CHI '06*.

[57] E. A. Locke and G. P. Latham. Building a practically useful theory of goal setting and task motivation. a 35-year odyssey. *Am Psychol*, 57(9):705–17, 2002.

[58] Harri Oinas-Kukkonen, University of Oulu, Marja Harjumaa, and University of Oulu. Persuasive systems design: Key issues, process model, and system features. *Communications of the Association for Information Systems*, 24(1):28, 2009.

[59] Dan Lockton, David Harrison, and Neville A. Stanton. Exploring design patterns for sustainable behaviour. 2013.

[60] BJ Fogg. A behavior model for persuasive design. In *Proceedings of the 4th International Conference on Persuasive Technology*, page 40. ACM.

[61] Google. Google fit. https://www.google.com/fit/, 2016.

[62] Matthias Kranz, Andreas MöLler, Nils Hammerla, Stefan Diewald, Thomas PlöTz, Patrick Olivier, and Luis Roalter. The mobile fitness coach: Towards individualized skill assessment using personalized mobile devices. *Pervasive and Mobile Computing*, 9(2):203–215, 2013.

[63] B.J. Fogg. *Persuasive Technology: Using Computers to Change What We Think and Do*. Morgan Kauffman Publisher, 2003.

[64] Fabian Groh. Gamification: State of the art definition and utilization. 2012.

[65] Christine Bauer and Simone Kriglstein. Analysis of motivation strategies in running tracking applications. In *Proceedings of the 13th International Conference on Advances in Mobile Computing and Multimedia*, pages 73–79. ACM.

[66] Peter C. Terry, Costas I. Karageorghis, and Mary Katsikitis. Psychophysical effects of music in sport and exercise: an update on theory, research and application. 2006.

[67] C. I. Karageorghis, D. L. Priest, P. C. Terry, N. L. Chatzisarantis, and A. M. Lane. Redesign and initial validation of an instrument to assess the motivational qualities of music in exercise: the brunel music rating inventory-2. *J Sports Sci*, 24(8):899–909, 2006.

[68] Matt Jones, Steve Jones, Gareth Bradley, Nigel Warren, David Bainbridge, and Geoffrey Holmes. Ontrack: Dynamically adapting music playback to support navigation. 2008.

[69] Matthew Mauriello, Michael Gubbels, Jon E. Froehlich, Matthew Mauriello, Michael Gubbels, and Jon E. Froehlich. Social fabric fitness: the design and evaluation of wearable e-textile displays to support group running. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 2833–2842. ACM.

[70] J. Poppenk, S. Kohler, and M. Moscovitch. Revisiting the novelty effect: when familiarity, not novelty, enhances memory. *J Exp Psychol Learn Mem Cogn*, 36(5):1321–30, 2010.

[71] J. O. Prochaska and W. F. Velicer. The transtheoretical model of health behavior change. *Am J Health Promot*, 12(1):38–48, 1997.

[72] Konstantinos Giannakis, Konstantinos Chorianopoulos, and Letizia Jaccheri. User requirements for gamifying sports software. In *Proceedings of the 3rd International Workshop on Games and Software Engineering: Engineering Computer Games to Enable Positive, Progressive Change*, pages 22–26. IEEE Press.

[73] Unknown. Android operating system. https://developer.android.com/index.html, 2016.

[74] Unknown. Android wear. https://developer.android.com/wear/index.html, 2016.

[75] Unknown. Firebase. https://firebase.google.com/docs/, 2016.

[76] Unknown. Android developer about intent. https://developer.android.com/reference/android/content/Intent.html, 2016.

[77] Unknown. Wearable data layer api. https://developer.android.com/training/wearables/data-layer/index.html, 2016.

[78] Pankaj Sareen. Cloud computing: types, architecture, applications, concerns, virtualization and role of it governance in cloud. *International Journal of Advanced Research in Computer Science and Software Engineering*, 3(3), 2013.

[79] Jaroslav Pokorny. Nosql databases: a step to database scalability in web environment. 2013.

[80] Zhou Wei, Jiang Dejun, Guillaume Pierre, Chi-Hung Chi, and Maarten van Steen. Service-oriented data denormalization for scalable web applications. In *Proceedings of the 17th international conference on World Wide Web*, pages 267–276. ACM.

[81] Unknown. Google play services. https://developers.google.com/android/guides/overview, 2016.

[82] Briony J Oates. Researching information systems and computing. pages 267, 245, 220, 2006.

[83] Geoff Lancaster. *Research Methods in Management*. Routledge, 2007.

[84] Asbjørn Johannessen, Line Christoffersen, and Per Arne Tufte. *Forskningsmetode for økonomisk-administrative fag*, volume 3. Abstrakt forlag, 2011.

[85] Macartan Humphreys and Jeremy M. Weinstein. Field experiments and the political economy of development. 2009.

[86] Bayo Lawal. Repeated measures design. pages 697–718, 2016.

[87] Elin Skretting Lunde. Bedre helse blant høyt utdannede. http://www.ssb.no/helse/artikler-og-publikasjoner/bedre-helse-blant-hoyt-utdannede, 2001.

Appendix A

Preparation questions

- Age?
- Do you prefer running with a friend or alone? Why?
- Do you have a running route you prefer?
- How many times do you run a week?

Interview guide

- Are you familiar with running with applications like Endmondo, Runtastic of similar? On smartphone or smartwatch?
- Are you familiar with running with a wearable like pulsewatch?
- How was it to run with the app?
- How were you affected by the fact that you could see yourself and your friend on the map?
- What do you think about the feedback? Did it make you feel a certain way?
- How was it to be behind your friend?
- How was it to be in front of your friend?
- Did you feel that you were running together, or did you feel it was a competition?
- Would it be different if you didn't know the person you ran against/with? why?
- How is it different from running with the app, then run alone? What would you prefer?
- How is it different from running with the app, then run with a friend? What would you prefer?
- Do you miss anything in the app?
- Do you have any more comments?

Appendix B

Questionnaire

- Perceived enjoyment?
- Perceived exertion?
- How motivated where you to run faster?
- How motivated where you to not stop during the run?

Questionnaire results

1. strongly disagree
2. disagree
3. neither agree nor disagree
4. agree
5. strongly agree

ID		enjoyment	exertion	motivation to run faster	motivation to not stop
1	with app	5	3	5	5
1	without app	4	4	3	5
2	with app	3	4	5	4
2	without app	4	5	4	4
3	with app	5	4	5	5
3	without app	4	4	3	4
4	with app	3	5	4	2
4	without app	4	4	4	4
5	with app	5	5	4	5
5	without app	4	4	3	4
6	with app	4	3	4	5
6	without app	4	3	2	4
7	with app	5	4	4	5
7	without app	3	3	3	5