Behavior Change Support for Physical Activity Promotion: A Theoretical View on Mobile Health & Fitness Applications

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Abstract

Physical inactivity is the main cause for most cardiovascular diseases as well as premature mortality in the Western world. Prevention may include changing people’s behavior and encouraging them for a physically active way of life. Smartphones as our daily companions have a huge potential to influence the behavior of non-movers and to integrate physical activities into their daily routine.

In this paper, we present a typology of mobile application features to change the sedentary behavior of non-movers. The features are characterized based on how they are useful in the behavior change process and on the psychological factors they address. Research is therefore based on two psychological models: The Transtheoretical Model of Behavior Change and Fogg’s Behavior Model. Both models are combined to explain the theoretical aspects of health and fitness applications. We propose a new theoretical model how to support physical activity with mobile services and come up with propositions for this theoretical model.

The Delphi technique is used as an empirical research method to summarize 30 mobile application features from domain experts. There are two major results: First, the consulted experts reveal what kind of intervention strategies are suitable in order to promote physical activity. Second, the study brings forth how the application features carry out support for behavior change. According to the user’s motivational stage and the user’s psychological characteristics, application features are assigned to different user types to support and increase physical activity.

1. Introduction

Physical inactivity is seen as a major cause of reduced quality of life, numerous diseases and premature death [1]. Alongside, the number of deaths due to physical inactivity has been currently experiencing a huge soar and increased from a global value of 1.9 million deaths in 2002 to an annual average of around 3.2 million deaths today, a boom of nearly 69% in just over one decade [2]. Besides the increased risk for premature mortality, the disregard of a physically active lifestyle also heavily correlates with the development of chronic diseases. Many epidemiologic studies completed over the past century support this association [3]. A sedentary lifestyle is responsible for 15% of the 1.6 million newly diagnosed chronic diseases each year [4] like cardiovascular disease (CVD), cancer, type 2 diabetes, various respiratory diseases, and osteoarthritis [3]. Medical treatment and annual health care costs continue to rise into trillions of dollars each year due to cardiovascular diseases alone [3]. Those individuals threatened by chronic diseases and premature deaths from inactivity are defined by Rütten et al. [5] as “non-movers”. Non-movers are described as high-risk-individuals for chronic diseases. They claim themselves not to perform any activity leading them to come out of breath [6].

However, subsequently the key question arises of how to motivate non-movers to become physically active. Changing the behavior of individuals through persuasion is usually achieved by human-to-human communication: e.g., when psychologists or fitness coaches support and teach individuals. A modern approach of persuasion can be established by human-computer interaction (HCI). Behavior change realized with HCI can be done e.g., by using smartphones that send persuasive messages to an individual in order to reinforce, change or shape his or her attitude or behavior [7]. Unfortunately, 50% of mobile fitness users stop using their fitness tracking device after six months [8]. This is due to the lack of behavior change constructs which are necessary for long-term engagement [9]. In particular, Bort-Roig et al. [9] emphasize that the use of smartphone features, like built in sensors in combination with behavior change features...
strategies are crucial for realizing the full potential of mobile technologies to enhance physical activity.

The vast penetration of smartphones among population transforms this piece of technology into an everyday virtual coach for many individuals. As people are keeping their smartphone with them most time of the day, they have access to data anytime and anywhere. This represents optimal conditions to intervene and persuade smartphone users with physical activity behavior change applications using tailored feedback and advice at the appropriate time and place [10]. Furthermore, health and fitness applications utilize in-built sensors such as the global positioning system (GPS), accelerometers, cameras and microphones. Latest smartphones are equipped with a barometer to determine the user’s relative elevation and a gyroscope to detect whether the user is driving or walking [11]. The number of sensors can be extended through external devices for further input of the user’s body parameters.

Penetration, availability and technical abilities are advantages of the smartphone making it an ideal persuasive interface with big potential to motivate behavior change of individuals.

2. A Typology of Mobile Behavior Change Support Services

A lack of structure can be identified in how existing fitness applications influence the user. Therefore, we created a typology of fitness application features used for physical activity promotion. The following section describes the methodology used for developing and categorizing the portfolio of health and fitness services. The Delphi method was used to identify features with medical experts like doctors and personal trainers.

Methodology – A Delphi Study

Behavior change support with mobile IT covers a wide range of interdisciplinary fields: health and fitness applications in general are located within the field of HCI [12]. Within the health and fitness domain, disciplines such as psychology, sport- and medical sciences [13], as well as the technological part involving theory on persuasive technology and best practice examples of fitness applications have to be taken into account. Having a profound insight into all areas of the theory, we were able to choose relevant experts for the Delphi study.

We selected experts from the disciplines mentioned above in order to meet the requirements of this interdisciplinary topic. The most important source of information concerning physical activity are experts in the fields of sports and medical sciences. As sport scientists and physicians are focusing on individual physical and mental health, they have profound experience about which intervention strategies are relevant or proven successful to change the behavior of individuals. For the technological side it was necessary to include IT specialists and User Experience experts. In total, eight experts participated in the Delphi study.

In the first Delphi round, we collected and analyzed ideas for mobile applications to support physical activity. Main goal of this step was to transform the expert’s ideas into concepts for mobile application solutions that incorporate their idea as an IT service. Each application idea should consist of a description and a visualization in form of a mock-up. In general, the requirement specification and design of each application idea consisted of three consecutive steps: Outlining the ideas as expert’s description and hand-sketched mock-up, designing digital mock-ups on the basis of sketches, and specifying software requirements by using the Volere template [14]. We present a portfolio of 30 health and fitness application concepts. Each concept contains a description as well as a mock-up demonstrating a possible mobile solution.

The applications have been grouped into five categories based on the primary intention the experts stated during the Delphi study:

Risk and Fitness Assessments: In the category of Risk and Fitness Assessment, applications are used either to determine the user’s risk for certain diseases or to check their level of fitness. Risk Test: A risk test is primarily used to check the user’s probability to suffer from diseases such as heart attacks. A common way to check user’s cardiac risk is calculated according to Wilson’s et al. coronary prediction algorithm, which is based on the Framingham Study [15]. Results of the risk test are then represented e.g., on a scale ranging from a low to high risk for the disease. Fitness Tests: Fitness test applications are used to assess the user’s overall level of fitness measured with a certain sport exercise. E.g., a simple way to check health in terms of body fitness can be done by calculating the body mass index (BMI). For testing the training level, such as the aerobic level, users can perform e.g. the ‘step test for three minutes’. The cardiovascular fitness level is determined based on how quickly the heart rate returns to normal after the exercise.

Five application concepts had been developed by the experts for this category namely ‘2 km Walking Test’, ‘3 min Step Test’, ‘Cooper Test’.
**Rewarding:** Fitness applications with integrated rewarding elements are a rudimentary way to boost user motivation. Rewards can be either simple messages such as a smiley after achieving a certain goal or even money in form of discounts for sportswear. An application with rewarding elements could track certain activities and for each activity, the user needs to achieve a certain goal, such as 10,000 steps a day. If all goals are achieved after a certain time, the user receives an insurance discount. Two of our application concepts are within this category namely ‘Health Insurance Bonus’ and ‘Gym Discount Calculator’.

**Progress Monitoring:** A typical progress monitoring application tracks the user’s physical activities and represents his or her activity history via progress charts. To monitor progress of the activities e.g., a trend arrow indicates whether the user increased or decreased his or her performance during a certain period. Features that are more sophisticated could add more data such as heart rate, blood pressure etc. to monitor the changes of the measured values. A high number of application concepts, developed by the experts, fall in this category: ‘Step Tacho’, ‘Energy Balance’, ‘Daily Activity Profile’, ‘Bio Impedance Analysis’, ‘Move and Smile’, ‘3D Body Avatar’, ‘My Progress’, ‘My BMI’, ‘5 Goals a Day’, ‘My Burnt Fat’ and ‘My Run’.

**Social & Competition:** This kind of persuasion, motivated via “social pressure”, is used by social and competition applications and is one of the most successful ways to persuade users to get active. Social and competition applications integrate social elements such as sharing results on social networks, public ranking lists, shared performance profiles etc. A useful way of applying social persuasion is achieved with an application that is solving the problem of finding like-minded people with similar sport interests’ or a similar fitness level. Once partners have gotten together group members can encourage and motivate or even challenge each other. The application concepts ‘People Like Me’, ‘Climb Up’, ‘Expert Chat’, ‘Post or Go’, ‘My Avatar’, ‘Share my Activities’ and ‘My Competitor’ are in this category.

**Coaching & Advise:** Sometimes users simply need a signal telling them to start with an activity immediately. Fitness applications with coaching and advice features are designed to tackle these kinds of challenges, e.g., with a reminder telling the user at the right time that it is sunny outside and displaying the distance to the next location for his or her favorite activity. Another example of how to build up user motivation can be realized with a virtual motivational coach. The user would receive little tasks and instructions what to do in order to build up their motivation and how to prepare for their goal. We find five application concepts in this category: ‘SF-36 Recommendations’, ‘Remind Me’, ‘Burn instead’, ‘Abiliti’ and ‘My Motivator’.

The 30 identified application concepts provide an interdisciplinary overview on health and fitness features to support physical activity, developed by medical and fitness experts. By identifying the core concepts embedded in the applications, a typology of five categories was build. While this typology will be further tested for robustness in future market analyses, it provides a state of the art overview of the different types of health and fitness applications.

### 3. A Theory to Support Behavior Change

In the previous section, we presented five categories of health and fitness applications. Still, it is unknown how behavior change support is carried out with these applications. However, within the fields of exercise promotion there are numerous behavior change models aiming to explain how individuals can learn to become physically active.

Currently, health and fitness applications on the market are not based on theoretical behavior change constructs at all [16]. In the following theoretical model, we include two existing models of behavior change to understand how health and fitness application influence the users’ behavior.

**Long-Term Behavior Change Strategies**

The Transtheoretical Model of Behavior Change (TTM) describes the behavior change of an individual as a process where he or she must progress through five stages of change over time in order to change a target behavior [17]. It is assumed that individuals do not change their behavior all at once; they change it incrementally or stepwise [18]. Five stages of the TTM must be passed in order to change behavior: Users in the stage of precontemplation are inactive and not aware of the need of change. When they get aware of the risk and plan to change their behavior they move forward to the contemplation and preparation stage. They move to the action and later to the maintenance stage when they start a new behavior and maintain it for a long period of time.

![Figure 1. Stages of Change in the TTM](image-url)
A range of important advantages makes the TTM superior to other behavior change theories when it comes to physical activity promotion. It describes an individual’s behavior change as a process over time while other models ignore the temporal aspect [19]. As the TTM describes change processes over a broad timescale (at least six months) stagnation and relapses are taken into account [20]. The model’s differentiation of stages can be easily operationalized for research and intervention development [18].

Psychological Micromanagement Strategies

The TTM is suitable for long-term behavior change intervening from the very beginning until the end of a change process. What is mainly lacking in the TTM for a more effective behavior change approach is a dimension of all-day micromanagement which addresses users on a more refined level in their daily routine [21]. Furthermore, applying the TTM with focus on persuasive mobile applications has its limitations as it neglects the user’s social, environmental and biological context in which change occurs [22]. What is needed is a second behavior model extending the TTM for the application of persuasive technologies in the health- and fitness domain [23]. We use Fogg’s Behavior Model (FBM) that is already well established within the context of persuasive technology solutions [24]. According to Fogg’s model, three elements must come together in order to perform a target behavior [24]: Motivation, ability, and an effective trigger. Only if all factors occur at the same time a target behavior happens. These elements can be influenced and enhanced in order to change a behavior or to make a behavior happen.

Motivational Strategies (Sparks)

When intrinsic or extrinsic motivation is the lacking element for an individual, the goal is to move him or her higher along the motivational dimension, at least so far until the behavior activation threshold is passed. Fogg defines three different core motivators that can have a positive effect on the individual’s motivation: Pleasure and Pain, Hope and Fear, and Social Acceptance and Social Rejection.

Ability Strategies (Facilitators)

The vertical axis of the model explains how hard a behavior is to do and which factors make it simpler. Fogg developed six different elements of simplicity [24]. Time (the amount of time required for someone to start performing a behavior), Money (monetary expenses needed for performing a behavior build barriers for individuals), Physical Effort (required physical effort refers to the amount of physical energy that is needed), Brain Cycles (some target behaviors require people to think a lot before and during the execution), Social Deviance (any behavior that violates social norms is considered as social deviance - if individuals have to break social rules the behavior is no more simple to do), and Non-Routine (every behavior that is not integrated in daily life and differs from habits takes extra effort for individuals).

Triggers

A trigger is defined as a signal or reminder that is telling the individual „Do it now“. There are three types of triggers proposed by Fogg [24]. Spark (For Individuals who are situated beneath the activation threshold because they are lacking in motivation a „spark“ trigger is required to boost motivation in order to get the individual beyond the activation threshold.), Facilitator (The goal of a facilitator is to trigger the behavior while also making the behavior easier to do in order to pass the activation threshold.), and Signal (In case the individual has both enough motivation and ability a signal is all that is required to trigger the individual to do the behavior.).

Theoretical Model

We see that the TTM and FBM are two constructs to describe different aspects of behavior change. With the TTM, the position in the process of behavior change can be determined while the FBM explains which psychological factors for behavior change are addressed. With both models, a hybrid model of behavior change can be formed. The first dimension covers the five stages of the TTM, listed on the horizontal axis. They are subdivided by cognitive and behavioral strategies. The vertical axis lists Fogg’s
strategies, classified by their type of influencing strategy: Spark, facilitator and signal. After designing the portfolio of application concepts in the first round of the Delphi study, the applications were evaluated in another expert round. The experts were asked to allocate each service within the TTM-Fogg Matrix. First, they should classify the application concepts according to the TTM stage(s) where they would use it to support behavior change. Second, they were asked to identify which of Fogg’s strategies is realized within the application. This leads to a detailed characteristic of each individual application concept determining where in the TTM process of behavior change the application should be used and which psychological strategies of the FBM are addressed by the application concept. Every application can now be placed inside a two-dimensional matrix.

The result is a matrix that can be used to classify any kind of health and fitness service according to the motivational stage (TTM) and the psychological elements (FBM) realized within the application.

What turns the matrix into a comprehensive classification tool for a broad portfolio of services is that it comprises both a timescale dimension and a psychological dimension. To position a service into the matrix, one can first identify its stage within the TTM and then determine which of the Fogg’s strategies are realized. As the matrix is easy to understand, it can be used by various stakeholders. Physicians and psychologists can identify the required applications after knowing their patient’s characteristics.

In a first step it needs to be checked in which phase of the behavioral change process the user is situated. One could classify the user into a stage of the TTM by means of a questionnaire. A well-known questionnaire is the University of Rhode Island Change Assessment (URICA) [25]. In addition, we need to know how the user can be triggered in his or her identified stage of change. This can be done with a second questionnaire to find out the main psychological characteristics of the user. The questionnaire should identify for which of the FBM strategies the user is receptive. This can be achieved with existing FBM questionnaires as well as confronting the user with application examples (including only a single FBM strategy very prominent per application) and asking him to rate these examples. With given answers to these questions we know which of Fogg’s strategies should be covered as core elements in the service to successfully persuade the user and let him start a target behavior. Having the user classified in each of the two dimensions, customized services can be addressed to the user.

The theoretical structure of this approach to tailor persuasive applications towards a user’s characteristics is shown below.

**Figure 3. Combined Matrix from the TTM and FBM**

**Figure 4. A Theoretical Model of Tailored Mobile Applications for Physical Activity Promotion**

### 4. Propositions

In this section, we examine proposed relations and core elements of the theory as well as theorize positive (higher TTM/FBM match) constellations of application categories and user characteristics. This is based on the experts’ classification of applications into the TTM-FBM matrix. Following the proposed theoretical model, we subsequently analyze and interpret characteristic patterns in the applications characteristics.

**Effects of application use and acceptance of physical activity:**

P1: The use of fitness applications to support behavior change is positively associated with an increase of physical activity.

Intervention strategies, also traditional human-to-human mediated ones rely on the long-term participation of the user. Sustainable behavior change is achieved by providing influence measures in form of
sessions, discussions, guided activities etc. for numerous times. The more intense the traditional coaching is, the higher are the expected results. Consequently, the amount of persuasive messages increases with the intensity of the interventions. For computer-to-human persuasion, the same correlation is assumed. This means that the behavior change effect is positively associated with the use of the persuasive application.

**Dependence of application use on user characteristics**

Our theoretical model suggests that the physical activity of non-movers can be increased by providing the right subset of applications based on the match of application characteristics and user characteristics. The “match” in our model describes how similar the user profile and the profile of the IT services. For the TTM, a perfect match means that the service provided by the application supports the exact same stage of the TTM that the user is currently located. For the FBM, a perfect match means that the application addresses the exact same psychological factors the user is receptive to. While other factors like gender and age are proven to influence the user acceptance as shown in the technology acceptance models, we propose that for the area of behavior change the psychological tailoring in form of the TTM/FBM plays a vital role.

**P2**: Applications that provide behavior change strategies for moving from the user’s current TTM stage to the following TTM stage are more likely to be used by a user in this certain TTM stage.

**P3**: Applications that address the same psychological factors of the FBM the user is receptive to are more likely to be used by a certain user.

**Typology of application features**

*Allocation of application categories in the TTM*

In the first study, we analyze patterns and tendencies found in the data from the Delphi study along the horizontal axis for all stages of the TTM. First and foremost, it is noticeable that most services are not assigned to one distinct motivational stage, which makes the distinction of services between TTM stages generally difficult. Main reason for this broad distribution of the services across all phases is that each expert had different points of view in which motivational stage users are addressed with a particular service: On the one hand, physicians consider e.g., the “Bio Impedance Analysis” application as supportive in the beginning of a behavior change process (Precontemplation and Preparation) to raise health consciousness of patients; on the other hand sport scientists consider the application useful after some months of completing exercises (Action and Maintenance) to check the progress of athletes. This categorization of services lead to distributed classifications along the TTM. Second reason is that experts classified services not to a single stage but in most cases to multiple stages of the TTM. Another pattern that becomes obvious is that the number of classified services for each row of the matrix tends to be higher in the last four TTM stages (Contemplation until Maintenance) compared to the first stage (Precontemplation). This reflects that the majority of the services address users in advanced stages. The smaller number of services in the Precontemplation stage also indicates the complexity in developing intervention strategies for non-movers (Precontemplators) as only a few services integrate intervention strategies that leverage behavior change for this group.

**P4**: Based on the experts’ rating in the Delphi study, the following combinations (P4a-e) of applications and the user’s TTM stage can be useful.

The matrix does not include the frequency of how many times a service was linked to a certain stage by the experts. Therefore, we present a ranking that shows the number of ratings for each stage. The higher the number the more important the service category is for the given stage. This allows a more profound analysis of services along the TTM stages.

![Figure 5. Ranking of Application Categories by TTM Stage (higher = better)](image-url)
**P4a:** Risk Assessment applications may be highly suitable for users in the early stages of the TTM (Precontemplation & Contemplation).

**P4b:** Progress Monitoring applications get more important the more active a user is and progresses in the TTM (Preparation, Action & Maintenance).

**P4c:** Coaching & Advice applications tend to be less important than risk assessment and progress monitoring in early stages of the TTM.

**P4d:** Rewarding features (monetary bonuses) tend to be a less important factor promoting sustainable behavior change.

**P4e:** Social & Competition features tend to get more important the better a user progresses in the TTM model to support early steps of behavior change as well as for maintaining new behavior over a long period of time.

A general trend can be identified for the service types Progress Monitoring and Social & Competition where the ranking increases from Precontemplation to Action and then stays at a high level to the Maintenance stage. The applications require a certain level of physical fitness and experience in sports. That is why experts assigned those services to advanced stages. Main reason why these service types reach their peak in the Action stage is because this is the phase in the TTM where experts were certain that the intervention strategy behind each of these services could successfully trigger a user: Users in the Action stage would already have developed enough self-efficacy for changing their behavior in order to actively perform the target behavior. The analysis shows a completely different trend for the service type Risk Assessment. Applications for Risk and Fitness Assessment are most often assigned to the Precontemplation phase. For all the subsequent stages, the number of assignments declines. Risk and Fitness Tests support users primarily for checking their health or fitness levels. This type of service does not require individuals to be physically active, but challenge them cognitively – therefore addresses people in the very beginning of a behavior change process that starts with building risk awareness for the unhealthy behavior. Surprisingly, Rewarding applications tend to be less effective as they purely rely on an external factor (e.g., money) and do not foster intrinsic motivation.

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**Allocation of application categories in the FBM**

**P5:** Based on the experts rating of the Delphi study, the following combinations (P5a-e) of applications categories and the user’s FBM characteristics are promising.

The majority of services realize strategies for motivating (“Sparks”) as well as for reminding (“Signals”) users. Obviously, the strategies Pleasure/Pain, Hope/Fear are core elements of the service portfolio. We can thus state that the basis for behavior change of all five service types is realized in Fogg’s Behavior Model. A large number of services also appear within the “Signal” row of the matrix. This characteristic just reflects the idea behind Fogg’s Behavior Model – that every behavior change always requires a trigger to initiate a behavior.

On the other hand, we can find a smaller number of services in the center of Fogg’s model – services with facilitators. In the facilitator section, service types are better distinguishable because they typically conform to a certain strategy: For each strategy one distinct service type dominates, especially for “Social Rejection”, “Time”, and “Money”. Exception is the strategy “Brain Cycles” standing out with a large number of different services among all other facilitator strategies.

**P5a:** Risk Assessment applications may address motivational factors of the FBM as they address the core motivational elements Hope/Fear.

We can find all risk calculator and fitness test services among the motivating strategies of Fogg’s model. Motivating elements are of high importance for this service type as their main intention is to raise health consciousness of the user, usually achieved through motivation. On the one hand, this service type should trigger a feeling of fear in case an advanced risk for diseases is detected, (e.g., Cardiac Risk Calculator). Serving as a source of negative motivation, most users will be motivated to reduce their detected risk by adapting to a healthy lifestyle to increase their life expectancy. On the other hand a good fitness test result (e.g., 2 km Walking Test) or a low risk for heart attack will give the user a feeling of pleasure and hope pushing him or her to start or continue with physical exercises in order to avoid a decline of their “healthy” parameters.

**P5b:** Progress Monitoring applications tend to facilitate behavior change (Ability) as they reduce manual monitoring effort (Brain Cycles) and secondly
tend to be a motivating factor by providing overview of gathered data (Hope).

All Progress Monitoring service types have in common to appear in the Brain Cycles row of the matrix. The link between Progress Monitoring and Brain Cycles is reasonable: Progress Monitoring applications simplify the process of documenting the user’s activities chronologically (e.g., My Run, My BMI, My Progress) or they calculate their physical progress over time (e.g., Bio Impedance Analysis, 3D Body Avatar). Traditionally, athletes had to record all exercise data manually and by calculating their training progress curves on their own. This usually meant an exhausting cognitive effort, which BJ Fogg referred to as brain cycles. They should be avoided in any case when it comes to facilitate behavior change. With mobile applications, this cognitive barrier is overtaken and significantly facilitated. In case he or she achieved an increase in activity, the user will get a happy and satisfactory feeling of his or her achievement and becomes motivated to continue with the physical activity program. This explains why the second common characteristic of all Progress Monitoring services is their allocation within the “Spark” area of the matrix. Noticing progress gives the user hope and urges him or her to improve their fitness even more. Moreover, social acceptance is a strategy, which is realized among some of the Progress Monitoring services. Main explanation is that an improvement of physical parameters such as the loss of fat or a lower BMI is strongly connected to social acceptance within society due to our aesthetic consciousness.

**P5c:** Coaching & Advice applications mainly address trigger elements in the FBM as they are instant calls to action.

As mentioned above, a coaching advice, according to Fogg’s model, is the trigger to tell the user to start a behavior “now” [24]. Before a reminder is effective, the user first needs to reach the activation threshold. Therefore, a reminder is always a complementary element in addition to a motivator or facilitator. Services such as ‘Remind Me’, ‘My Motivator’ or ‘Abiliti’ make explicit use of reminders by sending a signal.

**P5d:** Rewarding application features (monetary bonuses) are mainly addressing the facilitator element Money of the FBM matrix.

Two services within the portfolio aim to facilitate behavior by rewarding users with money after successfully achieving their activity goals. We can therefore find ‘Health Insurance Bonus’ and ‘Gym Discount Calculator’ almost exclusively in the “Money” area of the TTM-Fogg matrix. Rewards and particularly money can be very effective to persuade users for a behavior. However, services with rewarding elements are only effective for a short term and should therefore be used only in the beginning of behavior change. After users are externally motivated by rewards, they are more receptive for internal motivations such as progress monitoring services.

**P5e:** Social Communication application features act as motivating factors in the FBM as they correlate to the core motivators Social Acceptance & Rejection

The term of the service type Social and Competition already implies in which parts of Fogg’s model they can be found: Predominantly within the section of Social Acceptance and Social Rejection in the FBM model. The services with integrated social elements aim at facilitating behavior change by sharing information about activities or personal achievements with friends to generate social interaction and encouragement (e.g., posting the physical achievement of 15,000 steps/day on their social platform) and seeking social acceptance among peers or the social environment in general. Competition as an element of services is especially relevant for users who already developed enough self-efficacy and who want to compare their fitness level with others, thus seek for competition (e.g., ‘Climb Up’ or ‘My Avatar’).

In this section, we have presented propositions for our theory on the effectiveness of mobile health and fitness application on the user’s characteristics. We propose that the impact on behavior change, in this case in the field of physical activity promotion, depends on the match of user and application.

### 5. Discussion and Conclusions

This paper explores behavior change intervention strategies aiming at promoting physical activity of users in different stages of the behavior change process. Via multiple Delphi rounds, relevant experts were consulted for behavior change strategies and the design of the developed application concepts was discussed. The examined strategies were translated into concepts for mobile applications. Finally, these application concepts were assigned to different categories. We proposed a theoretical framework to tailor applications to user characteristics. Based on our study, we built propositions for types of applications that may be suitable for different user types. The resulting portfolio was categorized in our typology and evaluated in regards to how the categories support the theoretical model. The study is based on a combination...
of two well-established behavior change models to leverage the impact on users in changing their behavior successfully and to guide the behavior development process: TTM originates from the field of psychology and is used to classify user types into different stages within their behavioral change process. The second one, Fogg’s Behavior Model, is a model taken from the IS domain that is utilized to integrate operational intervention strategies. This combination helps to classify the developed health and fitness services for different user types. This study is a first approach towards solving a major issue within the fields of mobile health and fitness applications: The foundation of applications on a well-proven theoretical framework. The majority of current health and fitness applications on the market is lacking this crucial component and therefore fail to sustainably change behaviors.

Limitations
The results of the Delphi study are associated with uncertainties due to the varying backgrounds of the experts. Therefore, the classification of some services might be over- or underestimated. One of the main challenges for developing an application portfolio for health and fitness applications was to search for intervention strategies that are capable of persuading individuals successfully in the beginning of the behavior change process. However, the portfolio presented in this paper covers only a section of potential interventions. Therefore, a larger pool of experts especially in the fields of sports and medical sciences could offer input for a broader typology.

Implications for Research and Practice
While a relation between the TTM/FBM tailoring and application use is proposed in the theoretical model, the nature of this relation is not described in the model yet. The proposed tailoring, resulting in the TTM/FBM match will not directly influence the application use. It is more likely that mediating elements between match and application use have to be identified. For further research, we propose incorporating theories of technology acceptance into our model to explain how the constructs influence application use. A lot of research has been focusing on the TAM model and the UTAUT model in the last decades. They have been developed in a time before the dominance of “mobile-first” IT design. As mobile technologies are more personal and pervasive, other factors can influence the use of IT systems. This paper promotes a more psychological approach to understand technology acceptance and influence to take the particularities of mobile IT into account. Further research should examine if the existing theories of technology acceptance can help to understand the influence of TTM/FBM match on application use.

For practice, once the health and fitness applications are used, the long-term effect on behavior change has to be evaluated. To test the theoretical model the impact on physical activity has to be measured. To what extent does the use of health and fitness applications lead to a higher level of physical activity level? Is there a significant increase in physical activity over a long period of time? The proposed relation between application use and physical activity needs to be proven. Therefore, we propose a field study with a limited number of applications and participants. Since the complexity of the applications makes it infeasible to validate the model as a whole, a small but heterogeneous subset of application features can be tested with selected user from different TTM stages and FBM profiles to measure the impact of application use on the physical activity of these participants. If the long term effect of health & fitness apps can be described in detail, the view on the market of fitness applications and wearables can change. Instead of looking at features, sensors and technical capabilities, a profound description on the behavior change effect of these applications and wearables can be given. This can switch the focus from the question “What sensors are in this product?” towards “How will this product help me to change my behavior?”.

Future Outlook
In terms of technology, health and fitness applications are currently about to become smarter. The next level for mobile services is to consider the context and environment of users for a highly customized tailoring. Context-aware applications can only be used to their full potential if they have access to a broad range of data. The next generation of mobile technology is capable of collecting a rich and holistic set of user data. This is realized with sensors that can be integrated in garments, skin and sports equipment. Until now, we have to ask the user for assessing their psychological characteristics regarding the TTM and FBM. If more contextual data is available, detailed psychological characteristics might be derived automatically based on the user’s behavior and actions. Having the opportunity to adapt to the user’s behavior to a larger degree enables applications to assist in changing behavior on a more sophisticated level.

6. References


