With-Me – The European Platform to Promote Healthy Lifestyle and Improve Care Through a Personal Persuasive Assistant

WITH-ME (332885)

D2.2 Conscious User Health and Motivation Profiling

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Table of Content

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Abstract	This deliverable describes and proposes methods and solutions for creating and utilizing user models for health coaching purposes. User models are used in WithMe for matching the personal health profile, changes in motivation and changes in activity to coaching and interventions strategies. Model parameters and technical architecture are proposed, use cases are described and a prototype for monitoring of health activity, motivation levels and preferences is presented.
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1. Executive Summary

This deliverable describes and proposes methods and solutions for creating and utilizing user models for health coaching purposes. A **user model** is a virtual representation of the person containing information about his wellness status, health-related behaviours, goals, motivators and preferences. User models are used in WithMe for matching the personal health profile, changes in motivation and changes in activity with appropriate coaching and intervention strategies. By utilizing personal models, the WithMe health coaching system can select those BCTs (Behavior Change Techniques) that work best for a certain person in a certain situation, tailored to the characteristics of the user, thus leading to a higher level of motivation towards behavior change. In addition, the WithMe system can utilize the user model to tailor its interaction style and representation used to communicate with the user, e.g. regarding the recommendation of goals, selecting the right tone of voice and style for feedback and messages, creating communities of similar types of persons, finding opportune moments for delivering the interventions and improving personal self-awareness and self-understanding.

The ultimate purpose of the user model is to represent the user's motivation towards taking care of one's wellbeing, and providing insight on the factors that influence motivation. In WithMe, the term **motivation** refers to the person's willingness to make wellbeing-enhancing lifestyle changes, both in the long-term and short-term. The long-term motivation describes the person's rather stabile intentions towards a behavior change, whereas the short-term motivation involves daily variations in the willingness to act upon the long-term goals. **Motivational factors** determine whether the long-term motivation develops in the first place, and once the intention is formed, they influence the changes taking place in the person's motivation on a day-by-day basis. These factors have been identified in the field of behavioural sciences and described by numerous theories of behavior and behavior change, which we utilize as a basis for the WithMe user model. The WithMe system needs to be aware of these motivational factors in order to be able to tackle the personal issues which discourage the formation of good intentions and decrease the motivation to act accordingly in the everyday life of a person.

The constituents of the user model are founded on the behavioral and motivational theories described in the WithMe deliverable D2-1. The model should include parameters describing at least the following properties of the person: a) Wellbeing status and health-related risk behaviors for identifying the problematic health or wellbeing issues to be addressed with interventions, b) Readiness to change behavior, c) Motivational factors towards behavior change, especially the person's awareness, self-efficacy and intrinsic motivation, for identifying what kind of support the person needs, d) Personality, interests and preferences, for finding appropriate ways to encourage and motivate the person, e) Behavior change goals of the person and the action plan, f) Person's progress in the behavior change process, in order to keep track which interventions worked and which did not.

A technical architecture is presented on how the WithMe system could implement profiling. The **profiling solution** entity is responsible for storing and maintaining the user model. The **guidance engine** is responsible for the recommendation and delivery of the interventions and the monitoring of user progress, based on the knowledge described by the user model. For implementing the user model we propose to utilize a modular ontology-based approach defining constituents of the model and relationships between them. The model should be inherently dynamic, maintaining a link between past, current and the predicted future values of the model parameters.

Use cases and examples of utilizing user models and user profiling are presented based on the WithMe pilots. A prototype for monitoring of health-related activities, motivation levels and preferences is presented. The prototype involves also a profiling questionnaire to be used in the Finnish WithMe pilot, which focuses on reducing work-related stress and improving mental wellbeing. The profiling solution was tested in a small scale trial and it will be improved according to the results.

2. Introduction

2.1. Purpose, context and scope of this deliverable

This deliverable describes and proposes methods and solutions for creating user models for health coaching purposes. These models are used in WithMe for matching the personal health profile, changes in motivation and changes in activity with appropriate coaching and intervention strategies. Personal user models create the possibility for providing coaching programs tailored, automatically or semi-automatically, according to the needs and preferences of the users.

By utilizing personal models, WithMe can select those BCTs (behavior change techniques) that work best for a certain person in a certain situation, tailored to the characteristics of the user, thus leading to a higher level of motivation. Below are some examples of intervention tailoring:

- When the user has a high need for affect, an intervention focusing on emotions rather than on facts is selected.
- Physical exercises are adjusted according to the person's abilities and medical history, e.g. taking into consideration the person's back problems.
- The style of goal-setting is adjusted based on the person's personality: some people are motivated by clear and measurable targets, others by qualitative targets and the freedom of choice.
- The communication style and media are selected according to the personal preferences.

This document first describes the role of the user model in the WithMe system (chapter 2). In chapter 3, the constituents of the user model derived from behavioural theories are presented. The constituents are founded on the results described in the WithMe deliverable D2-1 ("SOTA on human motivation theory and coaching strategies"). State-of-the-art of user modelling, both from the perspective of Internet services in general and, more specifically, in the domain of health and wellness applications and services, is presented in chapter 4.

Chapter 5 proposes a semantic structure for the user model and provides examples of the actual model parameters. Chapter 6 focuses on defining how and for what purposes the user profiling solution is used in the WithMe system. The Finnish pilot case is used as a concrete example for describing how the profiling can be utilized in health coaching services. Also a set of methods for detecting motivation changes, activity levels and opportune moments is presented.

Chapter 7 describes the prototype created. This prototype enables collecting and presenting user model data from individuals. It also enables to follow the motivation changes and health activities during the coaching. Finally, results from the first small scale trial are presented.

Chapter 8 presents a summary, discussion and a condensed list of tips and guidance for implementing a person's health and motivation profiling.

2.2. Motivation profiling in WithMe

In WithMe, the term **motivation** refers to the person's willingness to make wellbeing-enhancing lifestyle changes, both in the long-term and short-term. The long-term motivation describes the person's rather stabile intentions towards a behavior change, whereas the short-term motivation involves daily variations in the willingness to act upon the long-term goals. **Motivational factors** determine whether the long-term motivation develops in the first place, and once the intention is formed, they influence the changes taking place in the person's motivation on a day-by-day basis. These factors have been identified in the field of behavioural sciences and described by numerous theories of behavior and behavior change. Based on these theories, the main constructs that determine the formation of intentions are awareness, self-efficacy, social influences, and attitudes or outcome expectations. At the background, also the personal values, personality, and the context of life influence intentions indirectly. There are also several factors influencing the short-term motivation of a person related to the person's abilities to perform the desired behavior and how much effort the person perceives the behavior to require. If the person is lacking the appropriate skills and tools to modify behavior, the motivation will diminish despite good intentions. For instance, having clear goals and an action plan are important predictors for success. Furthermore, barriers occurring in the everyday life of person (e.g. blue mood, lack of time, bad weather), and bad habits, which are

automatic or unconscious and thus difficult to break, can often be discouraging. However, with a good coping plan the person could be prepared to face the challenges of daily life. In section 3.2. these factors are described in more detail.

Motivation profiling in WithMe is about identifying these motivational factors and including them in the user model in order to be able to tackle the personal issues which discourage the formation of good intentions and decrease the motivation to act accordingly in the everyday life of the person.

2.3. Dynamic user model and user motivation profiling as part of a health coaching system

Health behaviors are any activities undertaken by a person which influence physical and mental health outcomes, including diet, physical activity, smoking, substance use, sleeping patterns, and stress and life management. In health and wellness interventions, the goal typically is to evoke a healthy change in the behavior of an individual.

Although there are lots of statistical similarities between the situations and lifestyle choices of people, we are all eventually individuals with different combinations of health behaviors, risk factors, motives, resources, personality traits and values, which influence our wellbeing in a unique way through complex interrelations. There is strong evidence that to be effective, behavior change support needs to be tailored to the individual's needs and characteristics (Noar et al 2011, Krebs et al. 2010, Kreuter & Wray 2003).

Traditional health promotion interventions have used personalization for a long time, mostly for tailoring information content to different target groups starting from pamphlets and leaflets to personal messages, and for initiating a behavior change plan. Obviously, ICT offers a lot of possibilities for developing more advanced, fine-grained personalized solutions, where the contents and timing of an intervention could be tailored not only to the personal characteristics of an individual, but also to the current situation or context where the person's decision making and activities take place, based on, for example, the constant measurements obtained from unobtrusive sensors. Personalization can be utilized, for example, in adapting the feedback messages from a service to better fit personal preferences, the current situation and characteristics of the user. This type of personalization, based on individual and group profiling, is already happening in many commercial web services such as Amazon (Linden 2003), but at a narrow level only, considering a limited amount of personal factors.

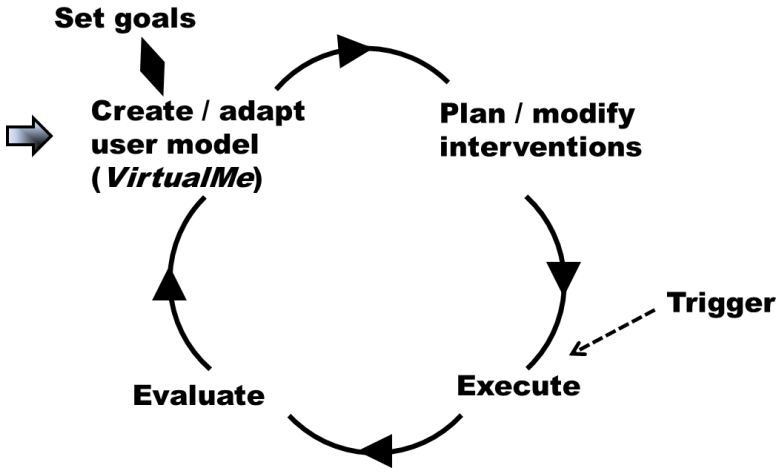
In With-Me, the goal is to take the personalization of health and wellness interventions to a more advanced level. In order to do this, a user model needs to be created and maintained to provide the essential information required for planning, communicating and delivering effective interventions that support, guide and empower the individual to make a lifestyle change. A computational user model of an individual, *VirtualMe*, is envisioned that is a holistic representation of the complex, dynamic nature of behavior and behavior change in the context of everyday life, covering dimensions ranging from health risks and motivation to social influences and environmental contexts, and taking into account the interconnection between mind, body and behavior.

In With-Me, one purpose of the user model is to automate the behavior change support to some extent. Thus, the model needs to be based on a solid set of theories of motivation and behavior change. In addition to the data elements, the user model defines the structure of the elements, relationships between them, and the principles of the dynamic evolvement of the model. The user model should be dynamic in order to be able to respond and update itself according to the feedback acquired during the behavior change process.

During the project, a *profiling solution* will be developed that creates and maintains the user model based on the needs of the With-Me pilots. Profiling refers to learning relevant knowledge about an individual or a population for populating the user model or group profiles utilizing intelligent algorithms that extract knowledge from the available data sources.

Figure 2.1. positions the VirtualMe user model in a health coaching system that personalizes interventions through an iterative process following a *plan – execute – evaluate - adjust* cycle.

Figure 2.1: Steps in health coaching



The whole process of health coaching begins with the user model. The user model should be populated at least with the minimum knowledge of the person that is required for creating the initial coaching plan. This information may be acquired through baseline measurements and/or questionnaires. Ideally, in the beginning, the user model could be populated also with “best guesses” extracted from the group profiles of similar individuals, and refined later as more personal information becomes available. The data content of the user model needs to be dynamic, iteratively built during the coaching process: Observations of the actual behavior, results from tests and surveys, efficacy of the earlier interventions, and characteristics of the surrounding environment - all can change the content of the model. Moreover, new information sources, relevant for the behavior change, can be identified during the coaching process and should be included to the user model.

Based on the user model, high-level and long-term goals are set for the health coaching (e.g. I want to boost my energy by exercising regularly and eating healthily). For example health risks, current habits, personal values, personality traits and life stage play an important role in defining the right goals. Self-monitoring and feedback linked to personal goals are of central importance for behavior change (vanOverloop2013). Thus, feedback on one’s progress towards the personal goals, for example based on biomedical measurements, needs to be linked to the user model.

The user model is used for planning the intervention toolkit and low-level intervention related goals that are suitable for the individual. This involves the selection and modification of interventions as such that they serve the needs of the individual, and the definition of the schedule and trigger rules for the interventions. In a semi-automated coaching system, the model can be used for proposing from a selection of available interventions the best-fit alternatives, from which the coach or the user selects manually the ones to be used. According to the principles of the Self-Determination Theory (STD) (Deci1995), coaching systems should support the autonomy of users: the degree to which individuals feel initiators of their own behavior. Hence, the user should play a key role in selecting and defining the interventions

The selected interventions are executed based on the defined intervention schedule. For some interventions there might be event- or context-based triggers in addition to the time-based ones. The triggers can be related to, for instance, the opportune moments when the likelihood of the person to perform the activity proposed by an intervention is the highest. For example, a reminder to drink a glass of water in the morning could be triggered when the person is preparing breakfast, inferred e.g. based on the detected wake-up time of the person and the usual timing of leaving home to work detected by the smart phone GPS. If this reminder would only use time-based triggering, it would easily create reminders while the person e.g. is still sleeping or has already left home for work. Wrongly timed reminders would have a negative effect on the adherence to the intervention.

During the evaluation phase, adherence to the prescribed interventions and progress towards the set behavior change or health goals are measured. This requires that the health behaviors of the person and their effect on health and wellbeing need to be measured. This can be done in several different ways depending on the interventions: users can mark down their activities, some activities can be sensed, biomedical measurements can be used to provide knowledge on health status, or sometimes tests conducted by health professionals are required. User involvement and commitment to the measurements vary depending on the evaluation method used. Unobtrusive and easy-to-use tools should be preferred. The evaluation results should be saved in the user model. The resulting feedback is used to adapt and update the user model, and to modify the intervention goals and the selection of interventions as needed. The user model collects information on what works and what does not work for the individual. This information can also be used to build group profiles that enable the creation of "patients-like-me" type networks and communities. Similar interventions might work for a group of people with similar characteristics. Thus, linking group profiles with interventions might be useful when selecting initial intervention recommendations for a person, assuming that the person is recognized to belong to a certain group.

In a summary, a health coaching system can use the user model for many purposes:

a) Selecting BCT's and interventions

- Recommending interventions, based on suitable behavior change techniques (BCTs) and tailor these interventions to the specific characteristics of the users, taking into account the individual's social and physical environment, and his way of living (habits). The person can pick and choose interventions from the recommended intervention alternatives.
- Identifying individuals who are in some ways similar and could benefit from same type of interventions, leading to the creation of group profiles. These group profiles could be utilized a) in recommending interventions to an individual, and b) connecting similar individuals together, e.g. through user communities, where users can provide peer support and coaching to each other.

b) Smart reasoning

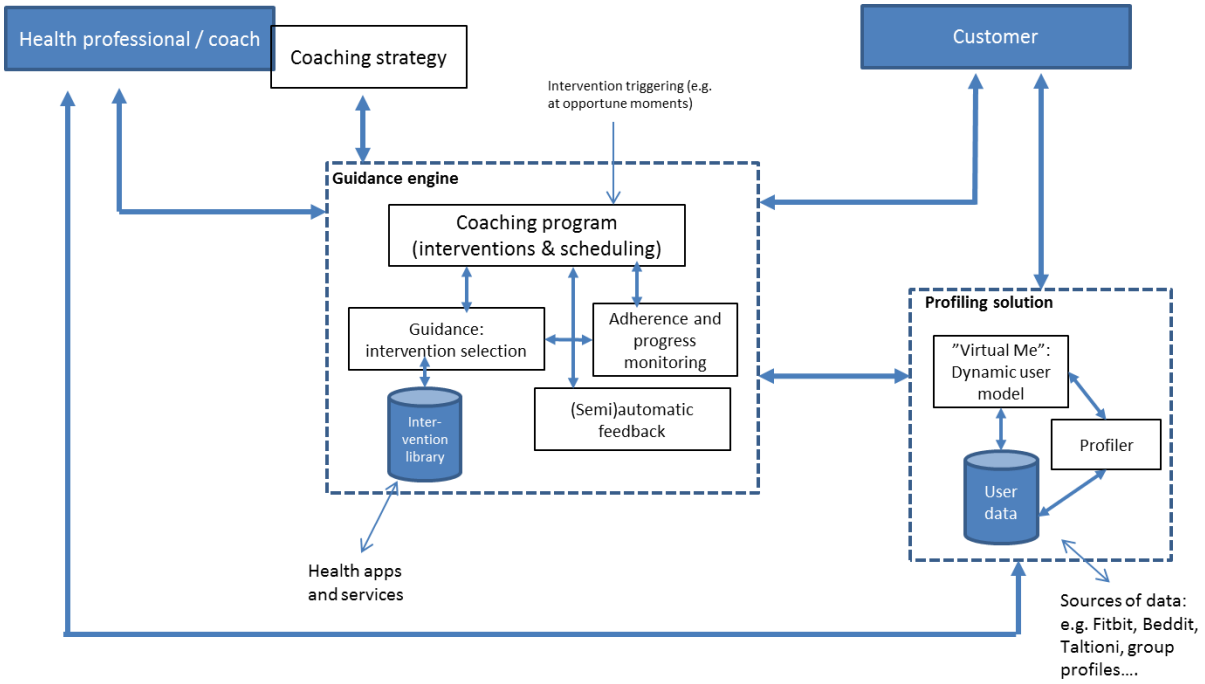
- Finding the most opportune moments for delivering the interventions to the individual based on his or her everyday life patterns and the current situation.
- Motivating the user to engage in the behavior change process by showing what a person's future will look like when he adheres to his work plan (BCT: Providing feedback on outcomes of behavior, Self-regulation theory). Another approach is to confront him with an image of his future if he would continue his bad habits (BCT: Fear appeals, Extended parallel process model (EPPM)). Future should be visualized to the user in a fascinating way involving elements such as appearance, energy, life satisfaction etc., not only the traditional vital signs.

c) Adapting the representation style

- Selecting the right tone of voice and feedback style for the automatically or semi-automatically generated feedback according to personal preferences.
- Improving personal self-awareness and self-understanding by creating compelling user interfaces, that give user the opportunity to browse the contents of his personal profile and explore the associations the system has discovered in the user's personal data. This requires advanced visualizations of various forms. Revealing the discovered knowledge gradually may be used for motivating the user to feed in more data to the user model.

Figure 2.2 depicts the architecture and technical modules of a semi-automated coaching system that recommends health interventions based on a user model that is created and maintained by a profiling solution.

Figure 2.2: Technical architecture and modules of a semi-automated coaching system which recommends interventions based on the user model of an individual



The Profiling solution entity includes a database of user-related personal data (past, current, future), which is connected with the dynamic user model ("VirtualMe"). This module defines the structure of and interrelations in the personal data. The Profiler module analyses data from different data sources and keeps the VirtualMe user model information up-to-date. When group profiles are available, they are also used as a data source for populating the VirtualMe.

The Guidance engine entity includes the recommendation and delivery of interventions, and the monitoring of user progress based on the VirtualMe user model. It also feeds new data to the Profiling solution with information regarding e.g. the selected and completed intervention tasks, adherence to the tasks and progress towards the health goals. The Guidance module has inbuilt intelligence for proposing or selecting suitable intervention goals and the actual interventions for the user from the library of interventions. Interventions can utilize also external services and applications (e.g. using the Fitbit service to help the user to reach the intervention goal of taking 10 000 steps daily). The Guidance module can also tweak interventions to better match the user's needs. Coaching program module gathers the selected interventions together and orchestrates the scheduling of the interventions. Interventions can also be triggered by external events, such as identified opportune moments for coaching. Triggers can be events (e.g. changes in data, completion of a task), context (e.g. place, current activity, social company) or time-based (e.g. time, date, workday, holiday). The Feedback module provides automatic or semi-automatic feedback, e.g. in the form of text or graphics, and the Adherence and progress monitoring module evaluates the user's adherence to the selected interventions and monitors the progress towards the defined intervention and health goals.

Finally, both the health coach and the user have access to the VirtualMe data: they can browse the data and add new information to the database. The Guidance Engine sends the intervention recommendations to the coach and to the user, and they can refine or modify the interventions as need arises. It is also important that the available interventions fit to the Coaching strategy of the health coach.

2.4. Some design principles for the WithMe user model

This chapter describes some design principles the WithMe user model development should follow. For practical implementations, however, we most probably need to focus on a subset of these principles.

The user model has to be **based on theories** of behavior change, motivation and learning, which define the core structure of the model, especially the central elements to be included. Since we are all unique regarding our life situations, needs and aspirations, the model should be **flexible and adjustable to different needs**. The architecture should be **highly modular** so that different sets of parameters and their internal dependencies can be plugged into the model as separate modules. The user model may, for example, have a special module regarding the variables related to "sleep coaching for sleep apnea". This ensures that the model can be flexibly used for different types of needs and behavior change goals, and that the development of the model can be done iteratively, testing out different parameters to find the most suitable ones. In addition, the **temporal character of different parameters can vary largely**. The parameters can range from fairly constant ones that are updated rarely or may not be updated at all, such as personality traits, values, or life stages, to highly dynamic parameters that might change even every minute, such as the heart rate measurements or step counts. The structure of the user model should include the time dimension for each parameter: the past, current and the possibly predicted future values.

The **core of the user model should be generic and simple**, pushing the extra complexity to the pluggable modules of the model. In the With-Me project, the user modelling structure and the profiling solution should serve especially the needs of the pilots. The pilots drive the parameter choices for the user model, and pilot-specific user models might be needed. However, at the same time it should be ensured that the general architecture of the user model is solid and expandable to serve also other needs.

The user model needs to be inherently **dynamic**. It can be initialized with a rough generalization of the user, but it should continue to **refine itself** as more data becomes available. The model should be able to learn from the user's usage patterns regarding the health coaching system and observe the actual behavior of the user, and adapt the model accordingly. Adaptation can be related to updating parameter values, adding new parameters and modules to the model structure, and modifying the established relationships between parameters and adding new ones during the coaching process.

It is essential that the **relationships between the parameters are modelled when feasible**. These can be temporal, hierarchical, interdependence or association relationships. Although the structure of the user model is modular, it is evident that these relationships need to cross borders between the modules. How to enable this in practice is one of the many design challenges of the user model.

Various sources of data are potentially available for the user model. We can use physiological signals, automatic tracking of behavior, statistical data from the behavior of others, user query answers, medical examination results, and so on. While many data sources may provide possibilities for automated inference on parameter values, not everything can be reliably measured or observed. Especially, there are still many challenges to overcome before it can be correctly deduced what happens in a person's mind, for instance, regarding the level of motivation, feelings or perceived barriers. Thus, information asked directly from the user is still very valuable. We should eventually find ways how to **make providing personal information rewarding and even fun** for the user. Task T-2 in WithMe "Engaging Serious Game Design" will further tackle this question. A user model that a) enables the user to "play" with and discover new associations within his or her personal data via fascinating visualizations, b) demonstrates the observed behavioral patterns of the user, and c) allows the user to reflect these findings upon his or her aspirations and goals could be part of the solution. Another idea is to reveal the discovered knowledge to the user gradually as the user provides more information about himself. These proposed methods also support the user in forming a deeper level of self-understanding, which is one of the key purposes of the user model and rewarding itself. Thus, the user model and the profiling solution are already valuable as such in promoting the change towards healthier behaviors. Moreover, as the coaching and the learning process of self-development proceeds, the corresponding past evolution and the predicted future trajectory of the user model could be visually presented to the user. The user could also use the model for predicting different future scenarios: "If I would behave like this, the virtual version of me (VirtualMe) would look like that". Thus, the user model architecture should provide the **possibility to integrate different ways for visualizing personal data and the evolution of the user model**.

User model should also provide support for creating **reminders** for the user, triggered by the context and user preferences for the way of reminding.

The user model will be **used by different types of stakeholders**, which requires that different views to the model, specific to the information needs of the stakeholders, are developed. For example, the parameters of interest likely vary for different stakeholders. Coaches and medical personnel might need to make private notes about the customer, family and friends might have visibility only to a subset of the person's parameters and local shops would have access only to couple of parameters relevant for them, such as special diets or eating habits.

Easy comparisons and matching to the user models of other people should be supported by the modelling structure, so that "patient-like-me" type solutions could be built, where personal data of different users are compared to each other, and people having similar life situations, needs and interests can be matched together resulting to the so called group profiles. The group profiles can be used for building community support and finding and recommending interventions that work for "people-like-me".

An example: Ann is participating in a coaching program targeting for improving her sleep. She finds a certain type of relaxation method that really works for her. The same method might potentially work for other people, too, whose personal data is similar to Ann's. Furthermore, the health coaching system can measure the effectiveness of the method, and if it turns out to be effective for people having similar data content in their user models with Ann's, the recommendation of the relaxation method to similar users will strengthen. This enables the creation of an autopilot system, where effective interventions are recommended more frequently, targeting more users, and the ones that do not work die out. Obviously, since we are all unique, two data sets from two different persons, exactly similar to each other cannot exist. The challenge is to define the level of similarity that is high enough for grouping people together. Likely, the users will be part of several different groups, each focusing on different areas such as diet, exercise, interests, social activity etc.

The user model needs to protect the **privacy** of the user. The user should be made fully aware of what data is shared to whom. Ideally, the user owns the data and controls what parts of the data can be shared with whom.

Validate data for guaranteeing the safety of the users. Periodical data validation should be utilized to ensure that the data is correct and meaningful. Source and origin of the data should be recorded to the database. Invalid data could have important negative impact on the intervention and behaviour and thus harm health.

3. Behavioral Theoretical Foundation of the User Model and Profiling

3.1. Behavior change theories in WithMe

Changing behavior is a process that takes time and practice. It is thus crucial that people are motivated and stay motivated. The WithMe system should utilize motivational coaching strategies, based on well-founded theories of human behavior change (Van Overloop et a. 2013). Evidence from reviews and meta-analyses indicate that theory-based interventions and extensive use of theories produce better results across various health behaviors than interventions without theoretical foundations (Kok1997; Noar2007; Peters2009; Webb2010).

Since the main purpose of a user model in a health behavior change system, as we see it, is to enable and support the selection of suitable behavior change techniques and the creation of interventions that are successful in assisting, guiding and motivating an individual to change his or her behavior, the model should contain knowledge of the person-specific factors that govern behavior, behavior change and motivation to change behavior.

Many theories exist on motivation and behavior change. WithMe project deliverable DT2-1 "SOTA on human motivation theory and coaching strategies" (VanOverloop2013) identifies a set of behavior change techniques to be utilized in the WithMe. Key theories selected included:

- Self-determination theory
- Theory of planned behavior
- Dual processes theory
- Social cognitive theory
- Self-regulation theory
- Theories on emotion

DT2-1 summarizes the theories: "*Self-regulation theory provides insight into how people regulate their behavior to reach a goal. Self-determination theory handles the basic psychological needs that all people strive for. Dual process theory states that there is a fast way of thinking that is automatic and a slow way of thinking that requires more effort. Since most of the time we use the fast way of thinking, we should anticipate this. Theory of planned behavior handles the slow way of thinking, and stresses the importance of the social norm: the behavior that is normal in a certain situation. The use of emotions is important because people's behavior is also motivated by emotions experienced in performing the behaviors and the anticipated emotions when reaching their goal. Lastly, social cognitive theory stresses the importance of self-efficacy and outcome expectations*."

In addition to these theories, especially the Finnish pilot also aims to utilize methods from the Acceptance and Commitment Therapy (ACT). ACT is a relatively new branch of cognitive behavioral therapy (Hayes2006), which has a primary goal of creating psychological flexibility through acceptance and mindfulness skills, commitment and behavior change skills, and crystallized personal values. Psychological flexibility is a skill that anyone can benefit from, and ideas from ACT can be applied to support general wellbeing

WithMe DT2-1 also linked the selected theories to corresponding behavior change techniques BCTs. Results of this work can be found from Table 3.1.

Theory	BCT	Determinants
Self-Determination Theory	Self-Monitoring	Competence
	Making own choices / motivational interviewing	Autonomy
	Providing an interpersonal environment and social support	Relatedness
Theory of planned behavior	Creating a different norm	Subjective norm

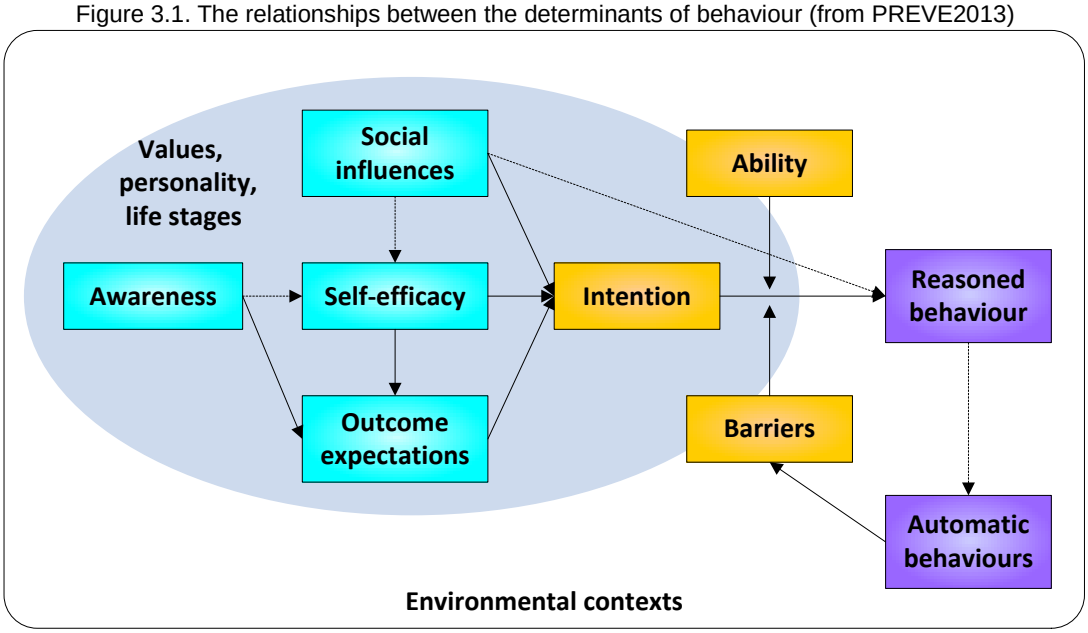
Dual processes	Approach-avoidance training	Automatic approach, Avoidance tendencies, Attitude, Automatic affective reactions
Social Cognitive Learning theory	Modelling	Subjective norms, Skills, Outcome expectancies
Self-regulation theory	Providing feedback on outcomes of behaviour	Self-regulatory strength, Goal persistence, Disengagement, Goal change, Self-efficacy
	Implementation Intentions	Accessibility, Environment, Habits
Theories on emotion	Narrative persuasion	Affective attitude, Emotion, Behavioural intention, Perceived risk, Perceived severity, Perceived vulnerability, Behavioural beliefs

Table 3.1: Overview of the selected theories and BCTs (VanOverloop2013)

3.2. Identification of factors for the user model influencing behaviour

To create the structure and parameters for the user model, we wanted to utilize a summarizing model for the key determinants of behavior. We decided to base our work on the results of the EU project PREVE (PREVE2013). Model (Fig. 3.1) (Honka2011) defines seven key determinants of reasoned behavior and behavior change. In addition to these seven key determinants, important elements defined in the theories of automatic behaviors, life stages, values and motivation were included in the hybrid model (Fig. 3.1.). We refer to these determinants also as the motivational factors to behavior change.

Figure 3.1. The relationships between the determinants of behaviour (from PREVE2013)



3.2.1. Reasoned behavior

Based on the dual-processes theory, the model makes a distinction between the **reasoned and automatic behavior**. Reasoned behavior refers to actions which are carried out with conscious thought and decision, and result from deliberate intention. **Automatic behaviors** are actions that are performed with little or no conscious thought, through fast and convenient peripheral decision-making channels

A person who has formed a strong intention to perform a behavior, has necessary skills and abilities to do so, and is free from constraints, is very likely to succeed with the behavior change process. Hence, the three main behavioral determinants for reasoned behavior (indicated in yellow in Fig. 3.1.) are as follows (Fishbein2001; Institute of Medicine, 2002):

- *Intention* to perform the behavior,
- *Ability* to perform the behaviour, and
- Absence of *barriers* or constraints which inhibit or discourage the behaviour.

Other four determinants (Indicated in blue: *awareness, social influences, self-efficacy*, and *outcome expectations*) influence mainly intention, either directly or indirectly. Furthermore, the interplay between environmental contexts and the person is a mediator to all behavioral decisions. Personality, personal values and life stages also mediate the effect of the determinants of behavior – what we hold important, what we pay attention to, and the way we see and interpret things.

Intention Nonhabitual and reasoned behaviors are guided by intention (Wood2005). In this context, intention refers to sufficient motivation and commitment to perform the behavior. It comprises the different motivational and commitment stages which indicate the readiness to change (from no intention to weak and strong intention).

Abilities and barriers can be roughly considered as opposites to each other. Ability refers to sufficient skills and resources to perform the behavior. Barriers stand for lack of skills or resources, or they can be actual constraints in the way of performing the behavior. Abilities have encouraging or enabling influence on behavior, whereas barriers inhibit or discourage the behavior. For example, despite of good long-term intentions, when facing barriers such as tempting situations, relapses are likely to occur if the self-control of a person is insufficient. This sudden change of mind is referred to as *preference reversal* (Bickel2000)*.*

Abilities and barriers can exist at many levels, ranging from public policies, laws and regulations, to communities, schools and workplaces, home, family and friends, personal traits and internal resources. Barriers regarding the internal resources of a person can be related to

- a lack of cognitive skills and psychological abilities (e.g. self-control to resist temptation, coping skills, self-efficacy, or self-confidence),
- limitations in physical capabilities or features (e.g. genetic predispositions, impairments, coordination),
- and unhealthy personal habits and routines (e.g. always eating chips while watching news).

External barriers could be related to

- social pressure or norms and culture (e.g. “all my friends smoke”),
- lack of time,
- limited money or material resources,
- and availability of and accessibility to the required environmental facilities, products and services (e.g. “I cannot jog here, because I do not feel safe”).

Awareness is a necessary but not sufficient prerequisite to behavior change. It implies *knowledge* and *comprehension* of benefits and risks of healthy and unhealthy behaviors. One part of awareness is the perceived threat, i.e. the perception of the personal susceptibility and the severity of the risks related to unhealthy behavior. The other central component is the perception of possible benefits related to healthy lifestyle. In addition to long-term health benefits, there can be other beneficial outcomes such as fitness, good appearance, or energetic feeling. Awareness of benefits can be sufficient to produce positive outcome expectations and thus positive attitudes towards the behavior. Thus, a person does not necessarily have to consider her or himself at risk to be motivated to change behavior.

Outcome expectations are the perceived likely consequences of behavior. Awareness of the behavioral consequences directly influences the expectations a person has on the outcomes. Important part of the concept is the *outcome expectancy* – the value a person places on the perceived consequences. This is largely influenced by personality, personal values, interests, and attitudes. Outcome expectations increase the motivation and intention to perform the behavior only, if the perceived benefits outweigh the perceived costs. The benefits and costs can be related e.g. to time, effort, or required lifestyle changes, and they can be psychological, material or financial.

Self-efficacy refers to the perceived capability of a person to accomplish a certain level of performance. In other words, it is the perceived control that a person has over his or her behavior, and the confidence in the ability to take action and sustain the action. Self-efficacy has a large influence on the outcome expectations and the actual intention, and it is related to self-image and self-esteem. A person with high self-efficacy tends to attribute successes to one's own capabilities and failures to external reasons, whereas a person with low self-esteem tends to think he or she is to blame for failures and successes are merely coincidences.

Improvement of self-efficacy usually involves training actual abilities, although increased awareness and knowledge can also have a positive impact. An example of a BCT that can be utilized is modelling, in which an expert shows the person how to correctly perform a behavior. A role model (coach –real or avatar-, peer) that has certain characteristics in common with the user, provides him information. This will convince the coachee that he is also able to change his behavior in a similar way. Therefore his self-efficacy will grow (Bandura1986). Some boundary conditions for successful application of modelling should be noted: the model should be representative for the user and the model must be (intrinsically) rewarding.

Social influences are perceived social norms, support and pressure. Since people usually have a strong need to adhere to social norms due to their desire to be approved by the group, they often behave as other people do, even if they are aware of the erroneousness of their behavior or do not approve it (Thaler & Sunstein, 2008). Discouraging social influences can thus prevent the formation of intention altogether, and encouragement and support can be powerful motivators to behavior change. Besides affecting behavior indirectly through intention, social influences can sometimes modify behavior directly in certain situations, where the person feels strong social pressure. Behaviors can also be learned by observing others. This influence is stronger if the observed person is someone who the observer admires or holds as a role model. Social learning can happen also by actual conveying of information from one person to another.

Values, motives and personality People have different motives for acting as they do, and are motivated by different ways. Personal values, motives, attitudes and personality traits have an influence on outcome expectations, the strengths and types of social influences, and the information sources the person chooses to pay attention to.

Values serve as guiding principles in people's lives. They are often defined as enduring beliefs or ideals shared by the members of a cultural group about what is good or desirable and what is not. Personal values evolve from circumstances with the external world and their strength can change over time. *Motives* are the abstract or concrete things that a person pursues, which emerge from the personal values and fulfil one's needs. However, they do not have to be conscious – a person can act in a certain way without being aware of the underlying motive, and many times this is the case. *Personality* can be summarized as a set of characteristics that persists over time. This set is a distinctive pattern of feelings and thoughts, attitudes and habits. Personal values and motives can be considered to form a large part of personality.

3.2.2. Automatic behaviors

As mentioned above, **automatic behaviors** are actions that are performed with little or no conscious thought. They exhibit some or all of the following features: *efficiency*, lack of *awareness*, lack of conscious *intention*, and lack of *control* (Verplanken2006). Two main categories of such behaviors can be identified: *habits* and *systematic biases*.

Habits (automatic behaviors in Fig. 3.1.) are behavioral dispositions to repeat well-practiced actions in certain, recurring circumstances (Wood2005). They are acquired by incremental strengthening of the association between a situation (cue) and an action. When behavior is new, untried, and unlearned, it is solely determined by intention. Repetition in a consistent context increases the automaticity of behavior.

Habits can be triggered by:

- Prior responses in a chain of responses (past behavior);
- Environmental cues, such as time of day or location. This means that the physical and social properties of one's environment, have a strong influence on behaviour (Thaler 2008);
- Internal states, such as particular moods;
- The presence of typical interaction partners.

Significant life changes in the physical and social environments of a person, the so called trigger events such as relocation, changing jobs, or starting a family, can disrupt habits and challenge habitual mind-sets, bringing behaviors under intentional control (Verplanken2006; Wood2005). These changes can be opportune moments for replacing the unhealthy habits with new, healthier ones.

The automaticity of habitual behaviors can be either an ability or a barrier to healthy lifestyle, depending on the circumstances and the behaviors in question. For example, choosing healthier food options during the daily shopping can become a habit over time, making it more effortless and fast to make healthy choices. However, getting rid of unhealthy habits is difficult since associations between environmental cues and unhealthy choices can strongly guide the unconscious decision-making process. As an example, sizes of the plates and sizes of food packages have been found to create an unconscious norm for "the normal portion size", and thus use of large plates leads to larger portion sizes and eating more (Wansink2006).

The time and the amount of repetitions required for habit formation appears to vary between individuals and depend on the complexity of the behavior. Creating new habits requires self-control and time. It is debatable whether complex behaviors, such as exercising, can ever become automatic or be considered as a habit (Lally2009).

Different types of systematic biases are discussed largely in the field of behavioral economics (Bickel 2000; Jolls2007; Thaler2008; Ariely2008) such as *discounting the value of delayed consequences*, assessing the likelihood of risks based on subjective experiences (*availability heuristic*), believing that the probability of the negative consequences of a certain behavior is unrealistically low (*optimism bias*), avoiding losses over acquiring gains (*loss aversion*), and settling for default options (*status quo bias*).

Some examples of systematic biases: *Discounting the value of delayed consequences*: instant gratification often wins over abstract long-term effects: e.g. enjoyment of eating unhealthy foods while watching TV vs. long-term health effects. *Availability heuristics*: "*I don't need to use a condom since I never got any diseases*." *Optimism bias*: "*I can well continue smoking since my grandfather smoked his whole life and he lived a long life*.". Knowing these types of biases can help in intervention planning.

3.2.3. Environmental contexts

The surrounding physical and social environments of a person provide the context for his or her behavioral decisions and habitual behaviors. The choices of the individual are influenced by the available products, services and facilities in the physical environment, and by social norms and messages, and the laws and public regulations that either facilitate or impede healthy behaviors. Furthermore, neighborhood socioeconomic characteristics have been shown to influence health (Pickett2001). The available environmental choices in the neighborhood are especially important for older adults' health and functioning (Yen2009).

The ways the available choices are displayed and organized, the so called *choice architecture* of the decision context, influences the choices of a person. There is no such thing as "neutral design"

(Thaler2008). For example, the defaults set in the environment matter: whether the healthy food items are placed easily at hand at the expense of unhealthy products in grocery stores, or whether the first thing in sight of a person is the stairs instead of the elevator when entering a building. Furthermore, with a certain framing of an option, its selection can be either encouraged or discouraged. The choice architecture and defaults present in the environment also guide the formation of habits.

3.2.4. Life stages

Life stages as a general concept implies that human life can be divided into distinct stages different from each other. People in different stages are likely to have differing characteristics, abilities, environmental contexts, and sources of motivation. It is essential to consider the effect of time and development in the life of a person to recognize possible trigger events for health and wellbeing interventions, and to understand the changes that occur in internal and external influences of behavior across the lifespan.

Changes across the lifespan are often classified into three broad domains, which are connected to each other (Boyd & Bee, 2006): physical, cognitive, and social domains.

- *Physical changes* include alterations in characteristics of the body, and in how individuals sense and perceive the physical world.
- *Cognitive changes* comprise of alterations in thinking, memory, problem-solving, and other intellectual skills.
- *Social changes* are associated with the relationship of an individual to others, such as social skills, personality, and beliefs about self.

Life stages include also age-related changes. These can be further classified into three categories with basic biological and environmental determinants, and interaction between them (Baltes et al., 1980).

- *Normative age-graded (universal) changes* are common to every individual, and fairly strongly linked to chronological age. Many of these are defined in the genetic code, but some changes stem from shared experiences or environmental influences. In each culture, the social clock (a set of age norms) defines a sequence of normal life experiences (e.g. education, work, marriage, children, and retirement). The influence of age-graded changes is the strongest in childhood. Events are normative if they occur to most members of a given cohort in similar ways (e.g. wars, major epidemics).
- *Normative history-graded (group-specific or evolutionary) changes* are shared by all the individuals who grow up together in a particular group. Culture is one of the most important factors grouping people, shaping the development of individuals and views of normal development. The influences of these changes are the highest in adolescence and early adulthood.
- *Non-normative (individual) changes* result from unique, unshared events, such as career changes or accidents, or from individual differences such as genetic differences and characteristics influenced by both heredity and environment (e.g. intelligence and personality). The strength of individual events increases as a person ages.

3.2.5. Effective communication

In addition of being aware of the determinants of behavior, effective communication is a vital part of a successful intervention strategy. Being aware of the need to change one's behavior to a healthier direction and of the benefits of healthy lifestyle is a precondition for behavior change, although not sufficient alone. Moreover, the role of adequate feedback during the behavior change process cannot be underestimated. Thus, the user model should include relevant information which can be used to design adequate messages to the person. Again, based on the PREVE literature review, particularly on communication theories, the determinants of effective communication have been identified.

Effective communication is persuasive and encourages thoughtful information-processing (Petty et al., 2002). The aim is to create messages which increase awareness and comprehension to inspire attitude and behavior change. The main determinants which influence the effectiveness of communication are *source*, *content* and *channel.*

Source The message should come from a *likable* source that is perceived as *credible*, and *powerful* (Petty1998). Credibility involves trustworthiness, honesty and expertise. The characteristics of the source have an impact on whether the message is perceived as meaningful and/or relevant, and on whether the recipient pays conscious attention to it.

Channel The message should be disseminated through appropriate channels that reach the individual. Possible channels include e.g. schools, workplaces, interpersonal relations (family and friends), and media (newspapers, TV, internet). Media is effective in increasing initial awareness, but the diffusion or adoption of ideas happen through interpersonal communication as people share their interests and experiences.

Content The message must achieve some level of *personal relevance* to encourage elaboration. The quality of arguments in a message, some of which are related to fostering the personal relevance, is determined by the following characteristics (Petty1998):

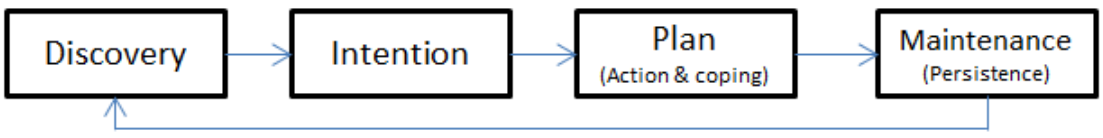
- *Expectancy value:* outcomes that are likely and desirable are preferred over unlikely and undesirable outcomes.
- *Causal explanations*: cause-consequence explanation convinces the recipient of the likelihood of the outcome.
- *Functionality:* arguments are more convincing if they match the recipient's worldview.
- *Importance:* the more relevant the outcome to the recipient, the more effective the message.
- *Novelty:* an unfamiliar or unique argument is more effective than a familiar one.

Messages can have two kinds of *appeals*: rational or emotional (Siegel2007). The suitability of an appeals style depends on the person in question, and on the information content of the message. Also, by *framing* the message appropriately, the person's attitudes and behavior can be influenced in a favourable way, since the choices that people make depend partly on the way problems are stated (Slater2006; Thaler2008).

3.2.6. Stages of behavior change

In addition of modelling the determinants of behavior, we built a model to describe the stages of the change. Behavior change is not a linear process; it is more like a continuum of different phases involving cyclical movement between the different levels of intention, including relapses and recoveries. Mainly based on the Transtheoretical Model (TTM) (Prochaska1997) and the Health Action Process Approach (HAPA) (Schwarzer1996), a simplified model of the phases of behavior change is presented in Figure 3.2.

Figure 3.2. Model of the phases of behavior change.



In the **Discovery** phase, the person first time becomes aware of the need to change behavior. This might stem e.g. from a perceived risk of developing a health condition ("*The doctor told me my blood pressure is seriously high and my risk for heart attack has increased, but that I can lower my blood pressure by changing my habits*."), from being unsatisfied with one's lifestyle in general, or from

learning about the benefits of healthy life. In this phase, the awareness determinant of behavior has a key role.

A person in the **Intention** phase has made the decision to change behavior, but does not have the tools to translate the intention into actions. The key questions answered in this phase are: *Do I really want to do this and why? What is my real high-level goal? Am I able to do this?* This phase is comparable to the Intention determinant in the figure 3.1. and addresses also the self-efficacy or the person. It is extremely difficult, if not impossible, to make people truly change their behavior via outside forces ("*My wife wants me to be more relaxed*.") or external rewarding (e.g. monetary rewards). The motivation towards the change has to come from inside the person. According to Deci (1995), the reasons why people decide to participate in a health program are in fact key predictors of success. If the reasons are superficial *("I want to lose 5 kg*.") or stem from external influences, the forecast for success is poor. Success follows when people get genuinely interested in changing their behaviors and understand their real motives driving the change. This leads to intrinsic motivation and to the feeling of autonomy, where volition guides one's choices and actions. Thus, the reasons and motives behind the behavior change attempt of a person need to be included in the user model.

Key methods in this phase aim to improve individuals' self-understanding on what kind of person one is and what are the drives behind one's behavior and choices, and to improve the self-efficacy regarding the change. Self-tracking tools and measurements that reveal the current status of a person and allow comparison to other people can be helpful in creating awareness about one's current situation and in establishing a baseline for the change (Consolvo2009; Li2011). It is important to concretize the pursued benefits of the behavior change and to visualize routes and steps leading to the benefits. To keep up the intrinsic motivation, choices should be offered and the person should be positioned as the final decision maker committing to the change. For many, principles of Acceptance and Commitment Therapy (ACT) (Hayes2006) can help in this phase, because it provides tools for linking personal values and goals together, which supports the development of intrinsic motivation.

In the **Plan** phase the key question is *How can I do this?* The determinants of behavior, intention and abilities, are considered in this phase. The central issue is to translate the motivation into clear, concrete and measurable goals including a time element ("*My goal is to fit with ease into my new jeans before the eastern holidays*."), and actionable steps leading to the goals. Goals can be set at different levels, ranging from abstract to more specific. The four levels defined by Powers et al. (1973) are *system concept, principle, program*, and *sequence* goals. System-concept is the most abstract and refers to the ideal self or society ("*I aim to do good for the mankind*"). Principle level refers to the set of more concrete goals which one tries to pursue to meet the ideal ("*Be productive*"). Program-level goals describe concrete activities to fulfil the principle-level goal ("*Reduce time using Facebook daily to 30 min*."), and sequence-level goals describe the detailed sequence of activities for reaching the program-level goals. In the plan phase, the goals should be defined on the program and sequence levels.

Self-efficacy and concrete planning are among the best predictors of healthy behaviors (Schwarzer, 2007). Appropriate action plans involve clear steps regarding what to do and when, and they cover also strategies for relapse prevention and coping strategies for recovering from a relapse (Sniehotta2005). Small relapses are very natural. Good coaches can turn these small relapses into moments of learning, and relapses can then in fact make people stronger later on.

The Action phase covers the initiation, maintenance and relapse recovery of behavior. The person first initializes the new behavior by trying it several times, and gradually he or she is able to maintain the behavior as it evolves into a habit as a result of repetition. However, relapses are probable, especially for complex behaviors that might not ever evolve to habits. The action phase covers the barriers, and the reasoned and automatic behavior elements of the hybrid model of the determinants of behavior change.

During the initiation and relapse recovery, it is important to apply self-monitoring, feedback and self-regulation processes such as those specified in the Control Theory (Carver1982). A systematic review (Ashford, 2010) showed that best intervention results have been gained when specific feedback on the past performance of the individuals and their peers, as well as vicarious experiences (e.g. seeing others successfully carrying out the behavior) was provided. The review covered physical activity interventions only. In a meta-analysis of 122 interventions targeting healthy eating and physical

activity, it was found that self-monitoring had the greatest impact compared to any one single technique (Michie2009).

4. State-of-the-art in User Modelling

This chapter provides a brief overview on how users are modelled in web applications outside the health and wellbeing area, such as in the educational and information retrieval systems, and recommendation systems for consumer products (section 4.1.). User modelling has been widely studied and utilized in these web-systems, and this experience should be utilized also in the development of personalized, health behavior change support systems. In section 4.2., we move to the health and wellbeing domain, and explore what kind of user information is collected in the web and smartphone applications of this domain. In section 4.3., the opportune moments for interrupting a person is discussed based on the literature of general context-aware systems, tackling particularly the issue of defining an opportune moment and exploring what kind of attempts there has been to detect these moments.

4.1. User modelling in the Internet

Personalization of Internet services is typically founded on user modelling. User modelling aims to construct models that in addition to containing and structuring user data, capture also the beliefs, intentions, goals and needs of a user. In user models supporting context-awareness, also the situation of the user and it's use is user modelling also needs to be assessed.

User modelling is extensively studied in the context of *user-adaptive web systems*. These are web applications attempting to tailor their appearance and behavior to the needs and preferences of each individual user or user group (Brusilovsky2007). User-adaptive web systems are used in several domains, for instance, in marketing and e-commerce, social networks, entertainment, and health (Honka2011).

In user-adaptive web systems, users are represented with a *feature-based* or *stereotype-based* modelling approach, or with a combination of these two. Systems utilizing feature-based user models maintain a separate model for each user, whereas stereotype-based modelling clusters users into homogenous groups based on feature values. If the feature values change for a certain user in the latter approach, the user will be re-assigned to another group. Combining these two modelling approaches facilitates the most personalized adaptation. (Brusilovsky2007b)

The most common and useful user features, or feature domains, represented in the user models of web applications are user knowledge, interests, goals or tasks, background information (e.g., profession, work experience, and job responsibilities), and individual traits (e.g., personality traits, cognitive styles, cognitive abilities, and learning styles) (Brusilovsky2007b).

Overlays of feature domains, the *overlay models*, are widely used in user modelling. In this structure, feature domains are broken down to smaller concepts, e.g., to knowledge fragments, objects of interest, or goal items. Each concept of a feature domain is associated with a value that represents the extent to which that concept applies to the user (Brusilovsky&Millán2007, Gauch2007). Overlay models are relatively easy to develop, and they can represent user features at an accuracy level sufficient to enable advanced adaptation (Brusilovsky2007b).

The simplest form of an overlay model, a vector model, maintains a set of concepts without considering their connections to each other. Although this model is able to maintain a detailed picture of a certain user feature, its construction requires observations about each of the concepts due to their independency. A more advanced form of the overlay model represents also relationships between the concepts, thus making inter-concept inference possible. Two main types of connected models are used: a tree-like concept hierarchy and a network of concepts, the latter being most common. The connective links can be prerequisite relationships or semantic relationships, such as "is-a" and "part-of" relations. The links enable the inference of concept values based on the observations regarding the connected concepts. For instance, if users are observed to master certain knowledge topics, it is likely that they master also the prerequisite topics. Domain ontologies or topic maps can be also used as a basis for the network-based overlay modelling, being a more sophisticated form of modelling than the concept-based network model. (Brusilovsky2007b, Gauch2007)

There are different options for representing the extent to which a certain concept applies to the person. The simplest and oldest way is to associate a binary value (yes – no) with the concepts. These are called *pure overlay models*. An extension of this approach is to associate a weight for each concept resulting to a *weighted overlay model*, where a qualitative, simple numeric or uncertainty-based value is stored with the concepts (Brusilovsky2007b, Gauch2007). In uncertainty-based models the values refer to the probabilities that a certain concept represents the user. A more advanced form of the weighted overlay model is a *layered overlay model*, where each concept is associated with several values that estimate the concept's representation power (Brusilovsky2007b). In this approach the estimates obtained from different sources (e.g. direct observation vs. inference) are separated from each other. Systems that exploit these types of models maintain different layers separately and combine them only in the process of adaptation decision-making.

The uncertainty-based models are especially important in user modelling, since there is often the need to deal with uncertain information. Most commonly, uncertainty is managed with a Bayesian network (Brusilovsky2007b). Fuzzy logic and neuro-fuzzy techniques are also used, but not as widely (Kavcic2004). An attractive potential use of Bayesian networks and neuro-fuzzy systems is to employ learning algorithms to shape the structure of user models (e.g. the connections between the concepts) automatically.

4.2. User modelling and motivation profiling in the health and wellness area

This chapter gives examples on how user modelling and motivation profiling have been used in the health and wellness area. In web-based health systems the most common user features are the current health behaviors, e.g. exercise and eating habits, and readiness to change behavior (Lustria2009). Other variables typically used include clinical risk factors, information needs, and demographics (Davis 2008, Cawsey 2007). Physical activity-based profiles have also been utilized (e.g. Greenlaw2010). Greenlaw's proposed profiling included user's personal motivators, favored activities, available time slots for exercising, and vital signs to classify fitness level. Achterkamp et al. (Achterkamp2013) utilized self-efficacy, state of change and the baseline activity level of the person when tailoring the feedback messages in their automated coaching system. Based on these parameters, users were classified into one of the eight categories, which all had a separate tailored feedback and coaching strategy.

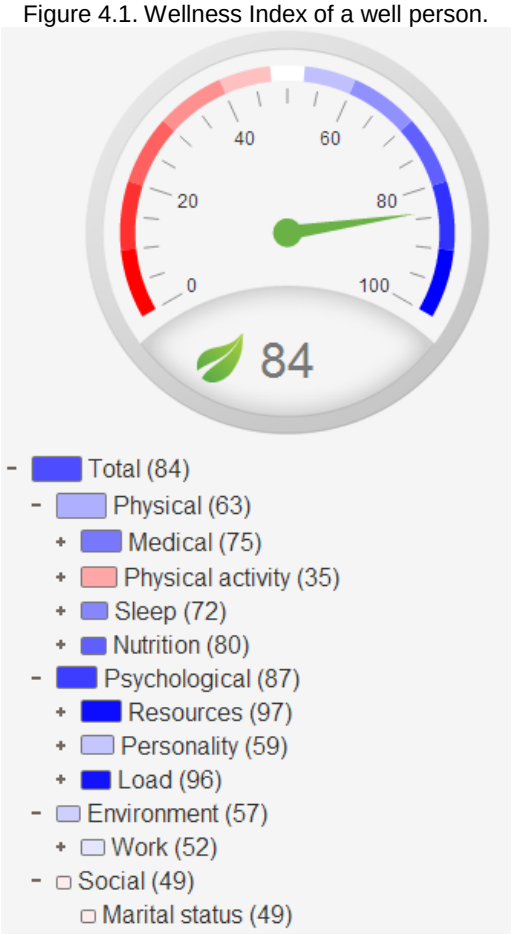
In addition to questionnaires and direct measurements, the information required for constructing user models is collected e.g. from health records or electronic medical records (Fernandez-Luque2011, Roitman2010), by exploring users social network profiles (Beach2010) and by services chosen or places visited (Kim2010). Moreover, the knowledge level of users can be inferred implicitly based on, e.g., users' answers to exercises, time spent on reading certain content, or the number of actions required to achieve a certain task (Brusilovski&Millán2007).

Huco Sports (www.hucosport.com) is an example of a commercial profiling service for sports and dieting needs. *Huco* aims not to offer psychological testing, but rather provide tools that would help customers to understand themselves better, and coaches to find the best ways to motivate the customers to exercise and to adopt a healthy lifestyle in general. Similarly, *WellKom*'s personal wellness profiling service (www.wellkom.org) uses web questionnaires to provide information about the current state of wellness and to facilitate self-motivated behavior change. Similar other testing and profiling services exist. *Wellocracy* (www.wellocracy.com) compares and provides information on "self-health" technologies such as activity trackers, heart rate monitors and mobile wellness and health applications. Wellocracy uses also profiling to find out the personal motivation style that fits the user, and can then utilize this information in its recommendations. The motivational style is tested with a very simple 10-item questionnaire. Wellocracy questionnaire segments people to four motivational styles: Social Butterfly, Team Player, Self Starter and Solo+Social.

VTT Technical Research Center of Finland developed a *Wellness Index* tool for computing and visualising the person's state of wellbeing. The computation is based on a learning algorithm that identifies the most relevant attributes predicting an outcome measure (here wellbeing state) from a population dataset. After initializing the tool with the dataset, the tool predicts the wellbeing state of an individual person by comparing the properties (attribute values) of the person to the population data. The visualisation example in Figure 4.1. is based on the data of a well person, and the tool has been initialized with the data of a Finnish working age population. The colours of the boxes associated with wellbeing attributes indicate, whether the attribute has a good (blue) or bad (red) value from the

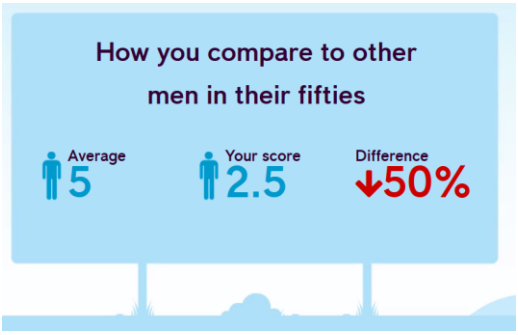
wellbeing viewpoint. The size of the box denotes the relevance of a certain attribute to the overall wellbeing, for instance, according to the population dataset at hand, the role of physical activity is stronger than the role of nutrition in determining wellbeing. The algorithm was originally developed to support clinicians in the early identification of Alzheimer's Disease (Mattila2011; MattilaJ2012).

Figure 4.1. Wellness Index of a well person.



Sleep coaching application and service *Sleepio* (www.sleepio.com) begins with a highly interactive training session. User first fills in a visually rich survey, where profiling information is collected. This information is then utilized for adapting an audiovisual training session for the person. Sleepio coaching then continues with a set of web therapy sessions based on the theoretical principles of the cognitive behavioral therapy. During the coaching sessions more profiling information is constantly collected and utilized for adapting the (automatic) coaching sessions to the person.

Figure 4.2. Extract from the results of the *Sleepio* sleep profiling analysis.



Daily Challenge (http://challenge.meyouhealth.com) is a social online application that suggests daily small, positive actions, or challenges, that improve health and wellbeing. The challenges are related to six wellness domains: physical & emotional health, healthy behaviour, basic access to health services and healthy products & environment, life satisfaction, and job satisfaction. As for the profiling part, the application includes a wellbeing survey, *Wellbeing Tracker,* which allows the user to follow his or her status on the six wellbeing domains, and compare the results to the average wellbeing status of his or her personal connections (Figure 4.3.). The Well-Being Tracker includes 42 questions. Each wellbeing domain is evaluated with a score from 1 to 100, and an overall wellbeing score is computed. The user can re-take any section of the questionnaire at any time. The application also prompts the user to re-take sections every now and then.

Figure 4.3. Wellbeing profile in *Daily Challenge* and the comparison of user's wellbeing status to personal connections.

Noom (www.noom.com) provides applications for weight loss and for other wellness areas. Noom provides personalized daily tasks, articles, tips and feedback. When constructing the user profile, Noom collects user information in small chunks, asking once and then few questions from the user. This way the application gradually collects profiling information and utilizes it for tailoring tasks and feedback for the person.

HealthMedia (www.healthmedia.com) is an example of a web-based health and wellness coaching service, where the first step is a consultation session beginning with an in-depth analysis of the customer. Health risks are identified by epidemiological need, stage of change, motivation, self-confidence and barriers. In the second phase, a personalized plan is created by combining profile information with the expertise of coaches. During the third phase the coaching program is implemented using web-based tools imitating live face-to-face coaching sessions. In the fourth and final step, regular check-ins are executed to assess how the customer is doing and whether the personalized coaching plan has worked or not.

ORCATECH health coaching platform (Rivera2013) utilized a dynamic user model (goals, motivations, barriers, health state, cognitive level) in both tailoring feedback and for selecting interventions and tailoring the action plan. Computational model derived from systems theory was utilized for inferring behaviors and health states and for identifying the status of the behavior change.

Yang et al. (Yang2010) created a wellness self-management platform providing dietary and exercise recommendations based on user's current location, activity state, intentions and preferences.

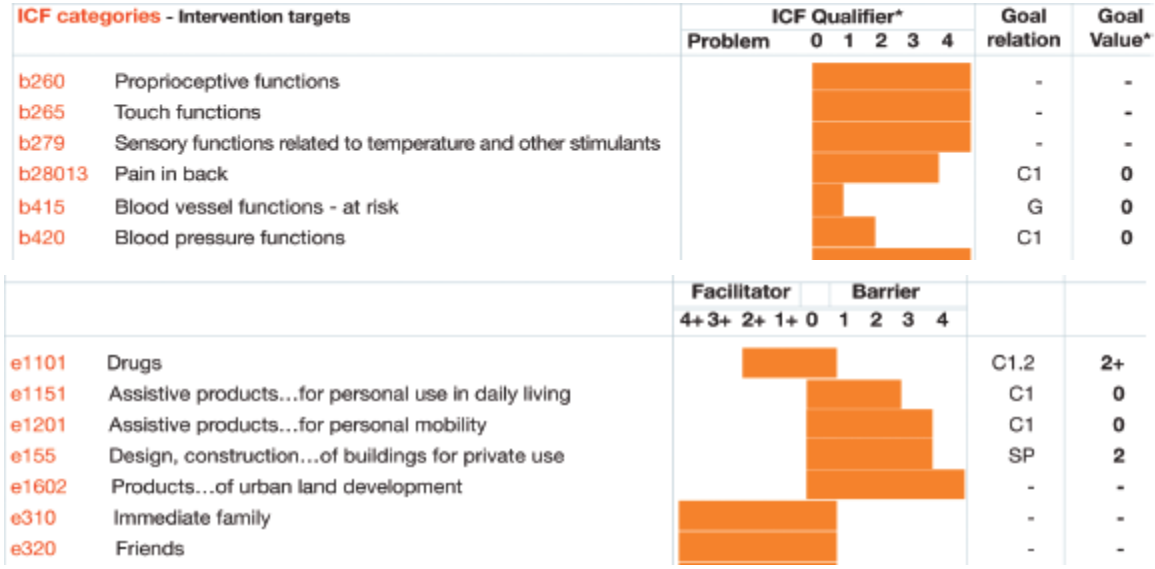
BeWell+ is a smartphone application that monitors sleep, physical activity and social interaction, and provides feedback to the user. It includes two main profiling functionalities: 1) it identifies the peer group the user belongs to and utilizes this knowledge in tailoring health goals for the person according to group norms, and 2) detects via smartphone sensors which of the three wellbeing dimensions is most problematic to the user and concentrates on providing support regarding it (Lin2012).

International Classification of Functioning tools (ICF) is a user modelling example from the health care (http://www.who.int/classifications/icf/en/). ICF provides a theoretical model for depicting person's functioning and disability. The disability (lack of ability to function in society) is considered as a negative outcome between environmental requirements and person's capacities. Disabilities can exist in different activities and daily functions, as well in participating in healthy behaviours. Functioning

term can be considered as a reverse of disability. The model of the functioning and disability consist of three parts which together form the core to model a person (body function and structure, activities and participation) which again have dynamic interaction between various health conditions and contextual factors (environmental and personal). There exists a wide range of categories for describing these factors and how they contribute to subject's functioning in the society. Body function and structure, activities and participation categories have been qualified from with 5 point scale (no problem … complicate problem) and contextual factors between -4 and +4 depending whether the factor is considered as barrier or facilitator.

In addition to theoretical modelling and parameterization of the functioning, ICF offers set of tools to support the care processes. ICF research branch has worked to find specialized category sets (i.e. subgroups of the whole ICF) for a certain target area like depression and sleep problems. (http://www.icf-research-branch.org/). The work is purposed to support both research and practise. ICF Rehab-cycle tools intend to facilitate the rehabilitation processes from assessment (core sets, assessment sheet, categorical profile), assignment (intervention table), intervention and evaluation content (www.icf-casestudies.org). Fig. 4.4. depicts part of the categorical profile targeted for spinal cord injury patients. Although the ICF tools are designed for clinical rehabilitation use, there exists motivation to utilize them in a prevention context as well.

Figure 4.4: Example of a part of an ICF categorical profile visualization for a spinal cord injury patient.



Up to now, we have not been able to find in the literature holistic health and wellness coaching solutions that would utilize personalization and user modelling at a deep level. Among the ones studied, ORCATECH system (Rivers2013) is among the most advanced. Commercial products such as the above-mentioned Noom (www.noom.com) perform well in collecting information from the user and in using that for personalizing the service on-the-fly. Several wellness companies exist claiming to deliver personalized automated behavior change support, such as *WellnessLayers* (www.wellnesslayers.com), but from the available material it is not easy to deduce how much and how they utilize user models and personal profiling.

4.3. Utilizing the context: detecting opportune moments for coaching

Potentially, *context-awareness* can be utilized for finding the opportune moments for coaching during the daily life. Dey et al. (Dey2001) have defined context as: "*Context is any information that can be used to characterize the situation of entities. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves*." In general, in context-aware systems the most popular variables used are location, time

and weather (Gavalas2011, Ozcan2010). Other variables include e.g. temperature, moods of users and the presence of people nearby (Honka2011).

Context-aware research has typically focused on inferring user's current states or activities based on combining information from GPS, activity sensors, time, calendar and social interactions. Current technology is able to perform this type of interference with a rather good precision. Even more complicated spatio-temporal events such as "*leaving home*" or "*returning from vacation*" can be detected (Holleis2010). Especially sports coaching services utilize also physiological signals, such as the heart rate, for deriving contextual recommendations and feedback (e.g. Buttussi2006).

Contextual information has been utilized in automated coaching systems especially in finding the opportune moments for delivering feedback such as encouragements, reminders and proposals for performing a health activity (e.g. Klaassen2013, Buttussi2006, Ho2005, Achterkamp2013). Opportune moments refer to moments when users are most receptive to interruptions and suggestions. According to Ho and Intille (Ho2005) users generally perceive context-aware interruptions to be less intrusive than random interruptions. Most appropriate moments for interruptions have been found to be, especially for mental tasks, during transition points between tasks (Bailey2008). Common approach in mobile systems for detecting task transitions is based on monitoring the movements of users (Ho2005). In the user study of a personal digital health coach with context-aware feedback (Klaassen2013) the two most preferred situations for receiving feedback were "relaxing in front of TV" and "during the lunch break". In this study users preferred progress report type messages over messages containing advices, tips or other more educational-type content.

Also the content of the message matters, since users can be even during tasks receptive to messages that they perceive as important or interesting (Fischer2010). When engaged with social interactions users are in general less receptive to interruptions (Ho2005).

An important aspect to be considered is also the moment when interruptions or interventions would be most needed or useful to users. This is in general harder to reliably detect automatically. Examples of such systems include a mobile stress management application that aimed to provide emotional regulation exercises to users at stressful moments (Morris2010), and a user-adaptive reminder system that triggers reminders for health-related activities at moments when the user is in close proximity to the place where the task can be performed (Kaushik2008).

Naturally, in addition to utilizing the contextual information, feedback messages should be tailored according to the personal profile. Achterkamp et al. (Achterkamp2013) utilized self-efficacy, state of change and the baseline activity level of the person when tailoring the feedback messages in their automated coaching system. Based on these parameters, users were classified into one of the eight categories, which all had a separate tailored feedback and coaching strategy.

Contextual guidance for feedback can also in many cases be directly asked from the users. Users can fill in preferences how and when they would like to get encouragements, reminders and other feedback messages (e.g. preferred delivery media, reminder times, tone and style of the messages, physical locations). This can help to improve the user experience of automatic feedback.

5. Proposed Architecture and Constituents of the User Profile

In this chapter, first we present the key constituents of the user model that we have identified as important, based on the theories of behavior and motivation presented in the Deliverable 2.1 and summarized in section 3.2 (section 5.1). We also provide practical examples of parameters for each constituent. Then in the section 5.2, we discuss the different layers of data abstraction that should be managed by the user model. Finally in section 5.3, we propose to utilize a modular ontology-based approach as the foundation of the model.

5.1. Constituents and parameters

As described in chapter 2, the main purpose of the user model is to facilitate the planning, communication and delivery of effective interventions. This requires the following (automatic) functionalities from a health coaching system which should be supported by the user model.

A. Recommendation of behaviour change goals
B. Recommendation of interventions to be included to the action plan
C. Tailoring of intervention materials and feedback messages
D. Delivering interventions at opportune moments
E. Measuring the effectiveness and suitability of the selected interventions, for instance, by monitoring changes in motivational factors, behavioural outcomes, or wellbeing status
F. Identification of groups of similar types of people for facilitating data-driven intervention recommendation

In order to support the above-mentioned functionalities, the user model should provide knowledge to the key questions that are important for designing effective interventions:

A. What are the problematic health or wellbeing issues? Which risk behaviors are causing these problems?
B. How motivated the person is to address these health issues? Is the person aware of the need to change behavior?
C. Which risk behaviors should be addressed first (e.g. snacking behavior)?
D. How to encourage and what motivates the person? Should the focus be on emotions or facts when raising awareness, providing feedback and tailoring the interventions?
E. What personal determinants should be engaged to elicit behavior change? What kind of support is needed? Who are the supportive persons in the environment of the user?
F. What are the external constraints and possibilities? What environmental determinants should be engaged to elicit behavior change?
G. In what phase of change is the person regarding the risk behavior? What worked well, what did not?
H. What are the opportune moments to provide support or intervene?

Based on the behavior change models described in section 3.2., we have identified the key constituents, or parameter groups, that we propose to utilize as a base structure for the content of the user model. These constituents and the related parameter types, i.e. the 2nd level parameter grouping, are presented in Figure 5.1. Our aim is to define a comprehensive high-level data structure that could be used as a common framework in different behaviour change applications in the area of health and wellbeing, covering all the parameter types relevant for supporting behaviour change. As we see it, the suggested constituents and parameter types could enable the construction of the holistic representation of the user, as we envision in chapter 2. Furthermore, they should be sufficient to provide answers to the above-mentioned questions, and thus facilitate the design of effectively personalized interventions. According to our analysis regarding behavioral theories, the minimum set of parameters which should be utilized for tailoring interventions are related to the constituents *Wellbeing status*, *Resources*, *Life situation*, and *Goals & Motivational factors*. The value of tailoring based on *Context* parameters, especially related to the current situation, is not yet clear in the literature of health interventions, most likely due to not having, as consumer products, truly unobtrusive sensing devices able to sense the context *continuously*. Technology in this area is

developing quickly, and when solutions such as the Google Glasses are in wider use, sensing the context can be more utilized. The parameters related to the 2nd level of grouping, which are certainly interesting for tailoring interventions, but do not have yet a solid theoretical or practical background regarding their role in health behavior change, are grayed out in Figure 5.1.

Figure 5.1. The proposed constituents of the user model and the relevant parameter types or groups.

In the following, we will explain what we mean with the parameter grouping presented in Figure 5.1., and provide several practical examples of the actual parameters (Figures 5.2-5.5). We also map the presented key questions related to the design of interventions to the parameter groups. Further details regarding many of the parameters can be found from appendix 2, and examples of questions that could be used to populate the parameters can be found from appendix 1. As a general comment, each of the presented parameters should be coupled with time stamps, and the evolution of the parameter values in time should be captured in the user model by maintaining the link between the past and current values, and supporting the possibility to generate predicted future values.

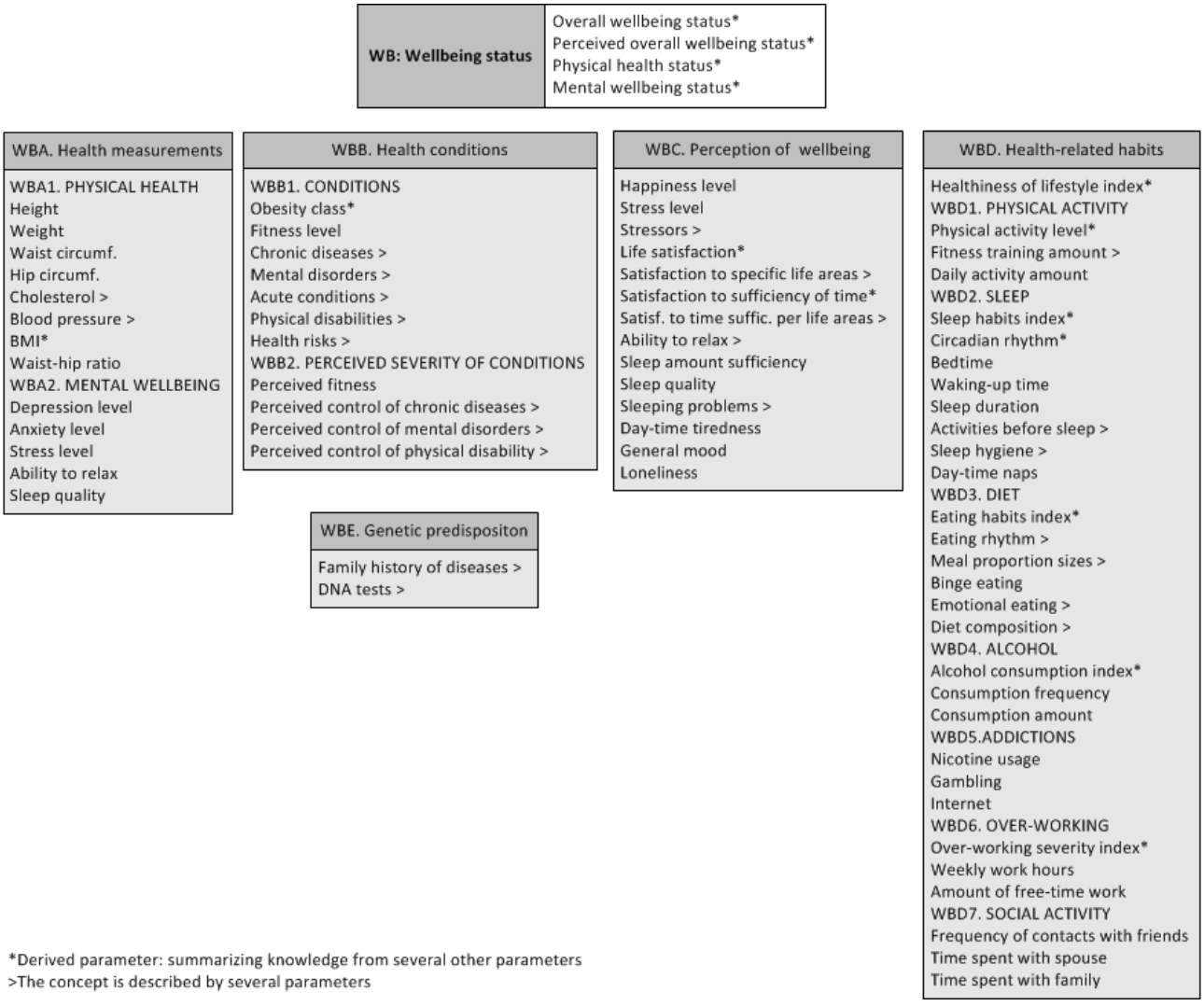
The reader should keep in mind that the relevancy of some of the presented parameters can vary significantly based on the health or wellbeing application area in question. In these examples, the parameters have mostly originated from the needs of the Finnish stress-management pilot, focused on young families balancing with the demands of work and family life. For instance, for the purpose of an exercise coaching system, the parameters describing health-related habits do not need to be as comprehensive as we suggest in Figure 5.2. On the other hand, we do not attempt to present a comprehensive list of all the possibly interesting parameters. Hence, some relevant parameters can very well be missing from the examples. Finally, identifying the interesting and most useful parameters is a continuous process, which will take place throughout the With-Me project. The current list of parameters is a starting point, and our aim is to find ways to describe the relevant information with fewer parameters in a more concise way.

The **Wellbeing status** constituent (Figure 5.1. and 5.2) involves parameters describing the person's physical, mental and social wellbeing, health risks, perception of wellbeing, and the health-related habits. These parameters provide knowledge regarding the health or wellbeing issues that should be addressed with the interventions (question A). There are several derived, high-level parameters that

we propose to be computed for summarizing the person's wellbeing state: a) healthiness of lifestyle based on health-related habits (WBD1-7), b) mental wellbeing status based on perceived mental wellbeing (WBC), measurements regarding mental health (WBA2), and health conditions (WBB1), c) physical health status based on physical health related measurements (WBA1) and health conditions (WBB1), d) perceived overall wellbeing status based on perceived wellbeing (WBC) and the perceived severity of health conditions (WBB2), and e) overall wellbeing status based on the healthiness of lifestyle index, and the mental and physical health statuses. In addition to automatic intervention recommendation, these summarizing variables can be useful for the coach to get a quick picture of the wellbeing status of the customer, and for the person himself or herself.

The *Health measurements* parameter group (WBA) includes only objective measures of health and mental wellbeing opposed to the person's own perception (WBC & WBB2). Comparing objective and subjective wellbeing measures is a means to assess the person's awareness regarding his or her wellbeing (question B). We also propose to include the *Genetic predisposition* (WBE) parameter group to the user model, but not as a mandatory component. The idea of utilizing genetic information for tailoring health interventions is still very new, but intriguing. The future will show how this kind of information could be effectively utilized. *HealthPuzzle* (http://www.arcticstartup.com/companies/health-puzzle) is an example of a wellbeing company, which aims to utilize gene testing for personalizing interventions.

Figure 5.2. Examples of parameters for the user model constituent *Wellbeing status*.



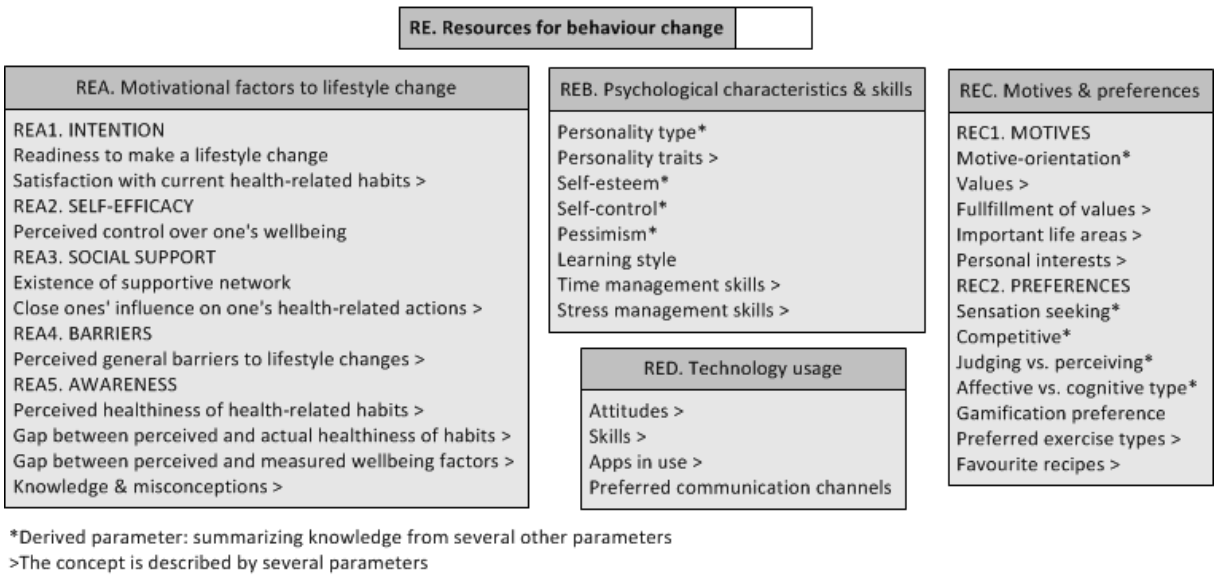
The **Resources** for behavior change constituent (Figure 5.1 and 5.3) comprises of motivational factors towards a lifestyle change at a general level, the person's psychological characteristics and skills, his or her motives and preferences derived partly from personal values, and technology usage habits and

skills. The motivational factors to lifestyle change are based on the determinants of behavior presented in section 3.2. They describe the willingness and commitment level of the person to start to shape his or her behavior in general, and thus provide some answers to the question B. In addition, they provide general insight to the underlying reasons for low motivation, which determine the kind of support to be provided to the person (question E). In order to evaluate objectively the person's awareness or knowledge level regarding his or her wellbeing and health-related habits (question B), we propose to compare the person's perceptions of the healthiness of his or her health-related habits and wellbeing condition (WBB2 & WBC) to the actual healthiness of the habits (WBD) and the objective wellbeing measures (WBA). User's knowledge or skills (e.g. on how to make a healthy meal) or misconceptions can also be tested by small questionnaires or quizzes.

We consider personality traits as a vital part of the user model, since they can reveal important psychological characteristics or skills (REB) that influence behavior, such as the tendency for pessimism or low self-esteem (Hagger-Johnson2003), which should be taken into account in the interventions (question E). Furthermore, the personality type together with the personal values reveal knowledge about the preference type of the person (REC2), such as Sensation seeking or appreciation for facts (cognitive type), which provide insight on how intervention materials or feedback should be tailored (question D) (Hagger–Johnson2008, Lianov2008). The *Big-Five* personality dimensions are widely used in the area of personality research, and they could also be utilized in the With-Me user model. The *Ten-Item Personality Inventory (*TIPI) is a short questionnaire to assess personality based on the Big-Five dimensions (see appendix 1 for the TIPI questionnaire). (Gosling2003)

Furthermore, knowledge on the person's general interests in life, the so-called motive-orientations (REC1), can be used to motivate the person in the behavior change process (question D). These could be inferred from personal values. *Schwartz value theory* is a good basis for identifying personal values, since it includes ten value types, which have been shown to apply universally in different cultures. Furthermore, certain combinations of these value types have been shown to influence human behaviour. (Schwartz1992, Lee2010) See appendix 1 for a non-validated questionnaire tool to discover the Schwartz values.

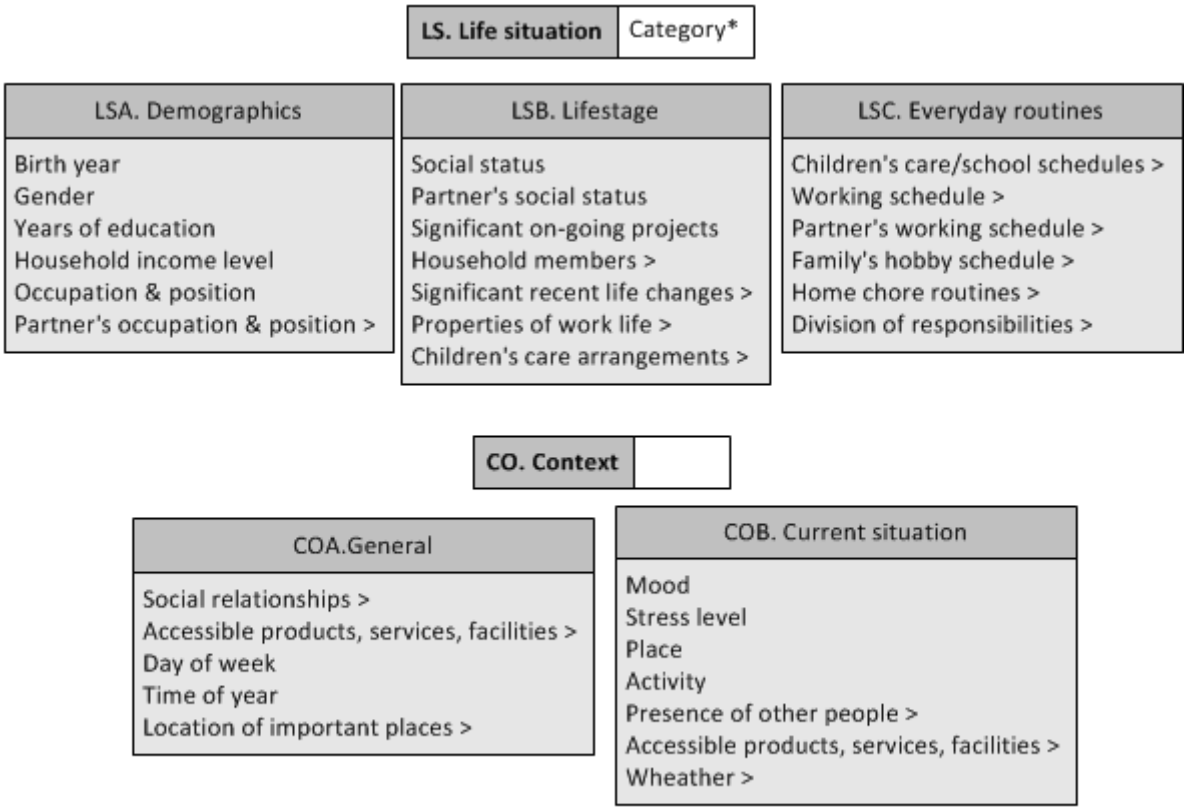
Figure 5.3. Examples of parameters for the user model constituent *Resources*.



The **Life situation** constituent involves parameters regarding demographics (LSA), the current life stage (LSB), and the everyday life routines (LSC) of the person. The **Context** constituent describes the general, rather constant, properties of the person's context of living (COA), such as the immediate physical environment and existing social ties, as well as the properties of the current situation of the person (COB) which can change several times a day (see Figures 5.1 and 5.4). These parameter constituents describe the external constraints and possibilities for behavior change (question F). This knowledge can be used to plan the details of interventions, such as whether to recommend jogging

indoors or outdoors, or whether to recommend buying fresh or frozen vegetables depending on the facilities and products readily available, or whether to suggest family activities depending on the life situation of the person. Life situation related parameters can be a very useful source of background knowledge, for instance, being a shift-worker (properties of work life) can explain sleeping problems, or having several hobbies in the family can be one cause for stress. Furthermore, the parameters related to the current situation (COB) can be used to assess the appropriate time to deliver an intervention (question H) (see section 4.3).

Figure 5.4. Examples of parameters for the user model constituents *Life situation* and *Context*.



The person's behavior change goals and the behavior change plan are derived from the user model constituents presented thus far: *Wellbeing Status*, *Resources*, *Life situation* and *Context* (Figure 5.1). We propose to include also the goals and the plan as part of the user model, since the health coaching system needs to keep track of the behavior change goals and interventions that have been recommended to the user, and selected or declined by the user. Furthermore, the system needs to monitor of the effectiveness of each intervention. However, it is neither necessary nor sensible to maintain the actual descriptions of the goals and interventions in the user model, but only a reference to them. We suggest maintaining these descriptions in an *Intervention library* separate from the user model, which we will shortly explain via Figure 5.6. Having a reference to the utilized goals and interventions in the user model enables the data-driven learning of suitable methods for certain user types and, furthermore, their recommendation to similar types of users.

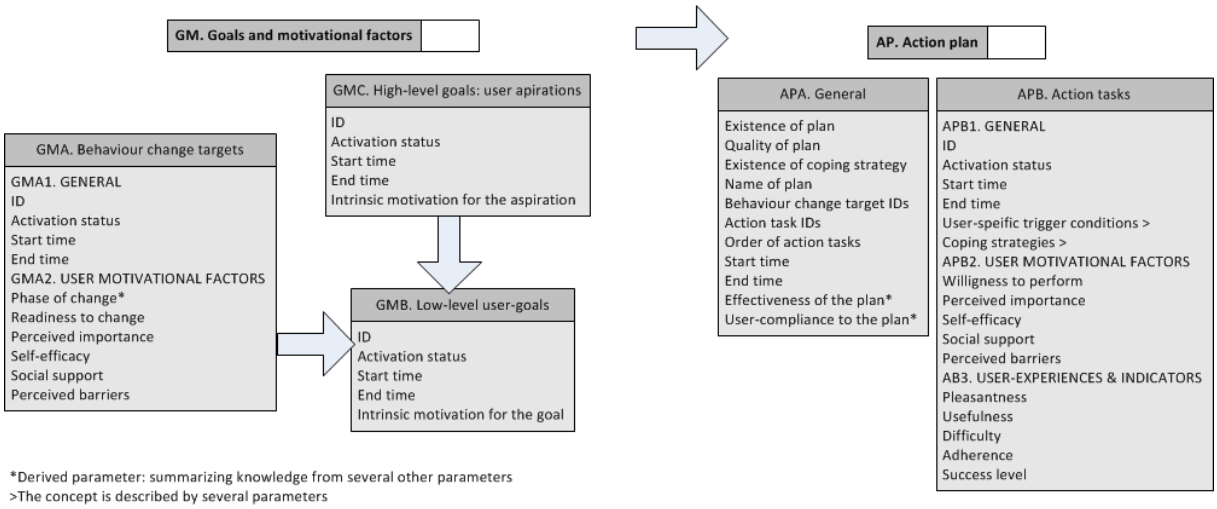
The **Goals & Motivational factors** constituent (Figure 5.5) includes the behavior change targets for the person, his or her motivation towards these targets, high level life goals or aspirations, and low level behavior change goals. The behavior change targets for the person (GMA) are derived from the health or wellbeing issues described by the *Wellbeing status* parameters. "Increase daily steps", "Go earlier to bed", "Eat more berries" and "Meet friends more often" are examples of behavior change targets. The person does not necessarily have to be aware of these targets, especially when he or she is completely uninterested to work towards them. However, depending on the severity of the problems, the health coaching system or the coach needs to keep track of them and address these targets in the

Action plan (Figure 5.5), for example, through awareness-raising interventions. Based on the target-specific motivational factors (GMA2), the decision on which health-related behaviors should be targeted first, with the person being aware of it, can be made (question C). One should target first the behaviors which the person is most willing to work on to ensure positive experiences (PREVE2011). Furthermore, the target-specific motivational factors together with the general motivational factors of the *Resources* constituent, refine further what type of support the person needs (question E).

The low level user-goals (GMB) are a bit more precise versions of the identified behavior change targets, selected or verified by the user, such as “I will increase my daily steps to 5000”, “I will go to bed by 11 pm during weekdays”, or “I will enjoy at least two portions of berries per day”. These correspond to the program level goals defined by Powers et al. (1973). Hence, these are the behavior change targets the person is motivated to pursue. The person should have at most 1-3 active goals at the same time to work on (Thaler2008). Aspirations (GMC) are system-concept level goals (Powers1973), which reveal the reasoning behind the selected behavior change goals, such as “I want to be more productive at work” or “I do not want to lose my temper with my children every day”. Aspirations could be derived from the personal values of the *Resources* constituent, and the low level goals should be linked to them. This way the identified aspirations could act as a source of inspiration for the person, provided that the connection between them and the behavior change goals is clear enough to the person. As discussed in section 3.2.2, it is important to identify whether the goals of the person are intrinsically or extrinsically motivated. This knowledge can be utilized to guide the person to focus on the intrinsic goals.

A behavior change **Action plan** (Figure 5.5) can be constructed for the user, once the behavior change targets and user-selected goals are identified. The Action plan includes the a) concrete intervention tasks (APB) corresponding to the selected low level behavior change goals, b) ordering of the tasks (APA), since in some cases it might make sense to schedule a task to begin after the person has completed certain other tasks, c) the person’s motivation (APB2) and experiences (APB3) regarding each task, d) other indicators regarding the suitability of tasks, and e) the effectiveness of the action plan and user’s compliance to it (APA). The user-compliance regarding the plan is derived from the user’s adherence level to the different action tasks. The effectiveness of the plan can be inferred from the observed changes in the *Wellbeing status* parameters, for instance, health-related habits, health measurements and perceived wellbeing, or in the *Resource* parameters, such as psychological skills or user-motivational factors to behavior change. In addition to user experiences, inferred indicators could be used to analyze the suitability of interventions. For instance, for an exercise task, the training heart rate zone can indicate the difficulty or effectiveness of the exercise.

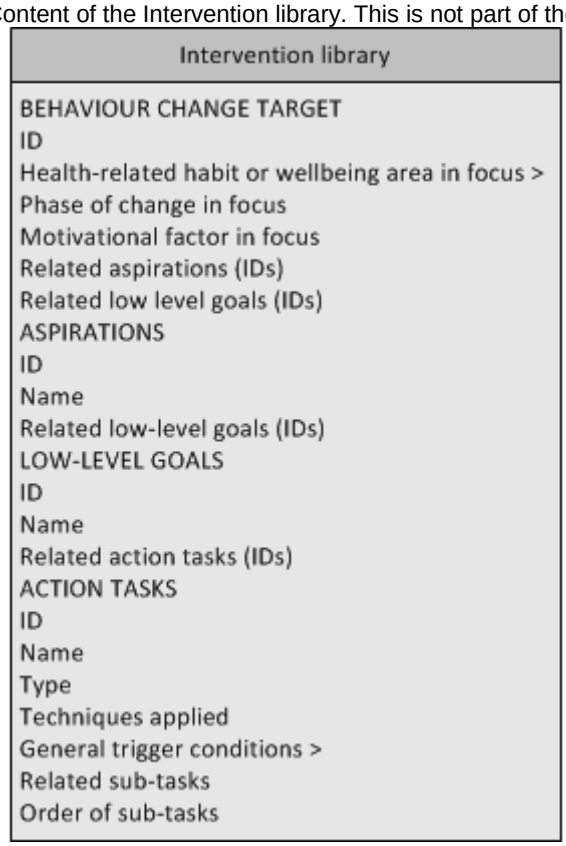
Figure 5.5. Examples of parameters for the user model constituents *Goals & motivational factors* and *Action plan*.



Finally, we present our initial suggestion for parameters used to describe behavior change goals and interventions in the **Intervention library** (Figure 5.6), which is a separate constituent from the user model. The IDs in the *Goals & motivational factors* and *Action plan* constituents correspond to the contents of the *Intervention library*. All the goals and interventions that should be available for automatic recommendation need to be defined in the library. Thus, the library should contain

descriptions for the following intervention items: behavior change targets, high-level goals (aspirations), low-level goals and action tasks. The library should include also the relational information between the items. The coach should be able to add or remove items from the library in a structured way, and for a completely automatic coaching system this should be made possible also for the users. However, in the scope of the With-Me project, it is sufficient to have the coach to modify the intervention contents. With the *techniques applied* –parameter for an action task, we refer to the taxonomy defined by Michie et al. (Michie2013).

Figure 5.6. Content of the Intervention library. This is not part of the user model.



5.2. Data layers

In the previous section 5.1, we did not consider the different layers of data abstraction regarding the parameters of the With-Me user model, though evidently user data of varying levels will be present. Hence, in addition to the modelling parameters, the user model needs to represent also the hierarchical data relations. Figure 5.7. summarizes different layers of data which need to be supported by the model: raw data, integrated and transformed data, aggregated data, and classified data.

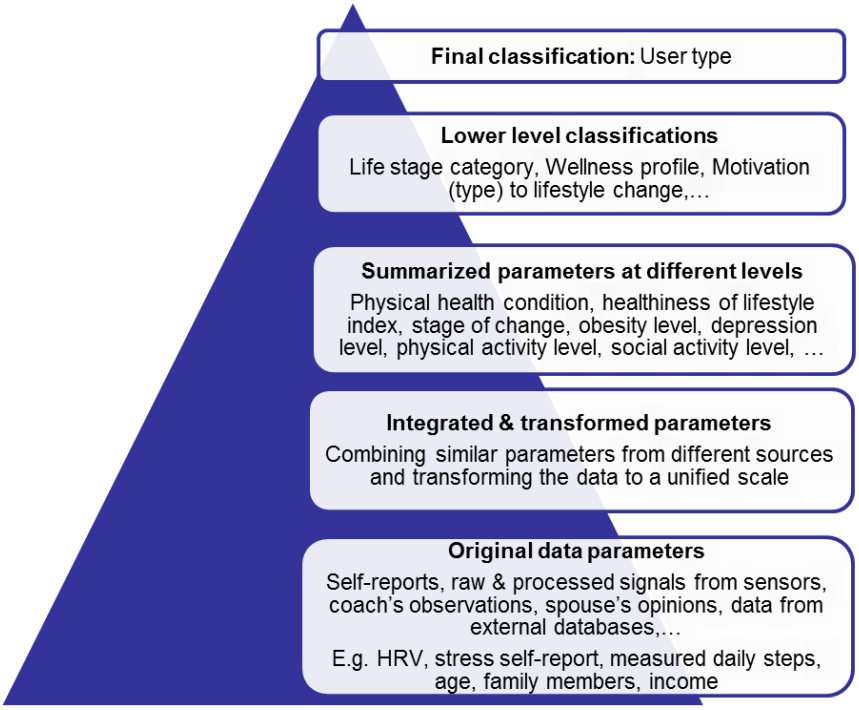
At the lowest level of data hierarchy is the **raw data,** gathered directly from the data sources and stored in the original format. The data sources can vary from different sensing devices measuring bio signals or contextual information to the inputs of the user, coach or other people, to the data acquired from external databases such as Personal Health Records, insurance databases etc.

The **integrated and transformed data** layer combines the data from different sources that represent similar concepts to a single global parameter by transforming the original parameter values to a unified scale. In addition, the generalization of the original parameters takes place in this layer, for instance, the discretization of continuous parameters, such as age, to certain classes. Data integration is an important functionality to be supported by the user model, since in reality similar concepts are measured in various ways, varying not only amongst different users, but also within one user. For instance, there are several mobile phone applications and sensing devices measuring daily steps or the quality of sleep, and the user can switch among these any time, or there are several questionnaire tools measuring similar concepts, such as the personality traits. Moreover, input for a concept might

be sometimes sensed and other times provided by the user directly. However, in the With-Me pilots, we will most likely have only well-defined, invariant data sources.
The **aggregated or summarized parameters** combine the pre-processed parameters of the previous data layer to high-level concepts. The level of aggregation can vary, for instance, Body Mass Index is a derived parameter of height and weight, which is lower in the aggregation hierarchy than the parameter Wellbeing status, which is derived from the health-related habits and wellbeing status related parameters as explained in the previous section.

The highest level of data abstraction involves parameters that identify interesting properties of the user to belong to certain classes, or could even classify the user to a certain group. The ideal would be to identify first a core set of summarizing variables (previous data layer) relevant for intervention recommendation, and as data from different users become available, the user modelling would converge to the relevant **classification** of different user types based on the parameters of various dimensions (section 5.1). However, finding the most useful set of parameters that should form the classification is a challenging data-driven problem, requiring the analysis of large, comprehensive data sets from hundreds of users, which we most likely cannot access within the scope of With-Me. A more realistic target for With-Me, is to explore the most suitable ways to summarize user data in general, and to search for the core set of parameters predicting behaviour and wellbeing.

Figure 5.7. Data hierarchy to be supported by the user model.

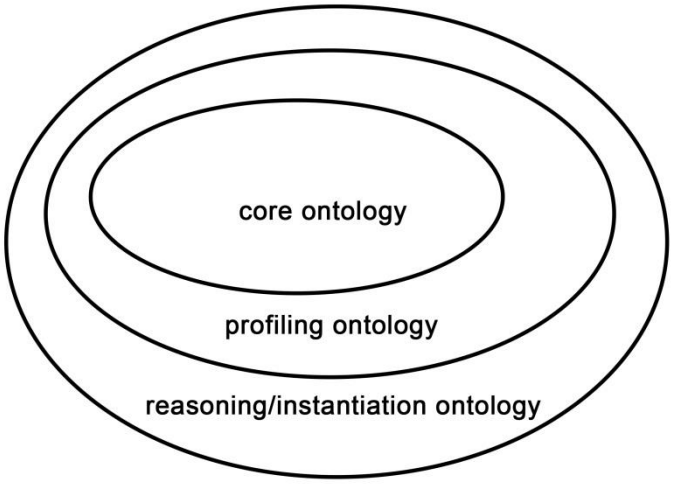


5.3. Ontologies for organizing profile data

The application of semantic technologies or ontologies for dynamic user modelling offers several important advantages. They a) guarantee a uniform language across different user modelling stakeholders (e.g. behavioral and computational experts), b) allow for semantic inter-usability of the formal user model across different applications and domains, and c) allow knowledge evolution and growth. Furthermore, ontologies provide a way to overcome the heterogeneity in data sources by defining which data inputs should be integrated together.

As implied in the sections 5.1 and 5.2., the With-Me user model is a hierarchical structure of parameter groups, where also the relationships between the groups are defined. Describing the user model through ontologies enables the further refinement and reasoning of the model. The user modelling ontology could be structured from a nested set of ontologies consisting of three levels of abstraction as presented in the Figure 5.8 below.

Figure 5.8. User modelling ontology of three levels of abstraction



The **Core ontology** (quantitative) is a complex ontological model containing the generic key concepts and knowledge relevant to user modelling. The creation and maintenance of this model requires solid expertise in ontology modelling. It is important to emphasize that this model involves quantitative user knowledge, for instance, regarding causes of overweight or lifestyle parameters in general. Behavioral scientists and potential coaches are closely involved as a source of domain knowledge and for validation purposes.

The core ontology model consists of 2 types of high-level key domain concepts: 1) *Constituent* which describes a hierarchy of the different user model constituents (*e.g. WellbeingStatus*, *Resource*, *LifeSituation*, *Context, Goal, MotivationFactor, …*) as identified above; 2) *ConstituentParameter*, which models the parameters describing the constituents (see Figure 5.1). These are related via the hasParameter relationship. Each (sub-)constituent is connected with its parameters through a set of relationships, which are sub-properties of this property. Some concrete examples are *WellbeingStatus* isComposedOf *PhysicalHealth*, *LifeSituation* isSpecifiedVia *LifeStage*.

The core ontology also defines a multitude of relationships between the different *Constituent* subclasses e.g. *LifeSituation* impacts *WellbeingStatus*, *Context* influences *Goal, Resource* comprisesOf *MotivationFactor*.

The original core ontology can be complemented and extended by creating a separate profiling ontology. The **Profiling ontology** (qualitative) is a relatively simple ontological model, defining the specific properties determining the different profiling factors. For instance, these can be very simple logical rules enabling to derive additional qualitative information about the user e.g. **IF** (*BMI* isAbove 25) **THEN** (*User* hasWeightProfile obese). However, the profiling ontology may include much more complicated reasoning capacity e.g. performing some personality classification/profiling based for example on the *Ten-Item Personality Inventory (*TIPI) or another questionnaire based methodology to assess personality based on the Big-Five dimensions. The main challenge lies in mapping the natural language description of a specific user profile into a formal logic representation without losing too much expressiveness. This requires close collaboration between ontology experts and behavioral scientists and potential coaches.

The **Reasoning / Instantiation ontology** defines all logic rules and instances necessary to realize the coupling between the two other levels. More concretely, it allows mapping the quantitative data inputs making use of the core ontology model into qualitative user models as defined in the profiling ontology. The purpose of this level is twofold: 1) to automatically derive user models based on the available user data; 2) to allow dynamic adaptation of the model when changes are observed, e.g. a change in behavior.

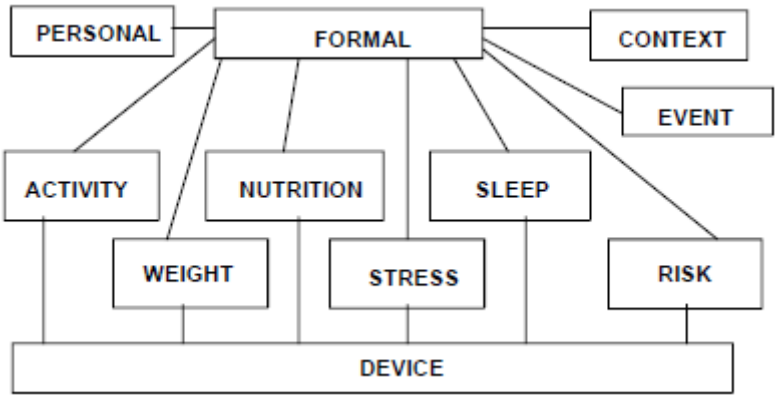
The semantic modeling and reasoning environment aims at facilitating the user modelling in practice and enables the possibility to

- capture and describe user modelling methodologies e.g. formal behavioral models and practical expert knowledge (e.g. coaches practical experience)
- reason and derive recommendations e.g. the applicable coaching methodology or opportune moments for interventions
- dynamically adapt the user model according to changing user-behavior and environment

Sirris has already some experience with the development of nested semantic models. In Tsiporkova et al. (2013), such modelling approach has been applied for the domain of multimodal interface design. The goal was to develop a uniform human machine interaction pattern model reflecting the need for a formalized description and an increased level of abstraction detail. The proposed hierarchical ontological model is structured in a nested set of models facilitating further model refinement and consistency validation.

At VTT, an ontology-based approach for managing personal health and wellbeing information has been implemented regarding the core ontology level shown in the Figure 5.8., and described in Sachinopoulou et al. (2007). We will briefly describe the approach and its benefits here, since this is very relevant for the development and definition of the With-Me user model. The implemented ontology involves a modular ontology structure, consisting of a high-level ontology, *Formal ontology*, and a collection of domain-specific ontologies: *Personal, Context, Activity, Nutrition, Sleep, Weight, Stress, Risk* behaviours, *Event* and *Device* ontologies. The Formal ontology connects the domain ontologies by defining the rules that guide data entries to the appropriate domains as shown in Figure 5.9. Having a high-level "upper" ontology, makes it possible to add more domain ontologies to the structure without breaking the existing ones. This type of modularity in the ontology structure enables distributed management and expansion of the data model (Sachinopoulou2007). Indeed, the implemented ontology collection is dynamic, continuously adapting to new evolving services, devices and measurement data. The ontologies are expressed by the Ontology Web Language (OWL), and generated with the Protégé tool (Lambrix2003).

Figure 5.9. Ontology structure of wellbeing information. (Sachinopolou2007).



The domain ontologies include rules for mapping data formats of heterogeneous sources to the ontology terminology. Most of the ontologies maintain information of the data source by including a reference to the Device ontology. Furthermore, Sachinopoulou et al. link ontologies with ISO Object Identifier (OID) codes: each term in each of the domain ontologies has a unique OID-code. This ensures the unambiguity in the modelling terminology and identifies uniquely every data input. The OIDs are utilized for identifying a) the domain ontology, b) the actual data input belonging to the domain ontology (e.g. a value of sleep quality parameter), and c) the means of collecting the data input. This identification enables the stored information to be available for intelligent search procedures exploiting the defined ontology semantics and the automatic processing of data.

Rules for mapping data to the ontology terminology is especially relevant for the data integration and transformation layer of the With-Me user model described in section 5.2. Maintaining information about the origin of the data (e.g. tracking device, database) is also an important requirement.

6. Use Cases for User Profiling in WithMe Project

6.1. Profiling solution: key use cases

Profiling tool will be used by coaches, by the customers (coaches) themselves and by other personnel involved with the coaching.

Coaches key use cases are related to getting recommendations of suitable interventions that would fit the customer and his current situation. Coaches would use the profiling tool for selecting those BCTs (Behaviour Change Techniques) that work best for a certain person in a certain situation, and for selecting and tailoring the actual interventions. Coaches also can use the profiling tool to collect information on what types of interventions in general work for certain types of persons. Coaches can also use the tool for tailoring the feedback to fit the customer profile.

Key benefits for coaches are related to saving time through automatizing part of the coaching and to improve the quality of the coaching with more personalized interventions and feedback.

For customers one of the key use cases is self-analysis and improved self-understanding. By having all the profile data linked together, the user can in various ways visualize his health situation and to compare it to other persons having similar profiles. Customer should be the owner of his data, deciding how and by whom the data is used. Customer himself also in many cases is the best source of data. By offering tools for self-analysis, a customer's interest to create personal data e.g. by answering the queries can increase.

Other personnel includes all the other participating in the health coaching process, e.g. physiotherapists, maternity care, family doctors, occupational health, insurance company and peer support groups. Key use cases for the user model and profiling tool include transfer of personal information between the organizations participating in the co-creation of health. Other care personnel can also be a source of the data, e.g. when maternity care conducts a post-natal survey of mother's depression risk or peer group proposes a new health intervention. Different organizations need also different types of views to the data.

There exist solutions for enabling the transfer of personal data between different organizations. In Finland Taltioni (www.taltioni.fi) is the new solution for storing personal health records and for arranging interoperability between different apps and services. In Taltioni the customer himself is the owner of his health data and makes the final decisions on what data is shared and with whom. By making our profiling tool compliant with Taltioni, we could in Finland offer the needed interoperability.

Following lists in more detail some example use cases, where different actors use the profiling tool.

6.1.1. Use case examples: coach

Coach gets recommendations for suitable interventions

Goal is to get a short list of ideas on what BCT's coach should utilize, and what concrete health interventions the coach could propose for the customer. Reason is that coach wants to reduce her workload and to get proposals that based on the profile fit the customer and the stage of his change process. Selecting the right intervention is an interactive process, where the coach gets more information and is able to narrow down her choices.

As an example: Matti is participating in a coaching program. He is suffering from sleep problems and of too easily losing his temper with his children. Matti has done a set of first tests including health surveys, a self-efficacy self-test and a personality test. Coach wants to get some proposals for potential interventions, based on which she could tailor the actual interventions. Coach selects the area from which she would like to get the proposals from. She selects "sleep and relaxation".

Profiling tool starts to search for proposals. It first analyses where Matti is in his change process, his intrinsic motivation level and the motives and reasons he has for the change and shows this information for the coach. Matti's motivation is quite low and tool informs this to coach and tells that Matti is still in the pre-contemplation phase and suggests that the interventions should help Matti to understand his situation, get more information and to build up the motivation. Coach gets 6 proposals for interventions which include e.g. stress analysis with Firstbeat stress analysis tool, analysis of life values and how well Matti is able to live according to his values, sleep quality analysis with the Beddit tool and Wellness Index analysis. Goal of the analysis is to help Matti to understand his current situation better. Coach selects the Firstbeat stress analysis and an info package on "symptoms of stress". System records a set of key measures for the profile data (anonymously) and the interventions selected. After the intervention the system asks from both coach and customer how much the intervention helped. This data is later used to improve the recommendations.

Coach checks health risk assessment results

Goal and reason for the task is that the coach wants to view the identified health risks of the customer, so that she can identify the suitable interventions.

Steps / example: Coach decides to base her analysis on the Medixine electronic health card, that calculates health risks based on the algorithms of the FINRISK research. Medixine health card combines lab results to a lifestyle survey. Through WithMe the system coach sends the Medixine card to the customer. Medixine checks from customers profile that lab results are already available from the Taltioni and it adds the results to the health card. Customer fills in the survey and coach views the results. Results are also visible to the customer.

Coach prepares feedback messages for the customer

Coach's goal is to send motivating feedback messages to the customer and to adapt the messages to the customer's preferences. Coach wants to both save her time and to have a bit of variability in the feedback. WithMe system checks from the profile the personality trait of the customer and his preferred communications channel. Coach gets a proposal for the feedback message and can either edit it to add more comments, ask for a new proposal or just send it as it is proposed.

Coach uses the "patients-like-me" feature to propose an intervention

Coach's goal is to select an intervention based on what has in the past worked for similar types of customers in a similar situation. Coach has been using the WithMe system for some time and created a personal archive of intervention methods, which contains information on when the intervention was used and what the profile of the person to whom it was used was. The archive contains also data (based on a questionnaire) on how well the intervention helped the customer in his behaviour change process. Based on this information, WithMe system can make a recommendation of "interventions that have earlier worked for customers having a similar profile as the current customer".

Coach analyses the customer's personality before a coaching meeting

Goal is to prepare for a coaching meeting. Coach uses the profile information to learn more about the personality trait of the customer, values, motivation, goals and barriers (e.g. insufficient knowledge, not aware, low self-esteem, everyday life barriers). Coach can also conduct interpersonal relation analysis (who are the most important people to the user, how active the user is socially).

Customer has before the meeting filled in this information through questionnaires that have provided interesting information also for the customer and helped him to understand himself better. Partly the information can also be deduced based on measured behavioural data.

Coach uses the profile tool to simultaneously give the same intervention for many customers

Goal of the coach is to be more effective and serve a larger number of customers. Coach uses the profiling tool to find people having similar situations, goals and problems and gives out the same interventions for all of them simultaneously.

Coach checks behavioral data of a customer

Goal of the coach is to find out something about the actual behaviour of the customer. Data describing the behaviour has been recorded to a web service (e.g. Fitbit, Wiithings, NikePlus). Example: Coach is interested to know how many steps customer has taken (how active he has been) during the past half a year. She does not know the web service customer has been using. Coach asks this from the WithMe system. Profile contains the information that the customer has been using Fitbit for recording the steps. Customer has through the Taltioni interface given the WithMe system right to read this information. WithMe system contacts Fitbit database and asks for the information. Answer is sent back to WithMe and coach gets it without needing to use Fitbit at all.

Automatic inference of opportune moments

In some health interventions it is important to identify the right moment to trigger the intervention. Profile would contain information also about the current situation (e.g. time, place, how quickly user is moving). This information can be utilized in the health interventions as an automatic trigger.

Coach conducts lifestyle analysis

Coach wants to analyse the lifestyle of the customer (behaviour patterns/habits, daily/weekly rhythms). WithMe system can help the coach (and customer) to analyse these by providing different types of visualizations for the context data, e.g. to show where and when the person typically is physically active and where and when not. Solutions for finding associations between variables could be used to teach and motivate the customer.

Coach contacts customer

Profile contains information about the preferred communications channel to reach the customer. Coach checks what the channel is and contacts the customer.

Coach analyses the progress of the customer (adherence, effectiveness)

Profile contains the history of the interventions. Intervention history should ideally store information about the adherence: e.g. how many times the customer performed the task in the intervention, how that compares to the target goal and how the adherence changed as a function of time. Effectiveness can be measured by a change in the wellness status, measured using questionnaires or health tests, or by simply asking the customer how effective the intervention was and how well it helped him.

Coach views and edits her private notes about the customer

Coaches can have a need to also make private notes about the customer, that they would not like the customer to see. Coach makes these notes into her own notes application and WithMe system links the notes and the customer profile data together, ensuring privacy of the coach notes.

6.1.2. Use case examples: customer

Customer gets recommendations for suitable health interventions

Customer wants to get recommendations for changes he could do in his everyday life to improve health. WithMe system utilizes the information in his profile to make proposals. Proposals are based

on what has in the past worked for similar types of customers in a similar situation. If needed, WithMe can ask for additional information for making the recommendations more viable. WithMe system can also provide customer more information and data to help in the process of selecting the intervention.

Intervention selection is an interactive process, where the customer himself should be the one creating an intervention that fits him, and getting the necessary data to increase his motivation for the change. After the intervention WithMe system asks how helpful the intervention was and how much it helped the customer. This information is utilized later for making recommendations for other customers.

Customer assesses his health risks

Customer conducts a health survey to assess his personal health risks. WithMe system combines answers to the query with the demographic data in the profile to provide more accurate risk analysis. Customer can also use the health risk analysis to predict the possible outcome of health changes by simulating the effect of changing some profile parameters (e.g. weight) to see how it would affect the health risks.

Customer analyses himself and his behavior with the profiling tool

Goal of the customer is to increase his self-understanding by using the profiling tool. This motivates him to fill in surveys and questionnaires. By answering the questionnaires customer has chance to compare his results statistically to the results of others. Profiling tools also provides questions and templates to help the customer to write down and analyse the actual motivations, reasons and goals of the health coaching and personal change process.

Customer uses the profiling tool to find like-minded people

Goal of the customer is to set up connections with like-minded people sharing the same values, goals and having similar types of problems to address. These people can provide peer support for him.

WithMe system searches for people having similar profiles. Search covers only people who have made the decision to open up their profile data and are willing to offer and get peer support from others. System makes a proposal to the customer: “I have found 3 persons very similar to you. Would you like to connect with them?”. If both parties agree, the connection is set and they can get peer support from each other.

Customer checks his behavioral data

Goal of the customer is to find out “something interesting” about his actual behaviour. Data describing the behaviour has been recorded to web services (e.g. Fitbit, Wiithings, NikePlus). Customer can pose direct questions like “How active have I been during the past week?” or use different types of visualizations to show the actual behavioural patterns he has. Solutions for finding associations between variables could be used to teach and motivate the customer.

Customer analyses his progress

Customer’s goal is to see how well he has been progressing towards the goals he has set with the coach. Progress can be visualized e.g. by showing the changes in the wellness status, measured using questionnaires or health tests.

Customer views and edits his private data

Customers can have notes and other private data that they do not want to share with anyone else. Profile makes it very clear what data is shared and with whom, and by default all data is private until it is explicitly shared.

6.2. Use cases for the WithMe pilot: examples from the Finnish pilot

Chapter 5: provided an idealistic view of the different types of parameters a personal profile could have. The actual pilots in WithMe will utilize a subset of these parameters. As an example case, this chapter describes the profiling parameters the Finnish WithMe pilot aims to use, and how the pilot will apply the profiling.

Finnish WithMe pilot aims to create and pilot services for improving the mental wellbeing and reducing the harmful stress. Pilot focus is on the individual, with strong emphasis on the support from the customer's social networks, especially the family. Services will be deployed through the occupational health. Health and wellness coaches use in the pilot semi-automated tools that, based on profiling, can propose effective interventions and follow the progress.

Target group in the pilot are young persons (25-35 years), whose risk level for developing mental stress related health problems has notably increased. Since the pilot aims to involve the whole family, participants should have a family with children.

Interventions in the pilot aim to

– teach mental skills and everyday life management,

– promote healthy habits,

– help to identify and conquer the barriers,

– support a healthy relationship,

– suggest tasks/activities/goals to be done/achieved as a family, couple and/or alone

Pilot also gives the customers tools to interpret and visualize their own health and wellness data, with the goal of promoting better self-knowledge and self-development.

Adherence and effectiveness are studied using biomedical data, health and wellness tests, interviews and questionnaires.

Pilot integrates together several services and applications. Pilot utilizes e.g.

- Movendos mobile- and web-based wellness coaching tool (www.movendos.com). Movendos models the wellness coaching as a series of repeatable tasks, which are delivered to customers over the mobile. Customers record their progress, get automated motivational feedback, follow their progress and communicate with the coach using the tool. Architecture enables easy adding of new tasks, tailoring the coaching programs and building automated feedback. Movendos enables several types of wellness tasks, e.g. following of daily habits, developing new healthy habits, food diaries, other types of interactive diaries, following up health-related parameters such as the weight, creating sports-related training programs and following progress. In the pilot the content of the coaching is mostly delivered to customers using the Movendos tool.
- Firsbeat's heart rate variability based analysis technology (Myllymäki2011) is utilized for the measurement of stress and recovery. All customers in the pilot conduct a 3-day lifestyle assessment, which provides information about the daily stress and recovery patterns and the quality of sleep. Analysis also gives practical proposals on how to reduce the stress.
- Oiva: Mobile phone and web-based intervention for improving the mental wellbeing (Mattila2012). Oiva includes a set of activities and exercises for enhancing psychological flexibility and wellbeing, based on the principles of Acceptance and Commitment Therapy (ACT).

Figure 6.1. An example of results from the Firstbeat 3-day stress and recovery assessment and proposal for reducing the stress.

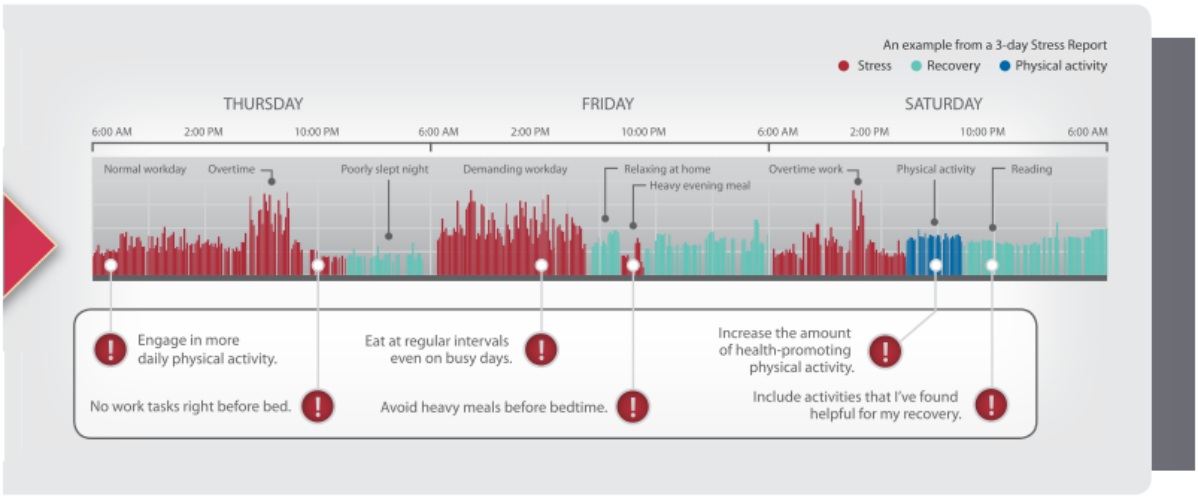


Figure 6.2. Examples of health and wellness tasks delivered to customer's mobile using the Movendos tool. Each task in the list can be clicked open to record the progress and to view the progress summary.

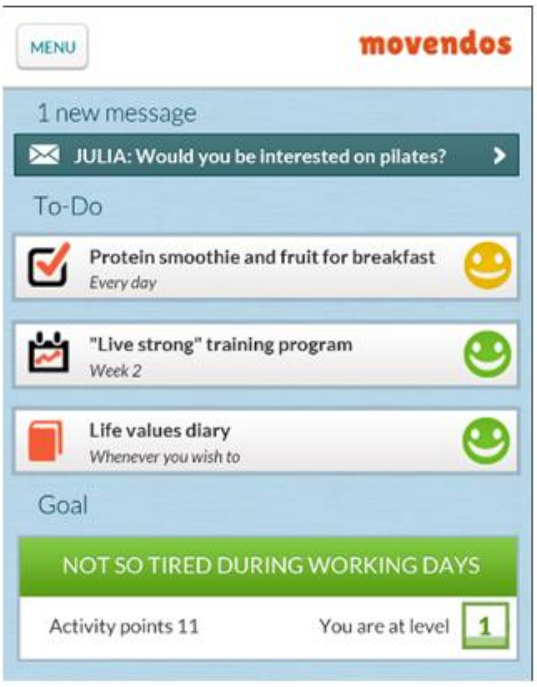
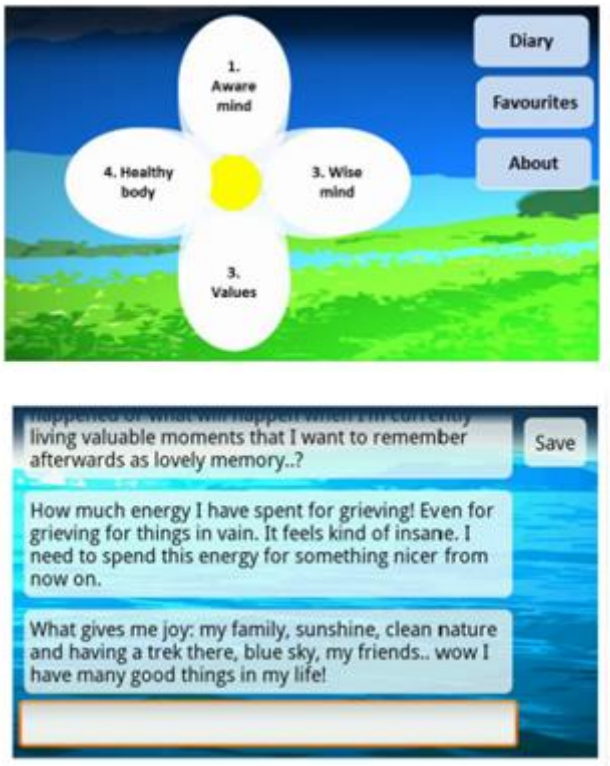


Figure 6.3. Main menu of the OIVA mobile application and example of a diary in OIVA.



Finnish pilot aims to use profiling for the following key use cases.

Coach (and customer) get recommendations for suitable wellness goals and interventions

System proposes suitable wellness goals and interventions based on the profile data, taking into consideration especially where the customer is in the change process, what his goals are and what the level of his mental and physical health is. Process is semi-automatic and interactive with the coach making the final choice. Profiling tool also visualizes the adherence and earlier activity levels of the user and could propose for example changes in the goals based on this. Profiling also is used to find methods that “have worked for people like me”.

Automatic feedback messages based on the profile

System provides automatic and semi-automatic varying feedback messages for the customer. These messages include greetings, encouragements and health tips. The tone of the voice and type of the messages is automatically tuned using the profile information. The customer can also tune the tone of the voice himself.

In the semi-automatic mode coach uses the feedback feature to get proposals for messages and she can edit the messages further.

Interactive analysis and editing of the profile

Coach and customer can both view the profile data using different types of visualizations. This is used especially to understand better customer’s lifestyle, personality type, daily habits and their effect on health. To some extend we also aim to provide possibilities for doing simulations with the profile: visualizing the effect on health when some of the parameters are changed.

6.3. Use cases for the WithMe pilot: examples from the Belgian pilot

This chapter describes the profiling parameters the Belgian With-Me pilot aims to use, and how the pilot will apply the profiling.

The Belgian WithMe pilot aims to create and pilot services to reduce the weight of obese people with a cardiovascular risk. This, by motivating the coachee to be more physical active and to eat and drink healthier. The pilot services combine face-to-face coaching on a regular schedule and online coaching through the WithMe system (in between sessions). Focus lies on self-analysis, goal setting, social support and personal values.

The services will target individuals and will be deployed through private healthcare as well as occupational health. The pilot study will focus on occupational health. Target group in the pilot are young (25-35 years), overweight (or obese) persons, with cardiovascular risk due to their weight.

Health and motivation coaches use in the pilot semi-automated tools that, based on profiling, can propose effective interventions and follow the progress.

Interventions in the pilot aim to:

– Create awareness and promote healthy habits,
– Teach skills on how to be physical active and eat and drink healthy
– Create a work plan/tasks/ goals about physical activity and healthy eating,
– Track daily activity and food intake
– Visualize health data and provide feedback, with the goal of promoting better self-knowledge and self-development.
– Help to identify and conquer the barriers,
– Support and motivate a healthy person to keep working on healthy habits

Adherence and effectiveness are studied using biomedical data, health and wellness tests, interviews and questionnaires. The pilot integrates together Ready2improve face-to-face coaching services and (existing) applications and tools (e.g. The Improver app).

Pilot aims to use profiling for the following key use cases.

Coach (and coachee) get recommendations for suitable interventions

System proposes suitable interventions based on the costumer's profile data, taking into account his level of mental and physical health, his motivational **profile, where the customer is in the change process and what his interests** and goals are. This process is semi-automatic and interactive. Final choices are made together with the coach during the face-to-face sessions.

> ***Example****: Based on the profile data an exercise plan was suggested. Since the user is not into sports at all, it includes Nordic walking sessions.*
>
> *Based on the medical history of the user (back problems) some exercises are excluded by the system.*

The profiling tool also visualizes the results, patterns and adherence of the user, provide specific feedback (related to personal goals/change in habits/improvement of health factors) and could propose for example changes in the goals or in the exercise plan, based on this.

> ***Example:*** *By tracking the heart rate of a user during the performance of exercises, the system can detect if the exercise is too light/too heavy and suggest an adjustment. Also, based on the profile and earlier registrations the system can generate smart defaults when a user fills in his food diary.*

By combining physiologic data, mood entry and some motivational questions, the system we can detect stress and motivation. In case of stress or low motivation the coach receives an alarm signal.

The type of interventions that the system suggests will depend on the user's motivational profile.

Example: *For a person who has a high need for affect, the system will focus on emotion (e.g. a video testimonial of a person similar to the user explaining his feelings before and after his change trajectory). For a person with a high need for cognition, the focus will lay on explaining facts.*

*Mini-games, gamification and competition does not work for everyone. Based on the user profile the system can select what is suitable. The theme of a mini-game could be adjusted to the goals of a person, e*g: *Peter has a tendency to eat fatty foods. The With-Me system suggests to play a little game (Smartphone application) where Peter has to toss hamburgers in a trash bin and catch fruits and vegetables. A variation could be throwing cigarettes or alcoholic drinks in a trash bin.*

Profiling also is used to find methods that "have worked for people like me". This is valuable information for a coach, but can help the system with recommending suitable interventions for user who just started (not much information is available at that moment).

Automatic motivational and feedback messages based on the profile

The system provides automatic and semi-automatic varying feedback messages for the customer. These messages include greetings, encouragements/motivational messages, examples and role models and health tips. The tone of the voice and type of the messages is automatically tuned using the profile information. The customer can also tune the tone of the voice himself.

In the semi-automatic mode coach uses the feedback feature to get proposals for messages and she can edit the messages further.

Example: *At a certain point the user receives a testimonial video to create awareness and encourage him to keep going. The profiling system selects a video of a person similar to the coachee.*

Based on the user profile the system decides which channel it will use to send small motivational messages (SMS, e-mail, smartphone notification, …).

Recommendation to join a certain online peer group

By using the characteristics of the user, the system recommends a certain online peer group to join. Other users in this group are similar to him (e.g. by gender, age, profession, health history, …). Also, the system could introduce the coachee to a specific other user of the system that could become a good mentor for him.

Interactive analysis and editing of the profile

Coach and customer can both view the profile data using different types of visualizations. This is used especially to understand better customer's lifestyle, daily habits and their effect on health. To some extend we also aim to provide possibilities for doing simulations with the profile:

- Predict results if a coachee sticks to his work plan
- Visualize the users future with some kilo's less

7. User Profiling Prototype

7.1. General description of the prototype

A prototype was developed to test and demonstrate

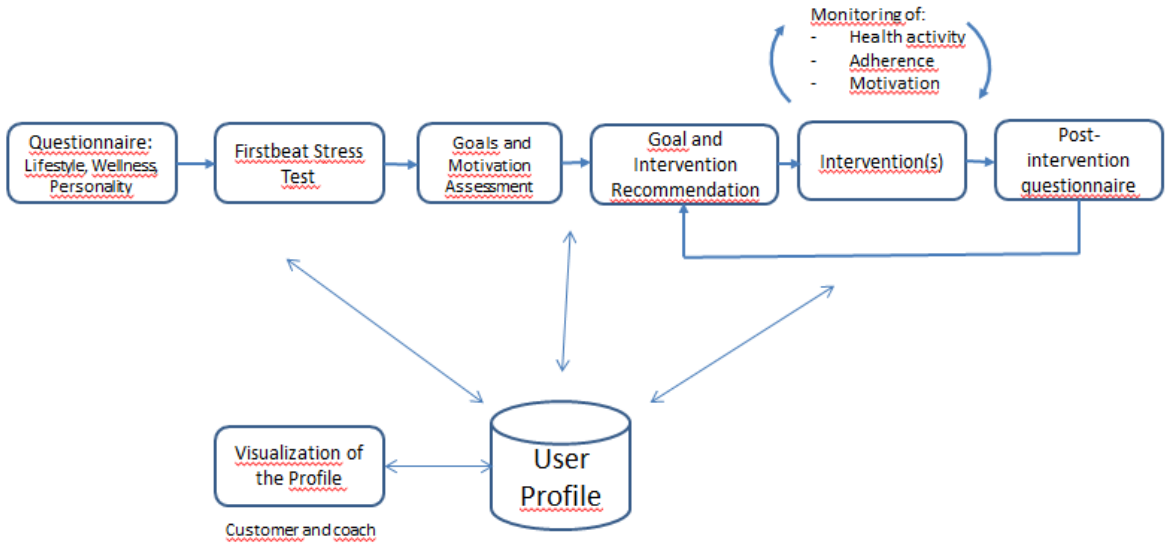
- Collection of the user profile data, including the motivational factors and preferences
- Visualization of the user profile for the coach and for the customer
- Monitoring of conscious health activities and the time-varying level of adherence and motivation

The prototype was tested with a small number of users to assess its usability and general understandability.

In the pilot the profile, conscious health activities, adherence and motivation information are used to tune and adapt the coaching strategy and the health and wellness tasks to the individual needs and preferences.

Prototype key elements are depicted in the Figure 7.1. First step is to collect basic profile information describing the current lifestyle, wellness and personality of the customer. This information is collected using a web-based mobile survey questionnaire and a 3-day lifestyle assessment using the Firstbeat lifestyle assessment tool. For the needs of the prototype the questionnaire is quite long. Target is to utilize the prototype to find the key parameters needed for the adaptation of the coaching strategy and for selecting the interventions. The questionnaire can then, based on the results, be shortened. It is also possible to split the questionnaire to several short question sets that can be gradually presented to the customer during the coaching. Full questionnaire can be found from Annex B of this document.

Figure 7.1. Elements of the conscious user health and motivation profiling prototype.



The next step is to assess the goals and motivational factors for the customer. Profile information is utilized to recommend / propose health and wellness goals. Based on the choices and the profile information interventions can then be proposed. The prototype does not yet include the logic for making automatic recommendations for the interventions, this will be a subject of further study and development.

During the interventions information is collected about the conscious health activities and on the adherence and motivation levels. Movendos tool is used for delivering the interventions to the customers, following up the progress and for the adherence follow-up.

After the intervention a post-intervention questionnaire is used to assess the personal expression of the task and its usefulness for improving health and wellness. Results of this are used to improve the recommendations for the interventions both at the individual and at the group level.

During all steps of the process the user profile is continuously adapted according to the results. Profile information is also visualized both for the customer and for the coach.

7.2. Lifestyle and wellness assessment

Mobile- and web-based questionnaires were developed for collecting information about the lifestyle and wellness status, including both mental and physical wellbeing. Questionnaires are tailored according to the needs of the Finnish WithMe pilot focusing on reducing stress and improving the mental wellbeing. Many of the pilot interventions are for the whole family, thus the questionnaire contains several detailed questions about the family situation.

First part of the questionnaire is utilized for collecting basic background information about demographics, work situation and family situation. Next set of the questions addresses the current health situation, containing questions needed for assessing if the customer passes the inclusion criteria for the pilot. Key inclusion criteria for the purposes of the pilot are that the customer does not have serious diagnosed diseases, he has been experiencing some stress-related problems, he preferably has a family with small children and is employed.

Second part of the questionnaire tackles the lifestyle and wellness situation, values, personality characteristics and the personal motivation to lifestyle change. Users are rating assumptions related to their own impression (e.g. *"I'm satisfied with my current eating habits", "I believe I can influence my own health and wellbeing"*) and answering questions collecting actual data (e.g. "*How many portions of alcohol do you consume during one week?", "How often do you perform physical activities which cause sweating and get you out of breath?*", *"Your weight?"*).

Personal values are assessed based on the Schwartz values (Schwartz1994) method, where the values are divided to Power, Achievement, Hedonism, Stimulation, Self-direction, Universalism, Benevolence, Tradition, Conformity and Safety. The questionnaire we built is slightly modified from a shortened version of the Schwartz values questionnaire presented by Lindeman et al. (Lindeman2005). In addition to describing an important part of the personality traits the values are also utilized for getting supportive information for the intrinsic vs. extrinsic motivation analysis.

Personality traits are analyzed using the TIPI (Ten Item Personality Inventory) (Gosling2003), which is based on the well-known and widely-utilized Big Five Personality Traits (John1999). These traits are; extraversion, agreeableness, conscientiousness, neuroticism and openness to experience. According to John and Srivastava: "The Big Five structure does not imply that personality differences can be reduced to only five traits. Yet, these five dimensions represent personality as the broadest level of abstraction, and each dimension summarizes a large number of distinct, more specific personality characteristics."

One question also addresses the personal learning style, aiming to assess if the style: is auditory, visual or kinesthetic. This is based on the Fleming's widely-used (Leite2009) VAK/VARK model of learning styles. Fleming claimed that visual learners have a preference for seeing (think in pictures; visual aids such as overhead slides, diagrams, handouts, etc.). Auditory learners best learn through listening (lectures, discussions, tapes, etc.). Tactile/kinesthetic learners prefer to learn via experience—moving, touching, and doing (active exploration of the world; science projects; experiments, etc.). This information can be utilized in tailoring and personalizing the content of the interventions.

Final part of the questionnaire addresses the personal motivation to lifestyle change, providing input for awareness, readiness for change and self-efficacy parameters in the personal data model.

Full questionnaire can be found from the annex B of this document.

Figure 7.2. An example of the questionnaire user interface

Pilot customers fulfilling the inclusion criteria next conduct a 3-day Lifestyle Assessment using the Firstbeat tools.

Firstbeat Lifestyle Assessment (Firstbeat Technologies Ltd, Jyväskylä, Finland) is a tool for healthcare, well-being and fitness professionals to concretize the health effects of various lifestyle factors. The goal is to support individual well-being by measuring, for example, the sufficiency of recovery, sleep quality, and health and fitness effects of exercise. Assessments bring out individual development areas and strengths in order to make it easier for well-being and health professionals to focus their guidance and action points for the client.

Firstbeat's analysis technology is based on recognition of different bodily reactions from heart rate and heart rate variability that are universally known to reflect autonomic nervous system activity (Task Force 1996). For example, the following essential bodily functions affect the heartbeat: autonomic nervous system adjustment, breathing, hormonal reactions, metabolic processes, physical activity, relaxation, movements and postural changes, cognitive processes, as well as stress, mental load, and emotions. The Firstbeat method has been utilized e.g. in studies of work stress and psychological stress interventions (Uusitalo2011; Lappalainen2013), sleep (Myllymäki2011), and sports coaching (Vesterinen2013).

The Lifestyle Assessment service includes performing a heartbeat measurement, analyzing the results, a feedback session, planning of goals and possible follow-up measurements. The client carries out a 3-day heartbeat measurement in normal daily life, and the data is analyzed with the Firstbeat software. Typically the measurement period includes 2 work days and a day-off, and the nights between these days. As a result, Firstbeat Lifestyle Assessment provides personal information about daily stress, recovery and physical activity.

7.3. Goal setting and forming the action plan

Next step in the process is to utilize the collected profile information to recommend goals and later interventions for the customer. Customers can, however, do not need to stick to the recommendations but can select any goal from the list of ready-made options, or they can define their own goals. Goals and interventions together form the action plan. Coach utilizes the profile information and the goal

recommendations in the motivational interview she holds with the customer before the actual interventions start. During this interview it still is possible to discuss and modify both the goals and the interventions. At the time of writing this document, the automatic goal recommendation has not yet been implemented.

After customer has selected a goal, system asks a couple of questions. The goal is to gain more information about the intrinsic vs. extrinsic motivation, self-efficacy and the stage of change for each goal.

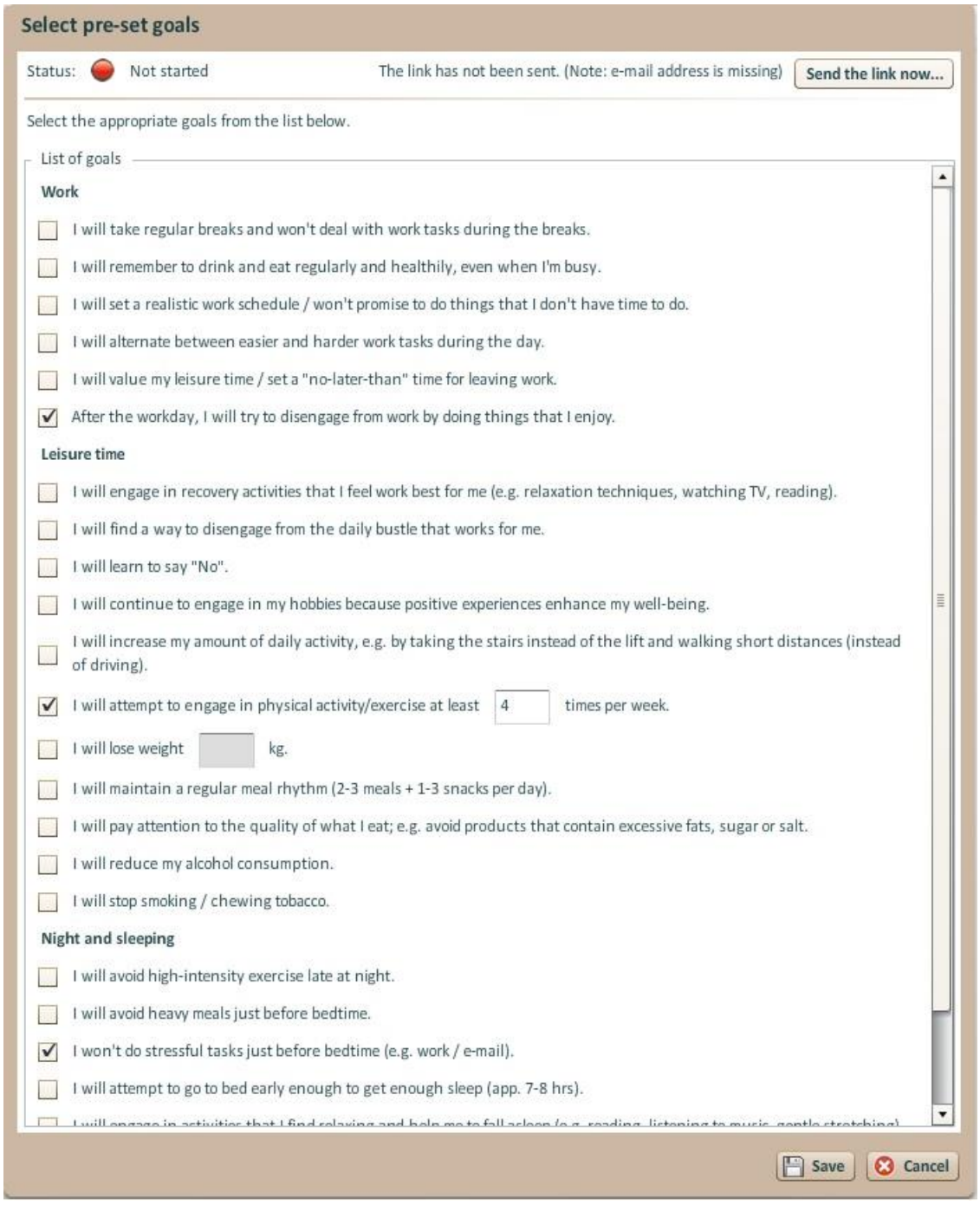
First questions focus on sources of motivation and the self-efficacy. First two questions are adapted from the Personal Striving Assessment (Emmons1986). Customer rates all assumptions using the scale 1-5 ((1 Strongly disagree - 5 Strongly agree)):

- *I selected this goal because I found it personally important and inspiring. The expectation or preferences of others did not influence my choice.*
- *I selected this goal due to the opinions of others or for the sake of someone, or because I would feel shame, anxiety or guilt if I did not choose the goal.*
- *I anticipate that it will be very challenging for me to reach this goal.*
- *I believe that my partner will support and encourage me to work towards the goal.*

Next question aims to address the state of change. Selecting option 1 refers to pre-contemplation phase, 2 to contemplation, 3 to preparation, 4 to action and 5 to maintenance.

Are you willing to put effort into achieving the goal you have set?
1 Not for a long time
2 Yes, within the next 6 months
3 Yes, soon (within the next 4 weeks)
4 Yes, I have been putting effort into reaching the goal already for some time (less than 6 months)
5 Yes, I have been working actively towards reaching the goal already for more than 6 months

Figure 7.3. Example of selecting a personal goal (Firstbeat Ltd)



7.4. Following of the motivation changes, adherence and conscious health activities

Conscious health activities are followed up using the Movendos tool. Coaching program in Movendos is modelled and implemented as a series of interventions. Interventions are modelled as a series of successive tasks having a repetition pattern: e.g. “Do every day”, “Do at least 4 times every week”, “Do every Friday at 16:00”, “Do at least 5 times during the coaching program”. Customers get reminders and can record their progress in different ways. Some task types record the progress automatically, in some tasks the user manually feeds in the information. Movendos provides also automated feedback.

All tasks have a “workbook” view for recording the progress and a “summary” view for showing the progress and supporting the user in striving towards the target. Movendos task types support a high level of personalization, where the contents of the task and feedback can be tailored according to the person and the situation.

Movendos records and makes visible in one place the conscious health activities and the progress towards the targets. Same information can be viewed both by the customer and by the coach. Many of the tasks are actually done outside the Movendos system using external apps and services, but Movendos is utilized to collect together the information about the conscious health activities and progress.

Examples of interventions include e.g.

- Learning a new healthy habit by repeating the same preferred behavior in the same situation. E.g. “Use stairs every day in the office instead of taking the elevator”. Customer gets reminders, records his daily behaviors to the system and strives to reach the habit by performing the behavior regularly. Preferred behaviors can be highly personalized according to the situation and the person.
- Maintaining a self-diary. Diary makes the actual behavior more visible and supports self-reflection. Different types of diary templates exist for e.g. following up the nutrition, sports and exercise, stressful situations and own behavior in those and for analyzing the motivation and factors affecting that.
- Activating the customer to exercise more and be more active by setting up activity targets and activity competitions. Activity is measured by using the FitBit (www.fitbit.fi) activity meter and related web service. User actively uses the FitBit system, and the activity levels are recorded automatically also to the Movendos system and compared to the target levels
- Measuring and following up different parameters related to health such as the weight.
- Creating and following up progress in progressive weekly training programs. Examples: sports and exercise programs, relaxation programs, gradual behavior change programs done in small steps.
- Delivering focused information packages and mini-questionnaires

Figure 7.4. Example of a Movendos habit-forming task. At the left the mobile workbook view for recording the progress. View at the right shows the customers progress towards the target. Regularly repeating the behavior takes the customer towards the “crown” and new behavior, while relapses in regularly repeating the behavior slow down the progress.

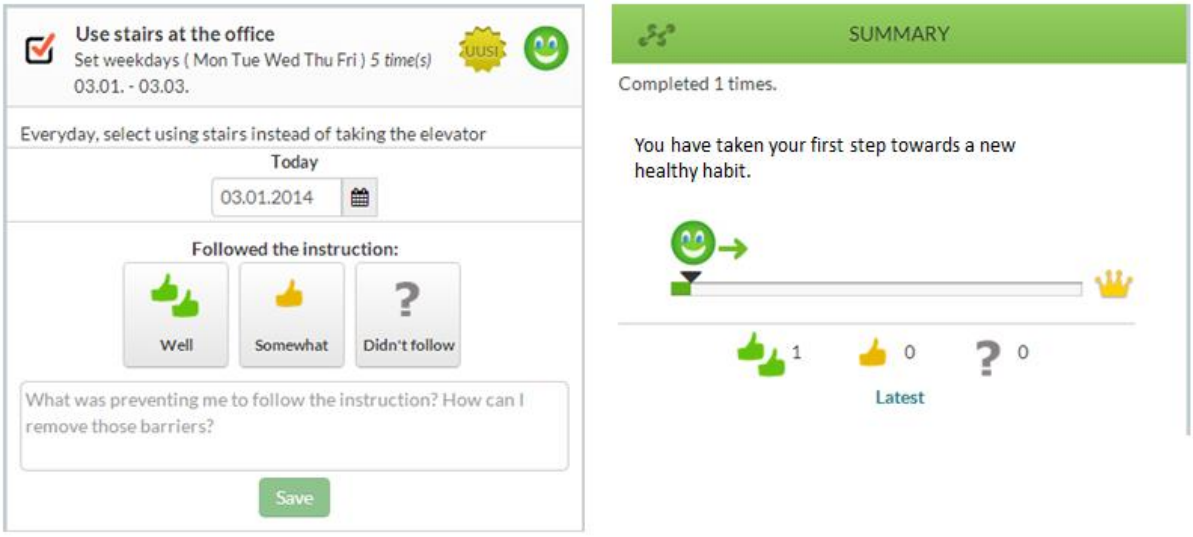
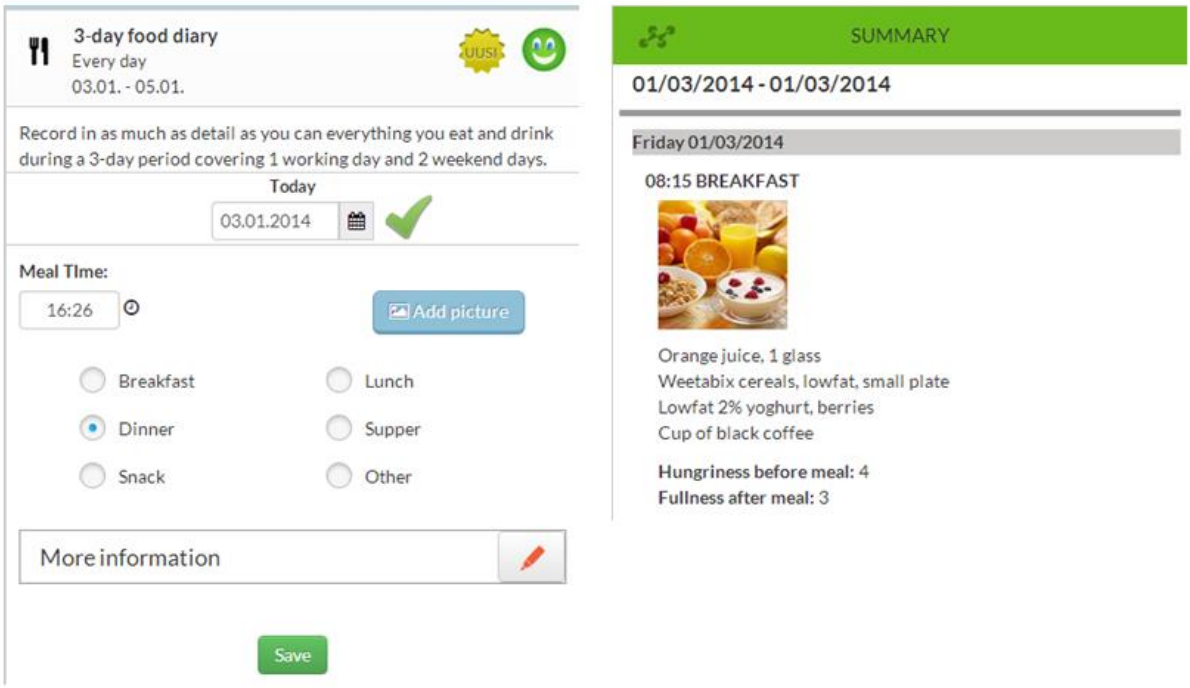


Figure 7.5. Example of a food diary task in the Movendos system.



In addition to following the conscious health activities, both motivation and adherence are followed up in various ways.

Movendos system is used to continuously monitor and record the adherence levels during the coaching. All interventions are scheduled according to the selected scheduling logic, and the system keeps track if users are actively doing the tasks or not. Adherence is also an indirect measure of the intrinsic motivation and changes in that, and changes in adherence can be used to automatically activate feedback messages and additional interventions aiming to improve the intrinsic motivation.

Adherence is followed up using a simple algorithm that measures:

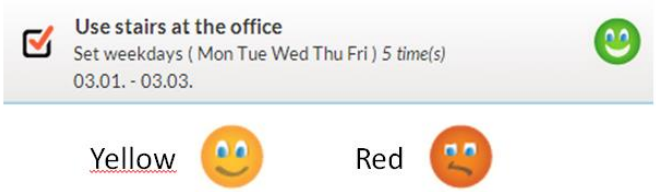
- *Short-term changes in adherence levels*: "has the customer lately performed the task according to the agreed schedule". These provide a quick indication if the customer starts skipping his scheduled wellness tasks. This short-term adherence measure has three states: red, yellow and green following the traffic light metaphor (see Fig. 7.6.).
- *Total adherence (TA) to the intervention during the coaching*: The relation of tasks performed by the customer (B) to the total number of scheduled tasks (A). TA = B/A. This is measured always from the beginning of the intervention.

The short-term adherence is used as a quick visual indicator both for the coach and for the customer to show how active the customer has lately been. The traffic light gradually turns from green to red, if the customer skips his scheduled wellness activities. Logic is the following:

- Miss one scheduled activity: indicator stays green
- Miss two activities successively: indicator turns yellow
- Miss three activities successively: indicator turns red
- Do the activity according to the schedule: indicator turns instantly green.

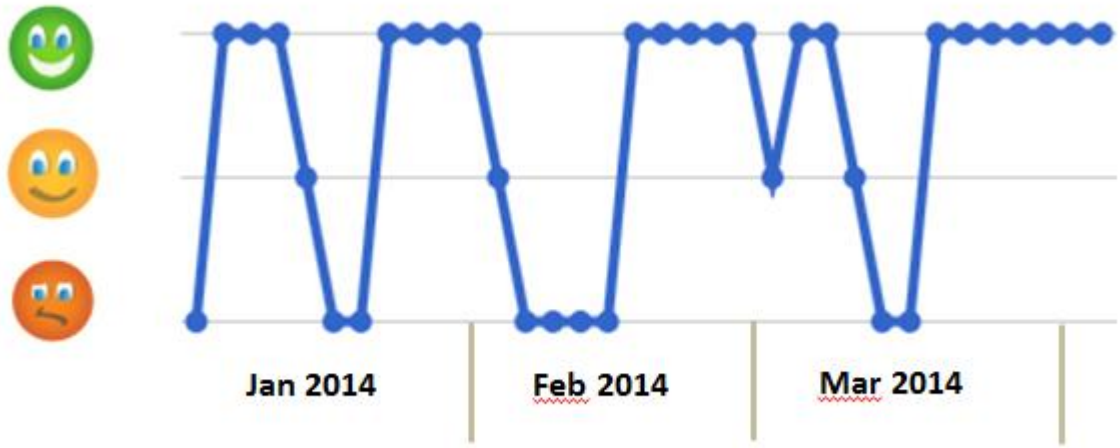
The logic aims to increase motivation and is "optimistic". Customer is not punished for missing one scheduled activity, and always when the customer starts again doing the task he is instantly rewarded with a green indicator.

Figure 7.6. Examples of indicating short-term adherence level in Movendos tasks



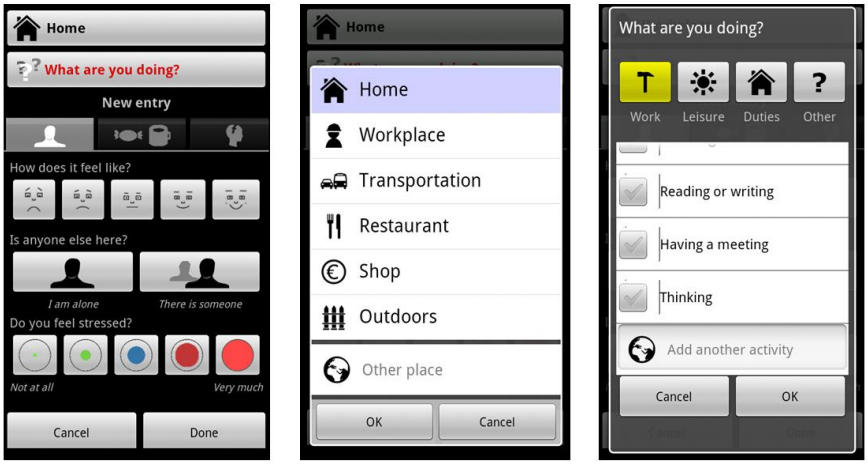
Short-term adherence levels can also be monitored as a function of time.

Figure 7.7. Example of the variability of short-term adherence levels over time during an intervention. In this example total adherence TA = 21734 = 0.62.



Additionally, for following up the feelings and motivational changes during the daily life, the pilot aims to use a mobile self-reporting tool developed by the Technical Research Center of Finland and the National Consumer Research Centre of Finland (Vanhala et al. 2012). Tool is an application for Android smart phones that prompts ratings of subjective experiences from the customers. Application utilizes also GPS and accelerometer of the phone, which makes it possible to try to find opportune moments for the prompts, for example based on the physical location of the user.

Figure 7.8. User interface of the mobile self-reporting tool developed by the Technical Research Center of Finland.



When the intervention consisting of a series of scheduled tasks finishes, the customer is prompted to answer a couple of questions related to the perceived usefulness of the intervention and the suitability of the intervention for customer. Movendos system is utilized for the prompting. These questions are:

- *It was fun to do this task*
- *I think this task was useful for improving my health and wellbeing*
- *This task was difficult*
- *I was very active in doing this task*

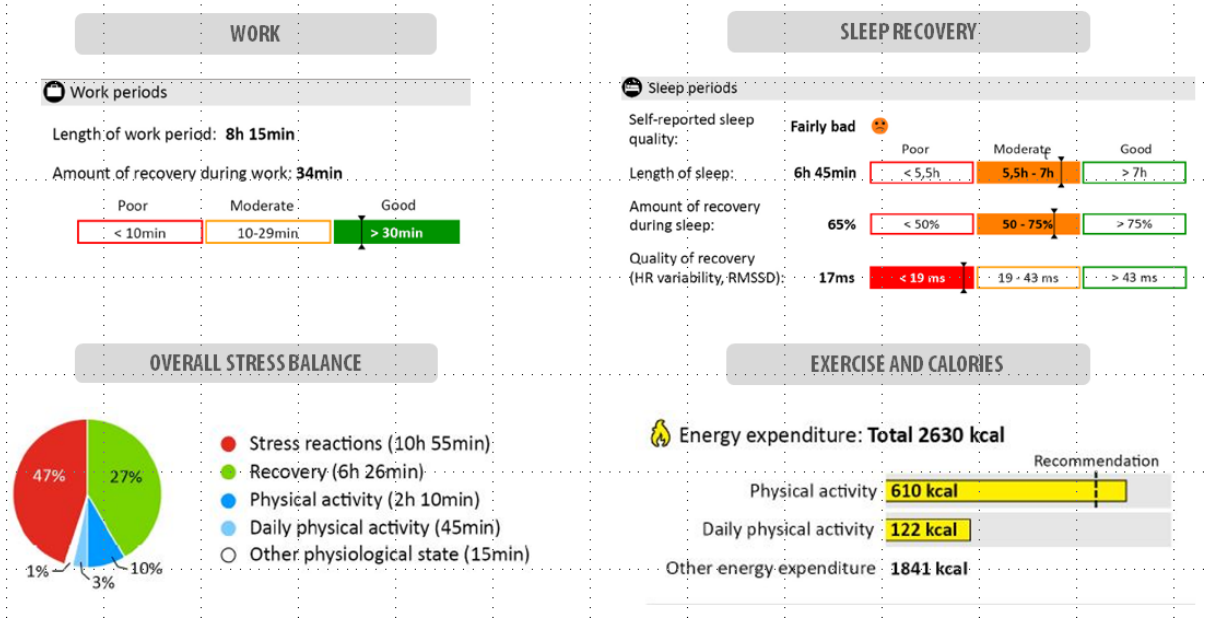
Customer rates these assumptions using the scale of: 1 Strongly disagree - 5 Strongly agree. Ratings results are stored into the profile and used for improving the recommendations for new interventions and new goals. When the system contains data from a lot of users, this information becomes also very useful for improving in general the quality of the recommendations and also for collecting data about the impact of the interventions. As in any Internet-based recommendation system, we can start providing recommendations such as "*people like you and in a similar situation where you are now, have often benefitted from….*".

7.5. Visualization of the profile information: examples

This chapter shows examples of ways how the profile information can be visualized for the coach and for the customer, so that it can be used to gain insight into the customer's situation and for supporting the choice of the interventions. Examples are based on the Finnish pilot.

In addition to questionnaires, Firstbeat measurements and lifestyle analysis tool are utilized to collect information about the actual stress and recovery patters during a 3-day period. Measurement also gives concrete results on the amount and quality of sleep and on the actual amount of exercise. This information is stored to the profile and can then be compared to the individual perceptions of the customer about sleep quality, stress and amount and quality of exercise.

Figure 7.9. Example of the results of a Lifestyle Analysis conducted using the Firstbeat measurements



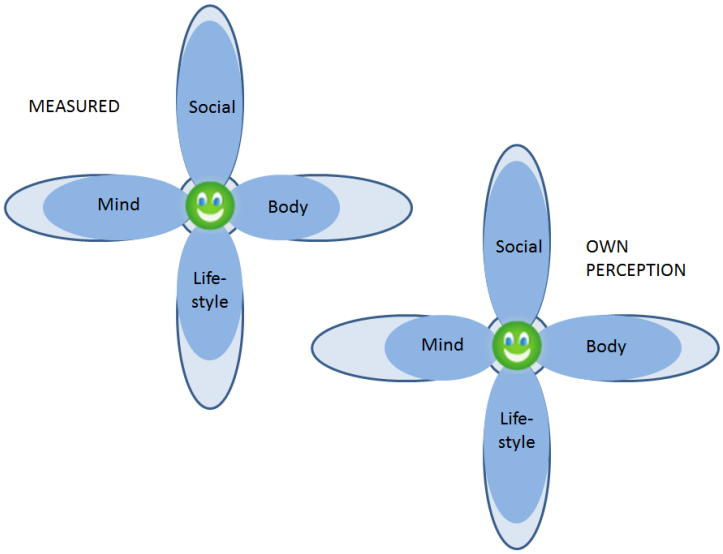
The Finnish pilot will also utilize activity tracking devices such as Fitbit (www.fitbit.com) for following up the amount of daily physical activity.

After the measurements and questionnaires customers wellness status can be summarized in various ways. Wellbeing status is divided into four areas: physical, mental, social and lifestyle-related. Figure 7.10 shows one example of summarizing the status. Summarizing parameters describe the status as one number. It is possible to drill deeper into any of the areas to see the more detailed parameters. For the sake of an example, “Measurements / mental wellbeing” and “Mental wellbeing: own perception” are opened up in Figure 7.10. All the parameters used to describe the wellness profile in the Finnish pilot are listed in the Annex A of this document. Figure 7.11 shows a more visual way of presenting the same information. This visualization used the metaphor of a flower and its pedals to who the wellness status. Light blue background pedals show the “ideal situation” and darker blue pedals on top of it the measured wellness status, which can also be compared to the customer’s own perception of his wellness. Smiley face in the center of the flower shows the overall happiness level as perceived by the customer.

Figure 7.10. Example of a summary of a wellness status based on the profile information. Mental wellbeing parameter section shown opened up, others are closed.

WELLBEING: SUMMARIZING PARAMETERS						
Overall wellbeing status	■	■	■	■		
Perceived overall wellbeing	■	■	■			
Physical health	■	■	■			
Mental wellbeing	■	■	■	■		
Healthiness of lifestyle index	■	■	■			
Social wellbeing	■	■	■	■		
BODY: PHYSICAL HEALTH AND WELLBEING						
Measurements / physical health						
Health conditions						
Health conditions: own perception						
MIND: MENTAL HEALTH AND WELLBEING						
Measurements / Mental wellbeing						
Depression level	■	■				DEPS
Anxiety level	■					GAD-7
Quality of sleep	■	■	■			Firstbeat
Ability to relax	■	■				Firstbeat
Mental wellbeing: own perception						
Happiness level	■	■	■	■		
Stress level	■	■	■	■		
Stressors: work	■	■	■	■		
Stressors: family	■	■				
Stressors: Economical situation	■					
Stressors: Time	■	■	■	■	■	
Stressors: Personal	■	■				
Stressors: Negative life event						
Stressors: Other						
General life satisfaction	■	■	■	■		
General time management satisfaction	■					
Day-time tiredness	■	■	■			
Sleep quality	■	■	■			
LIFESTYLE						
Health habits / physical activity						
Health habits / sleep						
Health habits / diet						
Health habit / alcohol						
Health habits / other						
SOCIAL WELLBEING						
Life satisfaction						
Social support						

Figure 7.11. Summary view of the wellbeing status, comparing measured status and customers own perception of the wellbeing. Size of the pedals shows the difference between the current and the “ideal” situation. Size of the smiley face in the center shows the level of perceived happiness.



To find the right interventions for the customer it’s important to understand both the personality type. To describe the personality the Finnish pilot combines information from TIPI (Ten-Item Personality Inventory) (Gosling2003), Schwartz values (Schwartz1994), VAK/VARK learning theory (Leite2009) and the Personal Striving Assessment (Emmons1986).

Figure 7.12. depicts an example of using the profile information to create a description that helps the choice of an intervention and for adapting the feedback style. For example, the personality profile in Figure 7.12. scores 5 in the “social doer” dimension (the further the dot is from the center, the more prominent is the corresponding dimension). The person clearly would prefer team activities, but because the “competitive” dimension is low, they should not be competitive. Person also would like to receive clear guidance and he does not prefer free exploration. If the intervention would be in the area sports, for example team Pilates might be a good idea. Person also tends to worry too much and be too perfectionist in what he is doing. This needs to be considered in planning the interventions, and the provided guidance should emphasize how many exercises one should do, and that doing too much exercise might even be harmful.

Figure 7.12. Example of a personality profile. The further the dot is from the center, the stronger the personality dimension.

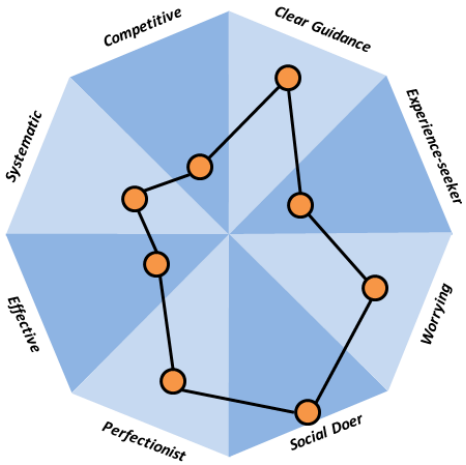
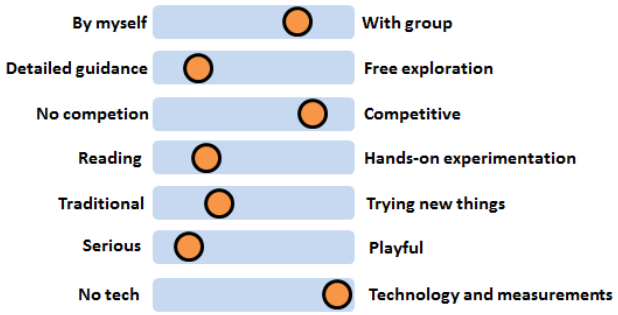


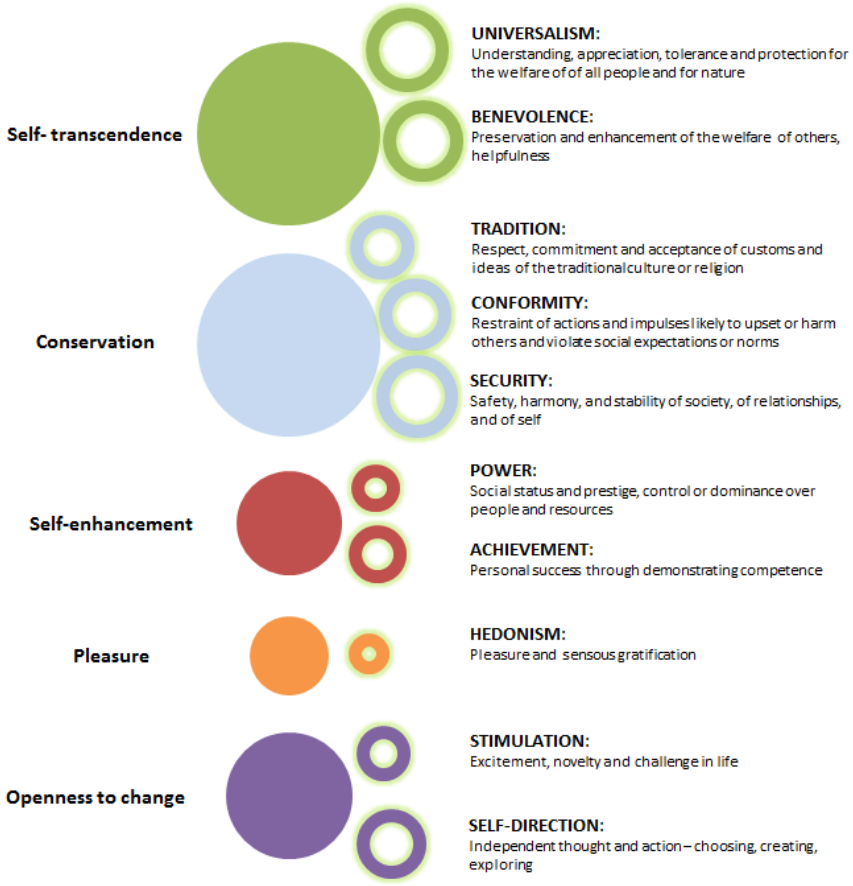
Figure 7.13. shows another way of visualizing the personality type. In this case the focus is on directly indicating the characteristics of the interventions that would fit to the personality type and to the preferred learning style. Chart combines information from the personal preferences parameters (see Annex Y for details), learning style and TIPI analysis. In the example case in Figure 7.13 person prefers competitive group activities, where measuring progress and playing with devices should play a high role. Interestingly, he also is at the same time a traditionalist, who prefers clear guidance. Continuing the ports example, team running competitions where heart rate and GPS monitoring are used might be a good idea for him.

Figure 7.13. Example of visualizing the personal preferences for interventions.



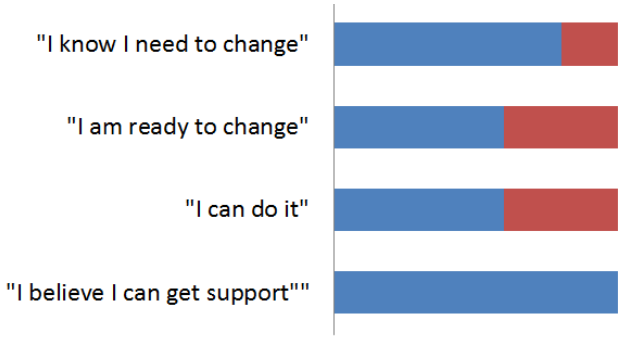
Value analysis is a good tool to understand better the deeper values of the customers. Figure 7.14. shows an example of visualizing the results from the Schwarz value analysis. Size of the coloured ball shows the importance of that particular group of values (Self-transcendence, Conservation, Self-enhancement, Pleasure and Openness to change) for the person. Size of the smaller circles at the right side correspondingly shows the relative importance of the more detailed values in that value domain.

Figure 7.14. An example of visualizing the results of Schwartz value analysis.



When the action plan has been created and right goals selected, it is useful to analyze the readiness for change and self-efficacy. Based on the parameters in the "Resources" section, Figure 7.15 summarizes the awareness ("*I know I need to change*"), readiness ("*I am ready to change*") and self-efficacy ("*I can do it*") into one chart, combining information from several profile parameters together. Figure 7.15 also shows the perception of the level of support from the close ones.

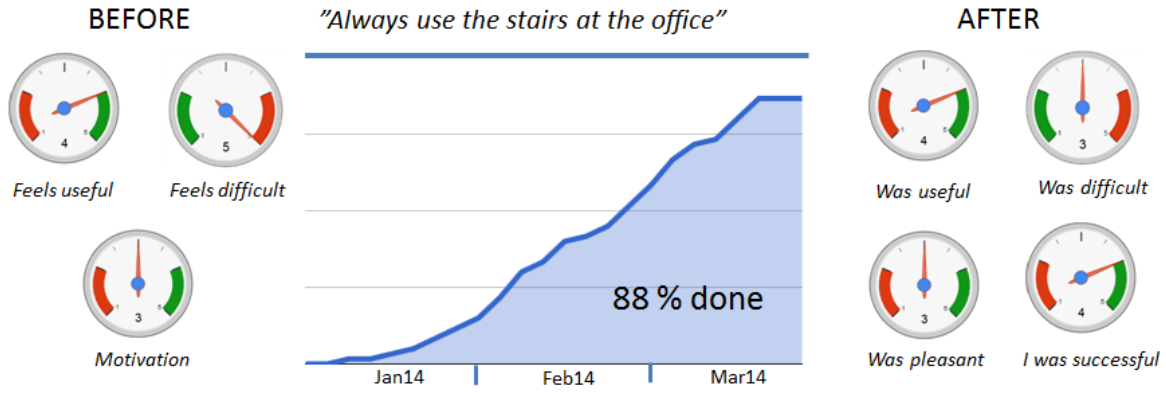
Figure 7.15. An example of visualization of the awareness of the need to change, readiness for change, self-efficacy and social support. The smaller the red part, the better the situation.



The motivation and user experience of each intervention is analyzed in the pilot system. Figure 7.16 depicts an example of a visualization combining together assessments before and after the intervention and the information about the adherence to the intervention (in this case a habit-forming task of "Always use the stairs at the office". Green areas in the gauge-type meters show the "green target area". Curve described the adherence by showing the customer activities as a function of time.

Straight line at the top of the image corresponds to “all scheduled activities done according to the action plan”. Total adherence (88 % in the example) is calculated as a relation of tasks performed by the customer to the total number of scheduled tasks. Own perception of adherence and success rate is also asked from the customer after each intervention, the result shown in the “I was successful” gauge meter.

Figure 7.16. An example of visualizing the motivation, user experience and adherence of an intervention.



7.6. Results from user testing

The set of questions included to the prototype, regarding the collection of user model data, were tested with four persons. The tested questions were in Finnish, but their English translation can be found in appendix 1. The aim was to test 1) how people interpret and feel about the questions, since many of them could be perceived as rather personal, and 2) whether the questions were understandable and the answering options sensible. Each of the test respondents were asked to fill out the prototype’s web-based questionnaires while thinking out loud. For each respondent a separate testing session was arranged. As the respondent answered the questionnaires, a researcher took notes about the respondent’s thoughts and feedback regarding the formulation of the questions. Two of the respondents were men, two had children. Most of them were employed full-time and lived together with a spouse. The mean age of the respondents was 30 years.

In general, the questions (in Finnish) were regarded as clear and easy to answer to. No one felt answering them as particularly burdensome, and none of the questions were perceived as awkward or unpleasant. However, for several questions, improvement ideas emerged from the tests. For these particular questions, the problems and improvement suggestions are presented in appendix 3.

8. Summary and Some Guiding Principles for Utilizing User Profiling

8.1. Key results and discussion

The purpose of WithMe task T2-2 was to propose methods and solutions for creating user models for health coaching. By utilizing personal models WithMe can select those BCTs (behaviour change techniques) that work best for a certain person in a certain situation, and can be tailored to the characteristics of the user, leading to a higher level of motivation. These models are used in WithMe for matching the personal health profile, changes in motivation and changes in activity with appropriate coaching and intervention strategies. Personal user models create the possibility for creating coaching programs tailored, automatically or semi-automatically, to the needs and preferences of the individuals.

The work plan description of T2-2 phrases the use of profiling as “continuous monitoring of conscious health activity, motivation levels/style and preferences”, “collecting user information at different moments in time” and “matching with coaching and intervention strategies”. The original description emphasized a lot the contextual/momentary adaptation of the coaching strategy. In our work, we decided to expand the coverage of the task. While contextual adaptation is an important area of profiling, the selection and recommendation of BCT’s and interventions and adaptation of the representation style of the coaching system based on user model are even more important.

We started by first describing the role user models and health and motivation profiling could play in the WithMe system. This was outlined in the **technical architecture** proposed, where we decided to propose that the profiling solutions could be implemented as an independent entity. A profiling solution would include a database of user-related personal data (past, current, future), which would be connected with the dynamic user model (named in the architecture “VirtualMe”). VirtualMe defines the structure and interrelations in the personal data. The Profiler module would analyze data from different data sources and keep the VirtualMe user model information up-to-date. Guidance engine in the architecture is a separate module including the recommendation and delivery of interventions, and the monitoring of user progress.

The Finnish WithMe pilot aims to implement the first prototype of the profiling solution and the guidance engine. By implementing the profiling solution as an independent entity, also other pilots in the WithMe project could utilize it. Goal of the WithMe architecture is to build an ecosystem where different services and applications can flexibly be combined together. The way how we model the profiling solution fits well to the WithMe architecture view, and should be included in the architecture. We aim to work actively with the technical architecture work packages to ensure that our input on how the profiling could be implemented is included in the final architecture.

In addition to architecture, we also proposed **design principles** that the implementation of the profiling solution should follow.

For the purpose of building a solid theoretical foundation for the user model, we decided to put a lot of effort on identifying the factors that influence behaviour and behaviour change. It is important to have these factors reflected in the user model parameters. We directly applied the results from the work package 2, Task T2-1, in which a set of behaviour change theories and techniques were selected for the WithMe. **Seven areas of factors influencing behaviour and eliciting behaviour change** were identified for the user model: Reasoned behaviours, automatic behaviours, environmental contexts, life stages, effective communication and stages of behaviour change. We feel one strong aspect of the created model to be in the way how it separates reasoned and automatic behaviour, where automatic behaviour refers to habits: actions performed with little or no conscious thought. Reasoned behaviour refers to actions which are carried out with conscious thought and decision, and result from deliberate intention. The three main behavioural determinants for reasoned behaviour are intention, ability and absence of barriers. We also built a **model for the stages of behaviour change**, utilizing TTM and HAPA models as the basis. The model has four steps: Discovery, Intention, Plan and Maintenance.

The core result of the work in this delivarable is a **proposal for a holistic architecture and model of the dynamic user profile**. The model is proposed to form the skeleton for architecture for the user model implementations in the WithMe architecture. The model is founded on a solid theoretical basis. It consists of five parameter groups: wellbeing status, resources, goals & motivation factors, life situation and action plan.

The wellbeing status combines together measurable and quantifiable health conditions, health-related habits and the persons own perceptions. By comparing own perceptions and actual measurements, the model can make estimates e.g. of the level of awareness. In the Resources group, motivational factors for lifestyle change, psychological characteristics, motives & preferences and technology usage are included. Our belief is that linking the behaviour change goals and interventions to personal values in life and using the values can make the goals and interventions more significant. This thinking is reflected in the way how the resources section is structured.

Our proposal is to link in the user model together the description of the person and his wellbeing status, his personal goals and motivational factors and the actual action plan: the interventions. User model keeps track of what interventions the person has done, records his progress and adherence and also keeps track on the own perceptions of the person on the usefulness of the interventions. This builds a "closed control loop", where the WithMe system can record which types of interventions work well for persons having similar user models. This kind of solution can scale well in the Internet: by having more and more users we can gather more user models, the system can continuously learn and provide better recommendations.

As far as we are aware, the user model structure we propose is the most comprehensive. We also uniquely combine together the parameters describing the user and the parameters describing the action plan. Proposed user model is wide and holistic, and the first implementations in WithMe will most probably not utilize it to its full extend.

We also **analysed the use of user modelling in services and application intended for health coaching and health promotion**. Up to now, we have not been able to find in the literature holistic health and wellness coaching solutions that would utilize personalization and user modelling at a deep level. Among the ones studied, ORCATECH system (Rivera2013) is among the most advanced. ORCATECH health coaching platform (Rivera2013) utilized a dynamic user model (goals, motivations, barriers, health state, cognitive level) in both tailoring feedback and for selecting interventions and tailoring the action plan. Computational model derived from systems theory was utilized for inferring behaviours and health states and for identifying the status of the behaviour change. Commercial products such as Noom (www.noom.com) perform well in collecting information from the user and in using that for personalizing the service on-the-fly. Several wellness companies exist claiming to deliver personalized automated behaviour change support, such as *WellnessLayers* (www.wellnesslayers.com), but from the available material it is not easy to deduce how much and how they utilize user models and personal profiling.

Context-based adaptation of services has been a hot research theme for quite some time, but up to now the results have not lived up to the promise yet. Context-aware research has typically focused on inferring user's current states or activities based on combining information from GPS, activity sensors, time, calendar and social interactions. Current technology starts to be able to perform this type of interference with a rather good precision. Even more complicated spatio-temporal events such as "*leaving home*" or "*returning from vacation*" can be detected. More widespread use of sensors and advanced technologies such as the Google Glasses will further open new possibilities for context detection. For adapting health interventions based on context, the harder problem than detecting the context is to infer what do. Real-life situations are complicated and if systems try to be "too intelligent" the danger of receiving annoying and false recommendations increases.

Contextual guidance can also in many cases be directly asked from the users. Users can fill in preferences how and when they would like to get encouragements, reminders and other feedback messages (e.g. preferred delivery media, reminder times, tone and style of the messages, physical locations). This can help to improve the user experience of automatic feedback.

Due to this, we decided not to emphasize the contextual adaptation of interventions as much as it was emphasized in the work plan of the WithMe project.

To concretize the use of user modelling, we also created a set of **use cases** that give concrete examples on how the user modelling can be applied in practice. We hope that the WithMe pilots can use these as inspiration for creating the pilots. The use cases also can be used in creating the WithMe architecture description (and have already been used there). We also describe the Finnish and Belgian pilot systems and how they plan to utilize the results and profiling in practice.

Finally, we present **a prototype**, that was developed to test and demonstrate: a) Collection of the user profile data, including the motivational factors and preferences, b) Visualization of the user profile for the coach and for the customer, and c) Monitoring of conscious health activities and the time-varying

level of adherence and motivation. The prototype at the same time forms the basis for the Finnish WithMe pilot system. The prototype is built on top of the Movendos health and wellness coaching web-based system created by TUT in earlier projects, For WithMe the system was expanded with a set of profling tools and questionnaires, that are utilized to collect and analyse the information needed for creating the user models. The questionnaires were also user tested and adapted according to the results. The questionnaires can be utilized by other WithMe pilots. The questions in the questionnaires are in the Appendix of this deliverable and can also be provided in electronic format.

For the prototype we also show different ways to visualize the user profile information for the key WithMe use cases. WithMe pilots can use these visualizations as inspiration. We also present simple ways to monitor and follow up the adherence to interventions and ways how the feedback mechanisms can be built.

User modelling and profiling is a wide area. We decided to both build and present a solid foundation for user modelling and to make it more concrete for WithMe implementations through examples, use cases and prototypes. We think that our results fulfil, and in some areas exceed, the goals set for T2-2, and we hope that the results will be utilized in WithMe architecture development and in the pilots.

8.2. Tips and guidance for utilizing user profiling in WithMe pilot

In this final chapter, we present a short bullet point list of tips and guidance for utilizing user profiling in WithMe pilots and in general in health and wellness coaching systems, based on this deliverable.

A health coaching system can use the user model for:

- Recommending health and wellness goals
- Recommending interventions, based on suitable behaviour change techniques (BCTs) and tailoring these interventions to the specific characteristics of the users
- Finding the most opportune moments for delivering the interventions
- Selecting the right tone of voice and feedback style according to personal preferences.
- Connecting individuals with similar user models together, e.g. through the creation of user communities, where users can provide peer support and coaching to each other.
- Improving personal self-awareness and self-understanding by creating a UI for the user model that enables the user to browse the content of the model and explore the associations the system has discovered in the user's personal data.
- Motivating the user to engage in the behaviour change process by showing what a person's future will look like when he sticks (or doesn't stick) to his action plan.

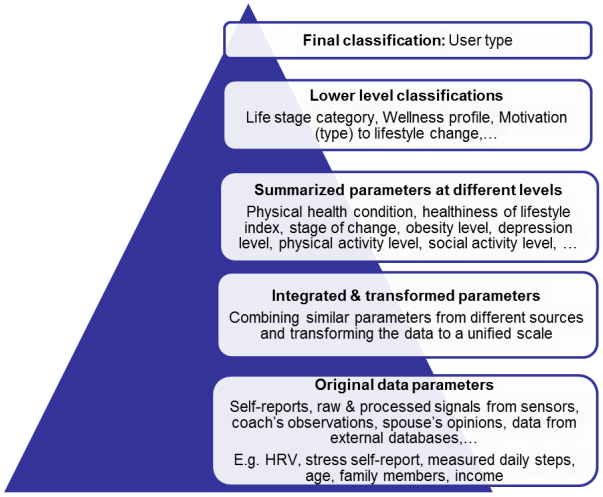
The main purpose of the user model is to facilitate the planning, communication and delivery of effective interventions. Thus, the model should maintain parameters regarding at least the following properties of the persons:

- Wellbeing status and health-related behaviours for identifying the problematic health or wellbeing issues to be addressed with interventions. Subjective self-reports of wellness status and health behavior provide a way to assess the person's awareness of the healthiness of his habits.
- Readiness to change behaviour for selecting the wellbeing issues to be first targeted.
- Motivational factors towards behaviour change, especially regarding awareness, self-efficacy and intrinsic motivation, for identifying what kind of support the person needs.
- Personality, interests and preferences, for finding appropriate ways to encourage and motivate the person.
- Behaviour change goals of the person and the action plan to be able to identify the effective interventions for the person.
- Progress in the behaviour change process, in order to keep track which interventions worked and which did not, for instance, by monitoring changes in motivational factors, behavioural outcomes and wellbeing, and monitoring the user's compliance to interventions .

Structure of user model

- We propose to utilize a modular ontology-based approach as the foundation of the model, which defines the structure of the model (parameter groups and relationships between them)
- Maintain a link between past, current, and possibly the predicted future parameter values
- In addition to the modelling parameters, the user model needs to represent also the hierarchical data relations.
- Information of the origin of the data (the data source) should be maintained

Figure 8.1. Data hierarchy to be supported by the user model.



Use of profiling in recommending goals and interventions

- Goal-setting is an important part of the behaviour change process: The person should have at most 1 to 3 active behaviour change goals at the same time to work on, which of he or she is well-aware.
- The behaviour change goals set for the user, should be the ones the user is willing to work on and for which the user shows intrinsic motivation
- There should always be an action plan, which involves the interventions and tasks that leads to achieving the set behavior change goals. A coping plan, where the person plans beforehand how to tackle drawbacks, is always a part of a good action plan.
- The person should always be the one who makes the final choice about the behaviour change goals and interventions, or at least this impression should be given to the user.
- The alternatives for goals and interventions should be pre-filtered for the person. The optimal number of choices to be presented may be 3 to 5.

9. References

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10. Appendices

10.1. Appendix 1: User profile questionnaires

The questions presented below are planned to be used in the Finnish pilot for populating part of the user model parameters presented in section 5.1, and for identifying the target population for the pilot. Following the elements of the conscious user health and motivation profiling prototype introduced in section 7.1, the questions are grouped into three sections:

1) Lifestyle, Wellness, Personality
2) Goals and Motivation Assessment
3) Post-intervention questions

1) Lifestyle, Wellness, Personality –related questions

Questions	User model parameters
Demographics	**Life situation (LS): Demographics (LSA)**
Year of birth	
Sex **1 female** **2 male**	
How many years of education do you have after comprehensive school? **_____ years**	
Occupation: **_____**	
Work	**Life situation (LS): Lifestage (LSB):** ***Properties of work life***
How many years have you being working after your graduation? **0 I have not finished my studies yet** **1 Less than a year** **2 1 – 2 years** **3 3 – 5 years** **4 6 – 10 years** **5 More than 10 years**	
Do you work **1 full-time (over 35 hours / week)** **2 part-time (less than 35 hours / week)**	
Usual working hours: **1 Office hours** **2 Shift work without night shifts** **3 Shift work including night shifts** **4 Other, what? _____**	
Is your work **1 physically active** **2 sedentary**	
What is your position at work? **1 Trainee** **2 Expert** **3 Manager** **4 Other, what? _____**	
Family	**Life situation (LS): Lifestage (LSB)**

Do you live together with a partner? **1 Yes** **2 No** **Which of the following choices best describes your partner's life situation?** **1 Working full-time (over 35 hours / week)** **2 Working part-time (less than 35 hours / week)** **3 Unemployed** **4 Student** **5 Retired** **6 Housewife or housefather** **8 Paternity leave** **9 Other, what? _____**	*Household members* *Partner's social status*
Children living in the household: **0 No children** **1 Below 1 years, number of children:____** **2 1-3 years, number of children: ____** **3 4-6 years, number of children: ____** **4 7-12 years, number of children: ____** **5 12-16 years, number of children: ____** **6 Over 16 years, number of children: ____** **Are there children in the household, who do not live with you continuously?** **1 Yes** **2) No** **If yes, please enter the number and ages of the children:** _____ **Small children's (below 7 years) daycare arrangements in the family:** **0 There are no small children in the family** **1 All the children are taken care at home** **2 All the children attend daycare outside home** **3 Part of the children are taken care at home and some outside home**	*Household members* *Children's care arrangements*
Health	**Wellbeing status (WB)**
Height (cm):	Health measurements (WBA): Physical health (WBA1)
Weight (kg):	Health measurements (WBA): Physical health (WBA1)
Do you have a chronic disease or a disability? **1 No** **2 Yes, but it does not bother my normal life** **3 Yes, and I am now learning to live with my condition** **0 I would rather not tell** **If you answered yes to the previous question, could you to tell what kind of disease or disability you have?** _____	Health conditions (WBB): Conditions (WBB1): *Chronic diseases, Physical disabilities* Health conditions (WBB): Perceived severity of conditions (WBB2): *Perceived control of chronic diseases, Perceived control of physical disability*
During the past 6 months, have you being suffering	Health conditions (WBB): Conditions

from recurrent physical symptoms (like pain) that disturb your normal life? **1 Not at all** **2 Less frequently than monthly** **3 Monthly** **4 Weekly** **5 Daily** **0 I would rather not tell**	(WBB1): *Acute conditions* Modified from 36-Item Short Form Health Survey (SF-36).
In general, I feel healthy and well. **1 Strongly disagree** **2 Somewhat disagree** **3 I do not know** **4 Somewhat agree** **5 Strongly agree**	Perception of wellbeing (WBC) Modified from Firstbeat Lifestyle Evaluation questionnaire (Firstbeat).
In my opinion, currently my physical condition is good. **(1 Strongly disagree - 5 Strongly agree)**	Health conditions (WBB): Conditions (WBB1): *Fitness level* Modified from Firstbeat Lifestyle Evaluation questionnaire (Firstbeat).
Mental wellbeing	**Wellbeing status (WB)**
I am happy, in general. **1 Strongly disagree** **2 Somewhat disagree** **3 I do not know** **4 Somewhat agree** **5 Strongly agree**	Perception of wellbeing (WBC): *Happiness level* Modified from the Finnish Happiness-Flourishing Study questionnaire (Joutsenniemi2013).
In general, I am satisfied with **a) my work** **b) my relationship with my partner** **c) my relationships with my other close ones** **d) my life situation** **e) my financial situation** **f) the division of daily responsibilities and home chores with my partner** **g) myself and my achievements** **(1 Strongly disagree – 5 Strongly agree)**	Perception of wellbeing (WBC): *Satisfaction to specific life areas* Modified from the Finnish Happiness-Flourishing Study questionnaire (Joutsenniemi2013).
I feel I have enough time for my **a)partner** **b) children** **c) work** **d) friends and other close ones** **e) hobbies and self-development** **(1 Strongly disagree – 5 Strongly agree)**	Perception of wellbeing (WBC): *Satisfaction to time sufficiency per life area*
Usually, I feel lively and energetic **(1 Strongly disagree – 5 Strongly agree)**	Perception of wellbeing (WBC): *Day-time tiredness*
Stress refers to a situation, where you feel tense, restless, nervous or anxious. Often, stress makes it difficult to sleep while you constantly think about your problems. Do you nowadays feel this kind of stress? **1 Never** **2 Very little** **3 Somewhat** **4 Pretty much**	Perception of wellbeing (WBC): *Stress level* Perceived Stress (Leppänen2013).

5 Very much **0 I would rather not tell**	
If you have been experiencing stress lately, do you think it has been caused by **a) your work** **b) problems with your partner** **c) problems related to your children** **d) problems related to your other close ones** **e) your financial situation** **f) time management problems (feeling of hurry)** **g) personal mental reasons such as the fear of failure** **i) a serious negative life event such as a serious illness or death of a close one or serious crisis with your partner** **j) other reasons, what? _____** **(1 Not at all – 5 Very much, 6 I do not know, 0 I would rather not tell)**	Perception of wellbeing (WBC): *Stressors*
Below is a list of statements concerning you. Please select the option that best describes your mood during the past month. During the last month I have a) Suffered from insomnia b) Felt blue c) Felt everything was an effort d) Felt low in energy or slowed down e) Felt lonely f) Felt hopeless about the future g) Not got any fun of life h) Had feelings of worthlessness i) Felt all pleasure and joy has gone from life j) Felt that I could not shake off the blues even with help from family and friends Answer options: 0 Not at all 1 A little 2 Quite a lot 3 Extremely	Health measurements (WBA): Mental wellbeing (WBA2): *Depression level* Depression Scale (Poutanen2013).
Over the last two weeks, how often have you been bothered by the following problems? **a) Feeling nervous, anxious, or on edge** **b) Not being able to sleep or control worrying** **c) Worrying too much about different things** **d) Trouble relaxing** **e) Being so restless that it is hard to sit still** **f) Becoming easily annoyed or irritable** **g) Feeling afraid, as if something awful might happen** **Answer options** **0 Not at all** **1 Several days** **2 More than half the days** **3 Nearly every day**	Health measurements (WBA): Mental wellbeing (WBA2): *Anxiety level* Generalized Anxiety Disorder 7-item scale (Spitzer2006).
Lifestyle	
I'm satisfied with my current physical activity level. **(1 Strongly disagree - 5 Strongly agree)**	Resources (RE): Intention (RE1): *Satisfaction with current health-related*

I'm satisfied with my current eating habits. **(1 Strongly disagree - 5 Strongly agree)** **In my opinion, I sleep well and I get enough sleep.** **(1 Strongly disagree - 5 Strongly agree)**	*habits*
On the average, how many alcohol portions do you consume during one week? One alcohol portion is **- a bottle (33 cl) of medium strength beer, cider or long drink** **- a restaurant serving (4cl) of strong alcohol** **- a glass (12cl) of wine (alcohol over 5%) or light wine (alcohol approx. 5%)** **1 I don't drink at all** **2 I don't drink weekly** **3 1 – 2 portions** **4 3 – 4 portions** **5 5 – 10 portions** **6 More than 10 portions** **0 I would rather not tell**	Wellbeing status (WB): Health-related habits (WBD): Alcohol (WBD4): *Consumption frequency, Consumption amount* Modified from the Finnish Happiness-Flourishing Study questionnaire (Joutsenniemi2013).
Do you use tobacco-like substances? **1 Yes** **2 No**	Wellbeing status (WB): Health-related habits (WBD): Addictions (WBD5): *Nicotine usage*
How often do you perform physical activities which cause sweating and get you out of breath (for example, brisk walking, running, swimming, football, physically straining home chores)? **1 Not at all** **2 Sometimes** **3 1-2 times per week** **4 3-4 times per week** **5 More than 4 times per week**	Wellbeing status (WB): Health-related habits (WBD): Physical activity (WBD1): *Fitness training amount*
I skip lunch **1 almost every day** **2 few times a week** **3 about once a week** **4 rarely or not at all** **During evenings, I cannot control my eating** **1 almost every day** **2 few times a week** **3 about once a week** **4 rarely or not at all** **I eat or nibble when I feel stressed, tired or lonely, or when I am in a situation that causes me these feelings** **1 almost every day** **2 few times a week** **3 about once a week** **4 rarely or not at all**	Wellbeing status (WB): Health-related habits (WBD): Diet (WBD3): *Eating rhythm, Binge eating, Emotional eating* These eating habits influence the mood of the person (lively or tired).
Life values	**Resources (RE)**
Think about the following values. Read the value descriptions thoroughly. Which of the values are important to you, which less important? a) ***Power:*** **For me social status and prestige are important.**	Based on the Schwartz values questionnaire. Modified from (Lee2010) and (Lindeman2005).

I like to have control or dominance over people and resources. Wealth is also important to me. b) ***Achievement:*** **I want to be competent and successful in my work, studies or hobbies.** c) ***Hedonism:*** **I want to have fun and enjoy my life. I pursue activities that provide me pleasure and sensuous gratification.** d) ***Stimulation:*** **I want to experience novelty and exciting life. I am eager to take risks and search for adventures.** e) ***Self-direction:*** **I want to be an independent thinker and actor, and make my own choices in life. I am inquiring and curious. Creativity and originality are important for me.** f) ***Universalism:*** **I want to promote and protect the wellbeing of all people and the nature. I tolerate and appreciate different kinds of people.** g) ***Benevolence:*** **I want to preserve and enhance the welfare of my close ones, and spend time with them. Honesty and forgiveness are important to me.** h) ***Tradition:*** **I cherish traditions or religious principles. Things should be done as before.** i) ***Conformity:*** **I want to avoid conflicts and disharmony with others. I do not want to act against social expectations or norms.** j) ***Safety:*** **I want safety and stability in my life.**	
List the three most important values *in the order of importance* (1 = the most important). **1.** _____ **2.** _____ **3.**_____ **For the 3 most important values (value1, value2, value3), the following question is presented:** **During the past 6 months, how well have you been able to follow this value in your life?** **1 Not at all** **2 Poorly** **3 Moderately** **4 Well** **5 Very well** **List the three least important values *in the order of importance* (1 = the least important).** **1.** _____ **2.** _____ **3.**_____	Motives & preferences (REC1): Motives (REC1): *Values, Motive-orientation, Fulfillment of values* Motives & preferences (REC): Preferences (REC2): *Sensation seeking, Judging vs. perceiving, Affective vs. cognitive type* Psychological characteristics & skills (REB): *Self-esteem, Self-control*
Personal characteristics	**Resources (RE)**
Below are a number of personality traits pairwise. Please, evaluate how well each pair of traits applies to you as *a whole*. **a) extraverted and enthusiastic** **b) critical and quarrelsome**	Psychological characteristics & skills (REB): *Personality traits, Personality type, Self-esteem, Self-control, Pessimism*

c) dependable and self-disciplined **d) anxious and easily upset** **e) open to new experiences and complex** **f) reserved and quiet** **g) sympathetic and warm** **h) disorganized and careless** **i) calm and emotionally stable** **j) conventional and uncreative** **Scale:** **1 disagree strongly** **2 disagree moderately** **3 disagree slightly** **4 neither agree nor disagree** **5 agree slightly** **6 agree moderately** **7 agree strongly**	Motives & preferences (REC): Preferences (REC2): *Sensation seeking, Judging vs. perceiving, Affective vs. cognitive type* Ten-Item Personality Inventory (Gosling2003)
My favorite and most natural way of learning happens: **1 by listening to lectures and presentations** **2 by reading, or watching videos and demonstrations** **3 trying out myself hands-on** **4 I do not know**	Psychological characteristics & skills (REB): *Learning style*
Motivation to lifestyle change	**Resources (RE): Motivational factors to lifestyle change (REA)**
Are you ready to take concrete actions in order to improve your wellbeing? Actions can be related, for instance, to learning healthy habits, learning stress or time management, nurturing important relationships or increasing self-knowledge. **1 No, since I am well enough.** **2 Not for a long time, even though I feel a need to improve my wellbeing** **3 Yes, during the next 6 months** **4 Yes, during the next month** **5 Yes, and as a matter of fact, I have been taking care of my wellbeing already for a while** **6 I do not know**	Intention (REA1): *Readiness to make a lifestyle change* Modified from the General Health Survey (Nigg1999).
I believe that I can influence my own health and wellbeing. **1 Strongly disagree** **2 Somewhat disagree** **3 I do not know** **4 Somewhat agree** **5 Strongly agree**	Self-efficacy (REA2) Modified from Firstbeat Lifestyle Evaluation questionnaire (Firstbeat).
Imagine that you have decided to take actions towards improving your wellbeing. How do you think your loved ones would react to this? **I believe (or know) that my partner will support and encourage me to improve and maintain my health and wellbeing.** **(1 Strongly disagree – 5 Strongly agree, 0 I do not have a partner)**	Social support (REA3) Modified from the Multidimensional Scale of Perceived Social Support (Zimet1988).

I believe (or know) that my other loved ones will support and encourage me to improve and maintain my health and wellbeing. **(1 Strongly disagree – 5 Strongly agree, 0 I do not have a partner)**	
Were you honest, when answering the questions? **1 Yes, I answered honestly to all the questions** **2 Yes, I answered honestly to most of the questions** **3 No, I did not answer honestly**	

2) Goals and Motivation Assessment -related questions

The following questions are asked for each selected goal (see sections 5.1. and 7.3.).

Questions	User model parameters
I selected this goal because it is personally important for me. The expectations or preferences of other people did not influence my choice. **(1 Strongly disagree - 5 Strongly agree)** **I selected this goal due to the opinions of others or for the sake of someone, or because I would feel shame, anxious or guilt if I did not choose the goal.** **(1 Strongly disagree - 5 Strongly agree)**	Goals and motivational factors (GM): Low-level user goals (GMB): *Intrinsic motivation for the goal* Modified from the Personal Strivings Assessment (Emmons1986).
I anticipate that it will be very challenging for me to reach this goal. **(1 Strongly disagree - 5 Strongly agree)** **I believe that my partner will support and encourage me to work towards the goal.** **(1 Strongly disagree - 5 Strongly agree, 6 I do not have a partner)** **Are you willing to put effort into achieving the goal you have selected?** **1 Not for a long time** **2 Yes, within the next 6 months** **3 Yes, soon (within the next 4 weeks)** **4 Yes, I have been putting effort into reaching the goal already for some time (less than 6 months)** **5 Yes, I have been working actively towards reaching the goal already for more than 6 months**	Goals and motivational factors (GM): Behaviour change targets (GMA): User-motivational factors (GMA2): *Self-efficacy, Social support, Readiness to change, Phase of change* Modified from the Personal Strivings Assessment (Emmons1986), Multidimensional Scale of Perceived Social Support (Zimet1988) and General Health Survey (Nigg1999).

3) Post-intervention questions

At the end of each intervention, the following questions are presented to the user, whenever applicable (see sections 5.1. and 7.4.).

Questions	User model parameters
How did you experience the task? **a) It was fun to do this task** **b) I think this task was useful for improving my health and wellbeing** **c) This task was difficult** **d) I was very active in doing this task** **(1 Strongly disagree - 5 Strongly agree)**	Action plan (AP): Action tasks (APB): User-experiences & indicators (APB3): *Pleasantness, Usefulness, Difficulty, Adherence* Modified from the Intrinsic Motivation Inventory (McAuley1989).

10.2. Appendix 2: Parameters of the user model

In the following tables, details regarding some of the user modelling parameters introduced in section 5.1 are presented. For each of the user model constituents, a table of parameters is provided. The coding associated with the parameter categories refer to the codes used in figures 5.2 – 5.5 of section 5.1.

WB. Wellbeing status

Parameter category	Parameter	Value type	Details
Summarizing parameters	Overall wellbeing status	Categorical (scale 1-5)	Computed based on *Physical health status, Mental wellbeing status,* and *Healthiness of lifestyle index* (from category D).
	Perceived overall wellbeing status	Categorical (scale 1-5)	Computed based on the parameters regarding C. Perception of wellbeing and B2. Perceived severity of conditions.
	Physical health status	Categorical (scale 1-5)	Computed based on the parameters regarding A1. Physical health (measurements) and (health) B1. Conditions.
	Mental wellbeing status	Categorical (scale 1-5)	Computed based on the parameters regarding C. Perception of wellbeing, A2. Mental wellbeing (measurements) and (health) B1. Conditions.
A1. Physical health (measurements)	Height	Numeric (100-250 cm) + categorical (scale 1-5)	
	Weight	Numeric (40-250 kg) + categorical (scale 1-5)	
	Waist circumference	Numeric (50-200 cm) + categorical (scale 1-5)	
	Hip circumference	Numeric (40-200 cm) + categorical (scale 1-5)	
	BMI	Numeric + categorical (scale 1-5)	Computed based on *Height* and *Weight.*
	Waist-hip ratio	Numeric + categorical (scale 1-5)	Computed based on *Waist circumference* and *Hip circumference*. Waist-hip ratio is a better indicator for obesity than waist circumference only, especially for women.
A2. Mental wellbeing (measurements)	Depression level	Number (0 – 30)	Results of DEPS questionnaire (Poutanen2010).12 points or more points to depression.
	Anxiety level	Number (0 – 21)	Results of GAD-7 questionnaire (Spitzer2006). 10 points or more points to the risk of anxiety problem.
	Sleep quality	Number (-100 – 100)	Recovery during nights measured by the Firstbeat Lifestyle Assessment service (Firstbeat).
	Ability to relax		Recovery during daytime measured by the Firstbeat Lifestyle Assessment service (Firstbeat).
B1. Conditions (health)	Obesity class	Categorical (scale 1-5)	Induced based on *Waist circumference* and *BMI*.

	Chronic diseases, Mental disorders, Physical disabilities	Vector of nominal values (Y/N) + ASCII text for each parameter	
	Acute conditions	Vector of nominal values (Y/N) + ASCII text for each condition.	For instance, disturbing pain is regarded as an acute condition.
B2. Perceived severity of conditions	Perceived control of chronic diseases, mental disorders, physical disabilities	Categorical (scale 1 – 5) for each parameter	These parameters describe how well the conditions are under control. This can be evaluated based on the person's perception of the condition limiting everyday life. Having a disturbing condition can make it difficult to concentrate to a behaviour change plan.
	Perceived fitness	Categorical (scale 1 – 5)	
C. Perception of wellbeing	Happiness level	Categorical (scale 1 – 5)	
	Stress level	Categorical (scale 1 – 5)	
	Stressors	Categorical (scale 1 – 5), separate value for each stressor	Types of possible stressors: work, family, financial situation, time management issues, problems with self, e.g., low self-esteem, recent negative life events, etc.
	Life satisfaction	Categorical (scale 1 – 5)	Derived from *Satisfaction to specific life areas* (below).
	Satisfaction to specific life areas	Categorical (scale 1 – 5), separate value for each life area	Types of possible life areas: work, family, partnership, other important relationships, financial situation, satisfaction with self, etc.
	Satisfaction to sufficiency of time	Categorical (scale 1 – 5)	Derived from *Satisfaction to time sufficiency per life areas* (below).
	Satisfaction to time sufficiency per life areas	Categorical (scale 1 – 5), separate value for each life area	These parameters describe whether the person perceives to have enough time for different life areas demanding time: work, children, partner, friends, personal activities, e.g., hobbies, learning, or relaxation, etc.
	Day-time tiredness	Categorical (scale 1 – 5)	
	Sleep quality, Sleep amount sufficiency	Categorical (scale 1 – 5)	
D. Health-related habits	Healthiness of lifestyle index	Categorical (scale 1 – 5)	Computed based on *Physical activity level, Sleep habits index, Eating habits index, Alcohol consumption index,* D5. Addictions related parameters, *Over-working severity index* and D7. Social activity related parameters (see below).
D1. Physical activity	Physical activity level	Categorical (scale 1 – 5)	Computed based on *Fitness training amount* and *Daily activity amount* (below).
	Fitness training amount	Categorical (scale 1 – 5)	Derived from the sub parameters regarding the frequency, duration and intensity of training sessions.

	Daily activity	Numeric + categorical (scale 1 – 5)	Obtained from measurement devices such as Fitbit or HeiaHeia for step count.
D2. Sleep	Sleep habits index	Categorical (scale 1 – 5)	Computed based on *Circadian rhythm, Sleep duration, Activities before sleep, Bedtime,* and *Day-time naps* (below).
	Circadian rhythm	Numeric + categorical (scale 1 – 5)	Computed based on *Bedtime* and *Waking-up time* (see below) or directly from measurement devices, e.g. Vivago. This parameter requires data over several days.
	Bedtime, Waking-up time	Time (HH:MM)	
	Sleep duration	Numeric + categorical (hours)	Computed based on *Bedtime* and *Waking-up time.*
	Activities before sleep	Vector of nominal values	Activities that may influence sleep are tracked, e.g. exercise, working, watching TV, binge eating, consuming caffeine, socializing.
D3. Diet	Eating habits index	Categorical (scale 1 – 5)	Computed based on *Eating rhythm*, *Meal proportion sizes*, and *Diet composition* (below).
	Eating rhythm		Derived from eating frequency. Requires data over several days.
	Emotional eating	Categorical (scale 1 – 5)	Derived from the frequency of emotional eating incidences. Requires data over several days.
	Binge eating	Categorical (scale 1 – 5)	Derived from the frequency of binge eating incidences. Requires data over several days.
D4. Alcohol	Alcohol consumption index	Categorical (scale 1 – 5)	Computed based on alcohol *Consumption amount* and *Consumption frequency*.
D5. Addictions	Nicotine usage	Nominal (Y/N) + categorical (for freq.)	Also the usage frequency of nicotine products is associated with this parameter as a sub parameter.

RE. Resources for behaviour change

Parameter category	Parameter	Value types	Details
A1. Intention	Readiness to make a lifestyle change	Categorical (scale 1-5)	This is the motivation level of the person for making lifestyle changes in general, having values varying from no motivation to strong motivation.
	Satisfaction with current health-related habits	Categorical (scale 1-5), separate value for each habit	This involves the person's satisfaction, for instance, towards the physical activity amount, eating habits or sleeping habits.
A5. Awareness	Gap between perceived and actual healthiness of habits	Categorical (scale 1-5), separate value for each habit	Induced based on the differences between *Perceived healthiness of health-related habits* (below) and the actual healthiness of habits. The latter can be assessed from the Health-related habits (category WBD).
	Perceived healthiness of health-related habits	Categorical (scale 1-5), separate value for each habit	Physical activity amount, eating or sleeping habits are examples of health-related habits.

	Gap between perceived and measured wellbeing factors	Categorical (scale 1-5)	E.g. the awareness regarding sleep quality can be induced from the gap between perceived *Sleep quality* (WBC) and measured *Sleep quality* (WBA2).
A2. Self-efficacy	Perceived control over one's wellbeing	Categorical (scale 1-5)	Self-efficacy in general for improving and maintaining wellness.
A3. Social support	Existence of supportive network	Vector of nominal values (Y/N)	The important social ties of the person are identified. Members of one's social network include the partner and friends, at least.
	Close one's influence on one's health-related habits	Categorical (scale 1-5), separate value for each network member	Social support in general for improving and maintaining wellness. Members include the partner and friends, at least.
A4. Barriers	Perceived barriers to lifestyle change	Matrix of nominal and categorical (for severity) values + ASCII text	General perceived barriers hindering the investment on improving health and wellness. This is associated also with the sub parameter describing the severity of the barriers.
B. Psychological characteristics & skills	Personality traits	Categorical (scale 1-5), separate value for each trait	Based on the Big-Five personality traits assessment (Gosling2003). Traits: Agreeableness, Extraversion, Openness, Conscientiousness and Emotional stability.
	Pessimism	Categorical (scale 1-5)	Optimism is an important predictor for maintaining good health and self-efficacy. Pessimism could be possibly derived from low Emotional stability, and low Openness + ? (Hagger-Johnson2003).
	Self-esteem	Categorical (scale 1-5)	Could be possibly derived from high Emotional stability and satisfaction with self (in category WBC) + ? (Hagger-Johnson2003). Another possible measure for self-esteem is the Rosenberg Self-Esteem Scale (Rosenberg1979).
	Self-control	Categorical (scale 1-5)	Could be possibly derived from high Conscientiousness + ?
	Learning style	Nominal	Types: listening, reading or watching, hands-on.
	Stress management skills		Could be measured with questionnaires measuring psychological flexibility, e.g. ACT-ADVISOR (Chantry2008) or AAQ-II (Bond2003), or with the Cognitive Fusion Scale, which tests how much negative thoughts affect life (Gillanders2013). Stress coping strategies can be measured by COPE Inventory (Carver1997).
C1. Motives	Values	Vector of nominal values. Selection of the 3 most and least important values, ordered according to importance.	Based on Schwartz values (Schwartz1994). Values: Power, Achievement, Hedonism, Stimulation, Self-direction, Universalism, Benevolence, Tradition, Conformity, Safety
	Motive-orientation	Categorical (scale 1 – 5), separate value for each orientation	Induced based on *Values.* Motive-orientations: 1) Openness to change vs. conservation: motivated to follow interests in unpredictable and uncertain directions (Stimulation + Self-direction + Big-Five Openness?) vs. preserve status quo

			(Security + Conformity + Tradition), 2) Self-enhancement vs. self-transcedence (unselfishness): motivated to enhance own personal interests (Power + Achievement + Hedonism) vs. to transcend selfish concerns and promote the welfare of others (Úniversalism + Benevolence + Big-Five Agreeableness?). (Schwarz1994)
	Fulfilment of values	Categorical (scale 1-5 or 0), nonzero only for the 3 most important values.	
	Important life areas	Categorical (scale 1 – 5), separate value for each life area	Important life areas can be related to partnership, friends, work, parenthood etc., which can be deduced partly from *Values* and/or through an Acceptance and Commitment Therapy (ACT) intervention regarding prioritizing values.
C2. Preferences	Judging vs. perceiving	Categorical (scale 1 – 5)	Judging (high Conscientiousness, low Openness, high Self-direction, low Stimulation?): preference for clear guidance and plans. Perceiving: preference for open-ended tasks. (Schaubhut2009)
	Self-direction	Categorical (scale 1 – 5)	The person prefers to decide everything by him/herself. Can be induced from *Values.*
	Sensation seeking	Categorical (scale 1 – 5)	High Sensation seeking (i.e. low Conscientiousness and high Emotional stability, possibly also high Stimulation?): preference for novelty, intensity, and suspense. Low Sensation Seeking: preference for familiar and less sensational delivery of information (Hagger-Johnson2003).
	Competitiveness	Categorical (scale 1 – 5)	A competitive person might have the following characteristics (?): high Emotional stability, high Power, high Stimulation, (high Achievement), low Agreeableness, low Conformity, and low Self-transcendence.
	Social vs. independent actor	Categorical (scale 1 – 5)	A social person, who prefers to act in the company of other people, might have the following characteristics (?): High Emotional stability, (high Benevolence & high Agreeableness).
	Perfectionism (facts vs. overview)	Categorical (scale 1 – 5)	A person, who prefers facts and details, might have the following characteristics (?): high Conscientiousness, low Emotional stability, high Achievement, high Self-direction, low Hedonism and low Stimulation.
	Playfulness vs. sobriety	Categorical (scale 1 – 5)	A person, who is not playful, might have the following characteristics (?): high Conscientiousness, (low Emotional stability, low Openness), high Power, high Achievement, high Security, low Hedonism, (and low Stimulation).

LS. Life situation

Parameter category	Parameter	Value types	Details
A. Demographics	Birth year	Number (yyyy)	
	Gender	Nominal (M/F)	
	Years of education	Number	Used to describe education level.
	Occupation	Nominal	
	Position	Nominal	Positions: Trainee, basic employee, small boss, big boss, self-employed.
B. Life stage	Social status	Vector of nominal values	Status: part-time/full-time work, student, parental leave etc.
	Partner's social status	Vector of nominal values	See above.
	Children's care arrangements	Nominal	Options: Home care / outside home / some at home, some outside
	Significant recent life changes	Vector of nominal values	E.g. marriage, moving, death of a close person, getting a serious sickness
	Household members	Nominal (Y/N, for spouse / children) + Age – Number (0 – 10) matrix (for children)	Sub parameters: living with a spouse, number of children and their ages.
	Properties of work life	Nominal	E.g. work time regularity: office hours / shift work; work activity type: inactive / active

GM. Goals & Motivational factors

Parameter category	Parameter	Value types	Details
A1. General (regarding each behaviour change target)	ID	ID matching to the intervention library	IDs of behaviour change targets. Targets are either system induced based on LS, WB, RE parameter constituents, or defined by the coach. If the coach defines a target, (s)he is required to add the target to the intervention library and an ID will be created for the target. Targets can exist even without the user being aware of them.
	Activation status	Nominal	Status options: active / inactive / completed (successfully / failed). Inactive: the target is old, and not part of the action plan (AP) at the moment, though it should be when the timing is right.
	Start time / End time	Date	
A2. User motivational factors (regarding each behaviour change target)	Phase of change	Nominal	The phase of change regarding a behaviour change target: Contemplation / Preparation / Trial / Maintenance.

	Perceived importance	Categorical (scale 1-5)	This parameter tells about the person's awareness level regarding the importance of a behaviour change target. Perceived importance is often used in Motivational Interviewing.
	Self-efficacy	Categorical (scale 1-5)	Self-efficacy regarding a behaviour change target.
	Perceived barriers	Matrix of nominal and categorical (scale 1-5) values + ASCII text	Identifies the perceived barriers regarding a behaviour change target, and describes the severity of each barrier.
C. High-level goals: user aspirations	ID	ID matching to the intervention library	IDs of aspirations. Aspirations are either suggested by the system based on REC1. Motives, or by the coach, or inserted by the user. The user has to always confirm the aspirations. New useful aspirations should be added to the intervention library.
	Activation status	Nominal	Status options: confirmed / rejected / pending / disabled. The user can either confirm or reject recommended aspirations. Pending ones are the recommendations waiting for the user's response. The user can also disable the aspirations, which (s)he is not interested to pursue anymore (can be re-activated later on, though).
	Start time / End time	Date	
	Intrinsic motivation for aspirations	Categorical (scale 1-5)	For each confirmed (=active) aspiration, the person's intrinsic motivation is evaluated.
B. Low-level user-goals	ID	ID matching to the intervention library	IDs of the user goals, i.e. behaviour change targets selected by the user. Goals are either suggested by the system based on the identified GMA. Behaviour change targets, or by the coach, or inserted by the user. New relevant goals should be added to the intervention library.
	Activation status	Nominal	Status options: selected / rejected / pending / interrupted / completed. The user can either select or reject a recommended goal. Pending ones are the recommendations waiting for the user's response. The user can interrupt active goals, if (s)he is not interested to pursue them anymore (can be re-activated later on, though).
	Start time / End time	Date	
	Intrinsic motivation for the goal	Categorical (scale 1-5)	For each selected (=active) goal, the person's intrinsic motivation is evaluated.

AP. Action Plan

Parameter category	Parameter	Value type	Details
A. General (regarding the action plan)	Existence of plan	Nominal (Y/N)	Existence of an action plan is a key predictor for a successful change.
	Quality of action plan	Categorical (scale 1-5)	This may be evaluated by the coach.
	Existence of coping strategy	Nominal (Y/N)	
	Name of plan	ASCII text	
	Behaviour change target IDs	Vector of IDs	Behaviour change targets incorporated to the plan. The IDs should match the Behaviour change targets identified in GMA.
	Action task IDs	Vector of IDs	Tasks selected to the plan. The IDs should match the intervention library.
	Start time / End time	Date	
	Effectiveness of the plan	Categorical (scale 1-5), separate value for each effect	Induced based on observing changes in health-related behaviours and wellbeing parameters (see category WB), or motivational factors (REA, GM2)
	User-compliance to the plan	Categorical (scale 1-5)	Computed based on *Adherence* (in category B3) to action tasks.
B1. General (regarding each action task)	ID	ID matching to the intervention library	IDs of action tasks. Tasks are suggested to the user based on GMB. Low level user-goals, and the user is required to select the appropriate ones. New, relevant tasks, proposed by the coach or the user, should be added to the intervention library.
	Activation status	Nominal	Status options: current / rejected / pending / interrupted / completed / planned. The user can either select or reject the recommended task. Pending ones are the recommendations waiting for the user's response. Interrupted tasks refer to old tasks, which the user is not interested to complete (can be re-activated later on, though). Planned tasks are on-hold, waiting to be recommended to the user.
	Performance log	Date-Time-Activity matrix	Each time the user performs a task, the activity is recorded.
	Start time / End time	Date	
	User-specific trigger conditions	Vector of numeric or categorical values.	User-specific parameters related to CO. Context or WB. Wellbeing status constituents, which are to be inserted to the trigger-rules of a task.
	Coping strategy	ASCII text or a structured format.	Coping strategy for each task is described.
B2. User motivational	Willingness to perform	Categorical (scale 1-5) / Nominal	Strength of motivation to perform a task. This is related to the preparation, trial and

factors (regarding each action task)		(phases)	maintenance phases of behaviour change.
	Perceived importance	Categorical (scale 1-5)	This parameter tells about the person's awareness level regarding the importance of performing a task. Perceived importance is often used in Motivational Interviewing.
	Self-efficacy	Categorical (scale 1-5)	Self-efficacy regarding a task.
	Perceived barriers	Matrix of nominal and categorical (scale 1-5) values + ASCII text	Identifies the perceived (=expected) barriers regarding the performance of a task, and describes the severity of each barrier.
	Realized barriers	Matrix of nominal and categorical (scale 1-5) values + ASCII text	After performing a task for a while, the realized barriers and their severity are considered.
B3. User-experiences & indicators (regarding each action task)	Pleasantness, Usefulness	Categorical (scale 1-5)	The person's experiences regarding each task after performing them.
	Difficulty	Categorical (scale 1-5)	Difficulty of each task assessed after the user has performed them. This can be either asked from the person or deduced from other parameters.
	Adherence, Success level	Categorical (scale 1-5)	User's adherence to and success in performing the task. These parameters can be asked from the person and induced based on *Performance log* (B1) or observed behaviour (WBD).

10.3. Appendix 3: Results of the user study of the profiling questionnaires

Questions	Problems and improvement suggestions
How many years of education do you have after comprehensive school?	The aim of this question was to assess the education level of people. In order to answer this, the respondents had to take time to count the years, and one person even forgot to include the upper secondary school years to the count. In addition, the number of years it took to graduate with a university degree was higher for those who worked during their studies than for full-time students. This difference gives the wrong impression of the education level indicating that the one is more educated than the other. It would be better to specify the education levels directly as answering options to minimize biased data.
What is your position at work? **1 Trainee** **2 Expert** **3 Manager** **4 Other, what? _____**	A recently graduated person, still junior at work, did not find a suitable answer from the options. He was not a trainee; neither did he feel like an expert. He also pointed out that blue-collar workers might also find it hard to select a suitable answering option. Thus, the option 2 should be replaced with a broader term appropriate for different professions.
Stress refers to a situation, where you feel tense, restless, nervous or anxious. Often, stress makes it difficult to sleep while you constantly think about your problems. Do you nowadays feel this kind of stress?	A person with small children, going through several positive changes in life (e.g. moving to a new house, getting married) felt stressed out, but not in the negative sense. Despite the definition of stress in the question, he was not sure how to answer it. Adding the term “negative stress” could help to clarify the question more.
If you have been experiencing stress lately, do you think it has been caused by **a) your work** **b) …. i) …** **j) other reasons, what?** **_____** **(1 Not at all – 5 Very much, 6 I do not know, 0 I would rather not tell)**	None of the respondents had “other reasons” for stress, but instead of selecting the “Not at all” option, some selected “I don’t know”. Thus, having the “I don’t know” answering option for the j-th item does not seem to be informative, and it could be removed. In addition, one person revealed that even if he had some other reasons for stress, he would not bother to report them.
Over the last two weeks, how often have you been bothered by the following problems? **a) Feeling nervous, anxious, or on edge** **b) … f) …** **g) Feeling afraid, as if something awful might happen** **Answer options**	One person noticed that the time-scale between the answering options is not unified. He would have liked to have “Few days” as an option between the “Not at all” and “Several days” options. This is a good point, indeed, though we did not design the question. This is the GAD-7 measure for testing anxiety (Spitzer2006).

0 Not at all **1 Several days** **2 More than half the days** **3 Nearly every day**	
I'm satisfied with my current physical activity level. **(1 Strongly disagree - 5 Strongly agree)** **How often do you perform physical activities which cause sweating and get you out of breath (for example, brisk walking, running, swimming, football, physically straining home chores)?** **1 Not at all** **2 Sometimes** **3 1-2 times per week** **4 3-4 times per week** **5 More than 4 times per week**	A person recovering from a mild sport injury answered that he is not satisfied at all with his current physical activity amount. However, to the question regarding physical activity habits, he answered "3-4 times per week", since this is the amount of exercise he would usually perform, if not injured. If the sport injury was unknown, these answers might seem somewhat confusing. For reducing the possibility of acquiring misleading results, the questions regarding the satisfaction to health-related habits and the actual health-related habits should have the same time scale.
On the average, how many alcohol portions do you consume during one week? One alcohol portion is… **1 I don't drink at all** **2 I don't drink weekly** **3 1 – 2 portions** **4 3 – 4 portions** **5 5 – 10 portions** **6 More than 10 portions** **0 I would rather not tell**	One of the respondents admitted that he gave a bit more positive picture of his alcohol consumption habits than in reality, when answering this question. Indeed, it should be acknowledged in the user model that self-reports are always subjective, and might not tell the whole truth.
Think about the following values. Read the value descriptions thoroughly. Which of the values are important to you, which less important?	The term "value" needs to be defined. One of the respondents was not sure, whether the term refers to "a will to do something", i.e. goals or aims in life, or to the concrete actions of the person.
List the three most important values *in the order of importance* (1 = the most important). **1.** _____ **2.** _____ **3.**_____ **List the three least important values *in the order of importance* (1 = the least important).** **1.** _____ **2.** _____ **3.**_____	Choosing the three most important values were challenging for most of the respondents, since they had not thought about their values before, and some perceived all the values as important. When all the values were regarded as important, it was especially hard to prioritize them and even harder to choose the least important ones. Since the analysis of motive-orientations (Schwartz1994) is based on identifying the most important and least important values, it might be useful to add a follow-up question asking whether the person is sure about the selected value priorities. This would help to evaluate the reliability of the answers.
Below are a number of personality traits pairwise. Please, evaluate how well each pair of traits applies to you as *a whole*. **a) extraverted and enthusiastic** **b) critical and quarrelsome** **c) dependable and self-disciplined**	The term "complex" in item e) was difficult to understand for most of the respondents. One person chose to ignore the term completely and considered only the "open to new experiences" characteristic in her answer. This leads to wrong results, since

d) anxious and easily upset **e) open to new experiences and complex** **f) reserved and quiet** **g) sympathetic and warm** **h) disorganized and careless** **i) calm and emotionally stable** **j) conventional and uncreative**	each trait pair should be evaluated as a whole. An explanation for the term "complex" should be added, even though this is the validated TIPI measure (Gosling2003).
Were you honest, when answering the questions? **1 Yes, I answered honestly to all the questions** **2 Yes, I answered honestly to most of the questions** **3 No, I did not answer honestly**	This question raised a laugh in most of the respondents. One person admitted that he would answer "Yes, to all" even if he had not been entirely truthful with all the answers. Another person pointed out that generally people tend to answer truthfully if they take the trouble to answer questionnaires in the first place. This question could be removed or formulated differently.
I selected this goal because it is personally important for me. The expectations or preferences of other people did not influence my choice. **(1 Strongly disagree - 5 Strongly agree)** **I selected this goal due to the opinions of others or for the sake of someone, or because I would feel shame, anxious or guilt if I did not choose the goal.** **(1 Strongly disagree - 5 Strongly agree)**	One person pointed out that these two questions overlap, which is true. The second sentence of the first question could be removed.