A Context Aware Mobile Application for Physical Activity Promotion

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Abstract
Mobile applications to support physical activity have grown rapidly in the past years. Many users are attracted by the promised support for a healthier lifestyle. Still, the long-term effect of these applications can be doubt. A lack of theoretical foundation from behavior change theory is seen as a root cause for the lack of sustainable effects of these applications. Little is known about design concepts to include theoretical frameworks into application design while using the technological power of mobile technology. Addressing this gap, a concept is developed to include the Transtheoretical Model of Behavior Change and the Fogg Behavior Model into a mobile application for physical activity promotion. Based on a mobile sensor framework, context information is automatically collected to detect potentials for behavior change. The user is guided through a tailored path of behavior change with context aware persuasive services. The implications of the proposed concept for practice and research are discussed.

1. Introduction
Preventive self-care approaches aim at involving the patient into the process of medical treatment and achieve shared responsibility with him or her [1]. While this has been used in the treatment of chronic diseases as well as preventive measures like smoking cessation and nutrition [2], this study focused on physical activity promotion. As the user is not under permanent supervision of medical experts, the success of self-care applications depends to a large extent on the patient’s compliance and long-term involvement with the preventive measures [3]. Preventive measures work towards a behavior change on the patient’s side for a healthier lifestyle [2]. Therefore, understanding the process of behavior change is vital to support patients in their self-care actions and preventive measures. If the cognitive and behavioral processes of the patient are well understood, IT systems can be designed to guide and support the user in this process [4]. To leverage the impact of such IT systems, applicable behavior change theory is needed as a foundation to guide the development process.

Traditionally, behavior change strategies have been used in human-to-human communication [5] when fitness coaches or medical advisors interacted with their customers. Today’s mobile technologies enable new ways of communication which can either be computer-mediated, human-to-human communication or computer-to-human communication [4] when the IT system itself reacts to the users behavior. Mobile technologies are personal and pervasive devices providing high penetration [6], high availability [1] and high technological abilities [7]. They close the gap between professionals in preventive care and the patient by being in arm’s reach almost 24 hours a day. Their potential might be leveraged when behavior theories and models “guide the development of complex interventions that adapt rapidly over time in response to various inputs” [8].

If the services provided by mobile applications are built on theoretical frameworks of behavior change, mobile services can be offered depending on the user’s progress in the process of behavior change. Many users experience relapse and setbacks when trying to stick to a new fragile habit [6]. In order to achieve long-term sustainability in adapting new habits, it is important to integrate cognitive and behavioral strategies to integrate physical activity into daily life [9].

2. Related work
Promotion of physical activity with mobile technologies, especially smartphones, was examined in many projects in the recent years [10]–[13]. While fitness trackers and health accessories for smartphones are growing [14], the effectiveness of these solutions is in doubt. In 2014 Ledgers and McCaffrey from the strategy consulting think tank Endeavour Partners (Cambridge, MA) published a study [15] on wearable accessories for physical activity promotion. They call it the “dirty secret of wearables” [15] that more than 50% of customers have stopped using their fitness tracking device after 6 months after buying it. They conclude that behavioral science strategies are poorly implemented in available solutions but are needed and vital for long term engagement [15].
We focused on related research projects which used widely available smartphone technology in their research. Borg-Roig et al. [16] published a systematic review of the use of smartphones in physical activity promotion in 2014. In their literature review they examined papers from Web of Knowledge, Pubmed, PsycINFO, EBSCO ScienceDirect and Scopus up to September 2013. 13 studies were selected and analyzed, how behavior change towards more physical activity is supported by the projects. While five projects were based on behavior change theories, a theoretical framework was not reported in the rest [16]. The authors criticized the lack of theoretical foundation. They highlighted the importance of using smartphone features, like built-in sensors, in combination with behavior change strategies [16].

While the study of Borg-Roig et al. focused on papers from the medical and psychological area, we have found several projects published in ACM journals and conference to June 2012 [17]. The projects were screened for their underlying theoretical framework. Two reviewers performed the evaluation of the selected projects independently. Eight projects have been identified to support physical activity with mobile applications. While one combines Goal Setting Theory with the Transtheoretical Model and three of them use the Transtheoretical Model as a background, in four projects a theoretical foundation can not be seen. It is notable that the theoretical foundation does not seem to be stronger in later projects. The identified projects are shown in the table below.

<table>
<thead>
<tr>
<th>Project</th>
<th>Year</th>
<th>Underlying theory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Houston [18]</td>
<td>2006</td>
<td>Transtheoretical Model</td>
</tr>
<tr>
<td>UbiFit Garden [12]</td>
<td>2008</td>
<td>Transtheoretical Model</td>
</tr>
<tr>
<td>Mobile Mentor [13]</td>
<td>2010</td>
<td>-</td>
</tr>
<tr>
<td>Fitness Tour [19]</td>
<td>2011</td>
<td>Transtheoretical Model, Goal Setting Theory</td>
</tr>
<tr>
<td>RunWithUs [20]</td>
<td>2011</td>
<td>-</td>
</tr>
<tr>
<td>iDetective [21]</td>
<td>2011</td>
<td>-</td>
</tr>
<tr>
<td>Move2Play [9]</td>
<td>2012</td>
<td>-</td>
</tr>
</tbody>
</table>

**Figure 1. Projects on physical activity promotion**

Based on these findings, we support the suggestion of Borg-Roig et al. to strengthen the theoretical foundation in persuasive technology for physical activity promotion.

### 3. Requirements Analysis

Persuasive technology, a term coined by Fogg [3], cannot be seen as a monolithic IT artifact which can be applied to anyone in order to change his or her behavior. Persuasive Technology must be tailored towards a specific user and consider medical, psychological and environmental factors that influence his or her behavior [22].

#### 3.1. Persuasive Service Portfolio

This study focused on adults that are not under medical treatment for pre-existing medical conditions but may have risk factors that can lead to chronically diseases. The goal is to increase their level of physical activity in their everyday life to meet the WHO recommendations [23]. This means, based on the general WHO calculations, walking at least 10,000 steps a day, reach at least 150 min of cardiovascular exercise per week and two times at least 30 min of muscular exercise per week. Depending on the individual WHO recommendation and existing activity level, persuasive services have to guide towards the target level of physical activity in everyday life. Persuasive actions therefore have to be applied multiple times during the day, considering the users context such as motivation, activities and habits. Two time horizons are dominant in behavior change theories.

Large timescale theories focus on cognitive and behavioral conditions, which change over a long period of time. One of the predominant theories used in behavior change support systems is the Transtheoretical Model (TTM) by Prochaska et al. [24]. In this model, at least six months is needed to perform a sustainable attitude and behavior change. We use the TTM model as a basis for large time scale tailoring of persuasive measures. The TTM describes five different stages of behavior change an individual goes through: Precontemplation, contemplation, preparation, action and maintenance [25]. In the precontemplation stage, the individual has no intention to change his or her behavior in the near future. In the contemplation and preparation stages, awareness rises and the individual takes first steps to change his or her behavior. The action and maintenance stages describe the stages in which the new behavior is performed and afterwards maintained for a long period of time. Specific strategies are suggested to support the transition from one stage to the next. Nine strategies have been identified to be important for intervention programs [26] [24]. Strategies can be divided along the dimensions ‘cognitive-affective’ and ‘behavioral’ [24]. Cognitive-affective strategies are aiming at a change of mind by increasing awareness for the necessity to change, point out the impact of negative behavior and the relevance of positive behavior. Therefore, cognitive-affective strategies are mainly successful in the early stages of change, namely precontemplation and contemplation. Behavioral strategies focus on supporting the actual behavior after the decision to
change has been made. Therefore these strategies help
the individual to perform or maintain the changed
behavior.
Persuasive services have to be tailored depending on
the stage of change, in which the user currently is.
Inactive users, or so-called couch potatoes, are starting
in the first stages of behavior change [24]. That means,
that persuasive services should focus on cognitive
strategies in order to raise risk awareness and change
the users mind set. A well-known example of
persuasive messages with cognitive strategies is in the
field of smoking cessation. Shocking pictures of
smokers’ lungs are printed on the cigarette packets to
create risk awareness and visualize the health
consequences [27]. Active users, which have
progressed further in the process of behavior change,
should be addressed with persuasive services that focus
on behavioral strategies. A famous example is the new
years resolution problem when users are willing to
change their behavior at the beginning of the New
Year, but lack guidelines and tools to stick to their goal
over a long period of time [28].

3.2. Deciding when and how to persuade

Besides the long-term behavior change, a
dimension of all-day micromanagement is needed to
manage the little steps of behavior change. Widely
used theories, like the goals setting theory [28] state,
that target behavior and goals must be broken down
into smaller, achievable goals. These goals can be
tackled easier than focusing on goals that are too far
away to be reached in adequate time. The goals setting
theory proposes requirements (‘SMART’ goals) in
order to be suitable for behavior change. While goals
setting can be an important strategy for behavior
change, this study used a broader approach to influence
behavior. The Fogg Behavior Model (FBM) proposed
by BJ Fogg [22] is based on three elements that
determine, whether a behavior happens or not. Fogg
describes them as ‘Motivation’, ‘Ability’ and ‘Trigger’
while all of them have to be present at the same time.
A behavior takes place when the user is motivated
enough, has the ability to perform the behavior and is
triggered to do it. Behavior can therefore be described
as the formula:

Behavior = motivation*ability*trigger

To influence the motivation dimension, three pairs of
core motivator are described: Pleasure & Pain, Hope &
Fear, Social Acceptance & Rejection [29]. While
Pleasure & Pain focus on immediately perceived
emotions, Hope & Fear includes expected results in the
future. Social Acceptance & Rejection address the role
of the individual in contact with others or in a group
following inherent standards and values.

For the dimension of ability six factors are described
[29]: Time, money, brain cycles, non-routine, physical
effort and social deviance.
The crucial elements whether a behavior occurs or not,
are triggers. Even if the user is motivated enough and
the behavior is easy to do, an additional trigger is
needed as a reminder and call to action [29]. Triggers
will fail if either motivation is too low or ability is
lacking.
Persuasive services can boost motivation - called
sparks - or making a behavior easier - called
facilitators. They can also serve as a trigger. In order to
be successful in changing behavior, the services not
only have to be of the right type and at the right time as
proposed by Fogg [29]. We propose to also adapt the
services to the current stage of change in the TTM.
This means that the three types of services have to
focus on cognitive strategies if the user is in the earlier
stages of behavior change and should use behavioral
strategies when the user has already started to change
his or her behavior. The following list gives examples
on how persuasive services to promote physical
activity can be designed:

- Cognitive:
  - Spark: Visualizing the health impact of
    increased physical activity. By
    showing how risk factors for
    cardiovascular diseases, high blood
    pressure and diabetes can change, the
    current risk level (fear) and the
    health benefits (hope) that can be
    pointed out.
  - Facilitators: Showing, opportunities
    for physical activity in everyday life.
    Building first steps guidelines can
    reduce the needed brain cycles and
    outlines, how physical activity can be
    integrated in the daily routine (time).
  - Triggers: Monitoring daily activity
    and physical parameters like weight
    and body fat. The daily confrontation
    with the existing situation brings the
    need for action into the users mind
    and helps building risk awareness.

- Behavioral:
  - Sparks: Rewarding the user, even for
    small steps towards a physically
    active lifestyle. Strategies from goal
    setting theory can be used here.
    Rewards can be external, like
    monetary bonuses, or in form of
    virtual points and achievements.
    Getting rewarded for physical
    activity (pleasure) can also be used in
    social groups to make the own
progress and status visible to other members of the group (social acceptance).

- Facilitators: Making physical activity easier by providing information when, where and how to do sports, and helping to prepare the right sports equipment. This reduces planning activities (brain-cycles) and avoids fallbacks like missed training days (non-routine).
- Triggers: Reminders to interrupt unhealthy behavior. This focused on daily habits that can easily be changed, but are often too deep integrated into daily activity. While the user is mostly motivated enough and the behavior change does not require noteworthy resources, simple calls to action are needed to remind the user to change something.

3.3. Detection of Context Information

To start persuasive services in the right situation to induce a defined target behavior, a comprehensive insight into the users behavior is needed 24/7. This comprises health information as well as information about physical activity and even behavioral pattern how days are structured regularly. Human persuaders like personal fitness coaches can easily question the user or watch their behavior [30]. To bring this to an IT based persuasive service platform, context information of the user has to be gathered in a structured way. Context information is needed for two purposes. Information about the users health status, like preconditions, body composition, fitness level but also performed activities like daily steps, spent calories and training routines have to be gathered for medical interpretation. Individual fitness goals are derived from WHO recommendation for different user groups [23]. This defines the target behavior for each individual user. Information about the already performed activity allows a comparison of the target behavior and the actual behavior. The degree, in which users follow the medically indicated recommendations, is an indicator for compliance but also defines, if further behavior change is needed or not. Furthermore, context information is needed for psychological tailoring of persuasive services. This means, when and how persuasive services should be presented to the user. Sparks, facilitators and triggers have to react on the user’s behavior in order to support the little changes in everyday life [29]. Facilitators should react on context information such as weather information, working hours or sleeping times. Sparks can provide extra motivation when a major underperformance is predicted, based on the activity so far. Sparks can also boost motivation when a user is close to the daily goal and can reach it with just a slight increase in activity. Triggers need complex information about performed activities like sitting, walking or sleeping to interrupt unhealthy habits. This leads to the need for a comprehensive detection of context information. Every persuasive service needs individual subsets of context information to be placed efficiently. Therefore, when creating new persuasive services the amount of needed context information may grow. To support this by design, the context model of Dey and Abowd [31] is used as an underlying structure. Four categories of primary context are distinguished: Time, location, activity and identity. The so-called secondary context types provide detailed information about individual aspects of a primary context type [31]. Examples for relevant secondary context information are shown below:

- Time: Day/Night, Workday/Weekend, usual training time
- Location: POIs like Workplace, Home or Gym
- Activity: Steps, burned calories, activity types, intensity of activity
- Identity: Gender, age, body composition, heart rate, blood pressure, blood sugar, motivational state

The required types of secondary context information are defined by the persuasive services, as they need a subset of context information to be working correctly. This shows that the system work on pull mechanisms, where services demand for context information. Therefore each service has different requirements on the available information. At the current stage, the concept is restricted for the use as a virtual fitness coach. Persuasive services for treatment of chronic conditions require a lot more secondary context information, especially from the category ‘identity’ when monitoring blood- and cardiovascular data [32].

4. Concept for Context-based Behavior Change Support Services

The concept is created on the Google Android platform [33] and consists of 3 layers: Sensor framework, data analysis and service presentation. Sensor framework and data analysis are not visible to the user. All interaction is done with service presentation layer. The figure below shows the system architecture that is described in the following section.
4.1. Sensor Framework

Individual sensors have been used in many mobile IT applications since smartphones emerged. Often, the sensors are sold as fitness accessories for smartphone applications [34], [35]. This is suitable for e.g. step counters and corresponding smartphone application to monitor daily steps. Thus, the approach of hardwiring sensors to applications comes to its limits when more complex behavior has to be monitored. As shown in the previous chapter, numerous sensor information has to be gathered and combined automatically in order to give a comprehensive overview of relevant user context in all four primary context dimensions. A flexible and expandable approach is needed to collect and store sensor data from multiple devices. In addition, the quickly evolving economic environment of wearable consumer devices demands readiness for new or improved sensors in the next hardware generations. While hardware manufacturers change and precision improves, the output values of the sensors stay the same. We have seen improvements in the prevention of false positive step detection [33] as well as heart rate monitoring which can now be done with a fingerscan on the back of your smartphone [36]. However, the output data of these sensors is still the same (steps and heart rate in these examples).

To allow fixed types of context data and yet utilize improved sensor hardware, we have created a sensor framework for context information. Two types of measurement are distinguished. Event based measurement is used when a value does not radically change over short periods of time. This is the case for identity information like gender, date of birth, height and previous medical conditions. That information is manually entered in the user profile on the first use of the application. To evaluate the users motivational state and his or her progress through the different stages of the TTM, the URICA-E2 [37] standardized questionnaire for dimensional evaluation of the stages of change is used. Event based measurement is also used for information that is collected from external sensors which are stationary installed in the household or gym. For example this is the case for a wireless body scale to measure weight, body fat and heart rate. We use the ‘Withings Body Analyzer’ [38] which transfers measured data over inbuild wifi to the Withings server, where the data can be accessed via a REST based API. In the next iteration of the project, we will integrate the Withings Wireless Blood Pressure Monitor [39] and blood sugar and cholesterol sensors with the same API.

In contrary to monitoring of ‘identity’, which has to be event-based, information from the primary context types ‘activity’, ‘time’ and ‘location’ have to be recorded constantly because of their perishable nature. Interesting information does not only lie in the discrete values but also when looking at certain timespans. Therefore, information about activities and location are recorded as time series. A recording interval of one minute was chosen. This is an acceptable delay, before the system can react to new information but still keeps the amount of data in a manageable dimension for mobile devices. 1440 entities of continuous data measurement points are recorded per day. Each recorded entity contains information about what has happened in the minute before. Location is saved as the averaged measures from a FusedLocationProvider [40] which combines GPS, Wi-Fi triangulation with cell positioning. Activity Types like walking, driving, cycling etc. are detected with an ActivityProvider [40] which uses pattern recognition algorithms to tell activities apart. Calorie expenditure, walked steps and walking distance are calculated on the basis of the users height, weight and gender and the inbuilt step counter [33] in the smartphone.

By using the concept of ‘providers’ to collect context information from sensors, an abstraction layer is created. This allows switching from one sensor to another (e.g. from step counter in the smartphone to a step counter wristband). Furthermore, this makes it possible to extend the sensor framework to other sensor categories by creating new providers. The collected information is stored in a relational database. The framework and data structure is shown in the figure below.
4.2. Data Analysis

The set of context information, as described above, gives no direct insight into the user’s behavior. Meaningful knowledge about the user has to be extracted. We use data mining techniques on the context information to gain insight in two areas: The medical interpretation of the user’s health status and the psychological revealing of situations with behavior change potentials. A rule based inference machine [41] is used to analyze context information.

Medical interpretation analyzes the users health status and evaluates, if the current behavior influences the health positively or negatively. These indicators are called Health Key Performance Indicators (hKPI). While simple hKPIs like body mass index are easy to calculate [42], more complex indicators are needed to give risk assessment and recommendations. An established approach for valuating the personal cardiovascular risk for cardiac infarction and apoplectic stroke is the ‘Arriba’ calculator [43]. General practitioners use the concept in prevention talks. ‘Arriba’ is based on the long term Farningham heart study. Based on gender, age, smoking habits, blood pressure and cholesterol the personal 10 years risk for suffering from cardiac infarction or apoplectic stroke is calculated. The cardiovascular risk is used as used as the individual health score in the system. Furthermore, when having the cardiovascular risk, the preventive effect of physical activity can be quantified. It can be visualized as a percentage in risk reduction.

To generate precise physical activity recommendation, the WHO guidelines for physical activity are used [23]. Based on identity information, the appropriate WHO guidelines on cardiovascular and muscular activity for the specific user group are selected. The combination of these approaches gives an overview about the user’s current health status as well as clear recommendations for behavior change.

Psychological tailoring is needed to communicate the identified need for behavior change to the user. As described in Fogg’s concept, sparks, facilitators and triggers are needed at the right moment to make behavior change happen. To identify situations, in which persuasive services should be applied, expert knowledge of personal fitness coaches was collected. Personal fitness coaches guide their customers through the process of change by supporting them in their everyday life. Sometimes, 24/7 supervision is provided. Typical user stories and daily activity profiles have been evaluated with seven personal fitness coaches in expert interviews in 2013. They have identified situations, where they would influence their human customers towards behavior change. This comprises methods like wake-up calls, rewards for proper training or interruptions to have active breaks during the working hours. In a second step, recorded context data was analyzed to find patterns, which are characteristic to automatically detect the situations identified by the personal fitness coach. Patterns are formalized in rule sets where the premise is derived from patterns in the context information and the conclusion is the type of intervention the fitness coach would start. The figure below shows the two parts of the data analytics system, the medical analysis and the psychological analysis.

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The system is monitoring new context information in real time and evaluates the rule sets for matched pattern. Triggered rules are the indicator which kind of persuasive service should be presented to the user. So, a persuasive service can be seen like a piece of a puzzle that has one or more connectors, but does only fit in certain situations.
4.3. Service presentation

The design of persuasive services is based on the evaluation of successful services in existing mobile applications. In 2012, we conducted a market review and analyzed services in existing applications that have a high impact on the user acceptance [17]. Services with high impact on the user acceptance and clear connection to one of the Fogg service types are used in the system. The figure below shows the user interface of the main application.

The application is divided into three parts. The ‘performance’ view on the left focuses on ex-post analysis of the user’s health status, risk level and the physical activity performance in the past. Splitting the health score up into the subscores ‘cardio’, ‘muscular’, ‘balance’ and ‘stress’ gives the user an overview, which areas of health prevention are affected by his activities. The ‘goals’ view on the right focuses on the target activity level that has been identified as suitable for this user by using the ‘Arriba’ calculation and WHO recommendations. Goals are visualized as green circles, which fill up slowly while the user performs the activity. This is used for monitoring the daily steps, calorie expenditure and gym training sessions. Besides these goals, also negative behavior can be visualized in this way. Unhealthy habits like permanent sitting are visualized as red circles which appear when the user is exceeding the acceptable time of uninterrupted sitting. Red circles can be removed by interrupting the unhealthy behavior. The graphical representation gives a quick overview about the numerous daily goals and their level of achievement without cluttering the interface.

The focus of this paper lies on the middle view, which represents the ad hoc situation. The view is organized as a notification center where persuasive services appear, based on detected context situations. The list of services in the notification center can be seen as a to-do list for the user. Each service is triggered in certain situations and influences the user either as a facilitator, spark or trigger. By building rich notification, we also allow interaction with the service. Feedback can be given by clicking on a persuasive service and therefore accept the challenge or swipe it away if the service is inappropriate in the current situation. This mechanism allows iterative optimization of the underlying rule base and the service design. The following list gives an excerpt of persuasive services that appear in the notification center:

- **Cognitive:**
  - Spark: A summary of the current health score (fear) and the achievable risk reduction (hope) is presented every morning and evening. The service is triggered by the time of the day, the first use of the smartphone and when returning to the POI ‘home’ in the evening.
  - Facilitators: Short-term ‘driving’ activities are detected. The alternatives, when using the bike or walking are calculated in terms of needed time (time) and positive health impact (non-routine, brain cycles). By showing this information, the user evaluates replacing the car with walking or cycling at the next time.
  - Triggers: The user is prompted to measure his or her body weight every morning. While doing this, the step count and calorie expenditure for the previous day is shown. The connection of bodyweight and physical activity is brought to the user’s mind in that moment when he or she is already thinking about the bodyweight.

- **Behavioral:**
  - Sparks: Rewards in form of badges can be archived by reaching the WHO recommendations for daily steps. The user is rewarded with different badges as well when archiving the daily goal for multiple days in a row (pleasure, social acceptance).
  - Facilitators: On days with scheduled gym activities, the user is reminded
to pack the sports equipment in the morning. The gym reminder is triggered again as soon as the user leaves the POI ‘work’. This enables the user to go directly to the gym (brain cycles, time) and avoids the situation of having to get up from the couch at home again (non-routine).

- **Triggers:** During sedentary activities at the POI ‘work’, a persuasive message reminds the user to stand up and have an active break every 60 minutes. This acts as a simple, yet sufficient call to action to interrupt an unhealthy habit.

The figure below shows the ad hoc view where persuasive services appear.

![Figure 6. Ad hoc view](image)

In further iterations, the portfolio of persuasive services will be extended. The underlying sensor framework and data analysis layer build a basis for comprehensive situational support with persuasive services.

### 5. Research contribution & outlook

The paper has presented a concept of a context aware system for physical activity promotion. The proposed concept for sensor frameworks provides a basis for comprehensive and automatically sensing of context information. With new mobile sensors emerging in the field of consumer centric healthcare, a structured integration of context data is possible by creating further data providers in the framework. The assessment of health data and activity with data mining methods follows the idea of learning from health and fitness practitioners with the proposed expert system. Services are proposed with strong theoretical connection and fine-grained so the persuasive impact on the user can be evaluated in detail.

We also see contribution to research in the combination of the TTM as a long term theory with the FBM as short term theory. As stated by Bort-Roig et al.[16], many research projects lack a theoretical framework. Including behavior change theory in design science projects might be easier to handle when using the combination of TTM and FBM.

In future work, evaluation of several elements is needed. The artifacts have to be evaluated, following a design science approach:

- **Precision and reliability:** The precision and reliability of individual sensors, used in the providers, have to be evaluated. The reliability of the detected context information can then be quantified.
- **Rule base:** The precision and quality in the detection of situations for persuasive services has to be evaluated. The interventions events from human persuader (fitness coaches) are the standard to reach.
- **Service-theory-fit:** The individual services have to be evaluated, whether their design is following the theoretical framework. This leads to a precise characterization of each services regarding the TTM and FBM.
- **User acceptance:** To ensure compliance, user acceptance is important. Especially the interactive nature of the system makes it necessary that the user believes in the analytical capabilities of the system.
- **Behavior change impact:** The effect of an intervention with the proposed system on the overall behavior change process must be measured. The individual increase of physical activity and the reaching of WHO recommendation can be used as indicators. We also propose to use the time needed for the progression between the individual stages of change. Furthermore, as proposed in the TTM, the perceived self-efficacy and decisional balance should be used for measuring the behavior change process.

### 10. References


change six health behaviours: a review of reviews.,”


