



POWER2DM

“Predictive model-based decision support for diabetes patient empowerment”

Research and Innovation Project

PHC 28 – 2015: Self-management of health and disease and decision support systems based on predictive computer modelling used by the patient him or herself

POWER2DM D3.2

D3.1.1b Dynamic Behaviour Change Intervention Models for Self-Management

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EXECUTIVE SUMMARY

In the scope of Task 3.1 “Dynamic Behaviour Change Intervention Models for Self-Management” behaviour changes techniques (BCTs) relevant for POWER2DM were analysed. This deliverable describes BCT interventions meaningful for diabetes self-management. The document comprises the following sections:

Chapter 2 refers to target groups in POWER2DM.

Chapter 3 gives an overview of the theoretical background of behaviour change models and concepts for interventions used in POWER2DM. The focus of Behavior Change Techniques (BCTs) in POWER2DM will be on initiating and maintaining the behaviour change. A detailed overview of BCTs relevant for POWER2DM is given in the Appendix. A further psychological concept POWER2DM will take into consideration is the approach of the Acceptance and Commitment Therapy (ACT) dealing with values and barriers for fostering the patient’s long-term motivation.

Chapter 4 describes how self-management components, barrier identification and interventions will be included in the POWER2DM platform. The basis for coping with barriers and recommending interventions will be behaviour change models and concepts described in the previous section and listed in the Appendix. For addressing dynamically changing needs of individuals POWER2DM will include the concept of just-in-time adaptive interventions (JITIA) for providing interventions at the right time and only when needed.

Chapter 5 is dedicated to the interventions in POWER2DM themselves. Interventions will be provided immediately (JITIA), as feedback of the periodic review process and as recommendations at the end of a barrier decision tree workflow. The interventions are based on behaviour change techniques (BCTs), the degree of fulfilment of goals and activities and on rules.

Goals, activities and observations are core concepts for self-management. The ontology for goals and activities described in chapter 6 illustrates these core concepts and their relations to each other.

This document (D311b) is based on the preceding document D311a. The section 4 “Diabetes self-management and psycho-social barriers in POWER2DM”, the section 6 “Ontology for Goals and Activities” and the Appendix was updated. Section 5 “POWER2DM Interventions” is a new chapter in this document.

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1 INTRODUCTION

1.1 Purpose and Scope

The purpose of deliverable D3.1.1 is to describe behaviour change intervention models for diabetes self-management. This includes the analysis of relevant intervention models and based on that how POWER2DM components will include behaviour change models and concepts for interventions. The final chapter illustrates the metamodel (ontology) for goals and activities.

1.2 References

- POWER2DM Description of Work
- D1.1 User Requirements and Use Case Scenarios
- The use cases specified in D1.2 Requirements Specification of the POWER2DM Architecture

1.3 Definitions and Acronyms

ACT	Acceptance and Commitment Therapy
BCT	Behaviour Change Technique
DM	Disease Management
DSS	Decision Support System
JITAI	Just In Time Adaptive Intervention.
ODL	Observations of Daily Life

2 TARGET GROUPS

The types of users are already described in D1.1 “User Requirements and Use Case Scenarios”. In Chapter 3 “Persona’s” we described the layers of DM Self-management goals and psycho-social barriers. If a problem arises in self-management we need to asses in which area (e.g., glucose monitoring), which specific problem (e.g., too little monitoring) and the underlying reason (e.g., fear of disclosure of being a person with diabetes). Based on this framework we describe 7 persona’s that constitute 7 types of users.

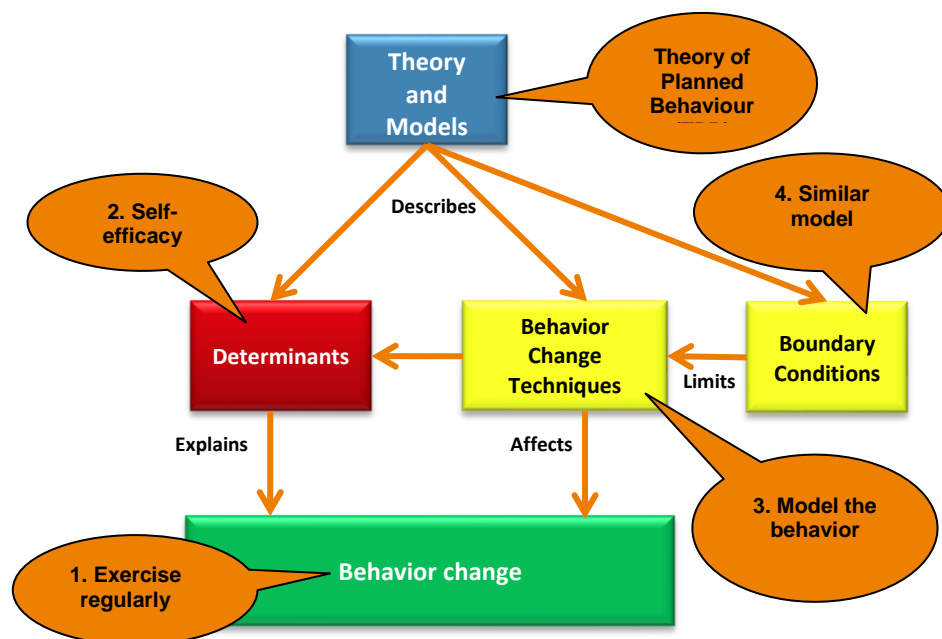
3 BEHAVIOUR CHANGE INTERVENTION MODELS AND CONCEPTS

This section gives an overview of the theoretical background of behaviour change models and concepts for interventions used in POWER2DM.

3.1 Behaviour Change Techniques and Stadia of Change

Most theories and determinants explain behavior, but do not describe how to change behavior. This distinction between explaining behavior and changing behavior is essential for methods that design interventions, like Intervention Mapping (Bartholomew et al., 2016). Also for designing the POWER2DM SMSS it is a crucial distinction. Figure 1 displays the relation between behavior (change) theory and technique. Theories may explain behavior by describing determinants (e.g., self-efficacy from the Theory of Planned Behavior), or how to change behavior (e.g. modeling from Social

Cognitive Theory), and provide limitations under which a determinant or technique is more or less effective (i.e., boundaries). For instance, modeling is more effective when the model is similar to the targeted person.



1.1.1.1.1 Figure 1 - Relation between theory, technique and behaviour, illustrated by promoting regular exercise.

Abraham and Michie (2008) defined 26 Behavior Change Techniques (BCTs) based on 195 descriptions of interventions to change a person’s lifestyle behavior. A BCT is an “observable, replicable, and irreducible component of an intervention designed to alter or redirect causal processes that regulate behaviour”. They can be used alone or in combination with other BCTs. These 26 BCTs consisted of 22 single techniques, and 4 more encompassing techniques; relapse prevention, stress management, motivational interviewing, and time management. Dusseldorp et al. (2014) grouped these 26 BCTs into three phases of behavior change:

- ◆ Motivation phase,
- ◆ Planning phase, and
- ◆ Action/Continuation phase (see Appendix 1).

Nowadays the focus in behavior change is more on behavior maintenance, as compared to behavior initiation (e.g., Kwasnicka et al., 2016). Several other classifications of BCTs exist. Currently, there are 93 unique BCTs that can be hierarchically-clustered into 16 groups (Michie et al., 2013, see also <http://www.bcts.23.co.uk/>).

In developing the POWER2DM SMSS we will use the CALO-RE taxonomy, which is a refined taxonomy of behaviour change techniques to help people change their physical activity and healthy eating behaviours (Michie et al., 2011). These two lifestyle behaviors are especially relevant for managing diabetes. In Appendix 2 the 40 BCTs from CALO-RE are described.

Relevant for POWER2DM

- The BCT taxonomy CALO-RE will be used because of its focus on changing physical activity and healthy eating behaviours.
- The focus will be on initiating and maintaining the behaviour change.

3.2 Values and Barriers based on Acceptance and Commitment Therapy (ACT)

Acceptance and Commitment Therapy (ACT) is a comprehensive theory of language and cognition that is an offshoot of behavior analysis. ACT differs from traditional cognitive behavioral therapy (CBT) in that rather than trying to teach people to better change their thoughts, feelings, sensations, memories and other private events, ACT teaches them to "just notice," accept, and embrace their private events, especially previously unwanted ones. ACT commonly employs six core principles to help clients develop psychological flexibility¹:

- ◆ Cognitive defusion – Learning methods to reduce the tendency to reify thoughts, images, emotions, and memories.
- ◆ Acceptance – Allowing thoughts to come and go without struggling with them.
- ◆ Contact with the present moment – Awareness of the here and now, experienced with openness, interest, and receptiveness.
- ◆ Observing the self – Accessing a transcendent sense of self, a continuity of consciousness which is unchanging.
- ◆ Values – Discovering what is most important to one's true self. They are those elements that give life meaning in a person's life.
- ◆ Committed action – Setting goals according to values and carrying them out responsibly.

The objective of ACT is not elimination of difficult feelings; rather, it is to be present with what life brings us and to "move toward valued behavior" (Hayes et al, 2012a). Acceptance and commitment therapy invited people to open up to unpleasant feelings, and learn not to overreact to them and not avoiding situations where they are invoked. From a psychological perspective the perspective is always one of empowerment: that a rich, meaningful, values-based human life is available to all (Hayes et al, 2012b).

3.2.1 ACT & diabetes

Diabetes is a chronic illness entailing a high risk of disability and death, when life styles are not adjusted and the adherence to medical treatments is low or not regular. Interventions aiming at managing diabetes-related distress may help people in dealing with its emotional challenges and to improve self-management skills. Many individuals with diabetes wish that they did not have diabetes. In addition, individuals who are diagnosed with diabetes have many things they need to do, to keep track of and worry about that they never had to address previously, e.g. watching one's diet, monitoring blood glucose levels, exercising regularly.

Literature demonstrates positive outcomes for diabetes patients treated with ACT interventions. By example, Gregg and colleagues (Gregg et al, 2007) randomly assigned 81 Type 2 diabetes patients to a 7 hours education group and to a group where education was associated with a mindfulness and acceptance training on difficult thoughts and feelings about diabetes, an exploration of personal values related to diabetes, and a focus on the ability to act in a valued direction while contacting difficult experiences. At three months follow up, in the group where 3 of the 7 hours diabetes workshop were focused on ACT processes, patients reported diabetes self-management improved significantly more and were more likely to show HbA_{1c} levels in the target range than in the control. Moreover, analysis have shown that changes in HbA_{1c} were mediated both by changes in self-management and diabetes-related acceptance.

A low diabetes acceptance can be associated with impaired self-care and glycaemic control. This was demonstrated by a study based on the *Acceptance and Actions Diabetes Questionnaire* (AADQ) which measures acceptance of diabetes-related thoughts and feelings and the degree to which they

¹ https://en.wikipedia.org/wiki/Acceptance_and_commitment_therapy

interfere with valued action (Schmitt et al, 2014). As diabetes is a lifelong disease accepting diabetes is a prerequisite for a successful diabetes self-management. Accepting diabetes means (Stenzel, 2012)

- ◆ accepting the diagnosed type of diabetes
- ◆ to be confident to be able to cope with diabetes and the therapy as part of my daily life
- ◆ to act in a way that the diabetes will not be a handicap to reach important goals in the future

Even more, fostering motivation and sustainable acceptance of diabetes is a main goal of ACT for diabetes.

3.2.2 Values

Personal values describe what is most important in the patient's life. They are those elements that give life meaning in a person's life. Personal values can refer to different areas in a person's life and can serve as a compass, guiding the person in the direction that he most wants to go in his life. ACT uses exercises to help dig down to values in important domains representing the deepest desires for the way a patient want to interacts with and relate to the world, other people and himself.

Values are not the same as goals. Values are directions we keep moving in, whereas goals are what we want to achieve along the way. A value is like a compass heading north. Goals can be achieved or 'crossed off', whereas values are an ongoing process. Not everyone has the same values, but there are four basic categories for areas of life that are typically valued by people (Harris, 2013):

- ◆ Work/Education – includes workplace, career, education, skills development, etc.
- ◆ Relationships – includes your partner, children, parents, relatives, friends, co-workers, and other social contacts.
- ◆ Personal Growth/Health – may include religion, spirituality, creativity, life skills, meditation, yoga, nature; exercise, nutrition, and/or addressing health risk factors like smoking, alcohol, drugs or overeating etc.
- ◆ Leisure – how you play, relax, stimulate, or enjoy yourself; activities for rest, recreation, fun and creativity

For example, clients may be asked to write about what they most deeply care about and how that has touched their lives or to write themselves a letter from a wiser future about what to hold dear in the present.

There are different approaches to work with values. The value identification process can be started with an imagination, e.g. with a funeral exercise as suggested by the authors of "The Diabetes Lifestyle Book" (Gregg et al, 2007) and the categories life area can be more detailed, e.g.

- ◆ Family relations, marriage/couples/intimate relations, parenting, friendships/social life, career/employment, education/personal growth and development, recreation/fun/leisure, spirituality, citizenship/ environment/ community life, health/physical well-being (Harris, 2013)

3.2.3 Barriers

Taking the time to sit down and think about what you most value in a given area are the important first step in mapping out a direction for creating a meaningful life. However, this leaves out the barrier to getting there. A big obstacle for many people in meeting realistic goals and activities for diabetes self-management and hence, in attempting to move towards their values, are barriers (Gregg et al, 2007), such as

- ◆ Time barriers – the process of finding time to live the personal values might be difficult at the beginning. It will require being choosy about which goals the patient focuses on to begin with and learning to set limits on things that are not consistent with his values.
- ◆ Energy barriers – refers to the energy to engage in a whole new set of behaviour and activities. If this is a problem patients should start with health-related values first (e.g. changes to your diet, exercise) to become energetic.

- ◆ Feeling barriers and thought barriers – dealing with e.g. feelings like sadness, loneliness, anxiety or maybe thinking about the disease is overwhelming and the patient can't stop it.

Barriers can be identified by assessing life areas and related values for importance and contentment. However, diabetes patients often have disease related problems. POWER2DM identified the following diabetes-specific problem areas with their particular problems:

- ◆ Insulin/Medication – low dose, high dose, low frequency, high frequency
- ◆ Diet – too few carbohydrates, too much carbohydrates, too few calories, too much calories, poor nutritional value
- ◆ Glucose monitoring – too little, too much
- ◆ Exercise – too little, too much
- ◆ Stress – stress too high

A detailed overview of typical problems and psycho-social barriers can be found in the appendix, in section 8.5.

Scores of values for high importance and low contentment presents gaps indicating barriers. For coping with barriers the user will be guided by a workflow based on decision trees. The “leaves” of a decision tree will be interventions as described in section 3.1.

Relevant for POWER2DM

- ◆ POWER2DM will provide a workflow guiding the user for identifying his/her personal values.
- ◆ Specifying goals for diabetes self-management in accordance to personal values increases the patient's compliance to treatment goals. In POWER2DM, personal values will be an additional basis for the patient's self-management goals and activities.
- ◆ If a patient is not able to live according to his/her values or has problems to meet his/her goals the patient is prompted by POWER2DM to identify barriers. POWER2DM will in particular provide decision trees for coping with typical diabetes related barriers.

3.3 Just-in-Time Adaptive Interventions (JITAs)

Unfortunately, it is observed that many of the self-management applications are not very effective when applied longer periods of time. Among many reasons, the most important ones are the false assumptions that individuals adhere to every step in their care plan, perform these actions on time and the same fixed intervention is effective for whole population. These assumptions do not take the behavioral and emotional state of the person into account. Recently, adaptive interventions have emerged as a new perspective on research-based prevention and treatment. The problem with fixed interventions is that the varying intervention needs of individuals may not be met optimally by using a single uniform composition, dosage, frequency, or content of the intervention. For this reason, an adaptive intervention assigns different parameters (dosage, etc.) of certain program components across individuals, and/or within individuals across time. All these parameters vary in response to the intervention needs of individuals, and they are assigned based on decision rules linking characteristics and behavioral context of the individual with specific levels and types of intervention components. Existing health behavior change theories provide the scientific knowledge and background for the design of adaptive interventions as they define the behavioral concepts and describing the factors and relationships among them that affect the health behavior.

With the advance in mobile phone technologies, the concept is mainly used for mobile phone intervention design as a special case of adaptive intervention, and called the **Just-in-time adaptive**

intervention (JITAI) (Spruijt-Metz & Nilsen et al., 2014). This concept holds enormous potential for adapting mobile phone delivered interventions to the dynamics of an individual's emotional, social, physical and contextual state, so as to prevent negative health outcomes and promote the adoption and maintenance of healthy behaviors. A JITAI is an intervention designed to address the dynamically changing needs of individuals via the provision of the type/amount of support needed, at the right time, and only when needed (Nahum-Shani, Inbal, et al, 2014). Recently, many studies focus on JITAIs and design and use them to support health behavior change in physical activity, eating disorders, alcohol use, mental illness, smoking cessation, obesity/weight management and other chronic disorders.

The main components of JITAIs are as follows;

- **Decision points** are points in time at which treatment decisions must be made. These decision points are specified by the designer of the intervention; at every given time interval (e.g. every week check medication adherence performance of patient), specified time points during a day (e.g. every night check the blood glucose management performance of a patient), following the collection of data (e.g. after every blood glucose measurement).
- **Intervention options** in JITAIs include types of support, sources and timing of support; and modes of support delivery.
- **Tailoring variables** are the parameters that influence timely personalization of intervention options to a patient's momentary needs. For example, the location of patient or mood of patient can be tailoring variable to determine the best intervention options. Tailoring variables can be obtained by self-reported or passively collected data about the patients behavioural, emotional, environmental, health status context.
- **Decision rules** are the algorithms that individualize the intervention by specifying which intervention option to offer, when, and by which means based on the tailoring variables. There is a decision rule for each decision point.

3.3.1 Computation Modeling of Behavioral Models and JITAI delivery

With the advances in computer science in anticipatory computing and sensing technologies, the development of computational models of behavioural change becomes popular (Velico Pejovic et al, 2014, 2015). The ultimate goal is to have testable models of behaviour with interoperable subcomponents that capture the complexity of behaviour in the real world and deliver JITAIs based on the reasoning and anticipation done over these models (Spruijt-Metz D et al, 2015). Such models would be developed incrementally, with initial models only responding to small amounts of input capturing only certain aspects of behaviour and interactions. In the current state-of-the-art, there are numerous modelling methodologies used, ranging from system identification complemented with model-predictive control, to agent-based modelling, and dynamic Bayesian network analysis, such as Markov modelling or related machine-learning approaches like reinforcement learning. One of these is the research, carried by Rivera with his research group² which advanced the research for adaptive health interventions and demonstrated how control systems engineering approaches can be used to model and improve an adaptive intervention process. In general, control systems are used to model complex dynamical systems and optimizing outcomes by applying control design algorithms and computer simulations. In fact, the same approach is used for adaptive interventions for behavior change. Experimenting the model and interventions in a randomized experiment and running further simulations on the collected data then allow researchers to modify the model parameters accordingly to increase the confidence and reliability of the model. In these early studies, some dynamic models are proposed and experimented for some specific manual interventions like smoking cessation, gestational weight gain with the Theory of Planned Behavior and self-regulation theories as the basis.

² Arizona State University, Control System Engineering Laboratory, Adaptive Interventions in Behavioral Health, <http://cseel.asu.edu/node/13>

Figure 2 illustrates the modelling of Social Cognitive Theory by using control system engineering methodology with a fluid system analogy. As shown, the concepts in the theory like Self-efficacy, or Outcome Expectancy are modeled as differential equations on inputs like observed behavior, perceived barriers, etc. and there are feedback loops (outputs of these states are input to the others).

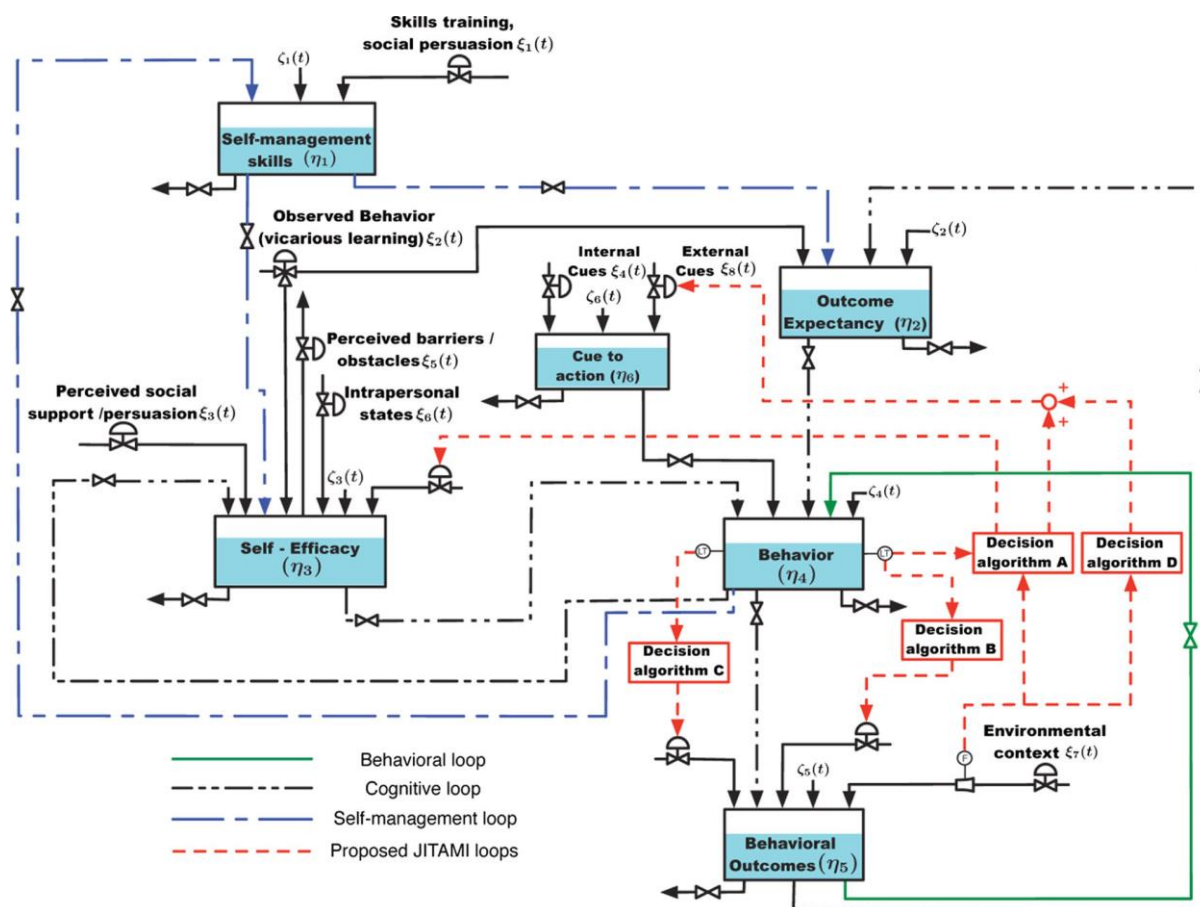


Figure 2 – Modelling of Social Cognitive Theory by Control System Engineering with Fluid system analogy

Relevant for POWER2DM

- POWER2DM will deliver JITAI over POWER2DM SMSS Mobile Application to support the diabetes self-management process for expected health behaviour changes in certain areas; adherence to medications and dietary, physical activity and other self-management plans.
- POWER2DM will focus on the personalization of interventions in terms of support type with behavioural change techniques (e.g. different motivation methodologies; motivation by outcome expectancy evaluation, or motivation by showing another patient's performance as an example), and timing of interventions.
- POWER2DM use reinforcement learning technologies to determine the type of intervention and best time to show the interventions

4 DIABETES SELF-MANAGEMENT AND PSYCHO-SOCIAL BARRIERS IN POWER2DM

This section describes how POWER2DM will include behaviour change models and concepts for coping with barriers and recommending interventions.

4.1 Action Plan Workflow

The Action Plan Engine offers a guided workflow for diabetes self-management including personalized adaptive computer-aided health behaviour change interventions to support the patient to obtain and maintain healthy behaviour change. The Action Plan Engine

- ◆ supports the patient for planning personal goals and becoming aware of personal values
- ◆ supports the patient for planning and executing self-management activities based on personalised goals and values and
- ◆ provides periodical feedback and interventions for improvements based on the patient's status and progress for fostering motivation
- ◆ provides historical analysis to detect patterns for determining or emphasizing feedback and interventions e.g. assess progress over time, determine barriers or temporary setbacks, etc.

The starting point is the treatment plan including long-term and short-term goals. The Action Plan cycle is an iterative cycle, typically on a weekly basis. If a patient specifies activities on a weekly basis the likelihood that these activities are realistic is higher than planning activities for a longer period. However, the Action Plan cycle can also be bi-weekly, monthly or of another duration.

The steps of the Action Plan cycle are described as follows:

- (1) **Specify & update self-management goals** – based on the treatment plan and optional on the personal values the patient defines his self-management goals. In case, there already exists some self-management goals the patient can update them accordingly.
 - If the patient has no changes on the treatment goals he adopts them in his list of self-management goals.
 - Although the patient can specify self-management goals for each value it would be meaningful to specify at least goals for those values where gaps (=barriers) were identified and actions are needed to cope with the barriers.
 - Example: patient is used on a very active life, likes parties and is a very sportive person. Recently, Type 1 diabetes was diagnosed and since then he is quite often suffering from hypos. He decides to check again the information material about hypos, to be observant about upcoming hypo events, to record them and to talk to his doctor at the next appointment about his problem. Hence, the patient specifies 3 self-management goals – check info material, record hypo symptoms and talk to the doctor.
 - The Action Plan Engine also provides information how to plan goals and activities properly, e.g. if a goal is too excessive or just too big and the patient got overwhelmed he could break it down in one or more realistic sub goals
- (2) **Specify & update activities** – in the next step the patients plans and updated the activities for the upcoming week. If desired, reminders can be activated.
 - Example: Nordic walking on Monday and Friday at 18:00, duration 30 min, reminder 15 min before
 - Example: measuring my blood glucose level all days at 7:00, 12:00, 19:00 and 22:00, reminder 5 min before

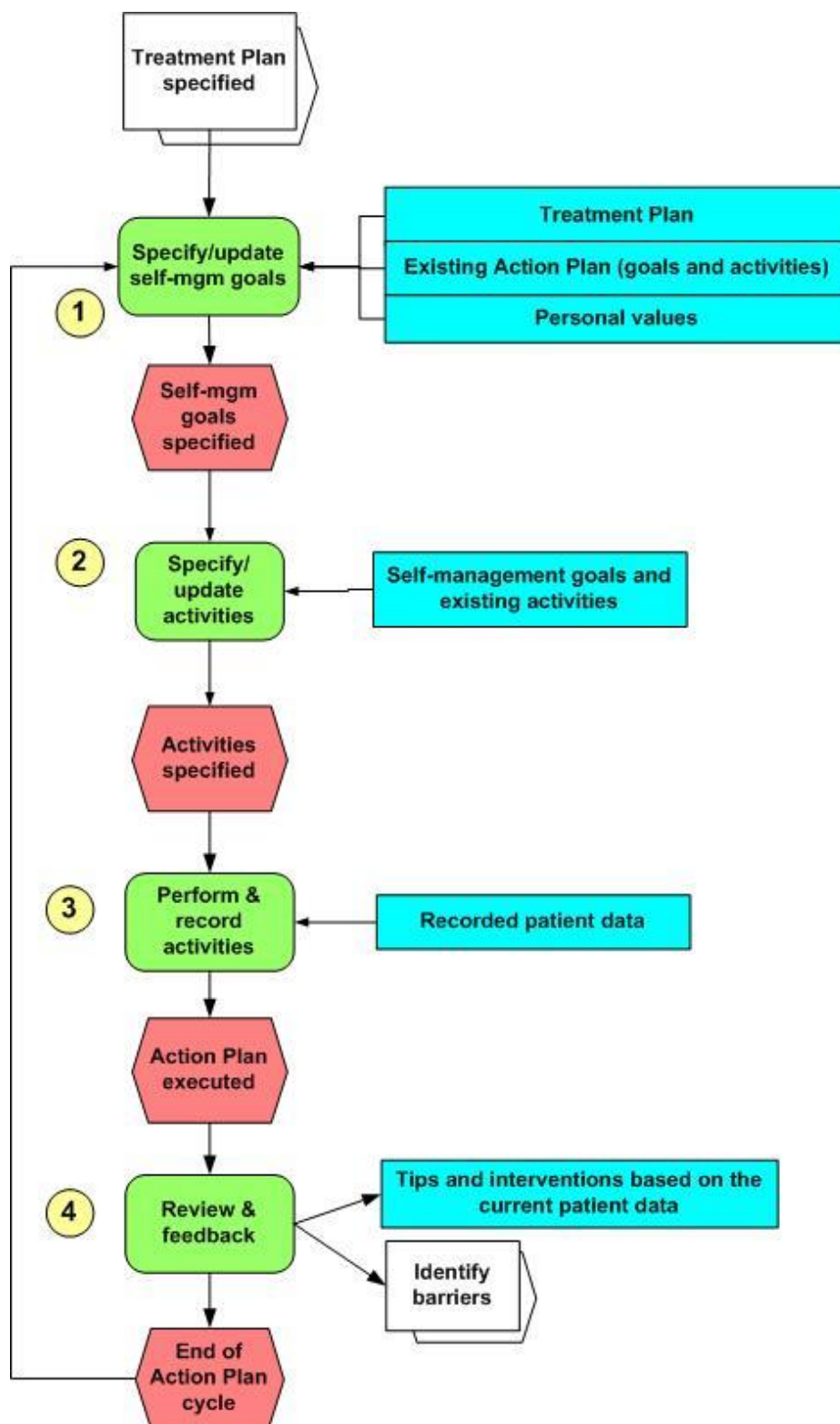


Figure 3 - Action Plan cycle

- (3) **Perform & record activity (self-monitoring)** – during the week, patient data will be recorded by devices but also manually. This phase supports the self-monitoring of vital data and behaviour
 - Example (device): values for blood sugar, blood pressure, weight

- Example (manually by e.g. Web forms or via Smartphone): high stress, bad mood
- (4) **Review & Feedback** – at the end of the week (or when the patient wants to ask for feedback) the Action Plan Engine evaluates and gives feedback how successfully the patient has fulfilled his planned self-management goals and activities. The patient might also review a wider time period beyond a week. The Action Plan Engine gives feedback about the overall performance, about the performance of all scheduled activities and related goals and about additional patient data (e.g. sleep problems) recorded within the review period. Additionally, the Action Plan Engine provides hints and advices (=interventions for self-management) for all activities, goals and additional recorded data.
 - The interventions aim at behaviour changes based on BCTs and can be of different types, e.g.
 - Information about diabetes and the consequences
 - Identifying possible barriers in case of low performance of an activity or critical journal entries (see section 4.3)
 - Referring to exercises or e.g. slide-shows for demonstrating alternative behaviours
 - Reminding the patient on his/her personal values
 - Referring to links providing additional information for specific problems, e.g. overcoming fear of needles
 - Including advices for e.g. relaxation in case of increased stress
 - Motivational messages
 - Additionally, the review can analyse historical patterns e.g. evaluating progress over several weeks and provide the patient with a “bigger picture” to help the patient plan better and even identify potential barriers. There might be patterns of interest supports motivational strategies and even help the patient realize his/her own barriers over time.

4.2 Value Compass

As known from ACT, the Acceptance and Commitment Therapy (Gregg et al, 2007), specifying (self-management) goals in accordance to personal values increases the patient’s compliance to treatment goals. Values describe what is most important in the patient’s life. They are those elements that give life meaning in a person’s life.

Personal values can refer to different areas in a person’s life and can serve as a compass guiding the person in the direction that he most wants to go in his life. Specified personal values are a basis for all self-management goals and activities. An integrated function of the Action Plan Engine will be the **Value Compass** guiding the patient through a workflow for identifying and updating personal values. This workflow comprises the following main steps and is based on the ACT approach (see section 3.2):

- (1) imaging an event where people speak friendly about the patient
 - e.g. 90th anniversary, the own funeral, farewell party, miracle question
- (2) specifying personal values for life areas by questions. Figure 4 depicts the possible life areas. The most important and primary life area for diabetes patients is “Health / diabetes / physical well-being”. All other life areas are optional. At the end of this step, the user will be requested to summarize the key messages what is important to him/her (= value) in one or more key sentences.



Figure 4 - Value Compass: Life Areas

- (3) The user is requested to assess all values by scores for importance and contentment for identifying gaps (=hints for barriers). The result will be presented as a chart (see Figure 5).

Gaining clarity

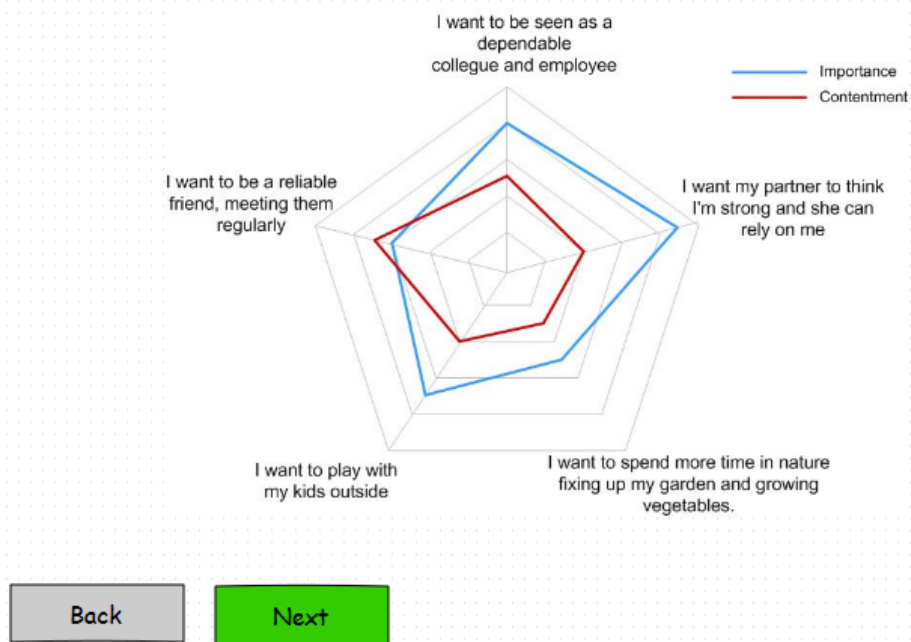
Take time to reflect on your key sentences.

Is there a gap between the importance and how content you are with a key sentence?

Share your values with your loved ones and try to think of actions to pursue your values and cope with your barriers.

Remember: Your key sentences and values are an ongoing process, not a static thing.

Come back and redefine them after specific periods or major milestones.



Back

Next

Figure 5 – Value Compass: importance and contentment of key sentences

- (4) The gap between (high) importance and (low) contentment is typically a hint that there is a barrier for this value. In this case, the user is prompted to be guided by a workflow for identifying barriers and proposing interventions will be suggested (see section 4.3)

Example: Anna wants to have children within the next few years, but currently her HbA1c is too high. It should be below 53 mmol/mol before she is “allowed” to try to get pregnant. She specifies importance = 10 and contentment = 2. The Action Plan requests her to specify what she needs (in particular from a not-medical point of view) to increase her HbA1c below 53 mmol/mol, to define a goal for that and to discuss this topic with her doctor.

The result will be personal values important for the patient in his life. Depending on the patient this might be a private section and it has to be the patient’s decision whether he wants to share his value compass or parts of it with e.g. his physician or not. However, it aims at fostering long-term motivation for self-management activities.

The patient can utilise this function as an additional input for specifying self-management goals in accordance with not only the treatment goals but also with his/her personal values, but also as input in case of an appointment with a physician or a psychologist when specifying the treatment plan.

4.3 Decision Trees for coping with Barrier

Appointments with physicians might be quarterly or once a year. Between these appointments at home the patient may realise that s/he will have some troubles to fulfil the treatment plan in accordance with his personal values. This function about coping with barriers aims to be a support for self-management when using the Action Plan Engine:

- ◆ for increasing awareness how coping with barriers can facilitate the patient to manage his diabetes properly,
- ◆ for specifying realistic self-management goals and activities with a high degree of fulfilment and
- ◆ in case there is no physician or psychologist available for discussing problems, the patient can actively seek information how to cope with barriers.

Within the POWER2DM project it will not be possible to cover all barriers diabetes patients are confronted with. However, the most frequent barriers are summarized in the table presented in section 8.5 “Self-management Problems and psycho-social barriers” and covers barriers regarding, insulin, carbohydrates, glucose monitoring, exercise and stress for both Type 1 and Type 2 diabetes. This table was a starting point for designing decision trees for coping with barriers and recommending appropriate interventions. The detailed decision trees for these five areas are described in section 8.6 “Decision trees for coping with barriers”.

The following three figures describe the basic approach how a decision tree guides patients through a workflow for identifying their problems with glucose monitoring. In the first step (see Figure 6) patients are asked to check whether they have any problem with their current goals. This can be e.g. a weekly request. If the patient says yes then they are asked to select one of the suggested topics. In this example the patient chooses “Glucose monitoring” as the problem.

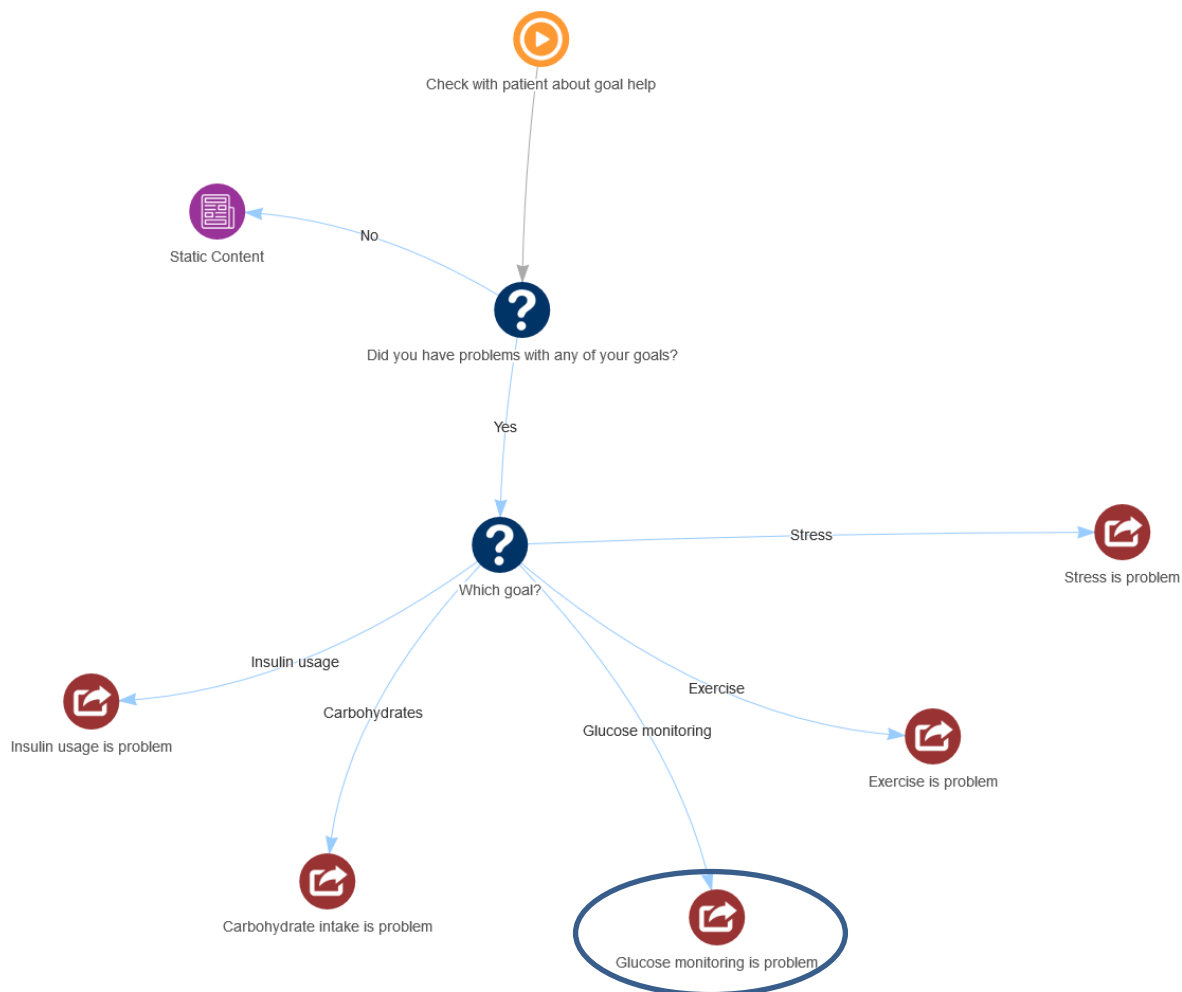


Figure 6 - Decision Tree for identifying goal problems

The red nodes can trigger new decision trees. The next step (see Figure 7) aims at finding out where and why the patient is having a problem with glucose monitoring. This patient indicates that he monitors too little. Next, POWER2DM asks for common problems regarding glucose monitoring barriers, e.g. dislike of needles, forgetting to monitor. If the patient cannot identify any specific barriers they are then asked about general barriers, e.g. not important, patient doesn't care. In our example, the patient indicates that he just don't like monitoring his blood glucose.

The answer triggers the next step (see Figure 8) suggesting interventions for coping with the user’s problem. For this barrier the patient is given the following options

- ◆ receiving more information about glucose monitoring and not feeling good about it
- ◆ reading/hearing/seeing stories from other patients about this
- ◆ choosing from exercises to try to cope with the barrier
- ◆ changing the related goal.

This is the leaf of the tree. Depending on the selected option POWER2DM leads to the next step, e.g. presenting the required information or to the goal menu for changing the related goal.

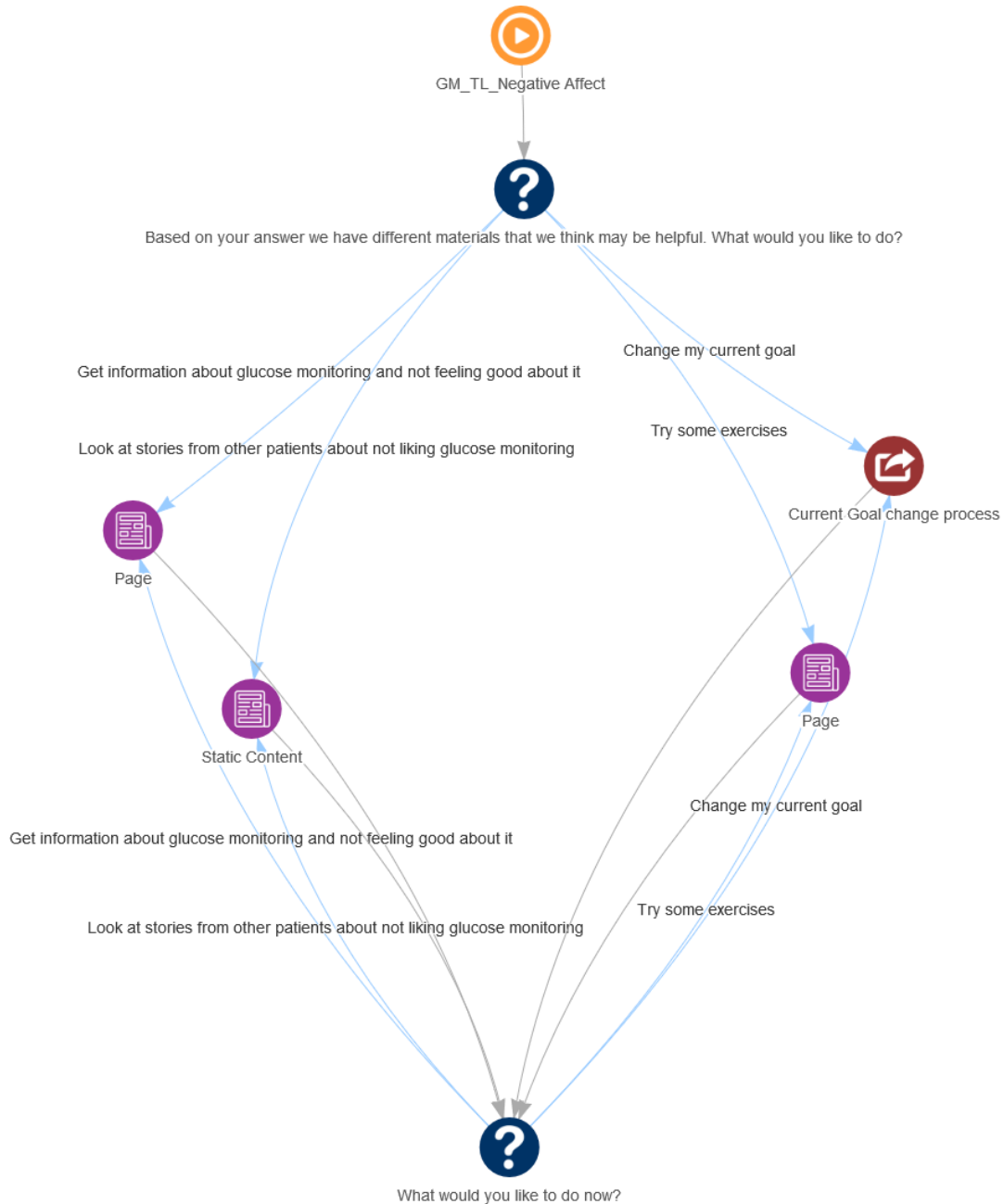


Figure 8 - Decision Tree for coping with negative effects

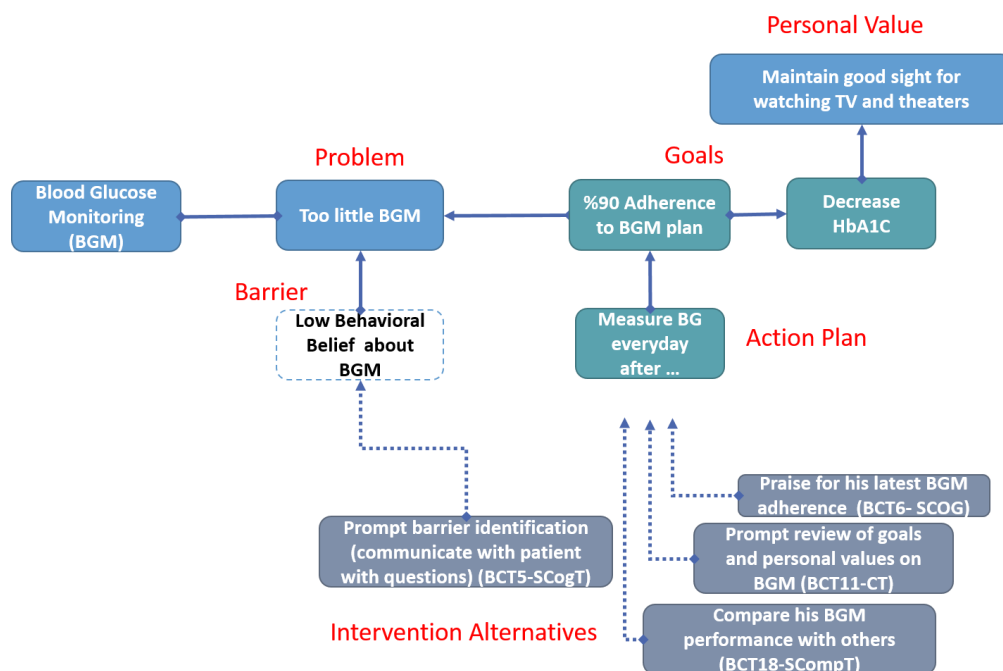


Figure 10 – An example for the relations

As **intervention options** POWER2DM focuses on the followings;

- Type of support (BCT Technique) suitable for patient for that time
- Timing of JITAI within the day by considering the interruptibility, expected effect for the intervention and intervention burden on the patient

From the research perspective, POWER2DM will search answers for following research questions;

Q1: Do habit gain for a daily self-management activity based on reminders differ at the beginning of self-management process and later in the process? (Lally, P et. al, 2010)

- **Hypothesis:** Yes. Patients would have a slower rate of habit gain at the beginning and comparatively faster rates at the later phases

Q2: Does the total number of interventions in a day making a patient uncomfortable differ over time?

- **Hypothesis:** Yes. Patients would tend to see less interventions as they would learn how to behave or they get bored of seeing interventions

Q3: Does interruptibility of patients affect the timely utilization of interventions (See Amelia Scenario) (Veljko Pejovic et. Al, 2014)

- **Hypothesis:** Yes. The view rate of interventions would increase if they are delivered at the moments when patients are more likely to be interrupted
 - e.g. When the phone screen is open or after they use a social application
 - e.g. When they do not drive
 - e.g. When they are at home

Q4: Does frequency of interventions affect the view rate/success?

- **Hypothesis:** Yes. Patients would less likely to view interventions if the temporal gap between subsequent interventions is small

Q5: Does timing of the intervention during the day affect the view rate/success?

- **Hypothesis:** Yes. Based on the personal preferences and daily routines patient might or might now want to see interventions during certain periods during the day

Q6: Does type of BCT technique in intervention delivery affect the view rate/success?

- **Hypothesis:** Yes, each patient may different characteristics and their responses may differ for different types of BCT techniques.
 - e.g. Motivating patient by showing a behavioural link (As you paid attention to your calorie intakes, you lost 500 gr last week)
 - e.g. Motivating patient by showing outcome expectancies (If you will adhere to your dietary plan, you may lose weight in next month)
 - e.g. Motivating patient by giving positive health behaviour examples in people's reference groups (Your friend adhere to his dietary plan, and lose 1 kg in last month.)

4.4.1 Methodology for JITAI design and implementation

In order to design an effective JITAI conceptually and implement it within the POWER2DM system, a trans-disciplinary study is needed where clinicians, psychologists and patients themselves work on the conceptual design (what will be beneficiary for the patient, in what cases, what BCT techniques can be used, the process, etc.) and software engineers work on the how this can be implemented and bound to the data collected and functionalities provided by the systems. Also it is very important to narrow down the scope to the most important JITAIs to be realistic about the implementation and evaluation of effectiveness of the designed JITAIs.

Figure 11 illustrates a fictional decision flow including several decision points and JITAI delivery based on several tailoring variables and rules. We do not intend implement such a complex workflow, we present it just to give an insight how we should design the JITAIs. Furthermore, it is not realistic to cover all possible cases that may occur during diabetes self-management care, it will help if such functionality can be provided for common problems experienced by patient groups.

In the light of this, we have designed the following methodology for the conceptual design of JITAIs that will be the reference point during the implementation (implementation of algorithms, UI interfaces, rules, flows, etc.).

- i) Identify the important cases (decision points) in self-management phase that may need a JITAI.
 - e.g. Time for a planned exercise is approaching and it is predicted that patient may not perform it as the habit is not performed yet
 - e.g. The problem “too little insulin” is already detected and scheduled time for insulin intake is approaching
- ii) Define the decision flow for each of these cases by further elaborating on the rules, sub decision points, flow
- iii) Identify the possible JITAI based on different BCT techniques for each leaf of the decision flow tree
 - e.g. Motivate patient for the approaching exercise plan by “BCT-2 Provide information on consequences.”
 - e.g. Motivate patient for the approaching exercise plan by “BCT-19 Social Comparison”
- iv) Define the details of the JITAI

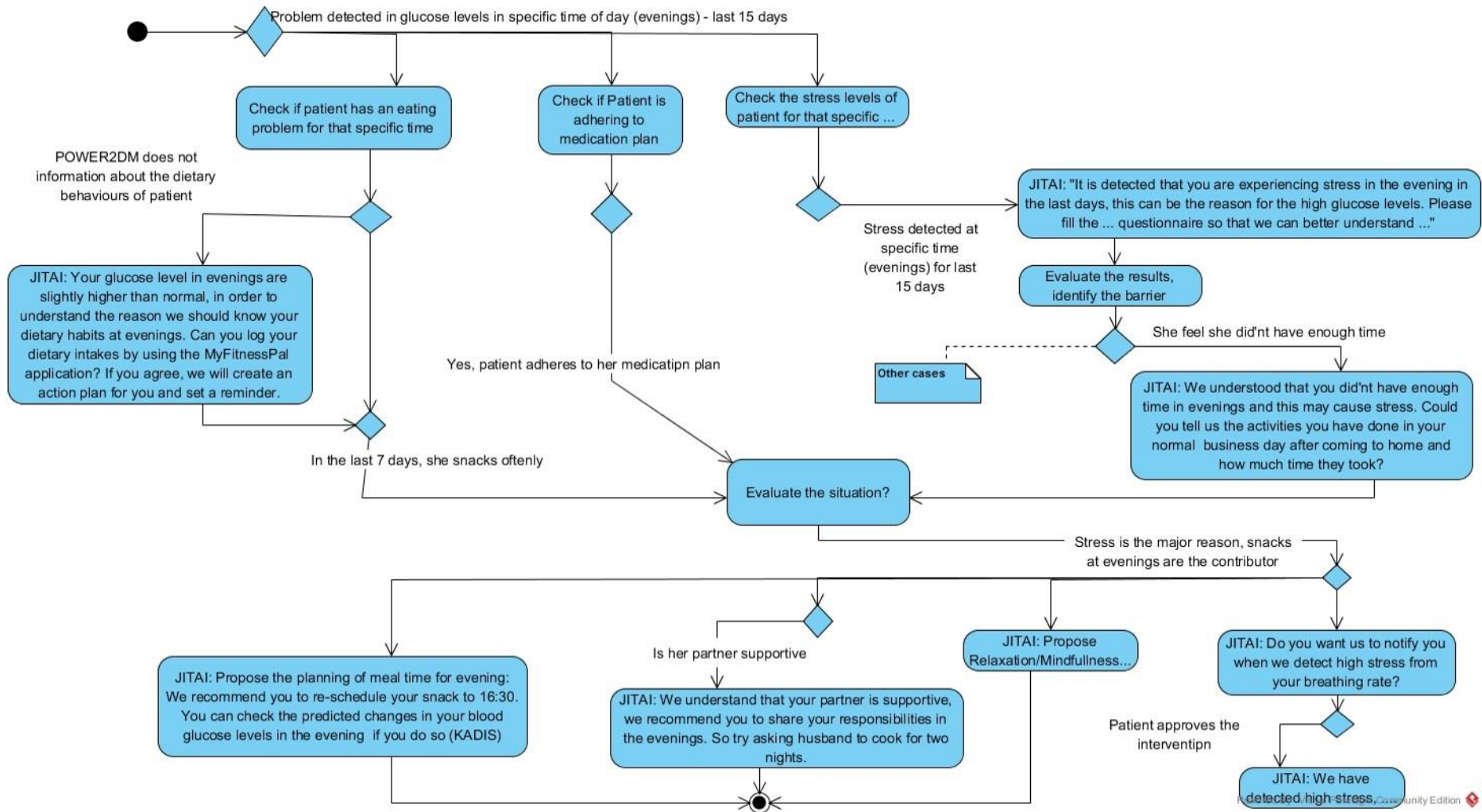


Figure 11 – A partial fictional decision flow for JITAIs

5 POWER2DM INTERVENTIONS

This section describes different approaches how POWER2DM includes interventions. The interventions focus on motivation and behaviour changes.

5.1 Interventions for the periodic review and for barrier decision trees

The Action Plan Engine provides interventions as part of the review phase and by suggesting interventions at the end of barrier decision trees. These interventions are stored in the intervention table which is based on a dual approach and supports both a psychological and a technical approach. From the psychological point of view the starting point is the compliance with the planned goals and activities. Depending on the degree of fulfilment different types of interventions/purpose and BCTs can be specified (see Table 1)

Trigger for intervention	Type of intervention/Purpose	Main BCT's
achieved more than goal / activity (plus/plus)		
	Motivational Message: - Positive reinforcement - Reinforcing/Increasing self-efficacy	e.g. Positive comparison with self e.g. General reinforcement
	JITAI/Warning	e.g. Planning
	Standard reminder	e.g. Planning/Goal setting
	Standard evaluation	e.g. Feedback/Review goals
achieved goal / activity (plus)		
	Motivational Message: -Positive reinforcement -Reinforcing/Increasing self-efficacy	e.g. Positive comparison with self e.g. General reinforcement
	JITAI/Warning	e.g. Planning
	Standard reminder	e.g. Planning/Goal setting
	Standard evaluation	e.g. Feedback/Review goals
almost achieved goal / activity (plus/minus)		
	Motivational Message: - Positive reinforcement - Reinforcing/Increasing self-efficacy	e.g. Positive comparison with self e.g. General reinforcement
	JITAI/Warning	e.g. Planning
	Standard reminder	e.g. Planning/Goal setting
	Standard evaluation	e.g. Feedback/Review goals
	Question to detect barrier	e.g. Prompt Barrier Identification
	Question to intervene on barrier	e.g. Prompt Behavior
	Intervention on barrier	e.g. Psycho-education
achieved less than goal / activity (minus)		
	Motivational Message: -Positive reinforcement -Reinforcing/Increasing self-efficacy	e.g. Positive comparison with self e.g. General reinforcement
	JITAI/Warning	e.g. Planning
	Standard reminder	e.g. Planning/Goal setting
	Standard evaluation	e.g. Feedback/Review goals
	Question to detect barrier	e.g. Prompt Barrier Identification
	Question to intervene on barrier	e.g. Prompt Behavior
	Intervention on barrier	e.g. Psycho-education

Table 1 - Behaviour change approach for interventions

From the technical point of view the “Trigger for interventions” will be the performance of successfully recorded activities. Based on the psychological approach, the performance comprises 4 categories

- ◆ Perf = 4 refers to “achieved more than goal / activity (plus/plus)”
- ◆ Perf = 3 refers to “achieved goal / activity (plus)”
- ◆ Perf = 2 refers to “almost achieved goal / activity (plus/minus)”
- ◆ Perf = 1 refers to “achieved less than goal / activity (minus)”

Based on that and on additional parameter rules are specified for each intervention. Not all patient data are related to a scheduled activity. Additional patient data can be recorded, e.g. when the user records sleeping problems, mood or stress. In this case the Likert scale is used as basic input for the rules (see example 4 in the Table 2).

The intervention table is developed by both partners with psychological expertise and technical partners. The definition format of intervention used by the Action Plan engine comprises the following parameter:

- ◆ **Text Source ID** – is the unique identifier for the intervention
- ◆ **Category** – refers to the review categories
 - Overall_performance – indicates the overall success rate of planned versus recorded activities
 - any_activities = total activity performance
 - any_goals = total goal performance
- ◆ **ODL** – indicates the type of recorded data
 - e.g. exercise, stress
- ◆ **Conditions** – subtype of ODL
 - e.g. “fatigue” as subtype of “problems”
- ◆ **Decision Tree ID** – is the unique identifier of a leaf in a decision tree. The intervention table not only includes interventions used for the review phase of the Action Plan Engine but also for suggesting some of them at the end of a barrier decision tree. Example 5 in Table 2 is used by both the review in case the performance of glucose activities is less than 3 and by the exercise decision tree in case there is a conflicting life goal. The decision tree ID “EX_TL_Conflicting_Life_Goals” represents the link between the “leaf” of the decision tree and the intervention in the intervention table. Number 6 in Table 2 is another example.
- ◆ **View** – refers to where an intervention is displayed
 - Review – for the periodic feedback
 - DT – the intervention is related to a Decision Tree ID in the decision tree leave

An intervention can be used for either review or DT or for both
- ◆ **Rule** – defining the conditions when the related intervention should be presented. Rules are primarily based on
 - Performance (perf [1..4]) – for planned activities
 - Likert Scale – for additional recorded patient data
- ◆ **Intervention** – describing the content of an intervention. The intervention in the intervention table can be of different types. The can be plain text (see example 1, 3 and 4 in Table 2), they can refer to an external website (see example 2 in Table 2), they can recommend an exercise (the Energy Battery in example 5 in Table 2) and they can refer to a more detailed explanation in the POWER2DM information material (example 6 in Table 2). An intervention can also include placeholders, e.g. for referring to an exercise, for recommending a section in the information material or for including parameters such as a date or the title of the related activity. Finally, if an intervention includes an activity POWER2DM offers the option to perform it immediately or add it to the user’s action plan for performing the activity at a later date.
- ◆ **Type of intervention / BCT** – refers to the type of intervention resp. the behaviour change technique used to be used for the intervention, e.g. goal support, social support

The following table presents some basic examples from the intervention table:

	Category / ODL / Decision Tree ID	Rule	Intervention	Type of intervention / BCT
1	overall_performance, any_goal, any_activity	Perf = 4	Great success! Allow yourself a small reward for it. Think of something that YOU like (a magazine/newspaper, taking a nice bath, drinking coffee on a terrace etc.)	Positive reinforcement
2	Exercise, nutrition, glucose, medication	Perf < 3	Do you feel adequately informed about diabetes and its effects on you? If yes, that is important and really good! If not, you might take a look the [following information material](http://www.diabetes.co.uk/emotions/). Many people with diabetes underestimate the effect it has on them, or feel that they should not complain about it.	Psycho-education on Emotional Impact
3	Exercise, nutrition, glucose	Perf = 1	When you feel it is difficult to achieve your goal and perform your activities, it might be good to try to remember why this goal is important to you. Can you think about the main reason(s) why you are pursuing this goal? When you have difficulty finding the importance of this goal, you might ask others (e.g. caregivers) why this goal is important in general. Then try to rethink why this goal is personally relevant to you. How can the pursuit of this goal help you in your personal life?	Intrinsic Motivation, Goal relevance
4	Stress	Likert < 4	What do you need to relax? Think about the things that make you feel relaxed and try to plan it for (later) today.	Psycho-education, Relaxation, planning
5	Glucose EX_TL_Conflicting_Life_Goals	perf < 3 within review period	It seems as if you performed less exercise than you hoped in the (#review-period). Do you know/understand why you exercised less? There can be several reasons for not performing exercise, such as not feeling like exercising, being too busy for exercise, being too tired to exercise or feeling too much stress to exercise. We could help you in trying to change this. If you would like more information on this now, then click on [Energy Battery](#energybattery). If you would like to do the Energy Battery later than schedule an [activity](#ACTIVITY)	Psycho-education on the influence of low mood and stress in exercise Stress-management
6	Glucose GM_TM_Fear_hypos_Process	Perf < 3	Good to know. Many people with diabetes are scared of hypo's. Do you want any information on fear of hypo's? If you want to continue please click here [here](#Txt_Fear_Hypoglycaemia) to continue with more explanations. If you would like to it later then schedule an [activity](#ACTIVITY)	Psycho-education

Table 2 - Interventions from the intervention table (examples)

5.2 Just-in-time interventions (JITAI)s

POWER2DM JITAI)s aim to help patient to adhere his action plans that is **obtain or preserve the healthy behaviour change** e.g. attaining the requested blood glucose monitoring behaviour, increasing physical activity, etc.

In this respect, in terms of triggering points (decision points) we have the following categorization for purpose of intervention;

- **After Event Motivation:** These are interventions for the first objective above and be delivered to motivate patient either after a performed action or daily performance or after a missed action.
 - e.g. "That was a good day! You walked 10% more than yesterday."
 - e.g. "You made so much progress this week! This was not your best day, but you worked hard, this week!"
- **Motivation with Reminders:** Also for the first objective, these are the interventions to be delivered before a planned action to remind and motivate the patient to do it.
 - e.g. "You have a scheduled BG monitoring after dinner and you are almost there! Keep on adhering your schedule and you will reach your goal this week."

As you see from the examples, each of these interventions has different **decision points** in time. For After Event Motivation, the point is after a performed action or measurement (which can be a passive measurement without act of patient like Fitbit data) or a completion of all actions for the day. For motivational reminders, it should be before the scheduled action.

After identifying the decision points, another crucial point is to take the decision whether the intervention is required/desired or not, the **decision rules** component of JITAI)s. A multidisciplinary discussion among consortium identifies four issues for decision rules;

- Decision should be in line with **clinical evidence regarding diabetes**; for clinical safety
- Decision should be in line with **health behaviour change theories**, so that they can be effective
- Decision should be in line with **patient's preferences**; because we don't want patient to stop using the application, increase the burden on him with too many messages or the ones that he/she does not like
- Decision should be in line with the **treatment plan** set by the physician for the patient; because it gives us the main objective of self-management period; the medical problem (e.g. too little glucose monitoring), the goal (e.g. 3 times a day) and planned actions (e.g. monitor your BG after breakfast, etc.) to solve the problem.

JITAI)s will be delivered only for patients' related treatment or self-management active goals and action plans set by physician or patient himself. So, if patient does not have a goal regarding physical activity for that period, no intervention will be delivered related with physical activity.

JITAI)s will be delivered based on patients' preferences for that specific goal and the intervention type (motivational reminder vs after event motivations). The following is the possible preferences;

- **Each Time (Always):** For each planned action for a specific time the intervention will be delivered. e.g. If patient select "mandatory" for "reminders" for "BG monitoring goal", a reminder will be sent for each planned action (once after breakfast, once after lunch, etc.).
- **Frequently:** The intervention will be delivered 70% of time for the planned actions. e.g. If 3 times daily BG monitoring scheduled for patient (21 measurements in a week), it means intervention will be delivered approximately for 14 of them in .
- **Occasionally:** The intervention will be delivered 30% of time for the planned actions.
- **Rarely:** The intervention will be delivered %10 of time for the planned actions.

- **Never:** The intervention will never be sent.

From the behaviour change (psychological) perspective there are different intervention types and Behavioural Change Techniques (BCTs). Some of them considered in POWER2DM as JITAI are as follows;

- **Positive comparison with self:** In general, this type of interventions provides a positive comparison of patient’s latest performance with his/her past performance and motivates patient
- **Positive comparison with others:** In general, this type of interventions
- **General reinforcement**
- **Planning and goal setting (simple reminder)**

Each of them can be used in different purposes (e.g. as reminder or after event motivation) with different contents according the patient’s goal context; patient’s latest performance(s) regarding his goal. Basic categorization of goal context is as follows;

- **Achieved more than goal**
- **Achieved the goal**
- **About to achieve goal:** Patient has very few remaining actions (or remaining time in a period) and is close to achieve his goal
- **Almost achieved the goal**
- **Achieved less than goal**
- **Unknown:** Not enough data to evaluate e.g. day is not finished yet so daily goal context is unknown

Patients’ goal context is evaluated in different temporal periods;

- **Each specific action:** If patient has completed a specific planned action with the requested requirements
- **Daily:** If patient reach the set goal for the day
- **Weekly:** If patient reach the set goal for the week. Week is evaluated from Monday to Sunday.
- **Monthly:** If patient reach the set goal for the month. Month is evaluated as 1st of month to 31st of month e.g. August, January.

A set of behaviors are selected for POWER2DM JITAI to cover and Table 3 shows the list and the way to set a treatment goal for patient for the behavior which also shows what is expected from patient and how patient’s performance (goal context) will be evaluated in JITAI delivery system.

Table 3 Behaviours covered by JITAI and the way to set the treatment goals for patient

Behavior Category	How to set the Behavioral Goal, options/alternatives?
BG Monitoring	(For SMBG) "Adhere your planned BG monitoring schedule": If patient and physician agrees to use SMBG device to monitor BG in self-management period.
	(For CGM or FSL) "Adhere your CGM monitoring schedule": If they agree to use a continuous/flash glucose monitoring device
Exercise Monitoring	Duration of exercise (moderate intensity) per week: "Achieve X minutes of performance per week"
Carb Monitoring	Just Logging: "Adhere your Carb logging schedule": If physician only wants patient to log his carb amount

	Achieve Low Carb: "Adhere your carb logging schedule and try to achieve low carbohydrates for meals": If physician also wants patient to get low amount of carbs for the meals. If this goal is set, patient should take low amount of carbs for expected meals to reach his/her goal
Steps Monitoring	Number of steps per day (default value = 8000): "Reach X steps per day"
Medication Adherence	"Log your diabetic medications and adhere your medication orders": If this goal is set, patient is expected to log his medication intakes according to the medication orders.

In the light of these, behavior change experts and technical team prepare a list of JITAIs for all the mentioned behaviors. Similar to the other interventions, JITAIs are maintained in the intervention table. Table 4 shows a part of the table with base columns for some of interventions. There are interventions related with each goal context with different BCT techniques.

Table 4 Part of JITAI table as an example

Goal Context	Rules Description	Main BCT Technique	[lang=en] Intervention Content
GOAL ACHIEVED	Patient achieves daily, weekly or monthly goal	Positive comparison with self	That was a good $\{\text{goal_temporal}\}$, you are $\{\text{comparison_value}\}\%$ better than $\{\text{comparison_temporal}\}$ in $\{\text{behavior}\}$.
GOAL ACHIEVED	Patient successively (at least 2) reached his weekly or monthly goals or (at least 3 days) daily goal	General Reinforcement	Great job! You successively achieved your $\{\text{behavior}\}$ goal for last $\{\text{streak_value}\}$ $\{\text{streak_temporal}\}$ s.
GOAL CLOSE TO ACHIEVE	Patient is very close to achieve his weekly or monthly goal	Positive comparison with self	You are almost there for $\{\text{goal_temporal}\}$! Just keep up your good work, and you will exceed your $\{\text{comparison_simulation_temporal}\}$'s performance with $\{\text{comparison_simulation_value}\}\%$.
GOAL CLOSE TO ACHIEVE	Patient has upcoming planned action and is close to achieve his daily goal	Simple reminder	Just to remind you; You have an upcoming planned $\{\text{action_name}\}$ schedule ($\{\text{action_time}\}$)! If you can complete it, you will reach your goal today
GOAL ALMOST ACHIEVED	Patient almost achieved daily or weekly goal for the first time in the last two days or last week, or month	General Reinforcement	Almost there for the $\{\text{goal_temporal}\}$! Keep up the good work and you will reach your goals next time.
GOAL NOT ACHIEVED	Patient does not achieve the last action but he was not that bad in the last two days	Positive comparison with others	It seems, you missed your last planned $\{\text{behavior}\}$ action. No problem, if you can complete your remaining tasks, still you will be $\{\text{comparison_simulation_value}\}\%$ better than $\{\text{comparison_simulation_temporal}\}$

Normally, rules for the JITAIs are defined with a specific rule language, but in the JITAI table we get the requirements from experts as textual description of rules. D3.4 Recommender Engine II will

provide the details of rule language. Here we just want to list of concepts (patient contexts) that these rules may depend on;

- **goal:** The goal context as described above that can be evaluated action specific, daily, weekly, monthly.
- **adherence:** Adherence score (percentage) between 0 and 1 for the behavior based on the set goals and action plans. Similar to goal context, this can be evaluated action specific, daily, weekly, monthly.
- **stress:** Stress reported(logged) by patient in POWER2DM
- **mood:** Mood reported(logged) by patient in POWER2DM
- **lapse[X]:** Number of Goals not reached in the last X temporals. The temporals can be again action specific, daily, weekly, monthly. e.g. number of goals not reached in the last 14 days
- **recovery[X]:** Number of Goals reached in the last X temporals. The temporals can be again action specific, daily, weekly, monthly. e.g. number of goals reached in the last 3 actions

As seen from the examples, intervention content are prepared as a template with some placeholders which will be adapted by the system based on patient context. For example, for the first one in table, patient will receive “That was a good week, you are 12% better than last week in BG monitoring” as a message if patient reaches his weekly goal and his week performance is 12% better than his last week’s performance for BG monitoring. Section 8.3 provides an overview of the placeholders used in JITAI contents and their possible contents (in English) based on the patient context.

5.3 Interventions for reinforcing a selected goal

It is known from end-user partners working with patients that patients are often overstrained when they are coping with several goals. Often it is easier for them to focus just on one goal and when this goal is sufficiently reached to focus on the next goal. For supporting this approach POWER2DM offers an additional concept: intelligent analysis of barriers to promote goal achievement. This concept is developed by TNO (Hilde van Keulen, Pepijn van Empelen) and applied in an intervention for adolescents to reduce their alcohol intake: What Do You Drink. This approach is also based on research by Brendryen et al. (2008, 2013, 2014) and adapted for diabetes patients in POWER2DM.

The user chooses one goal that he wants to achieve. For instance, if the patient and physician decided to improve glucose monitoring, the daily activities to reach this goal could be monitoring five times a day. To analyse barriers for not performing the activities and reaching the goal **four daily measures** will be assessed in POWER2DM. So, for each day an activity of this goal is scheduled and POWER2DM asks the user 4 questions:

- ◆ In the morning before the user starts with his activities:
 - Re importance – How important is it for you to perform your activity <activity-name> today?
 - Re confidence – How confident are you that you can perform your activity <activity-name> today?
- ◆ In the evening when the user has finished his activities:
 - Re stress – How much stress did you perceive today>?
 - Re mood – How did you feel today?

For all four categories a scale between 0 and 10 will be used, e.g. presented as a slider.

At the next periodic review the user will receive additional feedback about the goal and the activities to reach this goal in the review period. This feedback entails an intelligent analysis of possible barriers why activities were not performed. Depending on the kind of barrier an intervention is offered to overcome this barrier.

Figure 12 describes the decision tree for selecting the appropriate intervention. Herein a hierarchical stepwise analysis is made why the activities of the selected goal are not performed and thus their goal is not reached. The first decision point is whether these activities are performed and thus the selected goal is reached. This will be covered by the performance parameter (“perf” used in the intervention table) as described in the previous section 5.1. Cut-off scores for stress, mood, importance and confidence are used to divide them in low/high resp. positive/negative:

- ◆ Stress – low [0..4], high [5..10]
- ◆ Mood – negative [0..5], positive [6..10]
- ◆ Importance – low [0..6], high [7..10]
- ◆ Confidence – low [0..6], high [7..10]

We assess over a review time period (e.g. weekly) on which days the activities planned for the chosen goal are performed or not. If all activities are performed, the user receives a notification complimenting him with his performance (e.g. “well done”). Next, the user is asked if he wants to keep working on this specific goal or not. If he wants to continue with this goal he receives a notification wishing him “success” in performing the activities next week. If he decides to change his goal he is directed to the planning module. In this module he can adjust his goal and activities. For instance, the user could decide that 30 minutes of physical activity is not enough anymore, and he wants to increase this to 45 minutes per day. He can put this adjusted goal in the planning module, and also plan activities to reach this new goal. Or the user could decide that he wants to focus on a different goal, like his diet. He then is asked to formulate a goal related to his daily intake of carbohydrates. In every case when a new (adjusted) goal is formulated the user is asked to reflect whether this is a realistic goal. One way to do this is to compare his present behaviour (e.g., 30 minutes physical activity per day) to his goal (e.g., 45 minutes physical activity per day) and ask whether this is a realistic goal. If the user thinks not, he is redirected to the goal formulation. If he agrees that the goal is realistic POWER2DM will offer the user the choice to receive support in reaching his goal. If he does not want support he receives a notification wishing him “good luck”. If he wants support the user is offered an intervention from the planning module. For instance, that he can ask someone to be his buddy (see section 0, Box 1).

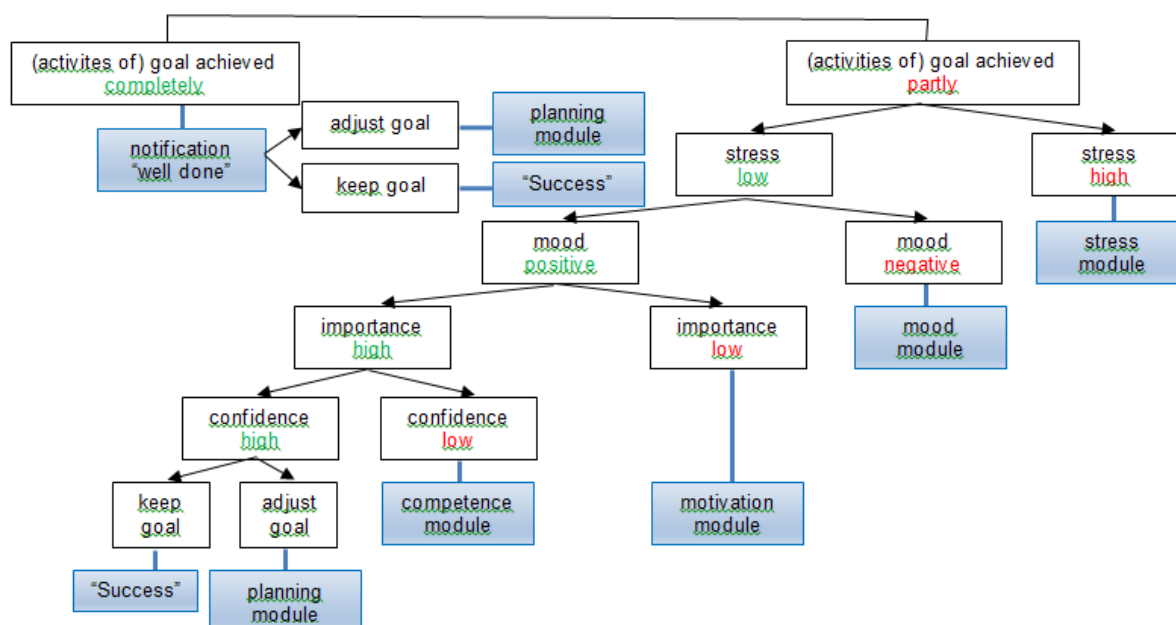


Figure 12 - Intervention decision tree

Now we describe the hierarchical analysis of barriers when the activities of the selected goal are not completely performed and thus the goal is not reached (right part of Figure 12). First, POWER2DM

compliments the user with the activities he did perform to reach the goal. It is important to provide as much as positive feedback as possible to motivate the user. Next, POWER2DM calculates whether on the days the planned activities were not performed, the user experienced a high stress level. If this is the case an intervention from the stress module is offered to alleviate the stress. An example from the stress module is the following message “Seek support from family and/or friends. You experience support when you are taken seriously, when people listen to you, and when they care about you. Support can also be practical: someone who thinks with you about a problem, or someone who advises how to solve a problem.”

If the stress level is low on the days the activities were not performed, the next step is whether on those days the mood of the user was negative. If so, an intervention from the mood module is presented to improve the mood of the user (see section 0, Box 2). If the mood was positive, then the next step is to address the importance of the activities for the user to reach his goal. If the importance is low, than an intervention from the motivation module is provided to enhance the importance (see section 0, Box 3). Finally, if importance was still high, the confidence in performing the activities is addressed. If confidence is low, an intervention from the competence module is given to increase the trust in performing the activities (see section 0, Box 4). Finally, if also confidence is high, POWER2DM asks the user if he wants to keep or adjust his activities and/or goal and the same procedure is followed as described for completely performing the activities and reaching the goal.

The interventions of the modules are all stored in the intervention table (see section 5.1). The interventions could also be used as Just In Time Adaptive Interventions (JITAI, see also 5.3). If POWER2DM measures a low mood it could send an intervention from the mood module to increase the mood of the user.

6 ONTOLOGY FOR GOALS AND ACTIVITIES

One of the core features in the Action Plan in POWER2DM is to support the patient in the identification of self-management goals, and the definition of single activities that help to achieve them. In order to build such a system we need to define the properties of goals and activities and their relation to other concepts used in POWER2DM.

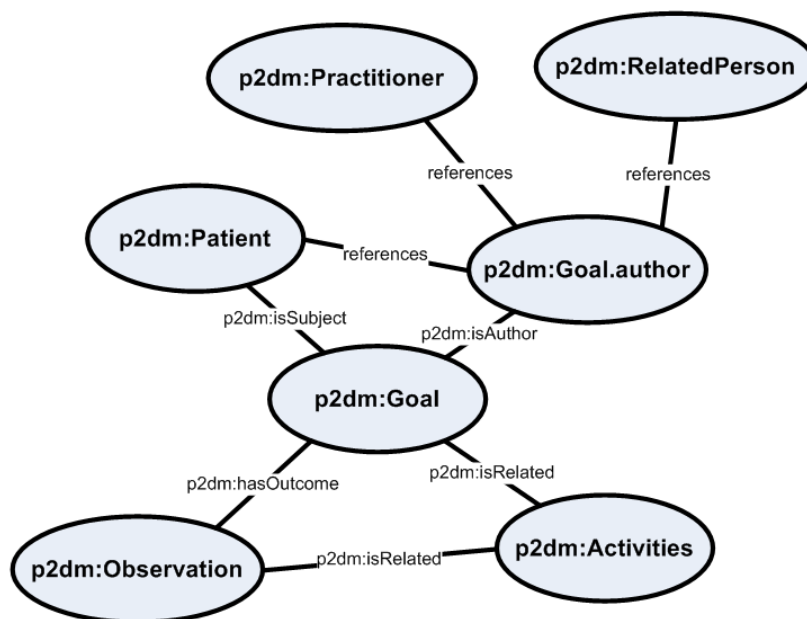


Figure 13 – Goals, Activities and their relation to Observations and Persons

Figure 13 provides an overview on the entities goals and activities and their major relations. The final specification of the goals and activity ontology will be included in the “Personal Health Data Model” of POWER2DM.

6.1 Goals

As described in section 4.1, the Action Plan requires the specification of dedicated goals that should be achieved during the therapy process. Goals can be either defined during the shared-decision making phase (**treatment goals**) or during the self-management phase (**self-management goals**). The goals in POWER2DM are modelled according to the FHIR type “Goal”³. It describes the intended objective(s) for a patient such as weight loss, restoring an activity of daily living, meeting a process improvement objective, etc. The properties which describe a goal are shown in the following table.

Concept	Description	FHIR Reference
patient	A Goal is always assigned to a single patient.	Goal.subject
dateTime	A concrete starting date (and time) when working towards this goal is intended to start	Goal.startDate
endDate	A time period until the goal is planned to be reached	Goal.targetQuantity
created	The timestamp, when the goal has been created for the first time.	
lastModified	The timestamp, when the last change on the goal has been applied.	Goal.Meta.lastUpdated
identifier	A UUID to identify the goal	Goal.Identifier.value
status	Status of the goal, such as “proposed”, “in-progress”, “achieved”	Goal.status
title	Name/title of the goal	Goal.text
description	Description of the goal	Goal.description
motivation	Motivational Message, explaining why it is important to work towards this goal.	Goal.motivationalMessage (extension)
relatedRecommendations	One or more related treatment goal(s) that have been recommended and agreed during the shared-decision making process.	Goal.goal-pertainsToGoal
relatedActivities	A list of activities related to the goal.	
reward	A reward that will be given once the goal is achieved.	Goal.reward
targetMeasure	A measurement that is used to measure the achievement of the goal. The target measure defines the kind of goal (e.g. physical activity, blood glucose management, etc.) as well as the specific value that needs to be reached for a certain measurement.	Goal.goal-target
addresses	A current situation (Problem, Personal Value, current Observation) describing the current state that should be changed by achieving the goal.	Goal.addresses
tag	On or more tag can be added to the goal in order to support better searching, sorting or filtering of goals.	Goal.meta.tag
category	A category for the goal	Goal.category
author	A reference to the author of the goal. This information is also used to distinguish between self-management goals defined by the patient and treatment goals defined during the shared decision making phase.	Goal.author

Table 5: Goals definition in POWER2DM

³ Specified by the FHIR Patient Care Work Group: <https://www.hl7.org/fhir/goal.html>

Although, technical the model is the same for both, self-management and treatment goals, they will differ in their usage. The patients can connect their self-management goals to the treatment goals for reference. In the following sections we provide some examples for treatment goals and related self-management goals.

6.1.1 Treatment Goals

Treatment goals are defined by the clinicians/physicians and can be either health-related or behavioral goals. A typical health-related treatment goal for a diabetic patient is to lower the HbA1c value. In that case, the target measure will contain the value that should be reached, e.g. 7%. On the other hand, the behavioral treatment goals could also target the adherence to specific physical activities, a blood glucose monitoring schedule or daily logging of the carbohydrate amounts of dietary intakes.

Some examples for behavioral treatment goals with target values are:

- Medication Adherence (number of compliant intakes/planned intakes as percentage)
- BG Monitoring Adherence (number of compliant monitoring/planned as percentage)
- Physical Activity Adherence strenuous physical activity per week (minutes/week)
- Activity Tracking (steps); Use activity tracker device to monitor your activity
- Dietary Monitoring (carbs)
- Daily average carb intake (g/d)

6.1.2 Self-Management Goals

Self-Management Goals are derived from (and therefore linked to) treatment goals. Self-management goals are formulated by the patients themselves. Some examples for self-management goals derived from the treatment goals are:

- Write a daily log on my carbohydrate intakes
- Exercise 3 times per week, e.g. walking, dancing, gardening

6.2 Activities

Goals are achieved by performing one or more activities. The duration of activities is comparably short, are scheduled to concrete dates and times and they should contribute to the achievement of one or more goals. The following table lists the properties required for defining activities. Activities can be mapped to an extended `ProcedureRequest` class from the FHIR model. Activities will be “acknowledged” by the appearance of an Observation. Therefore whenever a measurement result is recorded by the patient, the Action Plan Component needs to be informed in order to map it to an activity.

Concept	Description	FHIR Reference
Patient	An activity is always assigned to a single patient.	ProcedureRequest.subject
dateTime	A concrete starting date (and time) of the planned activity	ProcedureRequest.scheduled
endDateTime	The end date and time of the activity.	ProcedureRequest.scheduled
created	The timestamp, when the activity has been created for the first time.	ProcedureRequest.orderedOn
lastModified	The timestamp, when the last change on the activity has been applied.	ProcedureRequest.meta.lastUpdated
identifier	A UUID to identify the activity	ProcedureRequest.Identifier.value
title	Name/title of the activity	ProcedureRequest.text
description	Description of the activity	ProcedureRequest.Instruction.valueString

status	Status of the activity, such as “planned”, “finished”.	ProcedureRequest.status
type (category)	A category for the activity, e.g. physical activity, blood glucose measurement. This should match with the related goal category (see below).	ProcedureRequest.category
tag	On or more tag can be added to the activity in order to support better searching, sorting or filtering of activities, e.g. more concrete specification of the activity category, like “walking”.	ProcedureRequest.meta.tag
reminder	Reference to the setting of a reminder for this activity. If active, specify what type of reminder is used (email, sms, push notification, communication engine), and how many minutes before the activity a reminder should be sent.	[to be defined]
schedules	The schedule of the activity. Needs to support multiple repetitions per day (e.g. for insulin intakes)	ProcedureRequest.scheduled[x]
relatedGoals	A list of goals related to this activity.	ProcedureRequest.relatedGoal
relatedProblems	A list of related problems, if any.	ProcedureRequest.relatedProblem
relatedBarriers	A list of related barriers, if any.	ProcedureRequest.relatedBarrier
relatedObservations	The observations related to this activity	[to be defined]
actionDetails	The details for this action, including a numeric value (e.g. the planned distance for a walking activity).	ProcedureRequest.actionDetail

Table 6: Activity definition in POWER2DM

The activities are scheduled once, twice or more times a day, either on one day or multiple days per week. Activities can be derived directly from the treatment plan, if it is provided. Examples for a treatment plan and the derived action plan would be:

- Treatment Plan: Measure Glucose daily 30 minutes after breakfast and 10 minutes before lunch
- Action Plan: Measure Glucose from Monday to Friday at 8:00 and 11:50, and on Saturday and Sunday at 9:00 and 13:20.

6.3 Related Concepts

For managing and evaluating goals and activities, some additional concepts have been introduced. These are parts of the “User Settings” and the recorded “Observations” which match the planned activities.

Concept	Description	FHIR Reference
Patient/Practitioner	User settings are always assigned to a single person.	Basic.subject
UserSettingsType	User Settings are grouped by type.	Basic.code
Key	Key string of the specific user setting	Basic.param.name
Value(s)	One or more string values for this parameter.	Basic.param.value[x]

Table 7: User Settings related to Goals and Activities

Among others, the user settings contain information about the patients’ daily events, like the wake-up times, the eating time for weekdays and weekends. These are required to calculate the actual scheduling of the activities.

Finally, the observations made by the patients are of a specific type, which will match to the planned activities. Each type may have a different timely tolerance for allowing deviations between observations and plans. These tolerance times may also be stored in the user settings.

Concept	Description	FHIR Reference
Patient	Observations are assigned to a patient.	Observation.subject
ObservationType	Type of Observation. Can be matched to the type of Activity or category of the goal. Depending on this type, an observation value (e.g. blood glucose, weight, etc.) will be stored.	Observation.code
Device	Device used for the Observation, if any	Observation.device
RelatedActivity	Related activity for this observation, if acknowledged by the patient.	Observation.acknowledged PlannedAction

Table 8: Observations related to Goals and Activities

7 LITERATURE

Abraham, Ch., Michie, S. (2008). A Taxonomy of Behavior Change Techniques Used in Interventions by the American Psychological Association, *Health Psychology* Vol. 27, No. 3, 379–387

Bartholomew Eldredge, L.K, Markham, C.M., Ruiter, R.A.C., Fernández, M.E., Kok, G., & Parcel, G.S. (2016). Planning health promotion programs. An Intervention Mapping approach (4th ed.). San Francisco: Jossey-Bass.

BCT Taxonomy. BCT Taxonomy (v1): 93 hierarchically-clustered techniques. 2016 [cited 2016 August 30]; Available from: <http://www.bct-taxonomy.com/resources>.

Brendryen H et al (2013). Constructing a theory- and evidence-based treatment rationale for complex eHealth interventions: development of an online alcohol intervention using and intervention mapping approach. *JMIR Res Protoc*, 2(1):e6.

Brendryen H et al. (2008). A digital smoking cessation program delivered through internet and cell phone without nicotine replacement (happy ending): randomized controlled trial. *JMIR*, 10(5):e51.

Brendryen H et al (2014). Balance – a pragmatic randomized controlled trial of an online intensive self-help alcohol intervention. *Addiction*, 109(2):218-226.

Dusseldorp, E., van Genugten, L., van Buuren, S., Verheijden, M.W., van Empelen, P. (2014) Combinations of techniques that effectively change health behavior: evidence from Meta-CART analysis. *Health Psychology*, 33(12), 1530-1540

Gregg, J., Callaghan, G., Hayes, S. (2007) *The Diabetes Lifestyle Book. Facing Your Fears & Making Changes for a Long & Healthy Life*. New Harbinger Publication Inc.

Gregg, J.A., Callaghan, G.M., Hayes, S.C., Glenn-Lawson, J.L. (2007) Improving diabetes self-management through acceptance, mindfulness, and values: A randomized controlled trial. *J Consult Clin Psychol* 2007; 75: 336-43.

Harris, R. (2013). The Complete Set of Client Handouts and Worksheets from ACT books. https://www.thehappinesstrap.com/upimages/Complete_Worksheets_2014.pdf

Hayes, St. C., Pistorello, J., Levin, M.E. (2012a). Acceptance and Commitment Therapy as a Unified Model of Behavior Change. *The Counseling Psychologist* 40(7) 976-1002

Hayes, St. C., Strosahl, K. D.; Wilson, K. G. (2012b). *Acceptance and Commitment Therapy: The Process and Practice of Mindful Change* (2 ed.). New York: Guilford Press.

Kwasnicka, D., Dombrowski, S.U., White, M., Sniehotta, F. (2016) Theoretical explanations for maintenance of behaviour change: a systematic review of behaviour theories. *Health Psychology Review*, 10(3), 277-296.

Michie, S., Ashford, S., Sniehotta, F.F., Dombrowski, S.U., Bishop, A. & French, D.P. (2011). A refined taxonomy of behaviour change techniques to help people change their physical activity and healthy eating behaviours – the CALO-RE taxonomy. *Psychology & Health*, 26, 1479-1498.

Michie, S., et al., *The Behavior Change Technique Taxonomy (v1) of 93 Hierarchically Clustered Techniques: Building an International Consensus for the Reporting of Behavior Change Interventions*. *Annals of Behavioral Medicine*, 2013. **46**(1): p. 81-95.

Nahum-Shani, Inbal, et al. "Just in time adaptive interventions (jitais): An organizing framework for ongoing health behavior support." *Methodology Center technical report* 14-126 (2014).

Lally, P., van Jaarsveld, C. H. M., Potts, H. W. W. and Wardle, J. (2010), How are habits formed: Modelling habit formation in the real world. *Eur. J. Soc. Psychol.*, 40: 998–1009. doi:10.1002/ejsp.674

Powers, WT. A cognitive control system. In: Levine, RL.; Fitzgerald, H., editors. *Analysis of Dynamic Psychological Systems, Volume 2: Methods and Applications*. Plenum Press; New York: 1992. p.

Ramsay, JO. The control of behavioral input-output systems. In: Walls, T.; Schafer, J., editors. *Models for intensive longitudinal data*. Oxford University Press; New York: 2006. p. 176-194.

Schmitt, A., Reimer, A., Kulzer, B., Haak, T., Gahr, A., Hermanns, N. (2014). Assessment of diabetes acceptance can help identify patients with ineffective diabetes self-care and poor diabetes control. *Diabet Med*. 2014 Nov;31(11):1446-51. doi: 10.1111/dme.12553. Epub 2014 Aug 2.

Stenzel, A. (2012) *Diabetes akzeptieren und Motivation gewinnen. Selbsthilfe mit der Diabetes-Akzeptanz- und Commitment-Therapie (DACT)*. Verlag Kirchheim

Spruijt-Metz, D., & Nilsen, W. (2014). Dynamic models of behavior for just-in-time adaptive interventions. *Pervasive Computing, IEEE*, 13(3), 13-17.

Spruijt-Metz D, Hekler E, Saranummi N, et al. Building new computational models to support health behaviour change and maintenance: new opportunities in behavioural research. *Translational Behavioral Medicine*. 2015;5(3):335-346. doi:10.1007/s13142-015-0324-1.

Veljko Pejovic and Mirco Musolesi. 2015. *Anticipatory Mobile Computing: A Survey of the State of the Art and Research Challenges*. *ACM Comput. Surv.* 47, 3, Article 47 (April 2015), 29 pages. DOI=<http://dx.doi.org/10.1145/2693843>

Veljko Pejovic and Mirco Musolesi. 2014. *InterruptMe: designing intelligent prompting mechanisms for pervasive applications*. In *Proceedings of the 2014 ACM International Joint Conference on Pervasive and Ubiquitous Computing (UbiComp '14)*. ACM, New York, NY, USA, 897-908. DOI=<http://dx.doi.org/10.1145/2632048.2632062>

8 APPENDIX

8.1 Overview of BCTs

The BCTs are grouped into three phases: Motivation phase, Planning phase, and Action/Continuation phase. Techniques are numbered according to the taxonomy of Abraham and Michie (2008). One technique may be important for several phases. In this case, the technique is classified to the phase it was most important. (Adapted from Dusseldorp et al., 2014)

Motivation phase	
Technique	Definition
1. Provide information about behavior health link	General information about behavior risk, for example, susceptibility to poor health outcomes or mortality risk in relation to the behavior
2. Provide information on consequences	Information about the benefits and costs of action or inaction, focusing on what will happen if the person does or does not perform the behavior
3. Provide information about others' approval	Information about what others think about the person's behavior and whether others will approve or disapprove of any proposed behavior change
4. Prompt intention formation	Encouraging the person to decide to act or set a general goal, for example, to make a behavior resolution such as "I will take more exercise next week"
25. Motivational interviewing	Prompting the person to provide self-motivating statements and evaluations of their own behavior to minimize resistance to change
Planning phase	
5. Prompt barrier identification	Identify barriers to performing the behavior and plan ways of overcoming them
7. Set graded tasks	Set easy tasks, and increase difficulty until target behavior is performed.
8. Provide instruction	Telling the person how to perform a behavior and/or preparatory behaviors
9. Model or demonstrate the behavior	An expert shows the person how to correctly perform a behavior, for example, in class or on video
10. Prompt specific goal setting	Involves detailed planning of what the person will do, including a definition of the behavior specifying frequency, intensity, or duration and specification of at least one context, that is, where, when, how, or with whom
16. Agree on behavior contract	Agreement (e.g., signing) of a contract specifying behavior to be performed so that there is a written record of the person's resolution witnessed by another
19. Provide opportunities for social comparison	Facilitate observation of nonexpert others' performance for example, in a group class or using video or case study
20. Plan social support or social change	Prompting consideration of how others could change their behavior to offer the person help or (instrumental) social support, including "buddy" systems and/or providing social support
21. Prompt identification as a role model	Indicating how the person may be an example to others and influence their behavior or provide an opportunity for the person to set a good example
26. Time management	Helping the person make time for the behavior (e.g., to fit it

into a daily schedule)

Action/Continuation phase	
6. Provide general encouragement	Praising or rewarding the person for effort or performance without this being contingent on specified behaviors or standards of performance
13. Provide feedback on performance	Providing data about recorded behavior or evaluating performance in relation to a set standard or others' performance, i.e., the person received feedback on their behavior.
15. Teach to use prompts or cues	Teach the person to identify environmental cues that can be used to remind them to perform a behavior, including times of day or elements of contexts.
17. Prompt practice	Prompt the person to rehearse and repeat the behavior or preparatory behaviors
11. Prompt review of behavior goals	Review and/or reconsideration of previously set goals or intentions
12. Prompt self-monitoring of behavior	The person is asked to keep a record of specified behavior(s) (e.g., in a diary)
14. Provide contingent rewards	Praise, encouragement, or material rewards that are explicitly linked to the achievement of specified behaviors
18. Use follow-up prompts	Contacting the person again after the main part of the intervention is complete
22. Prompt self-talk	Encourage use of self-instruction and self-encouragement (aloud or silently) to support action
23. Relapse prevention (relapse prevention therapy)	Following initial change, help identify situations likely to result in readopting risk behaviors or failure to maintain new behaviors and help the person plan to avoid or manage these situations
24. Stress management (stress theories)	May involve a variety of specific techniques (e.g., progressive relaxation) that do not target the behavior but seek to reduce anxiety and stress

8.2 CALO-RE BCT taxonomy

(Michie et al., 2011)

	BCT Technique	Description
BCT-1	Provide information on consequences of behaviour in general	Information about the relationship between the behaviour and its possible or likely consequences in the general case, usually based on epidemiological data, and not personalised for the individual (contrast with technique 2).
BCT-2	Provide information on consequences of behaviour to the individual	Information about the benefits and costs of action or inaction to the individual or tailored to a relevant group based on that individual's characteristics (i.e. demographics, clinical, behavioural or psychological information). This can include any costs/ benefits and not necessarily those related to health, e.g. feelings.
BCT-3	Provide information about others' approval	Involves information about what other people think about the target person's behaviour. It clarifies whether others will like, approve or disapprove of what the person is doing or will do. NB Check that any instance does not also involve techniques 1 (Provide information on consequences of behaviour in general) or 2 (Provide information on consequences of behaviour to the individual) or 4 (Provide normative information about others' behaviour).
BCT-4	Provide normative information about others' behaviour	Involves providing information about what other people are doing i.e., indicates that a particular behaviour or sequence of behaviours is common or uncommon amongst the population or amongst a specified group – presentation of case studies of a few others is not normative information. NB this concerns other people's actions and is distinct from the provision of information about others' approval (technique 3 [Provide information about others' approval]).
BCT-5	Goal setting (behaviour)	The person is encouraged to make a behavioural resolution (e.g. take more exercise next week). This is directed towards encouraging people to decide to change or maintain change. NB This is distinguished from technique 6 (Goal setting - outcome) and 7 (Action planning) as it does not involve planning exactly how the behaviour will be done and either when or where the behaviour or action sequence will be performed. Where the text only states that goal setting was used without specifying the detail of action planning involved then this would be an example of this technique (not technique 7 [Action planning]). If the text states that 'goal setting' was used if it is not clear from the report if the goal setting was related to behaviour or to other outcomes, technique 6 should be coded. This includes sub-goals or preparatory behaviours and/or specific contexts in which the behaviour will be performed. The behaviour in this technique will be directly related to or be a necessary condition for the target behaviour (e.g. shopping for healthy eating; buying equipment for physical activity). NB check if techniques applied to preparatory behaviours should also be coded as instances of technique 9 (Set graded tasks).
BCT-6	Goal setting (outcome)	The person is encouraged to set a general goal that can be achieved by behavioural means but is not defined in terms of behaviour (e.g. to reduce blood pressure or lose/maintain weight), as opposed to a goal based on changing behaviour as such. The goal may be an expected consequence of one or more behaviours, but is not a behaviour per se (see also techniques 5 [Goal setting - behaviour] and 7 [Action planning]). This technique may co-occur with technique 5 if goals for both behaviour and other outcomes are set.
BCT-7	Action planning	Involves detailed planning of what the person will do including, as a minimum, when, in which situation and/or where to act. "When" may describe frequency (such as how many times a day/week or duration (e.g., for how long). The exact content of action plans may or may not be described, in this case code as this technique if it is stated that the behaviour is planned contingent to a specific situation or set of situations even if exact details are not present NB The terms "goal setting" or "action plan" are not enough to ensure inclusion of this technique unless it is clear that plans involve linking behavioural responses to specific situational cues, when only described as "goal setting" or "action

		plan” without the above detail it should be regarded as applications of technique 5 and 6.
BCT-8	Barrier identification/Problem solving	This presumes having formed an initial plan to change behaviour. The person is prompted to think about potential barriers and identify ways of overcoming them. Barriers may include competing goals in specified situations. This may be described as “problem solving”. If it is problem solving in relation to the performance of a behaviour, then it counts as an instance of this technique. Examples of barriers may include behavioural, cognitive, emotional, environmental, social and/ or physical barriers. NB Closely related to techniques 7 (Action planning) and 9 (Set graded task) but involves a focus on specific obstacles to performance. It contrasts with technique 35 (Relapse prevention/ Coping planning) which is about maintaining behaviour that has already been changed.
BCT-9	Set graded tasks	Breaking down the target behaviour into smaller easier to achieve tasks and enabling the person to build on small successes to achieve target behaviour. This may include increments towards a target behaviour, or incremental increases from baseline behaviour. NB The key difference to technique 7 (Action planning) lies in planning to perform a sequence of preparatory actions (e.g. remembering to take gym kit to work), task components or target behaviours which are in a logical sequence or increase in difficulty over time - as opposed to planning “if-then” contingencies when/where to perform behaviours. General references to increasing physical activity as intervention goal are not instances of this technique.
BCT-10	Prompt review of behavioural goals	Involves a review or analysis of the extent to which previously set behavioural goals (e.g. take more exercise next week) were achieved. In most cases this will follow previous goal setting (see technique 5, ‘goal setting-behaviour’) and an attempt to act on those goals, followed by a revision or readjustment of goals, and/ or means to attain them. NB Check if any instance also involves techniques 6 (goal setting - behaviour), 8 (Barrier identification/Problem solving), 9 (Set graded tasks) or 11 (Prompt review of outcome goals).
BCT-11	Prompt review of outcome goals	Involves a review or analysis of the extent to which previously set outcome goals (e.g. to reduce blood pressure or lose/maintain weight) were achieved. In most cases this will follow previous goal setting (see technique 6, goal setting-outcome’) and an attempt to act on those goals, followed by a revision of goals, and/ or means to attain them. NB Check that any instance does not also involve techniques 5 (goal setting - outcome), 8 (Barrier identification/Problem solving), 9 (Set graded tasks) or 10 (Prompt review of behavioural goals).
BCT-12	Prompt rewards contingent on effort or progress towards behaviour	Involves the person using praise or rewards for attempts at achieving a behavioural goal. This might include efforts made towards achieving the behaviour, or progress made in preparatory steps towards the behaviour, but not merely participation in intervention. This can include self-reward. NB This technique is not reinforcement for performing the target behaviour itself, which is an instance of technique 13 (Provide rewards contingent on successful behaviour).
BCT-13	Provide rewards contingent on successful behaviour	Reinforcing successful performance of the specific target behaviour. This can include praise and encouragement as well as material rewards but the reward/ incentive must be explicitly linked to the achievement of the specific target behaviour i.e. the person receives the reward if they perform the specified behaviour but not if they do not perform the behaviour. This can include self-reward. Provision of rewards for completing intervention components or materials are not instances of this technique. References to provision of incentives for being more physically active are not instances of this technique unless information about contingency to the performance of the target behaviour is provided. NB Check the distinction between this and techniques 7 (Action planning) and 17 (Prompt self-monitoring of behavioural outcome) and 19 (Provide feedback on performance).
BCT-14	Shaping	Contingent rewards are first provided for any approximation to the target behaviour e.g., for any increase in physical activity. Then, later, only a more demanding performance, e.g., brisk walking for 10 minutes on three days a week would be rewarded. Thus, this is graded use of contingent rewards over

		time.
BCT-15	Prompting generalization of a target behaviour	Once a behaviour is performed in a particular situation, the person is encouraged or helped to try it in another situation. The idea is to ensure that the behaviour is not tied to one situation but becomes a more integrated part of the person's life that can be performed at a variety of different times and in a variety of contexts.
BCT-16	Prompt self-monitoring of behaviour	The person is asked to keep a record of specified behaviour/s as a method for changing behaviour. This should be an explicitly stated intervention component, as opposed to occurring as part of completing measures for research purposes. This could e.g., take the form of a diary or completing a questionnaire about their behaviour, in terms of type, frequency, duration and/or intensity. Check the distinction between this and techniques 17 (Prompt self-monitoring of behavioural outcome).
BCT-17	Prompt self-monitoring of behavioural outcome	The person is asked to keep a record of specified measures expected to be influenced by the behaviour change, e.g. blood pressure, blood glucose, weight loss, physical fitness. NB It must be reported as part of the intervention, rather than only as an outcome measure. Check the distinction between this and techniques 16 (Prompt self-monitoring of behaviour).
BCT-18	Prompting focus on past success	Involves instructing the person to think about or list previous successes in performing the behaviour (or parts of it). NB This is not just encouragement but a clear focus on the person's past behaviour. It is also not feedback because it refers to behaviour preceded the intervention.
BCT-19	Provide feedback on performance	This involves providing the participant with data about their own recorded behaviour (e.g., following technique 16 [Prompt self-monitoring of behaviour]) or commenting on a person's behavioural performance (e.g., identifying a discrepancy with between behavioural performance and a set goal – see techniques 5 [Goal setting - behaviour] and 7 [Action planning] – or a discrepancy between one's own performance in relation to others' – note this could also involve technique 28 [Facilitate social comparison]).
BCT-20	Provide information on where and when to perform the behaviour	Involves telling the person about when and where they might be able to perform the behaviour this e.g. tips on places and times participants can access local exercise classes. This can be in either verbal or written form. NB Check whether there are also instances of technique 21 (Provide instruction on how to perform the behaviour).
BCT-21	Provide instruction on how to perform the behaviour	Involves telling the person how to perform a behaviour or preparatory behaviours, either verbally or in written form. Examples of instructions include; how to use gym equipment (without getting on and showing the participant), instruction on suitable clothing, and tips on how to take action Showing a person how to perform a behaviour without verbal instruction would be an instance of technique 22 only. NB Check whether there are also instances of techniques 5, 7, 8, 9, 22. Instructions to follow a specific diet or programme of exercise without instructions how to perform the behaviours are not included in this definition. Cooking and exercise classes as well as personal trainers and recipes should always be coded as this technique, but may also be coded as 22 (Model/ Demonstrate the behaviour).
BCT-22	Model/ Demonstrate the behaviour	Involves showing the person how to perform a behaviour e.g., through physical or visual demonstrations of behavioural performance, in person or remotely. NB This is distinct from just providing instruction (technique 21) because in "demonstration" the person is able to observe the behaviour being enacted. This technique and techniques 21 (Provide instruction on how to perform the behaviour) and may be used separately or together. Instructing parents or peers to perform the target behaviour is not an instance of this technique as fidelity would be uncertain.
BCT-23	Teach to use prompts/ cues	The person is taught to identify environmental prompts which can be used to remind them to perform the behaviour (or to perform an alternative, incompatible behaviour in the case of behaviours to be reduced). Cues could include times of day, particular contexts or technologies such as mobile phone alerts which prompt them to perform the target behaviour. NB This technique could be used independently or in conjunction with techniques 5 (goal setting -

		behaviour) and 7 (Action planning) (see also 24 [Environmental restructuring]).
BCT-24	Environmental restructuring	The person is prompted to alter the environment in ways so that it is more supportive of the target behaviour e.g. altering cues or reinforcers. For example they might be asked to lock up or throw away or their high calorie snacks, or take their running shoes to work. Interventions in which the interveners directly modify environmental variables (e.g. the way food is displayed in shops, provision of sports facilities) are not covered by this taxonomy and should be coded independently.
BCT-25	Agree behavioural contract	Must involve written agreement on the performance of an explicitly specified behaviour so that there is a written record of the person's resolution witnessed by another.
BCT-26	Prompt practice	Prompt the person to rehearse and repeat the behaviour or preparatory behaviours numerous times. Note this will also include parts of the behaviour e.g., refusal skills in relation to unhealthy snacks. This could be described as "building habits or routines" but is still practice so long as the person is prompted to try the behaviour (or parts of it) during the intervention or practice between intervention sessions, e.g. as "homework".
BCT-27	Use of follow up prompts	Intervention components are gradually reduced in intensity, duration and frequency over time, e.g. letters or telephone calls instead of face to face and/or provided at longer time intervals.
BCT-28	Facilitate social comparison	Involves explicitly drawing attention to others' performance to elicit comparisons. NB The fact the intervention takes place in a group setting, or have been placed in groups on the basis of shared characteristics, does not necessarily mean social comparison is actually taking place. Social support may also be encouraged in such settings and this would then involve technique 29 (Plan social support/ social change). Group classes may also involve instruction (technique 21 [Provide instruction on how to perform the behaviour]) demonstration (technique 22 [Model/ Demonstrate the behaviour]) and practice (technique 26 [Prompt practice]).
BCT-29	Plan social support/ social change	Involves prompting the person to plan how to elicit social support from other people to help him/ her achieve their target behaviour/ outcome. This will include support during interventions e.g., setting up a "buddy" system or other forms of support and following the intervention including support provided by the individuals delivering the intervention, partner, friends, family.
BCT-30	Prompt identification as role model/ position advocate	Involves focusing on how the person may be an example to others and affect their behaviour e.g., being a good example to children. Also includes providing opportunities for participants to persuade others of the importance of adopting/ changing the behaviour, for example, giving a talk or running a peer-led session.
BCT-31	Prompt anticipated regret	Involves inducing expectations of future regret about the performance or non-performance of a behaviour. This includes focusing on how the person will feel in the future and specifically whether they will feel regret or feel sorry that they did or did not take a different course of action. Do not also code instances of this technique as the more generic providing information on consequences (techniques 1 [Provide information on consequences of behaviour in general] and 2 [Provide information on consequences of behaviour to the individual]).
BCT-32	Fear Arousal	Involves presentation of risk and/or mortality information relevant to the behaviour as emotive images designed to evoke a fearful response (e.g. "smoking kills!" or images of the grim reaper). Do not also code instances of this technique as the more generic providing information on consequences (techniques 1 [Provide information on consequences of behaviour in general] and 2 [Provide information on consequences of behaviour to the individual]).
BCT-33	Prompt Self talk	Encourage the person to use talk to themselves (aloud or silently) before and during planned behaviours to encourage, support and maintain action.
BCT-34	Prompt use of imagery	Teach the person to imagine successfully performing the behaviour or to imagine finding it easy to perform the behaviour, including component or easy versions of the behaviour. Distinct from recalling instances of previous success without imagery (technique 18 [Prompting focus on past success])
BCT-35	Relapse prevention/	This relates to planning how to maintain behaviour that has been changed. The

	Coping planning	person is prompted to identify in advance situations in which the changed behaviour may not be maintained and develop strategies to avoid or manage those situations. Contrast with techniques 7 (Action planning) and 8 (Barrier identification/ Problem solving) which are about initiating behaviour change.
BCT-36	Stress management/Emotional control training	This is a set of specific techniques (e.g., progressive relaxation) which do not target the behaviour directly but seek to reduce anxiety and stress to facilitate the performance of the behaviour. It might also include techniques designed to reduce negative emotions or control mood or feelings that may interfere with performance of the behaviour, and/ or to increase positive emotions that might help with the performance of the behaviour. NB Check whether there are any instances of technique 8 (Barrier identification/ Problem solving), which includes identifying emotional barriers to performance, in contrast to the current technique, which addresses stress and emotions, whether they have been identified as barriers or not.
BCT-37	Motivational interviewing	This is a clinical method including a specific set of techniques involving prompting the person to engage in change talk in order to minimize resistance and resolve ambivalence to change (includes motivational counselling). NB Only rate this technique if explicitly referred to by name, not if one identifies specific elements of it, this may happen if you have prior experience with this technique.
BCT-38	Time management	This includes any technique designed to teach a person how to manage their time in order to make time for the behaviour. These techniques are not directed towards performance of target behaviour but rather seek to facilitate it by freeing up times when it could be performed. NB Only rate this technique if explicitly referred to by name, not if one identifies specific elements of it, this may happen if you have prior experience with this technique.
BCT-39	General communication skills training	This includes any technique directed at general communication skills but not directed towards a particular behaviour change. Often this may include role play and group work focusing on listening skills or assertive skills. NB Practicing a particular behaviour-specific interpersonal negotiation e.g., refusal skills in relation to cigarettes or alcohol would not be an instance of this technique.
BCT-40	Stimulate anticipation of future rewards	Create anticipation of future rewards without necessarily reinforcing behaviour throughout the active period of the intervention. Code this technique when participants are told at the onset that they will be rewarded based on behavioural achievement.

8.3 Placeholders in JITAI content

Placeholder	Alternatives	[lang = EN] Placeholder Content
goal_temporal: Which temporal goal evaluation is done in the rule	if goal evaluation is; for instant action	latest
	for the day	day
	for the week	week
	for the month	month
comparison_temporal OR comparison_simulation_temporal: Which past performance that current performance or current potential performance is compared	If current action is his Best performance	your (second, third) best
	If today's is his Best day performance	your (second, third) best day
	If current week is his Best week performance	your (second, third) best week
	If current month is his Best month performance	your (second, third) best month
	If current performance is better than last X actions	last X times
	If current day performance is better than last X days	last X days
	If current week performance is better than last X weeks	last X weeks
	If current month performance is better than last X months	last X months
	If current action performance is better than last time	last time
	If today's performance is better than yesterday	last day
	If current week performance is better than last week's	last week
	If current month performance is better than last month's	last month
	If current month performance is better than some month in this year	last [JANUARY, FEBRUARY, etc]
	If current week performance is better than some week before	X week before
	If current day performance is better than some day this week	last [MONDAY, TUESDAY, etc]
	If current day performance is better than some day before this week	X day before
	If current performance is better than some performance before	X before
	If current action performance is better than his worst performance	your (second, third) worst
	If current day performance is better than his worst day performance	your (second, third) worst day
	If current week performance is better than his worst week performance	your (second, third) worst week

	If current month performance is better than his worst month performance	your (second, third) worst month
comparison_value OR comparison_simulation_value: How much current or current potential performance is better than compared past performance in terms of percentage	Between 0-100	
streak_temporal: Which temporal successive achievement (or other) has happened	If successive achievement is done for the individual actions	time
	If successive achievement is done for days	day
	If successive achievement is done for weeks	week
	If successive achievement is done for months	month
streak_value: Number of successive achievements	2 to any number	
comparison_population_percentage: What percentage of POWER2DM patient population (those who has monitoring the behavior; or in short has a related goal) patient's current or current potential performance is better than	Between 0-100	
comparison_population_number: How many of persons in POWER2DM patient population (those who has monitoring the behavior; or in short has a related goal) that patient's current or current potential performance is better than	should be at least 10 percent.	
behavior: Name of the behavior	See behaviors e.g. BG Monitoring, etc.	
action_name: Name of the action	Depends on the actions of each behavior; Exercise type for exercise, medication name for Medication Adherence, etc. e.g. Exercise; "walking", "running", etc.	
action_time: Scheduled time for the planned action		(Weekdays/Weekend) (X minutes) before meals
		(Weekdays/Weekend) (X minutes) before breakfast
		(Weekdays/Weekend) (X minutes) before lunch
		(Weekdays/Weekend) (X minutes) before dinner

		(Weekdays/Weekend) (X minutes) after breakfast
		(Weekdays/Weekend) (X minutes) after lunch
		(Weekdays/Weekend) (X minutes) after dinner
		(Weekdays/Weekend) (X minutes) after wakeup
		(Weekdays/Weekend) (X minutes) before sleep
		(Weekdays/Weekend) (~) at XX:YY
		(Monday, Sunday, etc) (~) at XX:YY
		X times a (day, week), #Y
		X times a day at (Monday, Sunday, etc), #Y

8.4 Intervention Moduls

Box 1 Intervention from Planning module: *Asking for support from a buddy*

Example physical activity

A 'buddy' may help you reach your goal and increase confidence!

Who can you ask for support to help you [being physically active for 45 minutes each day]?

- o *Name: ... [name buddy]*

How can [name buddy] help you [being physically active for 45 minutes each day]? Choose one option. [howhelp]

- o *Say that he/she has confidence in me [confidence]*
- o *To remind me of the advantages of [being physically active for 45 minutes each day] [advantages]*
- o *Distract me from temptations [distract]*
- o *Else, ... [open entry field] [else]*

Your buddy can help you [being physically active for 45 minutes each day] by [howhelp]. In what way? [wayhelp]

[confidence] Say that he/she has confidence in me via: ... [wayconfidence].

[advantages] To remind me of the advantages of [being physically active for 45 minutes each day] via: [wayadvantages]

- o *WhatsApp*
- o *An e-mail*
- o *A personal conversation*
- o *Else, ...*

[distract] Distract me from temptations via: ... [waydistract]

[else] [Else] Via: [open entry field] [else]

This is a summary of how your buddy can support you [being physically active for 45 minutes each day].

Your buddy: [name buddy] helps you by: [howhelp] via: [wayhelp].

You have thought about asking a buddy for help. The next step is to do it. This is your decision!

Box 2 Intervention from Mood module: *Doing nice things*

Nice things result in positive energy, happy thoughts and more relaxation. List 3 things minimally that make you feel good. If you need some clues, click on examples [examples doing nice things].

1. ... [ACTIVITY 1]
2. ... [ACTIVITY 2]
3. ... [ACTIVITY 3]
4. ... [ACTIVITY 4]
5. ... [ACTIVITY 5]

You just thought of activities that make you feel good. Plan 1 or 2 of these activities the coming week.

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
		ACTIVITY 1			ACTIVITY 3	

If you want to we can send you a reminder so you won't forget?

- o *Yes, great* → [REMINDER doing nice things1] [REMINDER doing nice things2]
[REMINDER doing nice things3]
- o *No, thank you* → [turning off]

Examples doing nice things

Whether an activity is nice, really depends on your personal preferences. Below are some examples what other people like to do:

Johan (30 years): Going to the movies with a friend.

Sofia (48 years): Taking a walk.

Wilma (60 years): Visit the museum with my daughter.

[REMINDER doing nice things1] [REMINDER doing nice things2] [REMINDER doing nice things3]

*Do you remember that you planned to do nice things? Today you wanted to do: [ACTIVITY X].
Enjoy!*

Box 3 Intervention from Motivation module: *What is really important to you?*

Example physical activity

What is really important to you, and how does [being physically active for 45 minutes each day] fits with that.

Next is a list of values that may be important to your life. Which ones are the most important to you? Pick two, or add one yourself. [VALUE1] [VALUE2]

<i>Good partner</i>	<i>Friendship</i>	<i>Health</i>	<i>Money</i>	<i>Family happiness</i>
<i>Respect</i>	<i>Successful</i>	<i>Connection</i>	<i>Happiness</i>	<i>Acknowledgement</i>
<i>Good parent</i>	<i>Careful</i>	<i>Responsibility</i>	<i>Independence</i>	<i>...</i>

[Value1] and [Value2] are most important to you. What is their relation with [being physically active for 45 minutes each day]? Please elaborate.

The relation between [value1] and [being physically active for 45 minutes each day] is.... [RELATION1]

The relation between [value2] and [being physically active for 45 minutes each day] is [RELATION2]

What is really important to you and how does [being physically active for 45 minutes each day] fits in? This is what you said:

The relation between [value1] and [being physically active for 45 minutes each day] is [RELATION1]

The relation between [value2] and [being physically active for 45 minutes each day] is [RELATION2]

What does this mean for you? You don't have to fill out anything, but just reflect on what it implies for you? Or talk with others about it.

Box 4 Intervention from Competence module: Use personal strengths

Example physical activity

Reflecting on your personal strengths may help you boost your self-confidence. Look at the following positive characteristics, they might come in handy in various situations. Choose 2 who fit you best, or add one if you want to. [s STRENGTH1] [STRENGTH2]

<i>Social</i>	<i>Go-getter</i>	<i>Reliable</i>	<i>Creative</i>	<i>Honest</i>	<i>Helpful</i>	...
<i>Enterprising</i>	<i>Enthusiastic</i>	<i>Serious</i>	<i>Organised</i>	<i>Patient</i>	<i>Quiet</i>	...
<i>Friendly</i>	<i>Relaxed</i>	<i>Responsible</i>	<i>Flexible</i>	<i>Strong</i>	<i>Independent</i>	

Your positive strengths are: [STRENGTH1] and [STRENGTH2].

Did you know that these strengths can help you? For example, [being physically active for 45 minutes each day]. How could these strengths help you [being physically active for 45 minutes each day]? Please elaborate. If you need inspiration, see [examples].

[STRENGTH1] could help me [being physically active for 45 minutes each day] in this way: ... [SOLUTION1].

[STRENGTH2] could help me [being physically active for 45 minutes each day] as follows: ... [SOLUTION2].

[Examples]

Curious about what others say about how personal strengths can help you [being physically active for 45 minutes each day]:

- **Trudy (44 years)** → My personal strength is that I am reliable. When I intend [being physically active for 45 minutes each day], then I will absolutely do it. It makes me feel more reliable, not only for myself but also regarding others. So [being physically active for 45 minutes each day] helps me to feel more reliable.
- **Jacob (53 years)** → Patience is my personal strength. When I have planned [being physically active for 45 minutes each day], I am patient, even if I do not succeed right away. Then I know that I will manage eventually [being physically active for 45 minutes each day]. My patience enables me to succeed in my plans [being physically active for 45 minutes each day].

What are your personal strengths, and how may they come in handy [being physically active for 45 minutes each day]? This is what you said about it:

Your personal strength is [STRENGTH 1], and it helps you [being physically active for 45 minutes each day] as follows: [SOLUTION1].

Another personal strength is [STRENGTH 2], and it enables you [being physically active for 45 minutes each day] as follows: [SOLUTION2].

Hopefully, this will boost your self-confidence [being physically active for 45 minutes each day]!

8.5 Self-management Problems and psycho-social barriers

Ultimate Goal	Optimalisation HbA1c (= lowering risk of complications) and DM-QOL										
	Insulin -/+				Carbohydrates -/+		Glucose monitoring -/+		Exercise -/+		Stress -
Problem area	Dose too low	Frequency too low	Dose too high	Frequency too high	Too little	Too much	Too little	Too much	Too little	Too much	(physical)stress too high
Psychological Barrier (specific)	Fear hypo's	Fear hypo's	Fear hypers	Fear hypers	Fear hypers	Fear hypo's		Fear hypo's/hypers	Fear hypo's	Fear hypers	
	Fear weight	Fear weight			Fear weight	Eating problem				Fear weight	
		Fear injections					Fear 'needles'				
		Negative affect (NA)			Negative affect (NA)	Negative affect (NA)	Negative affect (NA)		Negative affect (NA)		Negative affect (NA)
		Fear Disclosure					Fear Disclosure				
		<i>Forgetting</i>			<i>Forgetting</i>		<i>Forgetting</i>		<i>Forgetting</i>		
		Conflicting life goals			Conflicting life goals	Conflicting life goals	Conflicting life goals		Conflicting life goals		Conflicting life goals
(general)	DM self-efficacy DM health beliefs DM knowledge/literacy/problem solving skills Locus of control <i>Motivation</i>										
Socio-demographic barrier	Lack of social support Comorbidity DSM: Axis IV problems (financial, work, relationship, family issues)										

Table 9 - T1DM: Multiple scenarios optimalisation DM SM (general)

Notes:

- Fear of hypers = fear of complications
- Negative affect (other than fear -> sadness, anger, depression, 'trauma') = avoiding confrontation DM because of negative emotions triggered by DM self-care

- *Coping = emotional and behavioral coping and is DEALING with negative affect (dysfunctional behavioral coping, usually is avoidance)*
- *Excess use of alcohol/drugs/nicotine = either coping or comorbidity....*

Ultimate goal	Optimalisation HbA1c (= lowering risk of complications) and DM-QOL									
DM SM goal	Calories/Carbs/Fat -	Exercise +	Oral anti-diabetics +	Glucose monitoring -/+		Insulin -				Stress -
DM SM problem	Too many/much	Too little	Too little	Too little	Too much	Dose too little	Frequency too little	Dose too high	Frequency too high	Too much
Psychological Barrier	Fear of hypo's	Fear of hypo's	(Fear of hypo's)		Fear of hypo's / hyper's	Fear hypo's	Fear of hypo's	Fear of hypers	Fear of hypers	
	Eating problem					Fear of weight	Fear of weight			
				Fear 'needles'		Fear injections	Fear injections			
	Negative affect	Negative affect	Negative affect	Negative affect		Negative affect	Negative affect			Negative affect
			Fear disclosure	Fear disclosure		Fear disclosure	Fear disclosure			
		Forgetting	Forgetting	Forgetting			Forgetting			
general	Conflicting life goals	Conflicting life goals	Conflicting life goals	Conflicting life goals		Conflicting life goals				Conflicting life goals
	DM self-efficacy DM health beliefs DM knowledge/literacy/problem solving skills Locus of control <i>Motivation</i>									
Socio Demographic Barrier	Lack of social support Comorbidity DSM: Axis IV problems (financial, work, relationship, family issues)									

Table 10 - T2DM: Multiple scenarios optimalisation DM SM (**general**)

8.6 Decision trees for coping with barriers

Based on the Table 9 and on Table 10 five decision trees were specified coping with typical barriers for diabetes patients

Question Level 1	Answer Level 1	Trigger	Question Level 2	Answer Level 2	Edge Level 2 (Decision Tree Identifier)	Question Level 3	Answer Level 3	Edge Level 3 (Decision Tree Identifier)				
Do you recognize any of the following problems regarding glucose monitoring?	I monitor too much	DDL_GM_TM	Do you monitor so much because of any of these reasons?	I am scared of having a hypo	GM_TM_Fear_hypos_Process							
				I am scared of (complications from) my glucose being too high	GM_TM_Fear_complications_Process							
	No	GM_TM_Supporting_Message										
	I monitor too little	DDL_GM_TL		I don't like monitoring my glucose	GM_TL_Negative_Affect_Process							
				I am too busy to check my glucose or Life just gets in the way	GM_TL_Conflicting_Life_Goals_Process							
				I forget to check my glucose	GM_TL_Forgetting_Process							
				I don't like to monitor, because it confronts me with possible higher blood sugars and the risk of	GM_TL_Fear_Complications							
				I don't want anyone to know about my diabetes	GM_TL_Fear_Disclosure_Process							
				I don't like to monitor, because it confronts me with possible higher blood sugars and the risk of	GM_TL_Fear_Complications							
				I don't like needles	GM_TL_Fear_Needles_Process							
I feel too sad/negative to monitor my			GM_TL_Depression									
No	----->	How about these?										
		What I do doesn't have an affect I'll never reach my goal no matter	GM_TL_Motivation_Process									
		Checking my glucose isn't	GM_TL_Goal_Importance									
		Checking my glucose doesn't	GM_TL_Monitoring_Importance									
		I don't know how or when to check my blood glucose	GM_TL_Problem_Solving_Process									
		No	GM_TL_Supporting_Message									
I monitor like I'm supposed to but I'm not happy about it	none		Do you feel unhappy regarding monitoring because of any of these reasons?	I don't like monitoring my glucose	GM_OK_Negative_Affect_Process							
				I don't like needles	GM_OK_Fear_Needles_Process							
				I don't like to monitor, because it confronts me with possible higher blood sugars and the risk of	GM_OK_Fear_Complications							
				I don't want anyone to know about my diabetes	GM_OK_Fear_Disclosure_Process							
				I feel so sad/negative when monitoring my glucose	GM_OK_Depression							
				No	----->				How about these?			
									What I do doesn't have an affect I'll never reach my goal no matter	GM_OK_Motivation_Process		
									Checking my glucose isn't	GM_OK_Motivation_Process		
									Checking my glucose doesn't	GM_OK_Goal_Importance		
									Checking my glucose doesn't	GM_OK_Monitoring_Importance		
		No	GM_OK_Supporting_Message									

Table 11 – Barrier decision tree for Glucose Monitoring

	Answer Level 1	Trigger	Question Level 2	Answer Level 2	Edge Level 2 (Decision Tree Identifier)	Question Level 3	Answer Level 3 (Decision Tree Identifier)	Edge Level 3	
Do you recognize any of the following problems regarding exercising?	I exercise too little	ODL_EX_TL	Do any of these problems sound familiar?	I am scared of having a hypo	EX_TL_Fear_Hypos				
				I am too busy or can't find the time to exercise	EX_TL_Conflicting_Life_Goals				
				I don't like exercising	EX_TL_Negative_Affect_Process				
				I don't want anyone to know about my diabetes	EX_TL_Fear_Disclosure_Process				
				I forget to exercise	EX_TL_Forgetting_Process				
	I feel too sad/negative to exercise	EX_TL_Depression							
				No	----->	How about these?	What I do doesn't have an affect on my diabetes	EX_TL_Motivation_Processes	
							I'll never reach my goal no matter how hard I try	EX_TL_Motivation_Processes	
							Exercising isn't important to me	EX_TL_Personal_Importance	
							Exercising doesn't affect my	EX_TL_General_Importance	
						No	EX_TL_Supporting_Message		
I exercise like I'm supposed to but I'm not happy about it	none		Do any of these problems sound familiar?	I don't like exercising	EX_OK_Negative_Affect_Process				
				I don't want anyone to know about my diabetes	EX_OK_Fear_Disclosure_Process				
				I feel sad/negative when exercising	EX_OK_Depression				
				No	----->	How about these?	What I do doesn't have an affect on my diabetes	EX_OK_Motivation_Processes	
							I don't really care about exercising	EX_OK_Personal_Importance	
							Exercising doesn't affect my	EX_OK_General_Importance	
							No	EX_OK_Supporting	
	I exercise too much	ODL_EX_TM	Do any of these problems sound familiar?	I am scared of complications from my glucose being too high	EX_TM_Fear_Complications				
I am scared of gaining weight				EX_TM_Fear_Weight					
No				EX_TM_Supporting_Message					

Table 12 – Barrier decision tree for Exercise

Trigger	Question Level 1	Answer Level 1	Trigger	Question Level 2	Answer Level 2	Edge Level 2 (Decision Tree Identifier)	Question Level 3	Answer Level 3	Edge Level 3 (Decision Tree)
ODL_CA	Do you recognize any of the following problems?	Sometimes/often I eat too many carbohydrates	ODL_CA_TM	Do you eat too many carbs because of any of these	Reducing my carbohydrates conflicts with other personal goals/social life	CA_TM_Conflict_Daily_Life	How do you feel when reducing your carbohydrates?	I feel frustrated that I am not able to monitor my carbohydrates as I want to/should	CA_TM_Goal_Frustration
					Reducing my carbohydrates makes me feel bad	CA_TM_Negative_Affect			
					I am scared of having a hypo	CA_TM_Fear_hypos			
					I don't want others to notice my diabetes, and the need to reduce my carbs	CA_TM_Fear_Disclosure			
					I feel I don't have the knowledge or skills to reduce my carbs	CA_TM_Knowledge_Skills			
					No	CA_TM_Supporting_Messa			
ODL_CAM_TL	Do you any of these problems sound familiar?	I don't monitor my carbohydrates enough	ODL_CAM_TL	Do you any of these problems sound familiar?	I am too busy/don't seem to find the time to monitor my carbohydrates	CAM_TL_Conflict_Daily_Life	How do you feel when monitoring your carbohydrates?	I feel frustrated about monitoring my carbohydrates	CAM_TL_Goal_Frustration
					Monitoring my carbohydrates makes me feel bad	CAM_TL_Negative_Affect			
					I just keep forgetting to monitor my carbohydrates	CAM_TL_Forgetting			
					I don't want others to know about my diabetes	CAM_TL_Fear_Disclosure			
					I feel I don't have the knowledge or skills to monitor my carbs	CAM_TL_Knowledge_Skills			
					No	CAM_TL_Supporting_Messa			
ODL_CA_TL	Do you any of these problems sound familiar?	I don't eat enough carbohydrates/I skip carbs, even when I (might) need them	ODL_CA_TL	Do you any of these problems sound familiar?	I am scared of (complications from) my glucose being too high	CA_TL_Fear_complications			
					I am scared of gaining weight	CA_TL_Fear_Weight			
					I feel too sad/negative to eat	CA_TL_Depression			
					No	CA_TL_Supporting_Message			

Table 13 – Barrier decision tree for Carbohydrates

Question Level 1	Answer Level 1	Trigger	Question Level 2	Answer Level 2	Edge Level 2 (Decision Tree)	Question Level 3	Answer Level 3	Edge Level 3 (Decision Tree Identifier)
It seems you have not injected what you had planned, do you recognize any of the following problems?	Sometimes/often I inject too little insulin (lower dosage)	ODL_INS_TL	Do you inject too little insulin because of any of these reasons?	I inject less insulin, because I am afraid of hypo's	INS_TL_Fear_Hypos			
				I inject less insulin, because I am afraid to gain weight	INS_TL_Fear_Weight			
				I inject less insulin, because insulin makes me feel bad	INS_TL_Neg_Affect			
				I feel I don't have the knowledge/skills to inject insulin properly	INS_TL_Knowledge			
				no	INS_TL_Supporting_Message			
I don't inject the amount of injections that I need	ODL_INS_AM		Do you skip insulin injections because of any of these reasons?	I often just forget to inject insulin	INS_AM_Forget			
				Injecting insulin conflicts with my daily life	INS_AM_Goal_Conflict			
				I inject less insulin, because I am afraid of hypo's	INS_AM_Fear_Hypos			
				I inject less insulin, because I am afraid of injections/needles	INS_AM_Fear_Needles			
				I inject less insulin, because I don't want others to notice my diabetes	INS_AM_Fear_Disclosure			
				I inject less insulin, because injecting insulin makes me feel bad	INS_AM_Neg_Affect	How do you feel when monitoring your carbohydrates?	I feel frustrated that I am not able to inject insulin as often as I want to/should	INS_AM_Goal_Frustration
							I feel sad/negative when having to inject insulin that often	INS_AM_Depression
							I have other negative emotions when having to inject insulin that often	INS_AM_Negative_Emotions
				I inject less insulin because I am afraid to gain weight	INS_AM_Fear_Weight			
				I feel I don't have the knowledge/skills to inject insulin properly	INS_AM_Knowledge			
no	INS_AM_Supporting_Message							
Sometimes/often I inject too much insulin	ODL_INS_TM		Do you inject too much insulin because of this reason?	I inject too much insulin, because I am afraid of complications/high blood glucose	INS_TM_Fear_Complications			
				no	INS_TM_Supporting_Message			

Table 14 – Barrier decision tree for Insulin

Trigger	Question Level 1	Answer Level 1	Edge Level 2 (Decision Tree Identifier)
ODL stress	It seems that you are experiencing a lot of stress. Do you recognize any of the following reasons?	I am generally too busy, which causes me to feel stressed	STR_Goal_Conflict
		My mood is low, which causes me to feel stressed as well	STR_Negative_Affect
		I seem to feel stressed without knowing why	STR_General
		No	STR_General_Apology

Table 15 – Barrier decision tree for Stress