Collecting heart beats
exploring the effects of progress feedback as a motivational intervention to increase physical activity

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Collecting Heart Beats
Exploring the effects of progress feedback as a motivational intervention to increase physical activity

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Definitions & Abbreviations

ACSM – American College of Sports Medicine
App – Mobile phone application
BLE – Bluetooth Low Energy
BMI – Body Mass Index
BPM – beats per minute
GPS – Global Positioning System
HR – Heart rate
HR Rest – resting heart rate
mBeats – heartbeats within a person’s heart rate training zone
Motivational Intervention – an intervention strategy aimed at keeping people motivated to sustain behavior
PC – Personal Computer
PInS – Philips Innovation Services
THR – Target Heart Rate
USB – Universal Serial Bus
Volitional intervention – an intervention strategy aimed at acting upon intention and initiating intended behavior
Vo2max – Maximum oxygen uptake in ml/kg/min; way to express cardio-respiratory fitness
WHO – World Health Organization
Abstract

Changing behavior is incredibly hard, and auxiliary tools that promote the behavior change might ease the discomforts of behavior change. Technical tools to increase physical activity are becoming increasingly ubiquitous. These tools typically consist of a monitoring device to measure the user’s physical activity, combined with an interface (e.g., mobile app) that motivates and supports the user to become more active. Many different strategies can be applied in such technical tools, all focusing on different aspects of physical activity and human behavior. It is however inconclusive how the different strategies contribute to this behavior and whether or not the strategies amplify each other or not. In order to create a framework for the most effective intervention design to increase physical activity, individual contributions of different intervention strategies should be studied. The present study investigated the effects of combining a volitional (willful) intervention with a motivational intervention, compared to the effects of a volitional intervention alone, by the use of an iPhone app. The goal of a volitional intervention is to translate intention into action. The volitional intervention used in the app was based on the principle of implementation intentions, by enabling users to define exactly when, where and how they will perform their physical activities. Once action is initiated, motivational interventions aim at keeping people motivated to sustain their behavior. The motivational intervention implemented in the app provided the user with feedback on heart rate and progress towards a goal. Eighteen Philips employees either received the volitional intervention alone or both the volitional and motivational intervention for three weeks, including one baseline week. Their objective was to collect a (weekly targeted) number of heart beats within a personalized heart rate training zone, named mBeats. Effects were studied by means of questionnaires and an in-depth interview about the psychological experiences, the motivational intervention and the usability of the app as a whole. Results indicated that progress feedback on heart rate indeed serves as a motivational intervention. Progress feedback on heart rate motivated people to exercise, because it made them more aware of their current behavior and the necessities for improvement. The combination of the volitional and motivational intervention showed more effective than the volitional intervention alone; providing the option to form implementation intentions had negative effects on physical activity. In general, the concept of collecting heart beats to improve cardio-respiratory fitness was received positively. However, this concept needs some alteration and the app showed some technical issues due to its immaturity. Participants gave valuable input for further development of this app as a means to improve cardio-respiratory fitness. The present study is a start in exploring the individual contributions of different intervention strategies on physical activity; more research should be done to expand on the knowledge of the effects of the currently explored strategies and to study the effects of other intervention strategies.
Preface

This report presents the work I have done for my graduation project conducted at Philips Research, Eindhoven, and it marks the end of my eight years of being a student. With this thesis I will complete the master Human-Technology Interaction at Eindhoven University of Technology (TU/e), which gives me mixed feelings. I have had the time of my life at TU/e and I am sad it has come to an end. On the other hand I am truly excited to start the next part of my life and explore all the possibilities that are ahead of me. However, before I do that, I have to thank some people that have made my life much easier over the past time, and without whom this thesis would not have been the same.

During the past seven months I have been part of the Brain, Body & Behavior group at Philips Research, in which I worked on a project related to health and physical fitness. For personal reasons, this project was incredibly valuable to me, and I would like to thank Philips for giving me the opportunity, funding and faith to execute this project. As part of the Protocol Free Health Assessment team, I was able to do the project my own way, while receiving feedback and input from all of the team members. I would therefore like to thank all the project team members for their help and enthusiasm, and for giving me great confidence in my work.

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Throughout the design phase of the app, I received much help and support from the people from PInS, who developed my app. I enjoyed working with them on creating this app together and therefore want to thank them for their input and making my research project possible. I would also like to thank the participants of my study, who generously shared their time and opinions with me.

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1. Introduction

Many people, especially people with office jobs, have a predominantly sedentary lifestyle (from the Latin sedere, ‘to sit’). A sedentary lifestyle is characterized by sitting behavior that is low in energy expenditure; such as watching TV, driving and computer use (Sedentary Behaviour Research Network, 2012). A common way to express energy expenditure is in Metabolic Equivalent Units (MET), with 1.0 MET corresponding to resting metabolic rate. Sedentary behavior is generally described as 1.0-1.5 METs (Pate, O’Neill, & Lobelo, 2008). As a comparison, running is associated with at least 6.0 METs (Ainsworth, et al., 2000).

A sedentary lifestyle, together with the worldwide changes in dietary patterns, increases the risk of obesity and cardiovascular diseases (World Health Organization, 2003). In 2011, 28.1% of all deaths in the Netherlands were caused by cardiovascular diseases, such as a stroke or a heart attack (Centraal Bureau voor de Statistiek, 2013). An independent risk factor for premature death from cardiovascular diseases is one’s cardio-respiratory fitness. Cardio-respiratory fitness, which refers to one’s physical fitness, is expressed in the maximal oxygen uptake by an individual (Vo\textsubscript{2max}; ml/kg/min). VO\textsubscript{2max} is widely used to assess cardiovascular health and performance as well as to develop exercise prescriptions (Whaley, Brubaker, Otto, & Armstrong, 2006).

In order to improve cardio-respiratory fitness, one needs to engage in enough physical activity at an adequate intensity. Dutch activity recommendations for a healthy lifestyle, also known as ‘Nederlandse Norm Gezond Bewegen’, are to engage in moderate-intensive physical activities five days per week for at least 30 minutes per day, performed in bouts of at least 10 minutes. For people with overweight the recommendation is 60 minutes for five days per week (Kemper, Ooijendijk & Stiggelbout, 2000). Currently, only 58% of the Dutch population meets these recommendations (Loketgezondleven.nl, 2013). However, besides getting enough physical activity, it is important to be fit in order to decrease the risk for cardiovascular diseases. To improve cardio-respiratory fitness the Dutch norm is to perform 20 minutes of intense exercise for 3 days a week. Only a meager 24% of the Dutch population meets this norm (Nederlands Instituut voor Sport en Bewegen, n.d.). For many people with a sedentary lifestyle, meeting these recommendations means they should exercise more than they currently do, in other words; they should change their current behavior.

As current behavior is usually routine and well trained, changing one’s behavior is incredibly hard, especially when the behavior change needs time, effort and brings discomforts. To decrease the discomfort of changing behavior, it can therefore be extremely helpful to use auxiliary tools, such as mobile apps, to assist the behavior change. Behavior change theories agree upon the fact that several behavioral factors influence readiness to change behavior; such as confidence (self-efficacy) and motivation. To influence these behavioral factors, many different intervention strategies can be applied in such auxiliary tools. However, little attention has been given to explore how the individual intervention strategies influence each other and the behavior. It is important to investigate this, in order to be able to design the most effective tools for assisting behavior change.

The present study compares the effects of a volitional (willful) intervention strategy with the effects of a volitional intervention strategy supplemented by a motivational intervention strategy, aiming to increase physical activity, using an iPhone app. This way, the effects of the motivational intervention can be explored. The goal of a volitional intervention is to act upon intention and
initiate the intended behavior. The volitional intervention used in the present app was based on
the principle of implementation intentions, by allowing users to define exactly when, where and
how they will perform their physical activities. Once action is initiated, motivational interventions
can try to keep people motivated to sustain their behavior. The motivational intervention imple-
mented in the app provided the user with feedback on heart rate and progress towards a goal.

This report provides information about the theoretical background, app design and the setup of
the study. The next chapter discusses theories and intervention strategies for behavior change,
which are explored and implemented in the app. Chapter 3 describes the study proposal and hy-
potheses. Next, the mBeats app is introduced in Chapter 4. Chapter 4 presents the study method-
ology. Results and discussion are presented in Chapters 6 and 7 respectively. Chapter 8 describes
the conclusions drawn from the present study.
2. Theoretical Background

2.1 Behavior change theories

2.1.1 Theory of Planned Behavior
Before we can apply methods to assist people in changing their behavior, we should understand the underlying principles of this behavior change process. There are several theories that predict behavior change. The Theory of Planned Behavior (Ajzen, 1991) for example, proposes that one's behavior can be explained by the intention to perform that behavior. An individual’s intention to perform a behavior is determined by three behavioral factors (see Figure 1). The first factor is attitude towards the behavior, which includes weighting the costs and rewards the person associates with that behavior. The second factor is subjective norm; the individual’s perception of the behavior which is influenced by the opinion of significant others such as peers, media or family. The final factor that determines intention is one’s perceived behavioral control, or self-efficacy beliefs, which refers to the perception that one has of their ability to perform the specific behavior. The Theory of Planned Behavior states that the stronger and more supported these beliefs are, the stronger the intention to change behavior and the more likely a person will actually perform the behavior. However, what this theory fails to explain is how to get from intention to behavior. Even though many people show positive intentions to change their lifestyle in a healthy way, many fail to act upon this intention (Sheeran, 2002). This phenomenon is called the intention-behavior gap.

![Figure 1. The Theory of Planned Behavior](image)

A meta-analysis that examined the utility of the Theory of Planned Behavior for predicting exercise behavior showed that both attitude and perceived behavioral control have a large effect size on exercise intention and behavior (Hausenblas, Carron & Mack, 1997). The effect size of subjective norm was somewhat lower, but still of medium size. A different study on predicting the maintenance of physical activity by the use of the Theory of Planned Behavior showed perceived behavioral control being the most predictive factor to influence intention and behavior (Armitage, 2005). So, even though the intention-behavior gap is a well-known phenomenon, the behavioral factors of the Theory of Planned Behavior do seem to predict both intention and behavior,
with perceived behavioral control being the most important factor. It therefore seems most important to increase perception about one's ability to perform a behavior; in order to raise intention and changing behavior.

2.1.2 Self-Determination Theory
A different theory that states that self-efficacy is an important behavioral factor to predict behavior is the Self-Determination Theory (Deci & Ryan, 1985), which is a theory of motivation. It focuses on the degree to which a person is motivated and self-determined to perform their behavior change choices. According to this theory, there are three psychological needs that influence one's intrinsic motivation to initiate behavior; autonomy, relatedness and competence. Autonomy can be defined as freedom of choice; people should feel they engage in certain behaviors because they choose to do so. Relatedness is defined by one's urge to interact with or be connected to others, which can be created by an accepting surrounding. As with the Theory of Planned Behavior, competence refers to one's perception about their ability to perform a certain behavior and will therefore be referred to as self-efficacy from now on.

This theory has some overlap and some differences with the Theory of Planned Behavior in predicting behavior. Both theories suggest that self-efficacy and the social surroundings of a person are important in predicting behavior. As with the Theory of Planned Behavior, competence (self-efficacy) was also found to be the most important predictor of exercise behavior in Self-Determination Theory (Edmunds, Ntoumanis & Duda, 2006). The difference between the theories is that one states the behavioral factors predict intention which in turn predicts behavior, whereas the other theory suggests the behavioral factors influence motivation to perform that behavior. To close the intention-behavior gap, it thus seems important not only to increase intention, but also to address motivation.

Overall, these theories agree upon the fact that certain behavioral factors are of influence on behavior and behavior change, such as self-efficacy and motivation. What these theories fail to explain, is how to influence these behavioral factors most effectively, so that the behavior is actually changed. In other words, what these theories do not explain is what strategies to apply to close the intention-behavior gap most effectively. To do this, it is key to initiate action and sustain this behavior; once someone has the intention and motivation to change behavior. To initiate action, people should commit to their specific plans and goals (Heckhausen & Gollwitzer, 1987). One model that goes beyond getting ready to change behavior and focuses on strategies to close the intention-behavior gap is the Rubicon Model of Action Phases (Heckhausen & Gollwitzer, 1987). Besides selecting goals and wishes, this model focuses on the realization of these goals.

2.1.3 The Rubicon Model of Action Phases
The Rubicon Model of Action Phases (Heckhausen & Gollwitzer, 1987) is based on a distinction between the motivational aspect of goal setting and the volitional (willful) aspect of goal striving. Besides being motivated to change behavior, people should have sufficient will to actually achieve their goals. According to the model, there are four phases that need to be accomplished to fulfill one's wishes; two motivational phases (pre-decisional, post-actional) and two volitional phases (pre-actional and actional). The four phases are separated by three transition points: making a decision, initiation of an action and the evaluation of the action (see Figure 2).
In the pre-decisional phase, preferences are set between potential goals and wishes (e.g. do I rather want to live a healthier lifestyle than to not care about my diet?). Not all wishes and goals can be accomplished, for example because they are unfeasible. In this phase, pros and cons are weighted to assess the confidence (self-efficacy) and motivation of a person for reaching a certain goal. Once people have the intention to accomplish a certain goal (e.g. to live a healthier lifestyle), they move to the pre-actional phase. Because the next step is initiating the goal-directed behavior, people might need to prepare and plan this initiation, especially when the goal-directed behavior is not well-practiced or not routine behavior (e.g. eating two pieces of fruit every day to live healthier). The goal of the pre-actional phase is therefore to plan the implementation of the chosen goal by defining when, where and how one is going to act upon one's goal (e.g. every day I eat one piece of fruit once I reach my office and another one during my lunch break). After action initiation, the actional phase follows, which aims to bring the goal-directed behavior to a successful end (e.g. actually making sure to eat two pieces of fruit each day). The final phase is the post-actional phase, in which the performance of goal achievement is evaluated by comparing the original wish with the outcome and assesses whether further action is necessary (e.g. did I eat two pieces of fruit today?). This evaluation may lead to a possible adaptation of one's wishes or implementation plans (e.g. do I really want to eat two pieces of fruit each day? Maybe I should eat a piece of fruit during my first coffee break instead of once I arrive at the office). Because of the comparison between original wish and outcome during the last phase, the post-actional phase is centered around the same theme (i.e. goal setting) as the pre-decisional phase and both phases are therefore described as motivational. The pre-actional and actional phase are both associated with volitional (willful) processes, because they are both associated with translating goals into action (Achtziger & Gollwitzer, 2008).

Based on the many behavior change theories, it can be concluded that there are many behavioral factors, one more important than the other, that predict intention, motivation and therefore behavior. The most agreed-upon predictive factor of behavior change seems to be self-efficacy, because it influences both intention and motivation. In order to influence these behavioral factors and to initiate goal-directed behavior to increase physical activity, many different intervention strategies can be applied. There is much empirical evidence that such intervention strategies influence people's behavioral factors, such as awareness and self-efficacy. Different kinds of intervention strategies can be applied to change behavior: Some strategies are designed to increase motivation for that behavior; motivational interventions, and other strategies to close the intention-behavior gap by initiating action; volitional interventions. As evidence is still mixed, it remains inconclusive how the different intervention strategies truly affect exercise behavior.
2.2 Intervention Strategies

2.2.1 Implementation Intentions
A volitional intervention that is described in the pre-actional phase of the Rubicon Model is creating specific plans for action. Planning was found to moderate the relation between intention and behavior and to mediate the impact of this intention on behavior (Norman & Connor, 2005). Gollwitzer (1993) calls these specific plans for action 'implementation intentions'. By forming implementation intentions, one defines exactly when, where and how a particular goal-directed behavior will be executed (Gollwitzer, 1999). Implementation intentions differ from goal intentions, which only define the 'what' portion of a goal. Implementation intentions are specific plans that specify a goal-directed response when a certain situation arises ('if situation X arises, then I will perform goal-directed behavior Y', e.g. if I go for a coffee break at work, I will eat an apple).

By forming implementation intentions, one creates a mental link between the environmental cues and the response necessary to obtain one's goal (Webb & Sheeran, 2007). In other words, a mental commitment is created that will initiate the then-component of the plan when the if-situation is encountered (e.g. pouring coffee at work reminds me that I should eat an apple). This mental link between the if- and then-component of one's plan results in a more immediate and more efficient initiation of the planned action, compared to people who have not formed implementation intentions (e.g. Webb & Sheeran, 2004; Lengfelder & Gollwitzer, 2001). Forming implementation intentions is a strategy that can help overcome volitional problems, such as getting started with a task despite distractions, persisting a task in spite of difficulties and resuming a task after disruption (Gollwitzer, 1996).

A meta-analysis of 94 independent studies shows that implementation intentions have a positive effect of medium-to-large magnitude (d = .65) on goal attainment (Gollwitzer & Sheeran, 2006). Therefore, forming implementation intentions seems to be a good strategy to assist people in taking action to improve their cardio-respiratory fitness. Nevertheless, de Vet, Oenema, Sheeran and Brug (2009) studied the effect of forming implementation intentions for increasing physical activity aimed at weight maintenance. No significant effect was found on BMI or physical activity. The authors suggest that, in order to have effect on physical activity, implementation intentions may need to be supported by motivational interventions. This is in line with the “Rubicon Model”, which states that motivational interventions can assist people in the post-decisional phase to persevere their behavior if the desired outcome is not reached yet. A study by Schunk and Swartz (1993) also hints in this direction of combining volitional and motivational interventions for a more positive outcome. They investigated the effect of progress feedback and goal setting on self-efficacy and achievement by the use of a writing assignment amongst children. Children were given either a strategy goal (i.e. learning the strategy to achieve the outcome), general goal (i.e. working productively), or an end goal (i.e. the to-be-achieved outcome). Half of the children in the strategy goal group received feedback on their progress, which should motivate them as it promotes self-efficacy and skill acquisition. They found that children in this strategy goal plus feedback group outperformed children in the general and end goal groups on self-efficacy, skill and progress in strategy learning. This suggests that a combination of setting a strategy goal (volitional) and receiving feedback (motivational) works better than just setting the end goal or doing nothing at all. Schunk and Swartz (1993) explain this finding by stating that the strategy goal highlights the use of a strategy to improve writing skills and that feedback will motivate because it conveys a feeling of being capable of continuing to improve one’s skills and thus raise self-efficacy.
2.2.2 Progress Feedback

During the post-actional phase of the “Rubicon Model”, which is a motivational phase, people will evaluate their actions and decide whether further goal pursuit is necessary. However, in order to make this decision, people need to know to what extent their goal is reached so far. This means they need some kind of feedback on their progress.

Progress feedback is often used to persuade people not to abort a specific task and is used by many systems, such as the progress bar shown while installing software or the number of people in line in front of you while waiting to speak with a help desk advisor. Not providing such feedback leaves people in the dark, degrading their experience with the system. Conrad, Couper, Tourangeau and Peytchev (2010) found in a study on web surveys that progress feedback indeed increases the task completion rate, compared to getting no feedback. However, if the progress feedback indicated a slow progress, people got discouraged to complete the survey. Other studies find similar results, for example when the feedback displays encouraging news, people are more satisfied and have a better experience than when the feedback is discouraging, such as a slow progress (Lawrence, Carver & Scheier, 2002). In most studies though, the tasks were one-time tasks, such as filling out an online questionnaire or participating in an experiment. The effect of feedback might be different for long-term behavior change tasks, such as exercising more to improve cardio-respiratory fitness, because the gain might be very different for long-term behavior compared to such short tasks. A study by Brug, Glanz, van Assema, Kok and van Breukelen (1998) shows that feedback on progress towards food intake recommendations, also on longer term, positively impacts fat reduction. This suggests that the effect of feedback indeed could be effective for long-term behavior change. However, the effect of the valence of the feedback was not tested here. Hurling and colleagues (2007) state that progress feedback on the longer term may increase awareness and provide a motivational intervention for behavior change, which is in line with the “Rubicon Model”. A study by Oenema (2004) confirms this finding; feedback increases the intention to reduce fat intake and increases awareness and intention to change vegetable intake. Raising awareness of one’s behavior has been found to be an important part of behavior change interventions. Without awareness of one’s current behavior, behavior change interventions targeted at increasing other behavioral factors might be ineffective, because people do not see the need to change (van Sluijs, Griffin & van Poppel, 2007). This is confirmed by Ronda, van Assema and Brug (2001), who show that awareness of one’s physical activity level is an important motivator to exercise more. A lack of awareness of one’s current behavior might thus impact the predictive value of the behavior change models.

2.2.3 Mobile apps for physical activity promotion

The number of smartphone users in the Netherlands was 61% of the population in 2012, and is still rising (de Volkskrant, 2013). Mobile phones are found to be an effective means to influence physical activity (Fanning, Mullen, & McAuley, 2012). Evidence shows that the more people engage in online health interventions, the more likely they are to improve and maintain their health related behavior (Wantland, Portillo, Holzemer; Slaughter, & McGhee, 2004). Hurling and colleagues (2007) tested a physical activity program based on Internet and mobile phone technology for nine weeks. This system provided multiple functionalities, such as an exercise planner (based on the principle of implementation intentions), activity charts (providing progress feedback) and motivational tips. They found positive results for using the system to support behavior change, as compared to not receiving any support. People who used the system were more satisfied with their level of fitness and wellbeing and showed a significant change in body fat percentage. Moreover, they showed a great increase in physical activity per week and a better maintenance of their physical activity over time.
A study by King and colleagues (2013) explored the effects of three different apps, all based on different behavioral theories. One was analytically framed, one socially and the third one was affectively framed. Even though the three apps focused on three different subjects, they all used a combination of several strategies per subject. Their results indicated all three apps were capable of increasing physical activity.

Even though the results from both these studies are very promising, it is unclear which of the many functionalities and strategies used in their tools were most effective in promoting behavior change. By carefully selecting and timing the different strategies for implementation in apps to promote physical activity, effectiveness of such apps can be increased. Before this can be done, the effects and contributions of the individual strategies should be studied. Because self-efficacy seems to be the most important predictor of behavior across theories, because it influences intention and motivation, it seems important to address this factor in apps that promote physical activity.
3. Study Proposal

Many people turn to technological tools, such as mobile phone applications (apps), to assist them in increasing physical activity, as changing behavior without some form of help is exceptionally hard. Apps have become a ubiquitous part of the Western culture and there are many mobile apps available that support physical activity, such as Fitbit, Digifit, Runkeeper and Moves. As stated before, mobile apps are found to be an effective mean to increase physical activity (Fanning, Mullen, & McAuley, 2012). Such apps allow people to, amongst others, track their progress, share their accomplishments and plan their activities. These apps use a smartphone device and the internal sensors of the phone or an external sensor as input, and can therefore measure the amount of physical activity. However, the sensors used in most of these apps do not measure the intensity with which one exercises. Fitbit, for example, counts the number of steps taken each day, but does not take into account the intensity with which these steps are taken. In order to improve the level of cardio-respiratory fitness, training at a specific intensity is necessary. Perceived exertion is a subjective way of measuring exercise intensity, but heart rate is a good and objective way to measure exercise intensity, as it correlates with energy expenditure (e.g. Strath et al., 2000). Some mobile apps allow connecting to a heart rate monitor, such as the Polar chest strap, and therefore allow exercise intensity to be measured objectively. This creates opportunities for the development of effective intervention designs for increasing physical activity and improving cardio-respiratory fitness. However, it is unclear how individual intervention strategies used in such apps, such as tracking progress and planning activities, contribute to physical activity. It is also unknown which strategies amplify each other and how, and which strategies do not. It is important to explore this, in order to create a framework for the development of efficient interventions to increase physical activity. The present study is a start in this direction.

Even though several studies found positive effects of volitional (willful) interventions on physical activity (e.g. Latimer, Ginis & Arbour, 2006), some suggest that the combination of volitional and motivational interventions is most likely to increase exercise behavior (Milne, Orbell & Sheeran, 2002; Prestwich, Lawton & Conner, 2003). This is in line with the Rubicon model of action phases (Heckhausen & Gollwitzer, 1987). The volitional strategy that has received much empirical support from many different fields of behavior change is forming implementation intentions (Gollwitzer, 1993), as discussed earlier. Progress feedback was found to be a motivational strategy that can increase people’s awareness (Hurling et al. 2007). The present study explores the effects of progress feedback in the form heart rate on physical activity; whether this form of feedback is motivational and whether the combination of a volitional and a motivational strategy to increase physical activity is indeed more effective than a volitional strategy alone. Moreover, the behavioral effects of progress feedback are studied, to figure out whether and how this feedback might affect people’s intentions and motivations.

An iPhone app, called mBeats app, was designed to assist people in improving their cardio-respiratory fitness, by providing a heart rate training zone and a target number of heart beats that one should achieve within this zone (mBeats target). This app receives heart rate information from a heart rate monitor bracelet, the Mio Alpha. The app contains a volitional intervention in the form of an activity planner. This activity planner is based on the principle of implementation intentions and allows users to plan exactly how, when and where they will perform activities. The activity planner then provides an estimation of the number of mBeats that will be achieved with a specific activity, and gives an overview of the number of mBeats planned in relation to the target.
Next to the volitional intervention, the app contains a motivational intervention. This motivational intervention gives immediate feedback on progression towards the target, by keeping track of the number of mBeats achieved by the user in relation to their target. Also, the user has the opportunity to view a history of their activity. For more information on the app, see chapter 5.

In order to explore the effects of progress feedback on physical activity, a mixed method study was conducted, with an emphasis on qualitative measures. 18 Philips employees used the mBeats app for three consecutive weeks. The study compared the experiences and motivations behind a volitional intervention (the activity planner) with those of the same volitional intervention augmented by a motivational intervention, in the form of progress feedback on heart rate. The participants were randomly allocated to either the no feedback condition in which they could use the activity planner only, or the feedback condition in which they additionally received feedback on their mBeats target.

Besides investigating the effects of progress feedback, the usability of the app and usability of the concept was explored in this study. Exploring usability can provide insights and ideas for the further development of the app and the concept. Moreover, usability might influence peoples’ satisfaction with the app, and therefore affects their motivation to use the app.

Progress feedback has been shown to be a motivational intervention for behavior change that increases people’s awareness of their behavior. It is therefore expected that receiving the progress feedback on heart rate will be experienced as a motivating element to engage in physical activity, and this motivation is positively influenced by progress feedback because this makes people more aware of their current physical activity. Literature suggests that the combination of a motivational and volitional strategy is the most powerful in changing behavior. Therefore, it is expected that people in the feedback condition report a greater increase in physical activity than people in the no feedback condition. However, because both intervention strategies have been proven to assist people in increasing physical activity compared to not using any strategies, it is expected that all people show an increase in physical activity during the intervention period. Lastly, literature also hints into the direction that the combination between both types of interventions is most powerful because it increases self-efficacy beliefs. It is therefore expected that participants in the feedback condition will show more confidence about their ability to achieve their weekly target than participants in the no feedback condition.
4. mBeats App

The mBeats app was especially designed for the purpose of this study. Main features integrated in this first prototype of the app are a planner element, based on the principle of implementation intentions and a feedback element that provides feedback about heart rate, mBeats target and progress towards this mBeats target. This chapter will provide background information about the concept of the app, discuss the design process of the app, and introduce the different elements that are used in the app.

4.1 Background information

As a method to improve cardio-respiratory fitness, the American College of Sports Medicine (ACSM) has been endorsing the heart rate (HR) reserve method for several years now, also known as the Karvonen Method (Karvonen, 1957). This method is often used to measure exercise intensity and calculate a Target Heart Rate (THR). This THR corresponds to a desired range of the heart rate that should be reached during exercising, to make sure one’s heart and lungs receive most benefit from the workout. The Target Heart Rate is derived from one’s resting heart rate (HR rest), a training intensity in percentage, and Heart Rate Reserve (HR reserve). The HR reserve is the difference between the predicted maximal HR and the resting HR of a person; HR reserve = (HRmax - HR rest). The formula for THR is as follows:

\[ THR = (HR\ reserved + %\ intensity) + HR\ rest \]

The THR for a person depends on the age and current cardio-respiratory fitness. The ACSM also published the weekly amount of exercise, with which a person of a specific age and fitness can effectively improve cardio-respiratory fitness. This differs from the WHO guidelines stated earlier because the ACSM also takes someone’s current fitness into account and is aimed at improving this fitness instead of maintaining fitness. Philips has created an algorithm, based on these ACSM Guidelines, which allows for personalized recommendations on the amount of physical activity needed to improve cardio-respiratory fitness.

Based on a person’s HR reserve, a training zone can be calculated, bounded by a lower and an upper threshold. This training zone can be derived from the algorithm. The lower threshold of this training zone is based on the HR reserve; the upper threshold is derived from the lower threshold plus 5%. In order to increase one’s cardio-respiratory fitness, a person should try to stay within this training heart rate zone when exercising.

By multiplying this lower threshold of a person with the recommended amount of exercise, a targeted number of heart beats is calculated; the mBeats target. For example, if someone’s lower threshold is 125 bpm and that person should exercise for 100 minutes per week, the targeted number of heart beats is 125x100 = 1250 mBeats. This target refers to the number of heart beats one should achieve per week within his or her training zone, in order to increase cardio-respiratory fitness. Heart beats that fall in the targeted training zone are called mBeats. mBeats can be achieved with any type of physical activity at adequate intensity. For example, a person is doing exercise for ten minutes, and his heart rate in this ten minutes is 132 bpm. If his training zone is between 130 and 137 bpm, he will then achieve 1320 mBeats for doing this exercise. Before the mBeats app, there was no tool available, based on this HR reserve method, which provides the user with immediate feedback on heart rate and progress towards the recommended amount.
of physical activity, in terms of collected heart beats, to improve cardio-respiratory fitness. The mBeats app provides the user with feedback on THR and the quantity and intensity of exercise of a person. The app receives information wirelessly from an unobtrusive wearable heart rate bracelet the Mio Alpha. The goal of the app is to improve cardio-respiratory fitness, by achieving a weekly personalized targeted number of mBeats. The mBeats target can be reached by performing enough physical activity at the right intensity. If the weekly target is achieved, one’s cardio-respiratory fitness will improve over time. A fully described example of the calculation of the mBeats zone and target for a person, used to personalize the app settings can be found in Appendix A.

4.2 Design process
During a first team brainstorm, the main features of the app were discussed and prioritized. Next, flowcharts were created to show the structure of the app interface; how the different screens interact and the content of the different screens. These flowcharts were discussed with software programmers from Philips Innovation Services (PInS), to verify whether and how all the elements could be realized within the allocated time period. Next, each of the screens was designed using Adobe Illustrator CS6, taking the Philips Communication guidelines and the Apple Human Interface Guidelines into account. Designs were discussed with a design consultant, to make sure all elements were well designed. Understanding of the interface elements was tested by paper prototyping; printed versions of all the app screens were shown to five people, who were asked to act out several scenarios with different elements of the screen. Difficulties were discussed to identify possible improvements. The screen designs were adapted based on the feedback. After final approval, all interface assets were handed over to the software programmers, who programmed the app. During this programming process, close contact was kept with PInS, to make sure that the app functioned as planned. The app was tested for bugs multiple times before the start of the study.

4.3 App Design
To increase simplicity the design of the app elements was based on standard Apple IOS interface elements. The rules and guidelines of these elements are available on the Apple developers’ website (2010). Philips orange was chosen because it reflects confidence, vitality, patience and assertiveness (Venema, 2013) and it creates a fresh and clean look. All images are of Apple iPhone 5 screen resolution (4 inch; 1136 x 640 px). The app is also compatible with Apple iPhone 4S. For the purpose of this study, the app consisted of three elements; a feedback element, an activity planner and a settings menu. The design of these elements will be discussed in detail in the next sections.

4.3.1 Feedback
The main screen of the app shows the training heart rate zone, current heart rate, target number of mBeats for that day, and progress towards this target (see Figure 3). The daily target is a dynamic calculation, based on the weekly target minus the already achieved mBeats for that week, divided by the number of remaining days for that week. In other words, if the weekly target mBeats is 14000 and on Tuesday 9000 mBeats are already achieved; the remaining 5000 mBeats are divided by the remaining five days of the week so that the daily target on Wednesday will be 1000 mBeats. This way, people can decide for themselves how they reach their weekly target, which is more important than reaching the daily targets. For example, users can spread the amount of exercise evenly over the seven days of the week, or exercise longer on three days out of seven. Even though the user receives a daily target, only the weekly target counts. The main screen shows a button ‘view mBeats history’. This button will lead to a weekly overview of the percentage of
achieved mBeats per day and per week (see Figure 4). If the user clicks on a specific day, a detailed overview of the achieved mBeats on that day is shown, in both statistics (see Figure 5) and graphs (see Figure 6). The statistics shows an overview of the number of mBeats achieved linked to a specific timestamp on that day. The graphs show both the cumulative achievement of mBeats during the day (Figure 6; top) and the course of the heart rate during the day (Figure 6; bottom).
4.3.2 Activity Planner

Next to the feedback element, the app has an activity planner element. This activity planner is an agenda function, which allows users to plan their daily exercises and specify how they will achieve their weekly target. This element is based on the principle of implementation intentions (Gollwitzer, 1999). On the agenda screen, a summary can be seen of the daily and weekly target and planned mBeats (see Figure 7). By adding activities to the agenda (see Figure 8), users can plan when, where and how they will achieve their target mBeats. The activity planner gives an estimation of the number of mBeats the user will achieve with each activity, if the activity is performed at the right intensity (i.e. with a HR that falls in one’s HR training zone). This estimation is made by multiplying the duration of the activity with the lower threshold of the training zone.

![Figure 7. Activity planner](image1)

![Figure 8. Activity planner - add activity](image2)

4.3.3 Settings & Connectivity

A settings menu was designed (see Figure 9) which allowed users are able to enter their personal settings (name, gender, height, weight and date of birth). Furthermore, a password protected section was added (see Figure 9; bottom). In this section, which can only be accessed by entering a password, the upper and lower threshold and the weekly target mBeats were set for each participant by the experiment leader. For research purposes, the activity planner and feedback elements of the app could be made invisible for the user and the logging data of both the history feedback as the activity planner could be saved to an iTunes folder. On each screen of the app, a connectivity icon was placed on the top right showing the connectivity status. The icon functions as a button that leads to the connectivity menu. In this menu, connection status to the Mio Alpha watch is shown (see Figure 10). When connection is lost, the icon in the upper right corner shows a red exclamation point and a pop-up notification will appear, stating that the connection is lost. The connection will automatically be reset when the user opens the app again.
4.3.4 Other elements

Other elements that were suggested during the brainstorm were left out at this point, because they were not required for the purpose of this study, and could bias the results. Furthermore, this study could possibly result in finding support for including these elements in the next prototype. The suggested elements were, amongst others, an automated fitness test to define the THR and training zone, an ad hoc activity planner that gives tips on the kind of activities one could do and ambient features that could take into account your location, agenda and weather forecast.
5. Study Methodology

5.1 Design
In order to test the usability of the app and to explore the effects of progress feedback, a three-week 2 x 2 mixed method study was designed. Participants were randomly allocated to either receiving the progress feedback or not (between subjects). The three weeks were divided into two parts (within subjects); a baseline week and two intervention weeks. During the baseline week, participants were instructed to wear the heart rate monitor and keep the app running, in order to collect physical activity data. During this baseline week all functionalities of the app were disabled. Participants were asked to be as physically active as usual. After the baseline week, the two week intervention period started in which participants were asked to achieve their weekly objectives. The study collected both quantitative and qualitative data about, amongst others, usability, experiences and behavioral factors, with the emphasis on the qualitative data. The study methodology was approved by the Philips Internal Committee Biomedical Experiments.

5.2 Participants
Twenty people were recruited and screened for participation in the study. Candidates were screened using the Physical Activity Readiness questionnaire (PAR-Q; Shephard, 1988) and the AHA/ACSM Pre-screening questionnaire (Balady, et al., 1998). These questionnaires assessed the health status of candidates, by asking about cardiovascular risk factors and other health issues, such as having asthma. In this way the health risks of exercising excessively can be assessed. None of the candidates showed major risks, such as having a serious heart condition or chest pains that could be made worse by a change in physical activity. Therefore no one was excluded from participation. Some participants showed minor risks, such as having had a minor heart surgery a couple of years ago or having a mild form of asthma. All of these participants indicated they already exercise quite often, had seen a physician about this in the past and were well aware of their limits and capabilities. Nevertheless, these participants were strongly advised to be careful when exercising excessively. They were told what kind of symptoms could possibly indicate any danger, and to stop when experiencing any of those symptoms.

Two people dropped out halfway, because the heart rate monitor caused them an irritated skin at the place of wearing. The final sample consisted of 18 participants who completed the study, of which ten male and eight female. All participants were Philips employees in the age between 26 and 50 (M = 40.33, SD = 7.45). Participants were recruited via posters, SocialCast (Philips’ online community website) and through word of mouth advertising, by requesting people who would like to try out a new way of improving their fitness. Out of the 18 participants, six were not Dutch. On average, participants were fairly healthy, with eleven participants having a normal BMI between 18 and 25, five participants were slightly overweight with a BMI between 25 and 27 and two participants were overweight with a BMI above 28. The calculated VO2max was below average only for the two people showing overweight.

5.3 Setting and apparatus
Most meetings took place at the High Tech Campus, Eindhoven, the Netherlands. Seven participants were located on different locations, so they were visited on those locations. During the whole study participants were free to use the iPhone app at any time and any location they wanted. Questionnaires were filled in on paper, and coded to keep the data anonymous.
Interviews were audio recorded using the Philips Digital Voice Tracer 7790. All paper based communication was done in English, face to face contact was done in either Dutch or English, depending on the native tongue of the participant.

Participants were given a Mio Alpha which is a heart rate monitor bracelet (see Figure 11), that sends heart rate data to the iPhone app via Bluetooth Low Energy (BLE; Bluetooth v4.0). This CE approved device measures heart rate with a range of 30-220 BPM with an optical blood flow sensor. Because of the Bluetooth Low Energy, the Mio Alpha is only able to connect to the iPhone 4S, iPhone 5 or iPod Touch 5th generation. Therefore only these three devices could be used during the study. Participants who did not own the right iPhone version were given an iPhone 5 for the duration of the study. Because the current version of the Mio Alpha does not have internal memory, participants were asked to keep their phone close by in order to keep connectivity and collect data. The distance range of BLE is fairly the same as the distance range of Classic Bluetooth, which is about 10 meters.

The mBeats app was internally developed by Philips Research and PInsS. The main functionality of the mBeats app is to visualize and track when the user’s HR is within a specific HR target zone, which is known to increase cardio-respiratory fitness. Moreover each heart beat within this HR target zone is referred to as an mBeat. The app counts the number of mBeats that are achieved to keep track of the user’s progress. The target mBeats is merely the desired HR threshold multiplied by the recommended time of exercise (HR threshold and exercise duration are in agreement with ACSM guidelines). For an elaborate example of how the HR target zone and the target mBeats are calculated for an individual, see Appendix A. Distribution of the app was done via an internal SharePoint, making it unavailable for external parties. The app data, i.e. heart rate data and planner data, was saved on the phone during the study and downloaded at the end of the study via iTunes. After the study, the mBeats app was removed from the users’ phone, which also deleted the app data.

5.4 Manipulation
The aim of the study was to gather insights in the effects of progress feedback as a motivational intervention to assist the volitional intervention of implementation intentions. To test this effect, half of the participants received the full iPhone app during the intervention period, with both the
activity planner and the feedback element (feedback condition). The other half of the participants only used the planner part of the iPhone app during the intervention period; for them the feedback functionality was not visible (no feedback condition). The app did collect the mBeats data for both conditions. For a full explanation of the intervention elements, see Chapter 4.

5.5 Measures

Several measures have been used in the present study; some for analysis, and others as a guide for discussion during the final interview. The emphasis of the study was on the final interview. The interview is described in section 5.4.5, but first the quantitative measures will be presented.

5.5.1 Behavioral factors: self-report items

A set of self-report items about behavioral factors (see Table 1) were created specifically for this study. The items questioned various topics, such as motivation to improve fitness, intention to increase physical activity and self-efficacy beliefs about sticking to a schedule. Each item was scored on a seven-point Likert scale ranging from strongly disagree to strongly agree. These items are not from a validated questionnaire, but created by the author in consultation with Philips supervisors. Two of the variables, Reported Physical Activity and Improve Fitness Motivation, were created by averaging multiple items (see Table 1). These two variables had satisfactory reliabilities with alpha’s ranging between .68 and .83 for the two measurement phases. All the items were answered both after the baseline as after the intervention weeks, to test whether the intervention had any influence on these self-reports. During the final interview, the answers to this questionnaire were discussed in more depth.

5.5.2 Usability

Usability was measured by the use of the Computer System Usability Questionnaire (CSUQ; Lewis, 1995), since this study was performed in a non-laboratory setting. From these 19 items (1-19, see Table 2), four variables were created (Lewis, 1995). The first variable is Overall Usability of CSUQ (item 1-19), the second variable is System Usefulness (item 1-8). Information Quality (item 9-15) is the third variable and the final one is Interface Quality (item 16-18). The average reliability (Cronbach’s Alpha) of these variables were respectively $\alpha = .92$, $\alpha = .88$, $\alpha = .72$ and $\alpha = .72$. Additional usability items were added (items 20-29), that were derived from the Usability, Satisfaction and Ease of use questionnaire (USE; Lund, 2001) and some usability questions provided by the Healthcare Information and Management Systems Society (mHIMSS, 2012). The latter questions were used to collect subjective data in a structured way for later discussion. These additional items were combined into the variable Additional Questions ($\alpha = .74$). All usability items were answered on a seven-point Likert scale (1 = strongly disagree, 7 = strongly agree). During the final interview, usability and user experiences were discussed in more depth.

5.5.3 Feedback and planning behavior

To test whether there was any effect of the activity planner and feedback on people’s experience, a set of questions were designed that was part of a questionnaire administered at the end of baseline (see Appendix B, page 68-69 for details). Part of this questionnaire consisted of questions about planning behavior; whether and how they already planned their exercises before the start of the study. The second part consisted of questions about exercise progress; whether and how they already kept track of their progress before the start of the study. The answers to these questions were not used for analysis, but merely as a discussion guide during the final interview, to explore how the app affected their planning and feedback behaviors and experiences.
For example, if participants beforehand stated they always planned their exercises, but they failed to do this during the study, it was discussed during the interview why this happened. The app collected data about planned activities from the planner and the history of progress feedback, which were also used for discussion during the interview.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reported Physical activity</td>
<td>1. Tick the circle that best describes your overall level of physical activity for the previous week*</td>
</tr>
<tr>
<td></td>
<td>2. I am currently regularly physically active</td>
</tr>
<tr>
<td></td>
<td>3. I am satisfied with my current level of physical activity</td>
</tr>
<tr>
<td>Recommendations awareness</td>
<td>In order to improve or maintain my physical fitness, I should exercise at least 5 days a week for at least 30 minutes</td>
</tr>
<tr>
<td>Risk awareness</td>
<td>Exercising enough reduces the risk of getting cardiovascular diseases</td>
</tr>
<tr>
<td>Goal setting motivation</td>
<td>Setting exercise goals will help to increase my motivation for doing exercise</td>
</tr>
<tr>
<td>Tracking motivation</td>
<td>Keeping track of my exercise progress keeps me motivated</td>
</tr>
<tr>
<td>Improve fitness motivation</td>
<td>1. I want to improve on my physical fitness</td>
</tr>
<tr>
<td></td>
<td>2. I am motivated to improve my physical fitness</td>
</tr>
<tr>
<td>Fitness level satisfaction</td>
<td>I am satisfied with my level of physical fitness</td>
</tr>
<tr>
<td>Intention level</td>
<td>I intent to increase my level of physical activity in the near future</td>
</tr>
<tr>
<td>Self-efficacy improving fitness</td>
<td>I am confident that I will improve my physical fitness in the near future</td>
</tr>
<tr>
<td>Self-efficacy stick to schedule</td>
<td>If I would schedule or plan my exercises for a week, I am confident that I would stick to the plan</td>
</tr>
<tr>
<td>Confidence achieve target</td>
<td>I am confident that I am able to reach the weekly target mBeats I am asked to achieve for this study</td>
</tr>
</tbody>
</table>

* question from the Physical Activity Rating Questionnaire (Jackson et al., 1990); seven options of physical activity ranging from no regular engagement in physical activity to regular engagement in heavy physical exercise

5.5.4 Physical activity

Subjective physical activity was measured using the Short QUestionnaire to ASsess Health enhancing physical activity (SQUASH; Wendel-Vos, Schuit, Saris & Kromhout, 2003). Participants were asked to assess their physical activity of the past week by reporting how many days per week they performed activities, how much time per day they did this and the intensity with which they performed this activity. These answers were reported on household activities, work activities, leisure physical activities, commuting activities and the average total. Another question was added to find out how representative the past week was for their average behavior. From these questions, subjective amount of light, moderate and intense physical activity can be calculated in minutes per week.

To find out how aware participants were about their actual physical activity, this subjective physical activity was compared to objective physical activity. The objective physical activity data were collected by the iPhone app during the baseline week. The app collected the timing, duration and
intensity of physical activity, in the form of number of mBeats achieved linked to a timestamp. However, because several participants reported both connectivity issues and forgetting to wear the Mio Alpha, it was unclear to what extent the data were gathered. Moreover, a participant might have exercised but not at the right intensity; the app did not register this heart rate data. Therefore, it was decided that the data collected by the mBeats app were not reliable and complete enough for further analysis.

Table 2. Usability Questionnaire Items

<table>
<thead>
<tr>
<th>Variable</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Usability</td>
<td>1. Overall, I am satisfied with how easy it is to use this app</td>
</tr>
<tr>
<td>System Usefulness</td>
<td>2. It was simple to use this app</td>
</tr>
<tr>
<td></td>
<td>3. I can effectively complete my work using this app</td>
</tr>
<tr>
<td></td>
<td>4. I am able to complete my work quickly using this app</td>
</tr>
<tr>
<td></td>
<td>5. I am able to efficiently complete my work using this app</td>
</tr>
<tr>
<td></td>
<td>6. I feel comfortable using this app</td>
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<tr>
<td></td>
<td>7. It was easy to learn to use this app</td>
</tr>
<tr>
<td></td>
<td>8. I believe I became productive quickly using this app</td>
</tr>
<tr>
<td>Information Quality</td>
<td>9. The app gives error messages that clearly tell me how to fix problems</td>
</tr>
<tr>
<td></td>
<td>10. Whenever I make a mistake using the app, I recover easily and quickly</td>
</tr>
<tr>
<td></td>
<td>11. The information (such as on-screen messages) provided with this app is clear</td>
</tr>
<tr>
<td></td>
<td>12. It is easy to find the information I needed</td>
</tr>
<tr>
<td></td>
<td>13. The information provided for the system is easy to understand</td>
</tr>
<tr>
<td></td>
<td>14. The information is effective in helping me complete the tasks and scenarios</td>
</tr>
<tr>
<td></td>
<td>15. The organization of information on the app screens is clear</td>
</tr>
<tr>
<td>Interface Quality</td>
<td>16. The interface of this app is pleasant</td>
</tr>
<tr>
<td></td>
<td>17. I like using the interface of this app</td>
</tr>
<tr>
<td></td>
<td>18. This app has all the functions and capabilities I expect it to have</td>
</tr>
<tr>
<td></td>
<td>19. Overall, I am satisfied with this app</td>
</tr>
<tr>
<td>Additional Questions</td>
<td>20. The app makes the things I want to accomplish easier to get done</td>
</tr>
<tr>
<td></td>
<td>21. I don’t notice any inconsistencies as I use the app</td>
</tr>
<tr>
<td></td>
<td>22. I easily remember how to use the app</td>
</tr>
<tr>
<td></td>
<td>23. I would recommend the app to a friend</td>
</tr>
<tr>
<td></td>
<td>24. It is fun to use the app</td>
</tr>
<tr>
<td></td>
<td>25. The app works the way I want it to work</td>
</tr>
<tr>
<td></td>
<td>26. The app minimized the number of steps it took to complete tasks</td>
</tr>
<tr>
<td></td>
<td>27. I needed to learn a lot of things before I could get going with this app</td>
</tr>
<tr>
<td></td>
<td>28. I felt very confident using this app</td>
</tr>
<tr>
<td></td>
<td>29. I found the various functions in this app were well integrated</td>
</tr>
</tbody>
</table>

5.5.5 Final interview
A one to one, semi-structured interview was conducted after the study. Questions used in the interview were open-ended, and non-directed, to find the user’s thoughts and experiences without misleading or filtering. The order of questioning was pre-defined in an interview guide but in most interviews the order of questioning was altered throughout the interview process, based on the direction taken by the participant. The topics discussed included the participant’s experience with the app overall and the two elements specifically; what they liked or disliked about it and what
they would add or change. Also, it was discussed how the app and the different elements affected them in terms of motivation, awareness and confidence. Furthermore, the usability of the app and the concept were discussed; whether there were any technical issues and whether anything was unclear or hard to understand. Self-report items, which were filled in after the baseline week and after the intervention period, were compared to each other and any different or outstanding answers were discussed in more depth; whether the app in any way contributed to these different or outstanding answers or whether there were other explanations for it. The interview guide can be found in Appendix D.

5.6 Procedure

5.6.1 Intake Meeting
After explaining the procedure to participants, participants signed an informed consent form at the intake meeting. Next, the health status of participants was assessed to reveal any risks when exercising excessively, by the use of validated questionnaires. Afterwards, participants filled in the demographics questionnaire and downloaded the app on their iPhone using a link that was sent to them per email. The Mio Alpha was handed out to the participants, and they were explained how to use it. Next, resting heart rate of the participant was measured by taking the average output of the Mio Alpha during the last 30 seconds of three minutes sitting still. Then, the demographics were used to calculate the training zone and target mBeats of the participants, and these values were inserted in the settings menu of the app. During the baseline week, the activity planner and feedback functions were disabled, so that only the settings menu and connectivity menu was available to the user. The researcher showed the participant how to make connection between the Mio Alpha and the app and asked the participants to wear the Mio Alpha and run the app during the day, and charge the iPhone and Mio Alpha during the night. Participants were told not to change their behavior during the baseline week. Finally, participants signed a disclaimer stating, amongst other things, any possible risks the participant may encounter. Participants were then sent off for the baseline week.

5.6.2 Second Meeting
After the baseline week participants were invited for the second meeting. During this meeting, participants were asked to fill in a questionnaire about, amongst other things, planning behavior, physical activity levels and behavioral factors (the complete questionnaire can be found in Appendix B). Next, the researcher enabled the planner function for the participants in both conditions. The feedback function was enabled only for participants in the feedback condition. The researcher explained the concept and the objective (training zone and targeted number of mBeats) to the participant. All participants were asked to plan their daily activities for the rest of the week on that same day, and every Monday following, using the activity planner. Lastly, all participants were given an information sheet containing the assignment, their target zone and target mBeats, safety guidelines and contact information in case of any questions or remarks. An example of this information sheet can be found in Appendix D. The participants then started their two-week intervention period.

5.6.3 Third Meeting
During the final meeting, which took place after the two weeks of intervention period, the data was downloaded from the iPhone using iTunes. In the meantime, participants filled in a questionnaire consisting of the same psychological items as during the second meeting. In addition, the
usability questions were asked. The complete questionnaire for the third meeting can be found in Appendix E. Afterwards, a semi-structured interview was held and audio recorded, in which the participants were interviewed about their experience with the mBeats app. Some pre-determined interview guidelines and the collected data (both from the questionnaires and the iPhone app), were used as a guideline for discussion. This open ended, semi-structured format was used flexibly, which gave room for elaboration or adaptation according to the demands of the individual context. The interview guidelines were used to set up a two-way discussion between interviewer and interviewee, whilst trying to avoid directive questions. The interview gave a better insight into the processes and events that occurred because of the mBeats app usage. On average, interviews lasted about 30 minutes. After the interview, the participants were thanked for their participation, the Mio Alpha was handed in and the mBeats app was deleted from the participant’s phone.

5.7 Analysis

5.7.1 Questionnaires
All self-report items on behavioral factors were analyzed using a 2x2 mixed ANOVA, with time as within-subjects factor and condition as the between-subjects factor, to find out whether participants in the two conditions rated the behavioral factors different before and after intervention. Besides two items that were created by averaging multiple questions, all items were analyzed separately, because correlations were too low to further reduce the data. The six usability items described in section 5.4.3 were analyzed with an independent sample T-test, to reveal any possible differences between both intervention groups on usability scores. All questionnaire analyses were performed with SPSS Statistics version 21. An alpha level of .05 was used for all analyses.

5.7.2 Final interview
The semi-structured interviews were transcribed verbatim by the interviewer. Next, thematic analysis with a theoretical ‘top-down’ approach (Braun & Clarke, 2006) was applied, using the coding software NVivo 10. From the first four transcribed interviews, initial discursive codes were identified. These codes were then grouped into themes and subthemes to create a coding scheme (see Table 3). All interviews were then analyzed based on this coding scheme. During this process, all data that exemplified one of the themes or subthemes was categorized, keeping the participant identification intact. Attention was paid to the possibility of new emerging codes. Once the coding was completed, eight core themes were defined. The data was then examined per theme to explore the differences and agreements amongst participant. Findings per theme were compared to explore possible causalities.

To minimize subjective bias in interpreting the data, a second person coded a subset of the data by the use of the coding scheme. The subset consisted of four interviews; two interviews per experimental condition. From these four interviews, two were held in English and two in Dutch. The second coder had no prior knowledge of the collected data, which ruled out the probability that the second coder was coding according to ‘what the researcher wanted to hear’. During the coding discussion between both coders it appeared that any differences in coding occurred only between themes and not between subthemes. Therefore, it was chosen to only differentiate amongst the eight core themes in the inter-coder analysis. Another reason for this was to reduce the number of variables. Via this method, an inter-coder agreement of Kappa = 0.816 (p < 0.001) was found, which is a nearly perfect agreement (Everitt, 1996). It can thus be assumed that the first coder was reliable in coding the data unbiased and the coding scheme was clear enough.
| 1. Feedback | 1. Missing feedback  
| 2. Positive about feedback element |
| 2. Motivation | |
| 3. Awareness | |
| 4. Planner | |
| 5. Lack of knowledge | |
| 6. Usability | 1. App usability  
| 2. Concept usability  
| 3. Watch usability |
| 7. Future | |
| 8. Additional features | 1. Advisory and/or motivational messages  
| 2. Automatic fitness test  
| 3. Additional parameters  
| 4. Info about the effects of all activities and exercises  
| 5. Miscellaneous  
| 6. Mio Alpha improvements  
| 7. Social aspect |
| 1. Feedback element  
| 2. General  
| 3. Planner element  
| 1. Positive about concept  
| 2. Target zone  
| 3. Weekly/daily (dynamic) target  
| 4. Weekly target feasibility (self-efficacy)  
| 4. Watch-Phone connection |
6. Results

This chapter describes the results obtained from the study that was carried out. Section 6.1 describes the results obtained from the in-depth interview that was held at the end of the intervention period. Insights in the effects of both app elements are described, as well as usability results and other findings. Section 6.2 describes the quantitative results. These results were obtained from the questionnaires that were administered before and after the intervention period. Quantitative results can be divided into behavioral factors and usability results.

6.1 Qualitative Results

In general, all participants from both conditions agreed upon the fact that the concept of the app was great in potential to assist people in their physical activity. Measuring heart rate and collecting heart beats was found to be a powerful, safe and objective method to regulate exercise intensity, make them aware of their physical activity level and what it takes to improve their fitness.

“.. especially for people that don’t go to the gym, but still want to exercise and the motivation, that little extra push, I think this is potentially very powerful, and fits very well within Philips.” (participant 1, feedback condition).

6.1.1 The effects of progress feedback

During the interview, all nine participants in the no feedback condition stated they were missing actuals about their achievements. Seeing their current heart rate, knowing their target HR zone and information about the estimated number of mBeats achieved per activity was not perceived as enough information to keep them motivated to exercise. Not seeing actuals made them unsure about whether they were doing the right thing because they had no idea how the expected related to reality.

“The piece that was hard for me was just that I couldn’t see where I stood. Like, if I needed to work harder to sort of make up for the end of the week, was I on track or not, I had no idea so I felt kind of blind about that.” (participant 4, no feedback condition).

After showing the feedback element of the app at the end of the interview, participants in the no feedback condition confirmed that this was the element that they missed the most in the app. They felt that the feedback element would have made it more fun, with interesting statistics about their physical activity, and would work incentivizing to exercise more. Seven (out of nine) participants in the feedback condition felt the same about the feedback element; the other two had no strong opinion about the feedback element.

“I think, if I had the other functionality [the feedback element], I would have been more like: ‘Wow, I am not reaching my target, so I have to go for a jog tonight or something like that.’ It’s a reality-check.” (participant 9, no feedback condition).

“I don’t need to keep track, but it was interesting to see this realization of my physical activity.” (participant 10, feedback condition).

Fourteen participants, from both groups, explicitly stated that receiving feedback about your progress towards a goal works motivating to exercise more. Most participants assigned this
increasing motivation to the fact that the feedback element increased their awareness of their amount of physical activity. Moreover, it showed them what is needed to improve their current fitness level. Because they gained more awareness of their physical activity, they were more consciously trying to engage in more exercises to improve this physical activity and achieve their targets. This awareness thus motivated them to do more exercise.

“If you monitor and track it’s much easier to meet the target. If you don’t do anything you will never get the motivation. If you have a measure that tells you; ‘ok, you are very lazy’, then you will tend to try to do better. If you don’t measure anything you don’t know you are lazy so you can continue to be lazy.” (participant 14, no feedback condition).

“I know it’s far [distance to work], but I didn’t realize that I was actually in a potential weight loss zone by just doing that [cycling to work] […] so there were moments with this [using the app] that I wanted to cycle faster to meet the goal.” (participant 8, feedback condition).

One participant stated the progress feedback did not necessarily motivate him to exercise more. His explanation was that he was already consciously exercising nowadays, because he had already found the intrinsic motivation to do so. Moreover, he used perceived exertion to tell him he exercised enough. The app therefore did not encourage him to exercise more.

“If I do those things [exercises], I am tired and I get the feeling I did plenty and I think: ‘well, that should do’. […] so this thing [the app] does not incite me to do more.” (participant 18, feedback condition).

The feedback about their heart rate and target zone was also perceived as very positive and motivating. Explanations for this motivation were that they gained insights in the effects of exercising on their heart rate and had an objective way of seeing they were not overdoing it.

“I realized it is a motivator for me when I see I can go a little harder without exceeding my capabilities, so in that sense it is clearly auxiliary.” (participant 12, feedback condition).

Even though participants stated the feedback on target zone and heart rate was motivating, eight people stated they were too unfamiliar with heart rate; what is normal, what is good and what is dangerous. Knowing and showing more about this would encourage them in exercising, because it makes it easier to regulate intensity and reach specific goals. This was especially important to one participant not receiving this feedback on target zone, who said to have several heart diseases in the family.

“You don’t really indicate when it is a danger zone. That is my obsession; when does it become dangerous and when doesn’t it? […] There are several heart diseases running in my family, so I wanted to build my confidence about my heart rate being fine.” (participant 11, no feedback condition).

To get an even better insight in their physical activity and the impact of it on their overall health, a majority of the participants stated they would want to receive more information about the effects of all their [daily] activities, instead of just information about the activities that contribute to their cardio-respiratory fitness. In other words, they wanted more information about the effects of the activities that take their heart rate below or above their zone. In the present app, activities that are not performed at the right intensity do not deliver any mBeats and are thus not shown. In other
words, not all activities count towards their goal, which causes a discrepancy between expectation and reality.

“It’s the same when you try to lose weight and you get on the scale and it [your weight] doesn’t go down; you will think: ‘Damn, nothing helps.’ and you will start to eat unhealthy again. Here it is; you are exercising and it doesn’t do anything, you don’t achieve anything. Then you will think: ‘Never mind, I’ll just stay at home.’” (participant 2, no feedback condition).

“It would be very demotivating if you say ‘you don’t get any points for that’ if you exercised, even if it were the smaller things.” (participant 1, feedback condition).

Five participants identified this discrepancy as being very demotivating. Because not all activities counted towards their goal, participants were not always motivated to do the minor activities that they might benefit from in other ways, such as walking the stairs instead of taking the elevator.

“I realized I did not achieve any mBeats while walking the stairs, or I would have to run up the stairs. That made me think: ‘well, let’s take the elevator then.’” (participant 15, no feedback group).

The discrepancy between expectation and reality might partially be attributed to the fact that three of these five participants clearly lacked knowledge of the concept and of the effects of exercising. They did not realize their zone was specifically calculated to improve their cardio-respiratory fitness and not all activities would raise their heart rate enough, and that exercising at an intensity level above or below their THR zone is good for their health as well, just not for their cardio-respiratory fitness.

“I didn’t understand what it meant that I wasn’t in that band […] you don’t know whether high is good or low is good. So just, in some sense, once you start measuring something, you want to be able to interpret it, you want to know.” (participant 11, no feedback condition).

In fact, most participants showed some lack of knowledge about the concept. Thirteen of the participants, independent of condition, wondered what mBeats were exactly, how they were calculated or counted, or how they relate to something they are familiar with, which made it hard for them to interpret their target mBeats and their target HR zone.

“How does that relate to a value I’m familiar with? For example, calories burned or energy expenditure […] I want some sort of explanation of what it actually means. What is a hundred mBeats?” (participant 10, feedback condition).

The app did not seem to contribute to participants’ self-efficacy beliefs. The vast majority of participants (15 out of 18) from both conditions were convinced they did not make their weekly target number of mBeats that was set for them. This had several reasons. Seven participants stated they had exercised less than usual, or less than planned, due to a busy schedule or other circumstances. Eight participants stated their target zone was too narrow to achieve the targeted number of mBeats; they either had no idea all heart beats above their zone would count as well or they would exercise in interval training, causing their heart rate alternating to go over and drop down below their zone. Seven participants stated their weekly target was not feasible because their target zone was too high, and not reachable with normal everyday activities, which meant they had to exercise much more or with a higher intensity to achieve their target than they were
used to.

“If I had a normal week, well, no, I didn’t reach my goal at all because I thought my goal was in this 5 beat band, which I thought was impossible so I didn’t think it was at all possible.” (participant 11, no feedback condition).

“Now I have tried those two weeks, it appears that your netto mBeats, I think, because I have no actuals, the netto mBeats you achieve is always less than those two hours [those two hours that this participant exercises per week].” (participant 13, no feedback condition).

One participant was convinced he did manage to achieve his weekly target. In fact, he found the target to be on the low side.

“Having an objective on a weekly basis is a bit strange for me, cause I will blow it in one exercise basically. Mine was maybe a bit low I would say. I mean if you really use this to exercise I would say it’s a bit low.” (participant 14, no feedback condition).

6.1.2 The effects of the activity planner

Half of the participants explicitly stated the activity planning element was unnecessary for them, because their current physical activities were already routine behaviors. Most participants did not even use the activity planner very often, even though their assignment clearly stated to do so. Reasons given were because their schedule was too busy, they forgot about it, they usually did not plan their exercises or it was a boring element. Also, it gives them an extra agenda to keep track of, which they found annoying.

“I sort of knew I would walk like 30 minutes a day, I do that anyway. Plan to me is subjective. If like, in my head, I think: ‘I’m gonna try to walk to the store 3 times a week’, and so, that’s not saying I’m gonna go Monday and I may go on Thursday and on Saturday, right? So it’s kind of quasi-planning.” (participant 4, no feedback condition).

One participant stated that, even though he did not plan much due to a busy schedule, planning his activities engaged him in exercising more consciously.

“Because I planned it, I was more consciously trying to do the exercise. And for a minute I really thought I would achieve the targets for sure. So it kind of motivates in that sense.” (participant 16, no feedback condition).

This urge to perform the planned activities was also recognized by other participants. Even though most participants did not use the activity planner element much, about half of them stated that planning their activities gave them an extra motivation to actually perform the planned activity. Surprisingly, it was mostly participants from the no feedback group who felt most compelled to stick to their planned activities. When not sticking to them, it gave them a feeling of guilt and disappointment. These participants thus seemed to recognize the advantage of planning their activities. However, they stated to lack the motivation to start planning.

“For me, when I start planning, of course I will stick to the planning. I just need to start planning haha.” (participant 14, no feedback condition).

The other half of the participants, mostly from the feedback group, said they could plan their
activities, but they dare to overrule their plans, whenever something more important comes up or they don’t feel like it. However, overruling their plans and thus not sticking to it would also induce a feeling of guilt for this group of participants.

“I am not afraid to overrule my planning, and just say: ‘I don’t feel like it, I am not going to do it now, I’ll do it another time’ [...] it should not be an obligation to exercise, it still is something from my free choice.” (participant 17, feedback condition).

If they had to plan their activities anyway, some participants indicated that they would not care about the specific time or location of performing an activity, and therefore leave those specifics out of the activity planner element. The fact that the activity planner gave them an estimation of how many mBeats they would achieve with a certain activity, was received positively, although people had some doubts about whether this calculation was correct.

6.1.3 Concept usability
As identified before, in general all participants were very positive about the concept of the mBeats app and saw lots of potential in it, especially because it is an objective way of measuring physical activity which gives better control of it and takes away doubts about physical activity. Nonetheless, to improve the concept further and make it more attractive to use some adaptations could be made. One of these adaptations was the width of the target heart rate zone. Most participants stated their target zone was too narrow and for some people too high. Moreover, more features and functionality could be added to make the mBeats app more accessible to all kinds of people with all kinds of purposes. The current app is specifically designed to improve cardio-respiratory fitness, but over half of the participants stated they would want more information about the effects of all activities, even activities that are in a different heart rate zone. Furthermore, they want the ability to set their own exercise goals, to for example maintaining health or losing weight. More suggestions for additional features will be discussed in section 7.4.3.

“You have to be really careful how you talk about fitness because it does mean different things to different people [...] me wanting to get fit is probably very different to the idea of a sports person wanting physical fitness [...] So you just have to make sure that you kind of allow for that in this kind of thing so you got all different levels of expectations covered in it really. I want to get fit to be generally healthy and not become overweight, basically that’s my motivation for fitness but it’s not a real driving. [...] So it would be good if it suits people like me as well, if you know what I mean, people that are just generally trying to be a bit more active in their day to day life.” (participant 11, no feedback condition)

6.1.4 App usability
Even though most participants found the app itself nice, useful and simple in use, most of them mentioned some technical difficulties or missing features. Most of these technical problems are attributed to the immaturity of the app and should be easily fixable, such as the connection loss between the iPhone and the Mio Alpha. This was found to be annoying and caused a loss in data collection.

“Well, the piece that was disappointing about this is that I truly did wear it and been having it on [the Mio Alpha], so it’s annoying that I kept it on and it’s not showing the beats and that’s, I don’t know, that would be truly disappointing to me if I was truly like, trying to work out.” (participant 4, no feedback condition).
Because the current Mio Alpha did not have any storage, participants had to keep the phone and Mio Alpha connected at all times. About half of the participants mentioned this was a hassle to them and they often forgot their phone when going somewhere. Six participants explicitly stated how great it would be if the Mio Alpha would have some kind of memory. Finally, because participants had to keep their phone connected to the Mio Alpha at all times, the battery of their phones would drain very fast, and would not make it to the end of the day for some of them.

“It’s not recording my activity the whole time, and it’s not that accurate a lot of the time, so it kind of made me not take it that seriously. The point is also, the physical activity I do didn’t really allow for me to have the phone with me the whole time, so that was annoying. If it would have at least some storage on the watch itself, even if it would be an hour or so and then it would stream it to the phone then it would be fine”. (participant 10, feedback condition).

Besides connection issues, the app itself showed some bugs as well. Especially the people in the feedback condition mentioned an increasing lag in the app, the longer it collected data. This lag was noticed mostly while loading the data in the history element of the app. Other bugs and lacks seemed to be only minor, such as the inability to connect the Mio Alpha to other iPhone apps without interrupting data collection in this app, and a picker element that did not seem to work correctly every time. Other improvements that were mentioned mostly involved the history element. Two participants had issues interpreting the numbers, colors and graphs used in the app, because the mBeats concept was still a bit unclear to them. Over half of the participants stated that the statistics and graphs of the history element were very useful, good looking and showing interesting information. However, to make them better understandable they could show a bit more information, or at least make the graphs zoomable.

“I love graphs, if you can zoom in and find extra numbers and information. Obviously, you shouldn’t put too much information in it; I really like it that it looks so clean, with only few buttons and elements to push.” (participant 5, feedback condition)

Even though most participants would perhaps not use the activity planner element often, they all stated the activity planner was good in terms of usability. Improvements could be the possibility to set reminders and to enter recurring events.

“I ride to work and come back home around the same time every day, and it’s around the same distance and the same time. So I would like to put that in, and then load it forward to the next like, year and have it as my plan.” (participant 8, feedback condition).

6.1.5 Additional findings: Weekly versus daily target
To our knowledge, this app is the first that uses the approach in which users are stimulated to achieve a weekly exercise target. Fifteen of the participants were in favor of a weekly target, as opposed to a daily target, because the amount of exercise they do is not the same for every day, but is fairly similar every week. Five of them stated that although they preferred a weekly target, they would be okay with having a daily target, as long as the daily target is integrated with what they have planned in their activity planner. Only three participants were in favor of the daily target, because it would motivate them to get enough exercise on a daily basis.
“It [the target] gets chopped into pieces, like, if you achieve this much, you are still on track to reach the weekly target. Because, if you would only have a weekly target, well, I think you would feel like: ‘nahh, I will do it later’, and then you will never do it. So I like a daily target, and maybe you will compare days as well then.” (participant 5, feedback condition).

Some participants stated that the actual value of the target was irrelevant, and they just wanted to know whether they were on track or not. Even though achieving the weekly target was the goal for the participants, the app also provided the people in the feedback condition with a daily target that changed dynamically according to their achievements so far that week. Even though some participants thought this dynamic target made sense, the majority of the participants stated it was hard to understand, and even demotivating when daily targets were not reached.

“The idea behind the dynamic target is good, but as soon as you are behind, it will work against you and you will think: never mind, I am not going to make it anyway. You are getting dynamically confronted with the fact that you are not doing your exercises.” (participant 5, feedback condition).

The only disadvantage mentioned about the weekly target was that the week counts from Monday till Sunday, while not all participants started on a Monday. Therefore they got the feeling they had a ‘broken week’, because one of the intervention weeks was split into two. This made it unable to reach their weekly target in the first week, when they, for example, started on a Thursday they had only three days left to reach their weekly target.

6.1.6 Usability Mio Alpha
Some people reported difficulties with the usability of the watch. They found it annoying that the device could only be charged by means of USB and therefore not usable without a laptop or PC. Also, the battery of the Mio Alpha was empty within a day and a half. This caused them to have difficulties keeping the watch charged. Five participants mentioned having trouble remembering to wear the device every day, because they do not usually wear a watch. About one third of the participants explicitly stated they would not want to wear the watch continuously every day, but only during exercising. Motives for this were because they did not see the importance of wearing it throughout the day if they were not collecting any mBeats, the Mio Alpha was not always accurate, and they thought the design of the watch was too robust. Even though there were some negatives with the Mio Alpha, in general, participants were positive about the watch. Heart rate was perceived as a good parameter to measure while exercising and helped to make sure you do not overdo it. Moreover, it is more convenient than wearing a chest strap monitor, although not for sports like volleyball where wearing a watch is conflicting with the activity itself. Seven participants stated it would be even better when the Mio Alpha were able to show more information, such as whether they are in their zone.

“I’m very enthusiastic about the Mio Alpha, about the watch. I think it is an amazing thing. It is great I don’t have to wear such a chest strap, this is much easier. I do think it is a huge thing to carry with you while running though.” (participant 16, no feedback condition).

6.1.7 Additional features
Even though participants were positive about the concept and the app, several features for improvement were mentioned to make the app more interesting and motivating. Half of the participants explicitly stated they would add more parameters, such as speed, distance and calories burned. This would make it easier for them to relate the mBeats to something they are already...
familiar with and to balance their calories burned with calorie intake. Ten people would like to add GPS tracking, or at least link the timestamps in the history element to a location, because it could give them insight in the effects of certain routes on their exercise performances.

“It could be easy to make a link [between GPS and the Alpha Mio] that says, especially if you are in an area with hills etcetera, that you can see this has a certain influence, not only on the distance traveled, but also on your heart rate.” (participant 12, feedback condition).

A majority of the participants mentioned that they would like advisory or motivational messages in the app. These could be tips on what kind of activities they could do to reach their target (eight participants), or information on how they are doing during exercising (six participants). In addition, six participants mentioned they want messages about their achievements so far, like how many beats they still need to achieve, and another six participants wanted motivational messages such as ‘good job’ or ‘you have been idle for a while, isn’t it getting time to go for a jog?’. Four participants would like advice or help in interpreting the data and their heart rate, to gain better understanding of how they were progressing.

“It is a bit invasive but in the end it’s a game. You want to improve your fitness. Somehow I think it’s always easier when you have someone to tell you: ‘hey, get your fat ass from the chair and go do some working.’ That’s why you need a coach.” (participant 14, no feedback condition).

A very debatable issue was whether or not to include social elements in the app. The majority of the participants would not want to connect the app to social media, but it would be okay if it was embedded in the app as long as it was optional. Some of the participants would rather involve close friends or family, so that they can motivate, challenge and encourage each other.

“What I would add, what might be a motivator, is that I could invite my boyfriend to join me while jogging […] that he would get a message saying: ‘hey, are you joining me for a jog tonight?’ so that we could do it together.” (participant 9, no feedback condition).

Because people were insecure about their current level of fitness and how to improve or maintain it, they would want the app to be able to objectively assess their current fitness level and use this information to create a personalized training program, with feasible goals and reliable, accurate heart rate zones.

“The thing that’s always hard to gage is ‘where am I?’. Like, I know I weigh this much and I know I am this tall and whatever and my body mass is this […] I don’t have a really good sense of where I’m at. Like, is there an assessment, or something like this, like a test or […] it sort of measures what you do […] it says how you do and then suggests that you are in bad health or not.” (participant 4, no feedback condition).

Other mentioned features were less prominent. Four people wanted to integrate the collected data with the planned activities, to make it easier to spot trends or allocate collected beats to activities. Also, they want the app to show trends or their progress towards their overall health related goal. All other features were only mentioned by one person out of 18, such as the ability to add photos to your workouts, synchronize the planner with the schedule of their gym, or receive voice feedback during exercising.
“If it can tell me whether or not I'm getting fitter on my day to day existence, I suppose that would be a useful thing. And then it would make it more relevant to wear it all the time.” (participant 11, no feedback condition).

6.2 Quantitative Results

6.2.1 Self-report questionnaire items

All self-report questionnaire items about behavioral factors were analyzed using a 2 by 2 mixed ANOVA, with condition (feedback or no feedback) as a between-subjects factor. Time was the within-subjects factor, with time 1 being after the baseline week and time two being after the intervention period. All questions were answered on a seven-point Likert scale, ranging from strongly disagree to strongly agree. Table 4 shows the means, standard deviations and F-statistics of all the items.

Analysis of Reported Physical Activity showed two significant effects. The first one was a main effect of time on reported physical activity ($F(1, 16) = 4.990, p = .04$). Looking at the means for this item in Table 4, it can be seen that the average reported physical activity decreased significantly during the intervention period. The second effect found for reported physical activity was an interaction effect of time and condition ($F(1, 16) = 10.557, p = .005$). Participants in the feedback condition reported a slight increase in being physically active after intervention, whereas the no feedback condition reported a decrease in being physically active after the intervention period (see Figure 12).

![Figure 12. Reported physical activity as a function of time](error bars display standard error of means)
A surprising finding was a significant main effect of time on Recommendations Awareness (F(1, 16) = 5.696, p = .03). Participants reported on a seven-point scale how strongly they agreed with the following recommendation: In order to improve or maintain my physical fitness, I should exercise at least 5 days a week for at least 30 minutes. At Time 1, participants significantly agreed more strongly with the recommendations compared to Time 2.

The variable Tracking Motivation (Keeping track of my exercise progress keeps me motivated) was answered fairly positively on average (M = 5.72, SD = .985 after intervention). No significant differences were found for this item.
Even though the average motivation to improve physical fitness (Improve Fitness Motivation) was high at both times ($M = 6.08, SD = .77$ and $M = 5.72, SD = .81$ at Time 1 and Time 2 respectively), this motivation decreased significantly over time, $F(1,16) = 7.860, p = .013$ (see Figure 13). No effect of condition was found.

![Figure 13](image)

Figure 13. Motivation to improve fitness as a function of time (error bars display standard error of means)

A marginal difference worth mentioning was that of intention level to increase physical activity levels between conditions ($F(1,16) = 4.204, p = .057$). Even though both groups reported fairly high intention levels, participants in the no feedback condition reported higher intention levels at baseline ($M = 6.22, SD = .667$) than did participants in the feedback condition ($M = 5.33, SD = 1.225$). Intention levels after intervention were far more similar for the feedback condition ($M = 5.66, SD = 1.00$) and the no feedback condition ($M = 6.00, SD = 1.00$). Further analysis showed the difference in intention levels at baseline was marginally significant ($t(16) = 1.912, p = .074$), while this difference in intention levels after intervention was not significant $t(16) = 1.00, p = .33$. This effect can thus be accounted to baseline and not the intervention. No effect of time was found.

Another interesting marginal effect of time was found on Self-efficacy Stick to Schedule ($F(1, 16) = 3.338, p = .086$). This means that, at Time 2, participants were less confident about sticking to their scheduled activities compared to Time 1 in both conditions.
Similarly, participants’ confidence about achieving their weekly target mBeats (Confidence Achieve Target) decreased significantly over time in both conditions ($F(1, 15) = 24.285, p < .001$, see Figure 14). Before intervention, participants were fairly confident about achieving their weekly target ($M = 5.53, SD = 1.007$). This confidence dropped dramatically after the intervention, participants were confident they did not achieve their weekly targets ($M = 3.00, SD = 2.092$). No effect of condition was found.

None of the other questionnaire items showed significant main or interaction effects.

6.2.2 Usability Questionnaire

People in both conditions rated Overall Usability of CSUQ equally, with an average usability rating of $M = 4.46$ (SD = 1.18) (see Table 5). Usability of the app is thus rated positively by both conditions, but not too positive. This indicates that the present app is a good start, but still has room for improvement.

On average, people in the feedback condition rated the quality of the interface as more positive ($M = 4.96, SD = 1.26$) than people in the no feedback group did ($M = 4.00, SD = .99$). Although this difference was not significant $t(16) = -1.80, p = .09$, it showed a marginal trend with a medium-sized effect $r = .41$. One of the questions involved in the interface quality item is ‘this app has all the functions and capabilities I expect it to have’, which also showed a marginal trend in the same direction $t(16) = -1.846, p = .083$, when analyzed separately. This suggests that planning activities alone is not enough for a person to stay motivated to use the app as an assistant in increasing physical activity. However, considering the low score on this item for the feedback condition ($M = 3.78, SD = 2.279$), the combination of the planner and the feedback seems not to be enough either.
No other significant differences were found for the remaining usability factors. Gender did not influence usability scores.

Table 5. Usability statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean (SD) per condition</th>
<th>Cronbach’s Alpha</th>
<th>t-statistics</th>
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<tr>
<td>Overall Usability</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>CSUQ</td>
<td>No feedback</td>
<td>4.42 (.91)</td>
<td>.915</td>
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<tr>
<td></td>
<td>Feedback</td>
<td>4.50 (1.46)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>4.46 (1.18)</td>
<td>( t(16) = -0.14 ) ( p = .88 )</td>
</tr>
<tr>
<td>System Usefulness</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No feedback</td>
<td>4.90 (1.15)</td>
<td>.880</td>
</tr>
<tr>
<td></td>
<td>Feedback</td>
<td>4.53 (1.56)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>4.72 (1.34)</td>
<td>( t(16) = 0.58 ) ( p = .57 )</td>
</tr>
<tr>
<td>Information Quality</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No feedback</td>
<td>4.19 (.78)</td>
<td>.718</td>
</tr>
<tr>
<td></td>
<td>Feedback</td>
<td>4.22 (1.70)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>4.21 (1.28)</td>
<td>( t(16) = -0.05 ) ( p = .96 )</td>
</tr>
<tr>
<td>Interface Quality</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No feedback</td>
<td>4.00 (.99)</td>
<td>.723</td>
</tr>
<tr>
<td></td>
<td>Feedback</td>
<td>4.96 (1.26)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>4.48 (1.21)</td>
<td>( t(16) = 1.80 ) ( p = .09 )</td>
</tr>
<tr>
<td>Additional Questions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No feedback</td>
<td>4.07 (.61)</td>
<td>.742</td>
</tr>
<tr>
<td></td>
<td>Feedback</td>
<td>4.61 (.97)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>4.34 (.83)</td>
<td>( t(16) = -1.43 ) ( p = .17 )</td>
</tr>
</tbody>
</table>
7. Discussion

Nowadays more and more people possess and use smart phones in their everyday lives. Few studies explored the effects of the use of mobile applications on behavior change. Whereas in some of these studies the use of mobile applications has been found to have a positive effect on behavior change (e.g. Allen, 2013), there still remains a lot to explore. For example, it remains inconclusive how the individual intervention strategies used in such apps contribute to this behavior change. Research on this issue is necessary for the creation of a framework for effective intervention design.

The aim of the present study was to explore the effects of progress feedback as a motivational intervention, to assist a volitional intervention in increasing physical activity. To study these effects, an iPhone app was designed that provided users with a heart rate training zone and a weekly target number of heart beats to be achieved within this zone, called mBeats. The user received feedback on their heart rate, their target and the progression towards this target. Moreover, the app had an activity planner, based on the principle of implementation intentions, in which users could plan exactly when, where and how they would achieve their target. The app wirelessly received information from the Mio Alpha, a heart rate monitor bracelet. Because the app designed for the present study is a first prototype built to explore the concept of immediate feedback on heart rate in the form of mBeats, usability was investigated as well.

For this study, eighteen people participated in a three-week mixed-method study, with a focus on qualitative measures. The first week was a baseline week and the last two weeks were intervention weeks. Half of the participants received only the volitional intervention, consisting of the activity planner. The other half received the full app, with both the volitional and motivational intervention; the activity planner and progress feedback on heart rate. After baseline and after the intervention, participants filled in questionnaires, consisting of questions about motivation, self-efficacy and awareness. After the intervention, participants also filled in a usability questionnaire. Moreover, an in-depth interview was conducted to gain a better insight into the effects of the feedback element and the app as a whole.

Mixed results were found. All participants in the no feedback condition indicated during the interview that this feedback element was missing; the activity planner alone was not enough for them to achieve their weekly targets. Not receiving the feedback left them in the dark about their progression and performance, which made them feel uncertain about whether what they were doing was right. Participants receiving the feedback also stated the feedback to be an imperative part of the app, because it made them aware of their current level of physical activity and how much activity was necessary to improve their cardio-respiratory fitness. Seeing that they were not reaching their mBeats target motivated them to try harder and exercise more often. This suits with the Theory of Planned Behavior (Ajzen, 1991) because awareness can affect people’s attitude towards a behavior. It is also in line with the findings from Ronda, van Assema and Brug (2001), who found that awareness of one’s physical activity is an important motivator for exercising. The average rating for whether keeping track of exercise progress would motivate participants (Tracking Motivation) was fairly positive for both conditions, suggesting that the progress feedback was indeed a missing part for the no feedback condition and was received positively in the feedback condition. This was also shown in the usability question ‘This app has all the functions and capabilities I expect it to have’, which was rated lower for the no feedback condition. Separate analysis
of this question showed a marginal trend suggesting the feedback condition was more positive about the comprehensiveness of the app, supporting the statement that the feedback element was important to them. Beforehand, it was expected that the progress feedback would be experienced as motivating, because it made people more aware of their current behavior. Based on the insights gained from the interview, this expectation is confirmed and progress feedback on heart rate could indeed serve as a motivational intervention.

Reported physical activity analysis showed a significant interaction effect of time and condition. Whereas participants in the feedback condition only showed a slight increase in reported physical activity, the no feedback condition showed a fairly large decrease after intervention, causing this interaction effect. It was expected that participants in the feedback condition would show a greater increase in physical activity than participants in the no feedback condition, because the combination of a volitional and motivational intervention was expected to be more powerful in changing behavior. It was also expected that both conditions would show an increase in physical activity compared to baseline. The current results did not reflect these expectations. However, because the feedback condition did not show the decrease in physical activity that the no feedback condition did, it can be assumed that the combination of the volitional and motivational intervention is indeed more powerful than the volitional intervention alone in changing behavior.

Participants who only received the volitional intervention of implementation intentions reported an unexpected decrease in physical activity. This is in contrast with the findings from the meta-analysis performed by Gollwitzer & Sheeran (2006), which showed a medium-to-large positive effect of implementation intentions on goal attainment. However, the present findings are somewhat in the trend of, and even more negative than, the findings from de Vet, Oenema, Sheeran and Brug (2009), which did not show any effect of implementation intentions on physical activity. They suggested that implementation intentions needed to be accompanied by a motivational intervention. One logical explanation for the present findings might be that participants stated they did not use the activity planner much. In most experiments, the forming of implementation intentions was obligatory and under supervision of the experiment leaders. In the present study, participants were only told to form implementation intentions right before the intervention period, and were not supervised during the intervention period. It seemed that, already quite fast after the intervention period started, participants experienced a drop in motivation to plan, most likely because they did not believe this strategy is important for success. Moreover, people reported that, if they had to plan their activities, they would not want to define exactly when and where they will perform that activity. However, that would mean their plans are not implementation intentions anymore and would thus not create the mental link with the environmental cues. Participants thus showed a lack of awareness of the advantages of this strategy.

Participants accounted their lack of planning to a busy schedule or forgetting it. This suggests that people’s desire to increase their physical activity was exceeded by other things, such as their busy schedule. Relating this finding to the Rubicon model of action phases, people thus seem to be stuck in the pre-decisional phase when it comes to increasing physical activity, because their preferences differed from increasing their physical activity. The high ratings on intention level contradict this suggestion though. However, because participants did not use the planner the way they were told and thus not used the implementation intentions the way they were intended, results about this strategy did not show the positive effects that were expected based on literature. Results are therefore inconclusive about the effectiveness of this volitional intervention on physical activity. Only providing the option to form implementation intentions does not seem to be enough to be an effective means to increase physical activity and even seems to decrease it. Possible
implications to improve effectiveness of this strategy are teaching the user about the advantages of implementation intentions and possibly even making it obligatory to set them, by only enabling other functionalities of the app after setting implementation intentions. Another possible improvement could be to add feedback about the strategy of implementation intentions. Implementing this strategy feedback promotes achievement outcomes and strategy usage better than just providing the strategy instructions (Schunk & Swartz, 1993). After making such adjustments to the app, more research should be done to study the effectiveness of this strategy for increasing physical activity.

Even though the implementation intentions in the present scenario did not show a positive effect, in a way it did show an expected effect; especially people only receiving the activity planner reported an urge to stick to their planned activities, which is exactly the goal of creating the implementation intentions. However, confidence ratings about sticking to their planned activities dropped marginally significant after the intervention period. This means that, before experiencing implementation intentions, people were more confident they would actually perform all their planned activities compared to after the intervention period. They thus experienced how hard it is to act upon intentions and thereby change behavior. To give users more assistance in acting upon intentions, the app could be more prominent in pushing people to stick to their planned activities, by for example giving reminders of their planned activities or sending motivational messages.

Independent of condition, all participants dropped confidence in their ability to reach the weekly target after using the app. This was shown in both the questionnaire and the interview results. In fact, the majority of the participants felt certain they did not and could not achieve their target provided by the app. This can be accounted to several causes. First, most participants found the training zone too high and too narrow. They mentioned that it is fairly hard to get a stable heart rate while exercising and they would easily exceed their target zone or drop down below their target zone. Second, it was barely possible to reach their target heart rate with everyday tasks, such as walking the stairs and cycling to work. They indicated that this caused a discrepancy between their expectancy and reality, because physical activity performed at a lower intensity did not count towards their mBeats target. The ACSM guidelines to improve cardio-respiratory fitness were not designed to account for everyday activities. A possible solution would be to count such activities as ‘activity beats’ instead of mBeats, as a way to show users that this kind of activity is important as well, but for different purposes such as weight loss or weight maintenance. Last, while fourteen out of eighteen participants beforehand reported that their exercise goal was to improve their fitness and their intention to do so was high, during the interviews at the end of the study it became clear that they did not want to try hard to actually change their exercise behavior much. Most people felt they already exercised enough, even though these exercises would not give them enough mBeats and thus not help in improving fitness. Combined with a target zone that was perceived to be hard to reach, users did thus not start to exercise more or with a higher intensity. This is in line with the findings from Lawrence, Carver, & Scheier (2002), who found that discouraging feedback decreased satisfaction and motivation. Even though there is a solution for most of these findings, which can easily be implemented in a next version of the app, they caused all people to feel incompetent and thus drop in self-efficacy. It was expected that people in the feedback condition would have higher confidence in achieving their weekly target than people in the no feedback condition; this cannot be confirmed based on the present insights. However, because most of the explanations can be accounted to the app concept, results are inconclusive and more research needs to be done to be certain about the effect of progress feedback on self-efficacy beliefs. In order to do this, the target zone should be broader than the 5% it is now, to make it easier for users to stay in their zones. Combined with the addition of ‘activity beats’, it is expected this would raise self-efficacy when receiving progress feedback.
On average, the motivation to improve physical fitness was fairly high both before and after the intervention, but still dropped significantly over time. Given that competence is one of the three psychological needs to be motivated to initiate behavior, according to the Self-Determination Theory (Deci & Ryan, 1985), the lack of confidence about their competence to achieve their weekly target might have affected the motivation to improve physical fitness. Moreover, because people realized they were not getting enough exercise at the right intensity to reach their target, they might have assumed that they were thus not getting enough exercise to reach the international guidelines for exercising. This might explain the finding that people showed a decrease in agreeing with these guidelines, if they had always assumed they were meeting the guidelines. However, the current findings are inconclusive about this assumption.

What was surprising was the unresolved debate about implementing a social element to the app. Based on the Theory of Planned Behavior and Self-Determination Theory, which both state that the social surroundings of a person can positively influence behavior, one could expect that participants would have been more positive about adding social elements such as social media to the app. However, no participants were strongly in favor of this. Providing the option but not making it mandatory to use a social element in the app might be the right solution here.

Overall, participants were very positive about the potential of the mBeats app and the concept of collecting heart beats to increase physical activity. Even though the participants showed a lack of understanding of the specifics of the concept, this did not seem to affect their opinion on the usability of the concept. Usability ratings were on the positive side of the scale, with no differences between conditions. The positive ratings confirm the potential of the app; however, with an average rating of 4.5 on a 7 point scale, usability is not rated extremely high. This can mostly be accounted to some technical issues and the limited functionality of this first prototype. Moreover, participants identified missing elements that would make the app even better, more interesting and easier to interpret. More gain can be achieved on usability, by taking all suggestions for improvements and additions into consideration for a next version of the app. Moreover, users should be taught about the advantages of the concept and measuring heart rate.

There are some limitations to this study. Even though eighteen participants is considered to be enough for qualitative measures to get a good grip on people’s thoughts and experiences, the quantitative results should be interpreted with caution; the small number of participants affects the chances of finding significant effects. Furthermore, the sample consisted of generally healthy Philips employees and may therefore not necessarily be representative of the overall population of people that want to improve their cardio-respiratory fitness. Lastly, there is no certainty in saying that the effects found for both conditions are merely to be accounted to the usage of the app, or that there are no other possible covariates, such as weather season for example.

Some other matters might have affected people's motivation to use the app. First, some of the participants in the no feedback condition became knowledgeable about the fact that there were two versions of the app available, for example because they either saw the full app being used by a colleague before the end of the intervention period. Also, most participants started their participation on a different day than Mondays, while the weekly target starts counting on Mondays. As a result, they were barely able to reach their weekly target in the first week, which might have affected their motivation. A factor that might have increased motivation is the fact that participants were aware that the collected data would be discussed afterwards. This could have motivated them to try harder to reach the target.
The technical flaws in the app, mostly caused by the unstable connection between the iPhone and the Mio Alpha, caused a loss in data collection. Therefore, the heart rate data were unreliable and it was decided not to analyze these data. Although subjective measurements showed an interaction effect of feedback on physical activity, more research needs to be done to confirm these findings objectively. The technical issues should be fixed in a future version of the app to study these objective effects, by for example using a heart rate monitor that has some form of data storage on it. These issues caused annoyance, which might have affected the motivation to use it. Many participants testified they did not use the app for several days during the intervention period. This shortens the intervention period even more, on the limited duration of this study. Effects of the motivational intervention for the longer term remain unknown. Novelty of the system might diminish over time, possibly decreasing motivation. This could be counteracted by strategies known to enhance motivation on the long term, such as cutting the task into sections by incorporating milestones to achieve along the way (Markman, 2011). Such strategies should be taken into consideration for implementation and exploration in the future. Moreover, the connection issues might have affected usability scores on the app. Even though the usability questionnaire was introduced with the sentence that the questions were about the usability of the app itself, it became clear during the interviews that some participants rated usability of both the app and the Mio Alpha. This also included the connection and thus the connection issues.

Besides the technical issues, results are promising in favor of the mBeats concept as a method to increase physical activity, and progress feedback on heart rate as a motivational intervention. Receiving progress feedback might not necessarily keep people motivated on the longer term, but not receiving this feedback surely seems to do the opposite. Results show how difficult it is to change behavior; even though all participants showed great intentions to improve their fitness, most of them failed to achieve their targets and increase physical activity. Effective auxiliary tools, such as apps that promote physical activity, therefore seem necessities for people that want to change behavior. The present app has not fully proven to be effective yet, however, many new insights have been gathered on how to improve effectiveness of the app. A next step in developing the mBeats concept and creating a framework for designing effective interventions is to investigate the effects of other intervention strategies on physical activity. Different strategies might have different effects and do not necessarily amplify each other when combined. All the ideas for improvement of the app suggested by participants are highly appreciated and are taken into consideration for implementation in a next version of the app.
8. Conclusion

Having a sedentary lifestyle is slowly becoming normal and it increases the risks of obesity and cardio-vascular diseases (WHO, 2003). To reduce these risks, it is imperative to improve one’s cardio-respiratory fitness, by engaging in enough physical activity at an adequate intensity. But, changing one’s behavior is notoriously hard and auxiliary tools that promote behavior change might increase the ease of behavior change. There are many technological tools available, such as mobile apps, to assist people in increasing their physical activity levels. Several of such apps include many different kinds of intervention strategies, and have been proven effective in increasing physical activity (e.g. Allen, 2013; Hurling et al., 2007). In order to create a framework for the most effective intervention design, it is important to study the individual contribution of the intervention strategies to this behavior. The present study investigated the effects of progress feedback on heart rate as a motivational intervention to assist a volitional intervention in increasing physical activity. An iPhone app was designed that consisted of a volitional and motivational strategy. The volitional intervention was based on the principle of implementation intentions, in the form of an activity planner. The motivational intervention consisted of progress feedback on heart rate, by providing users a target heart rate training zone, a target number of beats to be achieved within this zone (mBeats target) the progress towards this mBeats target and a history overview. These targets were calculated by means of an algorithm, which is based on ACSM Guidelines for improving cardio-respiratory fitness. Eighteen Philips employees either received the volitional intervention (no feedback condition) or both the volitional and motivational intervention (feedback condition) during three weeks, including one baseline week. Effects were studied by means of questionnaires and an in-depth interview about the concept as a whole, the behavioral effects, and the usability of the interventions and the app in general.

Evidence reflected that progress feedback on heart rate can indeed serve as a motivational intervention, because it makes people more aware of their amount of physical activity and what is necessary for improvement. This awareness in turn motivates them to exercise more and at the right intensity. Gathered insights also showed that this kind of motivational intervention is important for people, and adding the motivational intervention to the volitional intervention is more effective than a volitional intervention alone. In fact, reported physical activity, although not significant on its own, dropped in the no feedback condition, compared to their baseline ratings. This shows the importance of studying the individual effects of intervention strategies on physical activity and more research should be done in this area.

None of the interventions increased self-efficacy beliefs; all participants showed a significant drop in confidence in achieving their weekly mBeats target. This lack in confidence after the intervention period can mostly be accounted to the high and narrow target, which is part of the concept as currently implemented in the app, and not the individual intervention strategies. Some improvements of the concept should be able to repair this issue, and making it possible to properly study this effect. Possible improvements could be to either enlarge the target zone, or to have multiple target zones targeted at different objectives. Objective proof for the present findings should be obtained, by fixing technical issues and repeating the study.

Even though participants gave many suggestions for improvement, the general concept of collecting heart beats as a method to increase physical activity was received positively. Suggestions will be considered for implementation of a next version of the app and technical issues will be fixed.
However, the present study reflects that changing behavior is hard, and not all strategies seem to be as effective to promote physical activity as literature suggests. This study is a step in the direction of creating a framework for designing the most effective interventions for increasing physical activity. However, different strategies have different effects, and do not necessarily amplify each other when combined. Therefore, more research needs to be done to study the individual effects of other intervention strategies in order to design effective tools to assist people to change behavior.
9. Bibliography


Hurling, R., Catt, M., Boni, M. D., Fairley, B. W., Hurst, T., Murray, P., ... & Sodhi, J. S. (2007). Using Internet and Mobile Phone Technology to Deliver an Automated Physical Activity Program: Randomized Controlled Trial. *Journal of Medical Internet Research, 9*(2). doi:10.2196/jmir.9.2.e7


Appendices
Appendix A. mBeats calculation example

This appendix contains confidential information and is therefore excluded from this version of this thesis report.
Appendix B. Questionnaire meeting 2

Please decide your answers spontaneously. Don’t think too long about your decision to make sure that you convey your original impression. If a question does not apply to you, tick N/A.

It is your personal opinion that counts. There is no wrong or right answer!

Again, all answers will be confidential.

1. **Think about the past week. Please indicate how many days per week you performed the following activities, how much time on average you were engaged in this, and (if applicable) how strenuous this activity was for you?**

<table>
<thead>
<tr>
<th>Commuting Activities</th>
<th>Number of days per week</th>
<th>Average time per day</th>
<th>Effort</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Walking from/to work</td>
<td>[ ] days</td>
<td>[ ] hr</td>
<td>[ ] min.</td>
</tr>
<tr>
<td>b. Cycling from/to work</td>
<td>[ ] days</td>
<td>[ ] hr</td>
<td>[ ] min.</td>
</tr>
<tr>
<td>c. Not Applicable</td>
<td>[ ]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Work activities</th>
<th>Number of hours per week</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Light work (sitting/standing with some walking, e.g. a desk job)</td>
<td>[ ] hr</td>
</tr>
<tr>
<td>b. Intense work (Lots of walking or regularly lifting heavy objects at work)</td>
<td>[ ] hr</td>
</tr>
<tr>
<td>c. Not applicable</td>
<td>[ ]</td>
</tr>
</tbody>
</table>
### Household activities

<table>
<thead>
<tr>
<th>Household activities</th>
<th>Number of days per week</th>
<th>Average time per day</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Light household work</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(cooking, washing dishes, ironing, child care)</td>
<td>days</td>
<td>hr</td>
</tr>
<tr>
<td></td>
<td></td>
<td>min.</td>
</tr>
<tr>
<td>b. Intense household work</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(scrubbing floor, walking</td>
<td></td>
<td></td>
</tr>
<tr>
<td>with heavy shopping bags)</td>
<td>days</td>
<td>hr</td>
</tr>
<tr>
<td></td>
<td></td>
<td>min.</td>
</tr>
<tr>
<td>c. Not applicable</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Leisure time

<table>
<thead>
<tr>
<th>Leisure time</th>
<th>Number of days per week</th>
<th>Average time per day</th>
<th>Effort</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Walking</td>
<td></td>
<td></td>
<td>slow</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>moderate</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>fast</td>
</tr>
<tr>
<td>b. Cycling</td>
<td></td>
<td></td>
<td>slow</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>moderate</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>fast</td>
</tr>
<tr>
<td>c. Gardening</td>
<td></td>
<td></td>
<td>light</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>moderate</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>intense</td>
</tr>
<tr>
<td>d. House jobs (e.g. plumbing)</td>
<td></td>
<td></td>
<td>light</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>moderate</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>intense</td>
</tr>
</tbody>
</table>
Sport (please write down max. 4 sports you did the past week)
E.g. tennis, dancing, swimming

<table>
<thead>
<tr>
<th>Number of days per week</th>
<th>Average time per day</th>
<th>Effort</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>days</td>
<td>hr</td>
</tr>
<tr>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. 

b. 

c. 

d. 

Total

On average, how many days per week were you physically active for at least 30 minutes (all activities included)?
2. On a scale from 1-10, how representative was your physical activity during the past week for your average behavior in the past six months? (10 being an exact match)

1  2  3  4  5  6  7  8  9  10

The following two questions consist of pairs of contrasting attributes answering to the corresponding questions. The circles between the attributes represent gradations between the opposites from 1 to 7. Please tick the circle that most closely reflects your impression.

<table>
<thead>
<tr>
<th>Question</th>
<th>Very low</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. How would you describe your energy level on a typical day during the past month?</td>
<td>Very low</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>4. How fit or unfit do you think you are at the moment?</td>
<td>Very unfit</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
</tbody>
</table>

5. What is your goal for joining this study? (More answers possible, tick circle(s))

- O Lose weight
- O Maintain weight
- O Gain weight
- O Improve fitness
- O Maintain fitness
- O Decrease fitness
- O Get better at a specific exercise or sports
- O Learn about my physical activity
- O Learn about my heart rate
- O Other
ON A SCALE FROM 1 – 7 (1 = strongly disagree, 7 = strongly agree, N.A.), how strongly do you agree or disagree with the following statements? Please tick the circle that most closely reflects your impression.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly disagree</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>Strongly agree</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>6. I am currently regularly physically active</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td></td>
<td>O</td>
</tr>
<tr>
<td>7. I am satisfied with my current level of physical activity</td>
<td>O</td>
<td>O</td>
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<tr>
<td>8. In order to improve or maintain my physical fitness, I should exercise at least 5 days a week for at least 30 minutes</td>
<td>O</td>
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<tr>
<td>9. Exercising enough reduces the risk of getting cardiovascular diseases</td>
<td>O</td>
<td>O</td>
<td>O</td>
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<tr>
<td>10. Setting exercise goals will help to increase my motivation for doing exercise</td>
<td>O</td>
<td>O</td>
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<tr>
<td>11. Keeping track of my exercise progress keeps me motivated</td>
<td>O</td>
<td>O</td>
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<tr>
<td>12. I want to improve on my physical fitness</td>
<td>O</td>
<td>O</td>
<td>O</td>
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<td>O</td>
<td>O</td>
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<td>O</td>
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<tr>
<td>13. I am satisfied with my level of physical fitness</td>
<td>O</td>
<td>O</td>
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<tr>
<td>14. I am motivated to improve my physical fitness</td>
<td>O</td>
<td>O</td>
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<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
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<td></td>
<td>O</td>
</tr>
<tr>
<td>15. I intent to increase my level of physical activity in the near future</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td></td>
<td>O</td>
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<tr>
<td>16. I am confident that I will improve my physical fitness in the near future</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
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<tr>
<td>17. If I would schedule or plan my exercises for a week, I am confident that I would stick to the plan</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
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<td>O</td>
</tr>
<tr>
<td>18. I am confident that I will achieve my goal(s) for joining this study (see question 5)</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
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</tbody>
</table>
ON A SCALE FROM 1 – 7 (1 = strongly disagree, 7 = strongly agree, N.A.), how strongly do you agree or disagree with the following statements? Please tick the circle that most closely reflects your impression.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly disagree</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>Strongly agree</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>19. I always plan my exercise beforehand</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td></td>
<td>O</td>
</tr>
<tr>
<td>20. I always plan beforehand what kind of exercise I will do that week</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
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<td>O</td>
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<tr>
<td>21. I always schedule beforehand what days I will exercise that week</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
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<td>O</td>
</tr>
<tr>
<td>22. I always schedule beforehand at what time I will start exercising that week</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td></td>
<td>O</td>
</tr>
<tr>
<td>23. I always plan beforehand for how long I will exercise that week</td>
<td>O</td>
<td>O</td>
<td>O</td>
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<td>O</td>
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<tr>
<td>24. I always plan beforehand where I will exercise that week</td>
<td>O</td>
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<td>O</td>
<td>O</td>
<td>O</td>
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<td>O</td>
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<td>O</td>
</tr>
<tr>
<td>25. I always spontaneously decide to exercise</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
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</tbody>
</table>

26. Do you prefer to plan or schedule your exercise?

Yes  No  N/A

27. If you plan or schedule your exercise, do you write this down somewhere? (e.g. in your agenda)

Yes  No  N/A

28. If yes, where and what do you write down? (e.g. in your agenda; activity and starting time)
Exercise progress refers to your achievements with regard to your exercises. This could be in the form of amount of steps per day, or amount of weight loss, etcetera.

29. Do you keep track of your exercise progress?
   Yes  No  N/A

30. Do you prefer to keep track of your exercise progress?
   Yes  No  N/A

31. If you keep track of your exercise progress, how do you do that? (e.g. weekly amount of exercise, weight loss, diary, pedometer)

32. Do you currently have an exercise goal?
   Yes  No  N/A

33. If yes, what is your exercise goal? (More answers possible)
   O  Lose weight       O  Maintain fitness
   O  Maintain weight   O  Decrease fitness
   O  Gain weight       O  Get better at a specific exercise or sports
   O  Improve fitness   O  Other:

34. What do you currently do or not do to reach this goal?

35. Why do or don't you currently exercise?
ON A SCALE FROM 1 – 7 (1 = strongly disagree, 7 = strongly agree, N.A.), how strongly do you agree or disagree with the following statements? Please tick the circle that most closely reflects your impression.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly disagree</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>Strongly agree</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>36. I am confident that I am able to achieve the weekly target mBeats</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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</tbody>
</table>
Appendix C. Interview Questions Guide

**Usability (usability questionnaire):**

*Check usability questionnaire, did user disagree with any statements? If yes, discuss!*

How did you experience participating in the study?

How did you experience using the app? Why?

Did you encounter any issues during the study?

Was there anything unclear while using the app?

What, if any, elements did you like? What, if any, didn't you like?

Do you have any suggestions for improvement? Were there any elements that you were expecting to see?

**Planner:**

*Did they already plan beforehand (see questionnaire_m2)?*

Looking at the planner part; Is there anything about this functionality that you find interesting?

How, if applicable, did it contribute to achieving your targets? How did it or did it not contribute to your experience? Was it a valuable feature to help achieving your target?

What do you think about the fact you can plan your activities with the use of the app?

**Feedback:**

*Did they already keep track of exercise progress (see questionnaire_m2)?*

How did the feedback element (watch, main screen, history) contribute to your experience?

How, if applicable, did it contribute to achieving your targets? Was there an advantage or disadvantage of this element? Is the feedback element a good way to keep track of your progress? Are there any elements that you would like to see in a different way?

**NO FEEDBACK:** How did you keep track of your mBeats?

**Awareness (items 1-4, physical activity, fitness & energy level):**

Did using the app make you more aware of:

- your amount of exercise? If so, how? How did this influence you?
- Your level of fitness? How?
What were, if any, other factors that made you more aware of your physical activity?

Did it affect you in a positive way (e.g. did you feel the urge to exercise more?) or in a negative way (e.g. you knew you had to exercise but didn’t want to, this made you feel bad?)

How do you think this awareness will affect your physical activities in the future? Why?

How did the feedback or planner element contribute to your awareness?

**Motivation (items 5 - 9):**

Did the app (in a positive or negative way), affect your motivation to reach your goal? If so, how? (planner part, feedback part?)

What, if any, are methods you use to keep yourself motivated to exercise?

Are there any functions that you would like to see in the app that would help you to stay motivated?

**Self-efficacy (items 11-14): The feeling of being capable of reaching your goal**

Did the app in any way contribute to your self-efficacy beliefs? If so, how? (planner, feedback)

Are there any elements that you would like to see that would increase your self-efficacy beliefs?

**Other:**

How did you experience the weekly versus the daily target? What about the dynamic?
Appendix D. mBeats Fitness App - information sheet

Thanks again for participating in my study. Please read this document and try to stick to it. If you have any questions or remarks during the study, you can contact me at any reasonable hour.

Inge Thomassen
[contact information was presented here]

ASSIGNMENT
- Achieve your weekly target mBeats both weeks.
- Plan your activities for that week on the first day of the study and every Monday following till the end of the study, using the activity planner

TARGET
mBeats per week: 16669
Heart rate zone between 139 and 145 beats per minute
Maximum heart rate: 181 bpm

RULES AND GUIDELINES
- Please try to achieve your weekly target of mBeats both weeks
- You are allowed to, for example, achieve more mBeats today, and then do less tomorrow
- Remember that the weekly target is the absolute minimum; the more, the better
- For your safety, try not to exceed your maximum heart rate (see target)
- You can do any activity you want, but try to stay within your heart rate zone (see target) and try to stay with the list of activities in the activity planner
- If the connection between the app and the Mio Alpha is lost, you will receive a message. To reconnect the Mio Alpha with your iPhone, you will need to open the app to reconnect again. Without connection, your mBeats won’t be identified and thus not collected by the app.
- Charge your phone and the Mio Alpha while sleeping (this only takes a couple of hours), wear Mio Alpha when awake
- The Mio Alpha is waterproof
- For the best heart rate measurement, please wear the Mio Alpha a bit more backwards on your wrist, not on top of the knob
- Please do not reset or erase your phone data during the study, the data for this study will then get lost as well
Appendix E. Questionnaire meeting 3

Please decide your answers spontaneously. Don’t think too long about your decision to make sure that you convey your original impression. If a question does not apply to you, tick N/A.

It is your personal opinion that counts. There is no wrong or right answer!

Again, all answers will be confidential.

The following two questions consist of pairs of contrasting attributes answering to the corresponding questions. The circles between the attributes represent gradations between the opposites from 1 to 7. Please tick the circle that most closely reflects your impression.

<table>
<thead>
<tr>
<th>Question</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. How would you describe your energy level on a typical day during the past week?</td>
<td>Very low</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>Very high</td>
</tr>
<tr>
<td>2. How fit or unfit do you think you are at the moment?</td>
<td>Very unfit</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>Very fit</td>
</tr>
</tbody>
</table>

3. Tick the circle that best describes your overall level of physical activity for the previous 2 WEEKS:

- O I do not participate regularly in programmed recreation, sport, or physical activity. → Go to question 4

- O I participate regularly in recreation or work requiring modest physical activity (such as golf, horseback riding, calisthenics, gymnastics, table tennis, bowling, weight lifting, or yard work). → Go to question 5

- O I participate regularly in heavy physical exercise (such as running or jogging, swimming, cycling, rowing, skipping rope, running in place) or engages in vigorous aerobic type activity (such as tennis, basketball, or handball). → Go to question 6
4. Tick the circle that best describes your overall level of physical activity for the previous 2 WEEKS:

- O I avoid walking or exercise (for example, always uses elevators, drives whenever possible instead of walking)
- O I walk for pleasure, routinely use stairs, occasionally exercise sufficiently to cause heavy breathing or perspiration

*Go to question 7*

5. Tick the circle that best describes your overall level of physical activity for the previous 2 WEEKS:

- O I exercise between 10-60 minutes per week
- O I exercise more than 60 minutes per week

*Go to question 7*

6. Tick the circle that best describes your overall level of physical activity for the previous 2 WEEKS:

- O I run less than 1 mile (≈1.6 km) per week or spend less than 30 minutes per week in comparable physical activity.
- O I run 1–5 miles (≈1.6 km ~ 8 km) per week or spend 30–60 minutes per week in comparable physical activity
- O I run 5–10 miles (≈8 km ~ 16 km) per week or spend 1–3 hours per week in comparable physical activity.
- O I run more than 10 miles (≈16 km) per week or spend more than 3 hours per week in comparable physical activity.
ON A SCALE FROM 1 – 7 (1 = strongly disagree, 7 = strongly agree, N.A.), how strongly do you agree or disagree with the following statements? Please tick the circle that most closely reflects your impression.

<table>
<thead>
<tr>
<th>Statement</th>
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<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>Strongly agree</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>7. I am currently regularly physically active</td>
<td>0</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
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<td></td>
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</tr>
<tr>
<td>8. I am satisfied with my current level of physical activity</td>
<td>0</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
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<td></td>
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</tr>
<tr>
<td>9. In order to improve or maintain my physical fitness, I should exercise at least 5 days a week for at least 30 minutes</td>
<td>0</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
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<tr>
<td>10. Exercising enough reduces the risk of getting cardiovascular diseases</td>
<td>0</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
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<tr>
<td>11. Setting exercise goals will help to increase my motivation for doing exercise</td>
<td>0</td>
<td>O</td>
<td>O</td>
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<tr>
<td>12. Keeping track of my exercise progress keeps me motivated</td>
<td>0</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
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</tr>
<tr>
<td>13. I want to improve on my physical fitness</td>
<td>0</td>
<td>O</td>
<td>O</td>
<td>O</td>
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<td>O</td>
<td>O</td>
<td>O</td>
<td></td>
<td></td>
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<tr>
<td>14. I am satisfied with my level of physical fitness</td>
<td>0</td>
<td>O</td>
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<td>O</td>
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<td>O</td>
<td>O</td>
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<td></td>
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<tr>
<td>15. I am motivated to improve my physical fitness</td>
<td>0</td>
<td>O</td>
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<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
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<td></td>
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</tr>
<tr>
<td>16. I intent to increase my level of physical activity in the near future</td>
<td>0</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
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<tr>
<td>17. I am confident that I will improve my physical fitness in the near future</td>
<td>0</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
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</tr>
<tr>
<td>18. If I would schedule or plan my exercises for a week, I am confident that I would stick to the plan</td>
<td>0</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
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</tr>
<tr>
<td>19. I am confident that I was able to reach the weekly target mBeats I was asked to achieve for this study</td>
<td>0</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
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</tbody>
</table>
The next couple of questions are about your experience with the mBeats app

ON A SCALE FROM 1 – 7 (1 = strongly disagree, 7 = strongly agree, N.A.), how much do you agree or disagree with the following statements? Please tick the circle that most closely reflects your impression.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly disagree</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>Strongly agree</th>
<th>N/A</th>
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</thead>
<tbody>
<tr>
<td>20. Overall, I am satisfied with how easy it is to use this app</td>
<td></td>
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<td></td>
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<td>21. It was simple to use this app</td>
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<td>22. I can effectively complete my work using this app</td>
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<tr>
<td>23. I am able to complete my work quickly using this app</td>
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<tr>
<td>24. I am able to efficiently complete my work using this app</td>
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<td>25. I feel comfortable using this app</td>
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<tr>
<td>26. It was easy to learn to use this app</td>
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<tr>
<td>27. I believe I became productive quickly using this app</td>
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<td>O</td>
</tr>
<tr>
<td>28. The app gives error messages that clearly tell me how to fix problems</td>
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<td></td>
<td></td>
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<td>O</td>
</tr>
<tr>
<td>29. Whenever I make a mistake using the app, I recover easily and quickly</td>
<td></td>
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</tr>
<tr>
<td>30. The information (such as on-screen messages) provided with this app is clear</td>
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<td>O</td>
</tr>
<tr>
<td>31. It is easy to find the information I needed</td>
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</tr>
<tr>
<td>32. The information provided for the system is easy to understand</td>
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<td>O</td>
</tr>
<tr>
<td>33. The information is effective in helping me complete the tasks and scenarios</td>
<td></td>
<td></td>
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<td>O</td>
</tr>
<tr>
<td>34. The organization of information on the app screens is clear</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
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<td>O</td>
</tr>
<tr>
<td>35. The interface of this app is pleasant</td>
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<td></td>
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<td>O</td>
</tr>
<tr>
<td>36. I like using the interface of this app</td>
<td></td>
<td></td>
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<td></td>
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<td>O</td>
</tr>
<tr>
<td>37. This app has all the functions and capabilities I expect it to have</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>O</td>
</tr>
<tr>
<td>38. Overall, I am satisfied with this app</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td>O</td>
</tr>
<tr>
<td></td>
<td>Strongly disagree</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>Strongly agree</td>
<td>N/A</td>
</tr>
<tr>
<td>---</td>
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</tr>
<tr>
<td><strong>39.</strong> The app makes the things I want to accomplish easier to get done</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>40.</strong> I don’t notice any inconsistencies as I use the app</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>41.</strong> I easily remember how to use the app</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>42.</strong> I would recommend the app to a friend</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>43.</strong> It is fun to use the app</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>44.</strong> The app works the way I want it to work</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>45.</strong> The app minimized the number of steps it took to complete tasks</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>46.</strong> I needed to learn a lot of things before I could get going with this app</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>47.</strong> I felt very confident using this app</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>48.</strong> I found the various functions in this app were well integrated</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>N/A</td>
</tr>
</tbody>
</table>