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***Deliverable D14*:** Theory-based motivational behavior change strategies for the Responsive Engagement of the elderly promoting Activity and Customized Healthcare (REACH) project **(associated with tasks T4.1-4.2)**

**Abstract:** The overall goal of REACH is to promote physical activity and reduce the risk of functional loss amongst elderly through early detection and intervention. This deliverable report presents three key contributions to that goal; (1) a summary of relevant behavior change models, (2) theory-based motivational strategies for designing for behavior change interventions in the REACH context, complemented with every-day examples, (3) practical applications of the motivational strategies for each of the touchpoints (as defined previously in the REACH **D4** report).

These contributions should help the REACH teams and others to understand how to leverage state-of-the-art knowledge on the topics of motivation and behavior change for the REACH objectives in their particular context. More specifically, how to apply motivational strategies stemming from behavior change theories to create interventions that will be engaging and will have high levels of adoption amongst end users. Therefore, where applicable, empirical cases will be used to illustrate and operationalize the motivational strategies in a field context.

The report complements the literature review of motivational techniques and models from the **D3** and **D2** reports and highlights those that are most promising in the REACH context. The current deliverable (**D14**) is associated with **T4.1** and **T4.2**, both residing in **WP4**. The premise of these tasks, and the deliverable, is to investigate and inventorize applicable behavior change theories and strategies. The deliverable will also suggest and illustrate where possible, how these strategies can be developed into tactics, to be applied in the REACH touchpoints, defined in **D4**. Where applicable, empirical cases will be used to illustrate and operationalize the particular applications in a field context.

This report is a first attempt to bridge the gap between the theoretical knowledge of behavior change theories and the application of this knowledge to designing for behavior change practice in the REACH context. Considering the limited numbers of practical examples available in literature, we feel the field would benefit significantly from more practical guidelines that support designers in making their designs more engaging and appropriate for accommodating behavior change. Specifically, it will be of relevance to see a tailored list of recommendations suitable for elderly people, improving their levels of physical activity.

Since the current deliverable (**D14**) reports on ongoing tasks (**T4.1** and **T4.2**: M15-M36), it will be updated in accordance with the progress of work in these tasks.

| | |
|---|---|
| Lead Partner: | Koninklijke Philips Nederland (PHI) |
| Participants: | Alreh Medical (AM); Biozoon Gmbh (BZ); Hôpitaux Universitaires de Genève (HUG); Koninklijke Philips Nederland (PHI); Technical University Eindhoven (TUE); Technical University of Munich (TUM); Center for Playware/ Technical University of Denmark (DTU) |
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## Tasks of the involved partners with respect to the deliverable (and respective tasks) presented in this report:

| Partner | Short task description |
|---|---|
| Philips | Define scope, lead task, coordinate between all partners, lead behaviour change theories and motivational strategies analysis, participate in related work sessions. |
| TU/e | Coordinate between BZ, DTU and PHI, contribute to motivation, early trials, prior work REACH **D2** and touchpoints Socializing and nutrition, Gaming and training system & Wearables |
| AM | Application to touchpoint Personal mobility device |
| TUM | Application to touchpoint Active environment |
| BZ | Application to touchpoint Socializing and nutrition |
| DTU | Application to touchpoint Gaming and training system |
| HUG | Prior work REACH **D2**, final review |

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# Key expressions

**Abbreviations for partners:**

**AM**: Alreh Medical
**BZ:** Biozoon Gmbh
**DTU**: Technical University of Denmark
**HUG:** Hôpitaux Universitaires Genève
**PHI:** Koninklijke Philips Nederland
**TU/e:** Eindhoven University of Technology
**TUM:** Technical University of Munich
**ZZ**: ZuidZorg

**BC:** Behavior Change

**BCW:** The Behavior change wheel is a holistic behavior change model

**COMBI model:** COMputerized Behavior Intervention (COMBI) model is a holistic behavior change model

**D:** Deliverable report.

**FBM:** BJ Fogg's Behavior Model is a design behavior change model.

**Malnutrition**: Deficiencies, excesses or imbalances in a person's intake of energy and/or nutrients. The term malnutrition covers two broad groups of conditions. One is 'undernutrition, malnourishment'—which includes stunting (low height for age), wasting (low weight for height), underweight (low weight for age) and micronutrient deficiencies or insufficiencies (a lack of important vitamins and minerals). The other is overweight, obesity and diet-related noncommunicable diseases (such as heart disease, stroke, diabetes and cancer).

**RFT:** The Regulatory Focus Theory is a design behavior change model.

**SDT:** Self-determination theory

**T:** Task defined in the project proposal.

**Touchpoints**: The "Touchpoints" act as "graspable" front end towards the end users (elderly). The Touchpoints will serve as data gathering devices as well as mediator of services and interventions coordinated by the Engine towards the end user. Each Touchpoint is modular and made up of several subsystems which allow to adapt the system both for a certain person or setting as well as over time.

**TPB:** The theory of planned behavior is a psychological behavior change model.

**TTM:** The Trans-Theoretical Model (i.e. the Stages of change theory) is a psychological behavior change model.

**WP:** Work package defined in the project proposal.

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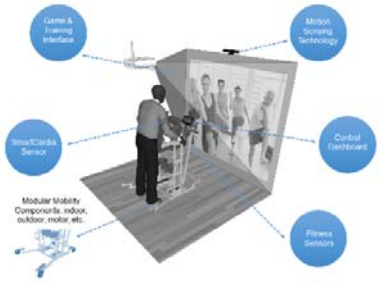
# 1 Background of tasks and activities related to T4.1-4.2/D14

In the REACH project, a sensing-monitoring-intervention system is developed that can be placed in an unobtrusive manner in various care settings and living environments of elderly citizens. The system will be able to: (1) use a set of sensors to detect selected vital signs, behavioural/care patterns, and health states; (2) predict – as early as possible – future health states, risks or events (loss of function, frailty, stroke, etc.); and (3) provide and coordinate proactively a set of customised services and products that have the overall aim at stimulating and supporting physical activities. Early intervention by REACH should allow for the time spent in a desirable health state (baseline health), and Healthy Life Years (HLYs) to be increased, and that the time spent in Long-Term Care (LTC) facilities is reduced. In that context, it will be shown that REACH can improve and speed up, on the one hand, the physical and cognitive rehabilitation of elderly citizens in deteriorated health states or suffering from a sudden incident, for example, by speeding up their transfer from acute care to rehabilitation to home care, as well as their health state improvement within one of these institutions. On the other hand, it will be demonstrated that REACH can be utilized in home/home care contexts for as long as possible to keep people in a desired base-line health state, mitigate the risk of deterioration, and finally slow down or prevent deterioration.

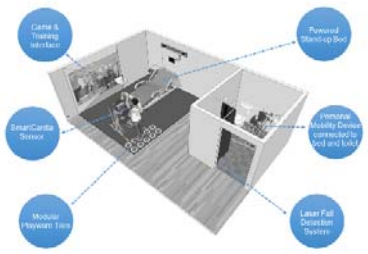
## 1.1 Touchpoints and Engine concept

Stating a key achievement of the first project year (in particular of **WP1**), the REACH consortium has developed and detailed a holistic conceptual solution, the "**Touchpoints and Engine concept**", based on an in-depth analysis of the four REACH use case settings, and the identification and inclusion of consortium internal and consortium external stakeholders (elderly, care personnel, insurances, etc.) in the system architecture development process. This conceptual solution fully reflects REACH's "Product-Service-System" value proposition. 5 physical touchpoints will function each as data gathering and intervention devices, which are bound together by cross-sectional, integrated engine (i.e. platform) functionality.

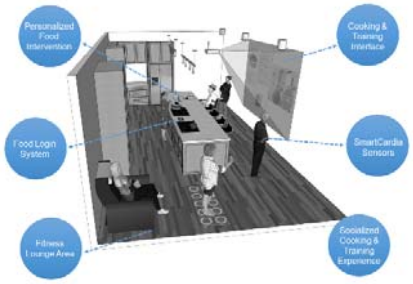
**Touchpoint 1:**
Personal Mobility Device



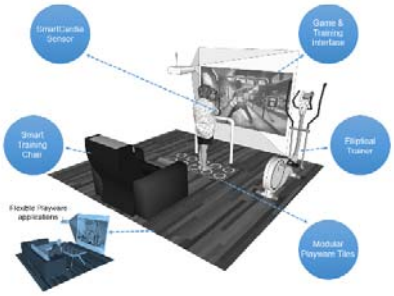
**Touchpoint 2:**
Active Environment



**Touchpoint 3:**
Socializing & Nutritional Monitoring
+ Intervention




**Touchpoint 4:**
Gaming & Training



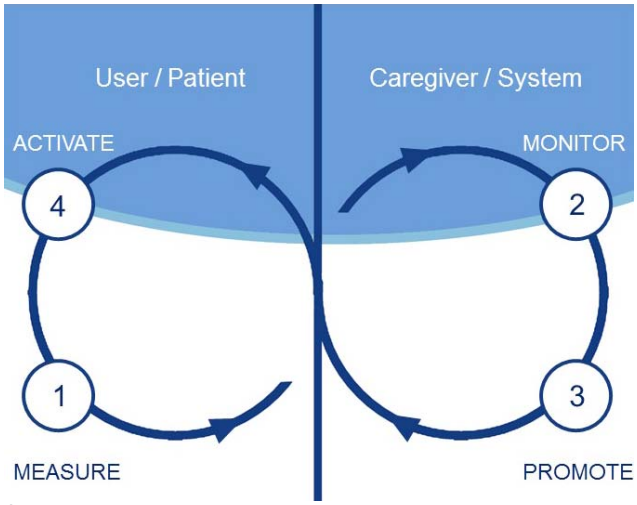

**Touchpoint 5**:
Wearables


"Touchpoints" will act as "graspable" front end towards the end users (elderly). Touchpoints will mainly materialize as "furniture" in a broader sense, i.e. elements that can be placed and moved within a certain environment or setting (e.g. beds, bath furniture, mobile walkers/standers, large scale interfaces, smart flooring tiles, smart tables, etc.) but also as ambient sensor add-on modules and wearables. The Touchpoints will serve as data gathering devices as well as mediator of services and interventions coordinated by the Engine towards the end user. Each Touchpoint is modular in itself (thus also serving as a kind of physical product platform) and made up of several subsystems which allow to adapt the system both for a certain person or setting as well as over time. The "Engine" ICT platform - in itself also modular with regard to its functionality – serves from the viewpoint of the end user as "invisible" back end system. In general, the end users (elderly) are supposed to interact with the "engine" primarily in an indirect way through the Touchpoints.

## 1.2 REACH's Human-System interaction approach

A number of core functional elements of REACH were identified as part of various REACH activities: measure, monitor, promote and activate. The service blue print concept sets this four elements into relation to each other and uses them to create a feedback loop that shall govern the interaction between end users and the REACH system via the Touchpoints. REACH should on one hand, continuously measure the user activities in the front end, while

at the back-end monitor the processes and identify/predict acute events and unusual patterns for potential activations by the system or caregivers at the front-end experience of the user again. The service blue print concept can be used to govern the implementation of the REACH human-system interface between the end-users and the Touchpoints.




**REACH core components of the "service blueprint" that shall govern the interaction between end users and the REACH system via the Touchpoints.**

## 1.3 Systems engineering, integration, and testing in REACH

With the overall system architecture detailed and the first early trials completed (see also deliverables **T1.4/D4 "Overall PSS-System Architecture"** and **T6.1/D25 "Coordination of system integration activity"**), it becomes obvious that it is impractical to test each Touchpoint with regard to its complex, subsequent chain of early detection, motivational techniques, and programmed interventions in a single trial. This unrealistically large and long trials if required are beyond the scope and resources of the project. Instead, a decomposition of the "testing problem" is suggested. For each Touchpoint separate testing parts/instances were created and each of this testing instances represents a separate trial with an own hypothesis, own outcome measures, and an instance-specific trial design. The table below shows the general concept for decomposition of the testing approach.

**Concept for decomposition of testing approach**

| Touchpoint | | Testing Instances | | |
|---|---|---|---|---|
| Name | Condition detected/adressed | Early Detection | Motivational Techniques | Programmed Interventions |
| TP1 Personal Mobility Device | Frailty and risk of falls | • Hypothesis:…<br>• Outcome measures:<br>• Study Design:… | • Hypothesis:…<br>• Outcome measures:<br>• Study Design:… | • Hypothesis:…<br>• Outcome measures:<br>• Study Design:… |
| TP2 Active Environment | Mobility | • Hypothesis:…<br>• Outcome measures:<br>• Study Design:… | • Hypothesis:…<br>• Outcome measures:<br>• Study Design:… | • Hypothesis:…<br>• Outcome measures:<br>• Study Design:… |

| | | | | |
|---|---|---|---|---|
| TP3 Socializing and Nutrition | Social interaction and nutrition | • Hypothesis:…<br>• Outcome measures:<br>• Study Design:… | • Hypothesis:…<br>• Outcome measures:<br>• Study Design:… | • Hypothesis:…<br>• Outcome measures:<br>• Study Design:… |
| TP4 Gaming and Training | General physical and cognitive ability | • Hypothesis:…<br>• Outcome measures:<br>• Study Design:… | • Hypothesis:…<br>• Outcome measures:<br>• Study Design:… | • Hypothesis:…<br>• Outcome measures:<br>• Study Design:… |
| TP5 Wearables | General physical and cognitive ability | • Hypothesis:…<br>• Outcome measures:<br>• Study Design:… | • Hypothesis:…<br>• Outcome measures:<br>• Study Design:… | • Hypothesis:…<br>• Outcome measures:<br>• Study Design:… |

## 1.4 Link of this deliverable to REACH objectives and previous work - premise

The REACH project aims to deliver a sensing-monitoring-intervention system that supports elderly citizens in attaining and maintaining a healthy activity level. The goal of work package (**WP**) **4** in this project is to analyze, explore, understand and deliver motivational behavior change strategies that support the technical partners in creating interventions that will be engaging in the context of early intervention and will have high levels of adoption amongst end users and their stakeholders.

The REACH project will address three stages (sensing, monitoring, intervention) of motivational behavior change loops separately. Sensing will be addressed in **WP2**, monitoring and analysis will be addressed in **WP3**. The design and planning of the intervention (be it physical and/or cognitive) will be addressed in **WP4**.

The current deliverable (**D14**) is associated with **T4.1** and **T4.2**, both residing in **WP4**. The premise of these tasks, and the deliverable, is to investigate and inventorize applicable behavior change theories and strategies. The deliverable will also suggest and illustrate where possible, how these strategies can be developed into tactics, to be applied in the REACH touchpoints, defined in **D4**. Where applicable, empirical cases will be used to illustrate and operationalize the particular applications in a field context.

The deliverable should inform the REACH teams working on the touchpoints, and help them understand how they may leverage state-of-the-art knowledge on motivational behavior change strategies and tactics for the REACH objectives in their particular context. It will also provide the REACH project with a shared understanding, terminology and framework for further discussing and assessing behavior change theory and motivational strategies for promoting activity amongst elderly.

## 1.5 Goals of this deliverable

The goals of the current deliverable are to (1) share an overview of the behavior change theories and models most relevant to the REACH context (Chapter 2), (2) explore how these theories translate into strategies and tactics that can be used in the actuation and intervention work done in the REACH project; where possible, examples and best practices will be shared (Chapter 3), and (3) to provide an overview of the five touchpoints, and

discuss how the theories, strategies and tactics can be leveraged to make an impact in terms of motivating and changing behaviors of the users for the better (Chapter 4). Where available, we support these suggestions with empirical evidence collected through field experiments carried out by the project partners connected to those touchpoints.

On a meta-level this deliverable aims to provide the project and project partners with a common understanding of principles related to behavior change methodology. Behavior change in science and practice is addressed from many different angles: social sciences, design, engineering, business and marketing. As partners from all these angles are represented in the consortium, it is essential to have a common vocabulary when engaging in discourse on the topic. This deliverable will share the language and definitions to be used in the project, and it will provide tangible examples where possible, to ensure a solid conversation amongst partners, and anchor the research findings in a shared understanding.

# 2 Overview of relevant behavior change theories and models

This section will describe the behavior change theories and models that are considered a solid foundation for the applications in the REACH project. Inclusion criteria of the theories as well as a short description of each theory/model will be provided. The theories have been loosely arranged so that we are starting with the psychological/psychosocial theories, followed by holistic models, and ending with the more applicable design theories. In the chapter hereafter (Chapter 3), actionable design strategies for the REACH project will be derived from the models and theories.

## 2.1 Definition of behavior change

According to the American Psychological Association (**Zimbardo & Weber, 1994**), the definition of behavior modification or behavior change is "The systematic use of principles of learning to increase the frequency of desired behaviors and/or decrease the frequency of problem behaviors". What these targeted problem behaviors are can differ from person to person, and between different intervention programs. For the REACH project, the scope is on increasing physical activity for elderly. In her system for designing effective behavior change interventions, **Michie (2011)** suggests to first identify key specific behaviors (often several) that are all closely related to the targeted behavior, by asking questions such as 'Who needs to do what differently, when, where, how?'. The answers to these questions will define the actual behavior that one aims to change with a behavior change intervention.
For the current report and the REACH project, we define behavior change as the change of (lifestyle) behaviors, that results in an overall increase in physical activity. A behavior change is seen as successful if the user is able to maintain this changed behavior during a longer period of time (at least a few weeks) after the onset of an intervention.
Our long term vision is to reach behavior change over an even longer period of time. Metrics for the future measurement of behavior change are the speed of adoption of a behavior change intervention, next to the change of the actual behavior.

## 2.2 Introduction

There are many models and theories on behavior change, some focusing on parts of the behavior change process (e.g. the Trans-Theoretical Model; **Prochaska & Velicer, 1997**), while others are more holistic, aiming to include all factors that can influence behavior change (e.g. the COMBI model; **Klein et al., 2011**). Most of the models have a psychological or psychosocial view on behavior change (e.g. theory of planned behavior; **Ajzen, 1991**), although we have also included frameworks that have been focusing on *designing* products or solutions (e.g. BJ Fogg Model; **Fogg, 2009**). The aim here is not to provide a fully comprehensive overview of all the existing literature on behavior change frameworks, but to highlight the ones that we feel are most relevant for pursuing behavior change through innovation, technology and design. This could be, for example, because of an ultimate holistic approach (the behavior change wheel; **Michie, Van Stralen, & West, 2011**), direct applications to design (Hook model; **Eyal, 2014**), or clear intervention value for changing behavior (intention implementations; **Gollwitzer & Oettingen, 2013**). Specific rationales for inclusion are also briefly mentioned per framework.

As successful behavior change for complex behaviors such as healthy lifestyle behaviors or increasing physical activity in particular is not a matter of making one decision at one point

in time, but the accumulated result of multiple health-related decisions and experiences throughout days, weeks, and months (**Rothman et al., 2008**), impacting this process also requires knowledge and successful application of various models and strategies. This report aims to give a comprehensive overview of behavior change models to provide insights into the theoretical background, a list of strategies on how to design for behavior change (Chapter 3), as well as examples illustrating past use of the strategies for further inspiration (Chapters 3 and 4). By providing an overview of existing behavior change frameworks taking earlier work from REACH deliverable **D2** (**Andersen et al. 2017**) into account, we hope to create awareness and inspire use of behavior change applications to better facilitate physical activity in elderly people.

## 2.3 Overview 1 – Psychological/psychosocial theories

### *2.3.1 Trans-Theoretical Model (TTM) (i.e. the Stages of change theory)*

The Trans-Theoretical Model has long since been recognized for describing the dynamic nature of behavior change (TTM; **Prochaska & DiClemente, 1992**). It is a cognitive model, initially developed to understand smoking behavior, applying a process view on behavior change. The process-perspective that this widely referenced model represents was the main reason to include in our over view here.
The trans-theoretical model (TTM) of behavior change describes six phases of change through which people move sequentially before and during the behavior change process (see Figure 1). The principle behind using a model of phases is that individuals in the same phase should face similar problems and barriers, and thus can be helped by the same type of intervention (**Nisbet & Gick 2008**). The TTM describes how people move through the phases pre-contemplation, contemplation, preparation, action, maintenance and finally termination stage, while trying to avoid relapse (**Prochaska & Velicer, 1997**). In the pre-contemplation stage, the individual is not aware of having a problem or does not see the necessity to change his behavior. During contemplation, the individual acknowledges that his behavior needs change, but does not have specific goals or a plan of action until the preparation stage. In preparation phase, the action is being planned, but not yet executed. In the action stage, actual behavior change is taking place, and in the maintenance stage, the behaviour has become a sustained habit. In this last phase, individuals usually do not rely on change processes like they do in action, however they are working to prevent a relapse of their old behaviour (i.e. return to an earlier stage of change).

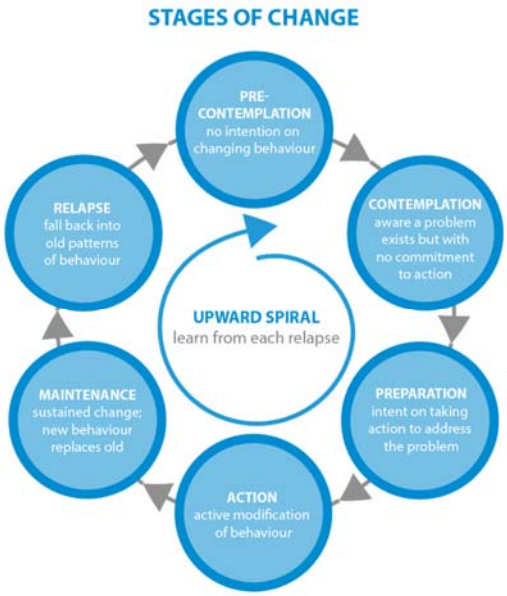



**Figure 1. Trans-Theoretical Model. Retrieved June 21, 2017, from https://news.illinoisstate.edu/2017/06/achieving-wellness-goals/**

The TTM helps us understand that due to the dynamic nature of the behavior change process, different behavior change strategies could be applicable to different stages. The model has been applied to a health psychotherapy context, for which different types of 'processes of change' have been identified for each of the stages: these processes are strategies and techniques people can use to change a problem behavior or adopt a healthy behavior (see Figure 35). There are five experiential processes (i.e., consciousness-raising, dramatic relief, environmental reevaluation, social liberation, and self-reevaluation) and five behavioral processes (i.e., counterconditioning, helping relationships, reinforcement management, stimulus control, and self-liberation). We have added design examples for those TTM processes to the REACH context that can be immediately applied to designing for behavior change (see Figure 35). For example, in the pre-contemplation stage, information provision is key, to make the person aware that a problem exists.

With regards to both limitations as well as the practical value of this model; the phases of the model do not mean that everyone reaches these phases or that all phases are passed through in an orderly sequential order. Sometimes people are put back to the start of the process without going through all phases or get stuck within a phase due to certain influencers. The model helps to assess across a journey at what stage people are at that moment and helps recognize when they are moving further or backward for a specific reason. This will enable to distill implications for types of interventions and the correct timing of these interventions, based on specific triggers.

### *2.3.2 Theory of planned behavior (TPB)*

The underlying assumption of the theory of planned behavior (TPB) is that behavior is preceded by an individual's intention (**Ajzen, 1991**). In turn, this intention is created by attitudes, perceived behavior control (i.e. one's perception of how difficult or easy it is to execute the behavior) and the social norm (see also Figure 2). For an individual, the following example could explain his (lack of) physical activity.

- Attitude (negative - positive): I like exercising.
- Perceived behavior control (hard – easy): It would be fairly easy for me to start exercising more.
- Social norm (disapproval - approval): All my friends exercise.
- Intention (weak –strong): I would like to increase my physical activity to become healthier.

The TPB has been widely applied in psychology to understand behavior (change) and has been used as a basis for intervention frequently. It could also be considered one of the first holistic behavior change models. It is important to note that the perceived behavioral control factor overlaps strongly with the concept of self-efficacy (i.e. how much does a person believe that he can reach the targeted behavior), that is also included in, for example, the COMputerized Behavior Intervention model (see Chapter 2.4.2).
A limitation of this model is that not all that happens in the process of behavior change is of fully cognitive nature in reality (**Wolff, 2011**). **Ajizen (2011)** argues that in his model, emotions can indirectly help to select the behavioral, normative and control beliefs that are readily accessible in memory or that serve as background factors. Nonetheless, he admits that the TPB does not sufficiently account for emotions affecting behavior in a more direct fashion.

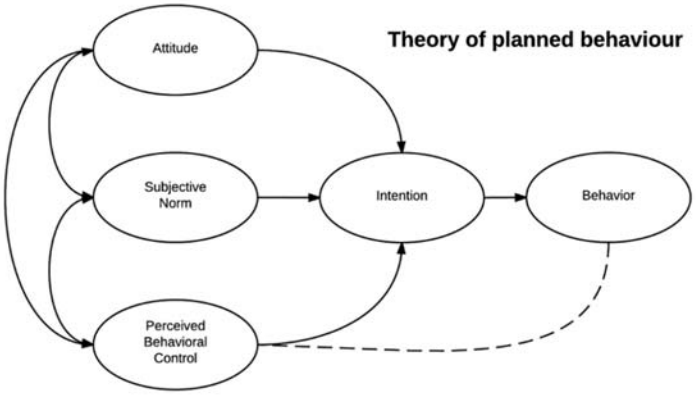



**Figure 2 Theory of planned behavior. Adapted from Ajzen (1991).**

### *2.3.3 Implementation intentions*

An implementation intention is an 'if – then' plan that helps individuals attain their goals (**Gollwitzer & Oettingen, 2013**). An 'if-then' plan is formed according to the following outline: If situation S is encountered, then I will initiate response R in order to reach goal X. For example, if I get home from work (situation S), I will immediately put on my sportswear and step on the treadmill (response R), to become more physically healthy in the end (goal X). Also, 'if-then' plans can focus on situations or cues that could be a potential barrier in reaching an end goal (e.g. if a friend offers me a drink on a party, I will drink a diet coke instead, to reduce my intake of alcoholic beverages). The idea is that the realization of goals is facilitated by forming an implementation intention that spells out the when, where, and how of this goal achievement in advance. The implementation intention enhances an individual's ability to self-regulate his behavior, reduces cognitive effort by pre-forming automatic associations on what to do in situation S, and makes the goal and goal-related triggers less abstract. Interestingly, **Gollwitzer (2005)** found that for people who pre-defined if-then plans, willpower depletion did not affect carrying out a difficult anagram task. Implementation intentions have also been shown to be effective in promoting the initiation

of goal striving, shielding of ongoing goal pursuit from unwanted influences, disengagement from failing courses of action, and conservation of capability for future goal striving (**Gollwitzer & Sheeran, 2006**).
Because implementation intentions have been shown to be effective in various contexts, including the one relevant for REACH of engaging in exercise (**Milne, Orbell, & Sheeran, 2002; Prestwich, Lawton, & Conner, 2003; Rise, Thompson, & Verplanken, 2003**) we decided to include it in this overview. **Milne et al (2002)**, for example, asked participants to form an implementation intention according to: 'During the next week I will partake in at least 20 minutes of vigorous exercise on ……. (day(s)) at …… (time of day) at/or in …….. (place)'. They found that participants who were asked to do this, and who also received information on the importance and effect of exercise for cardiovascular disease, showed higher levels of actual exercise behavior compared to those who received information but did not pre-define implementation intentions.
A limitation is that effective behavior change also demands a change in setting new goals and the theory does not explain how people can best select new goals as a first step, taking as a given that a user already has set a goal. In addition, implementation intentions are most likely to succeed in behavior change if strong goal commitment are in place. **Gollwitzer & Oettingen (2013)** describe several ways to make an implementation intention as strong as possible, to increase changes to success.

### *2.3.4 Dual (or trial) process models*

In dual process models, the emotional and the rational mind are combined. **Kahnemann (2011)**, was among the first to distinguish between a system 1 (fast, automatic, emotional, subconscious) and a system 2 (slow, rational, logical, conscious system). **Haidt (2005)** then used the illustrative elephant-rider metaphor for this model, with the elephant being emotional, irrational, and the rider being analytical and planning ahead. A third factor that often comes into play is the path that the elephant and rider use, which represents their environment. With regard to changing behavior, the potential conflicts between the rider and the elephant are abundant. For example, the rider would like to run 10K in 8 weeks, but the elephant really feels like relaxing on the couch tonight. **Heath and Heath (2010)** state that changes often fail because the rider cannot keep the elephant on the right path long enough (i.e. self-control and willpower are exhausted before the rider reaches her goal).
Dual process models lie at the core of several other behavior change theories, such as the theory of planned behavior (mostly focusing on the rider) and the Hook model (focusing on automatic habits, i.e. the rider). In addition, dual process models have been used in several interventions that aim at increasing physical activity in elderly (e.g. **Arnautovska et al., 2017; Wolff et al., 2016**).
An aspect that illustrates why the theory makes sense is the hot-to-cold empathy gap (**Loewenstein, 2005**), which explains why people often do things in the heat of the moment that they severely regret afterwards. When people are in an emotionally "cold" state (rider/rational) and are being asked to reflect on their own behavior, they are notoriously unable to predict how they will feel and act when they are in a hot (emotional) state.

### *2.3.5 Self-determination theory (SDT)*

The self-determination theory developed by **Deci and Ryan (1985)** states that behavior is driven by three psychological needs: autonomy (i.e. freedom of choice and feeling in control over one's own life), competence (i.e. the feeling of being effective in dealing with one's own environment) and relatedness (i.e. having close and affectionate relationships with others). According to **Ryan and Deci (2000)** satisfying these needs leads to enhanced self-

motivation and mental health. Alternatively, when fulfillment of needs does not take place, this will lead to reduced motivation and well-being. According to **Ryan and Deci (2000)** these needs are universal and all of them need to be satisfied for an individual to thrive. This theory helps us understand how motivation is formed and is also at the foundations of other theories, such as BJ Fogg's model (see Chapter 2.5.2). In an overview article by **Teixeira et al. (2012)** support was found for a relationship between physical activity adherence and the SDT, with a strong link to more autonomous forms of motivation.
In a systematic literature review by **Sweet and colleagues (2014)**, behavior change strategies related to self-efficacy (such as planning, consequences, and knowledge) were present in less than half of the trackers or absent in all seven devices that were under investigation. For elderly specifically, no evidence was found that SDT was applied successfully in behavior change designs focusing on physical activity by **Sweet and colleagues (2014)**.

## 2.4 Overview 2 – holistic models

### *2.4.1 Behavior change wheel (BCW)*

Much work that has been done in the area of behavior change describes behavior change interventions on an individual level, while other literature focuses more on policies supporting behavior change. **Michie et al. (2011)**, took these different perspectives into account in creating the Behavior change Wheel (BCW), an umbrella framework that seeks to bring structure to an expanding body of literature on behavior change (see Figure 3). A behavior change framework created from such a comprehensive analysis of the other literature is important to mention in this review.

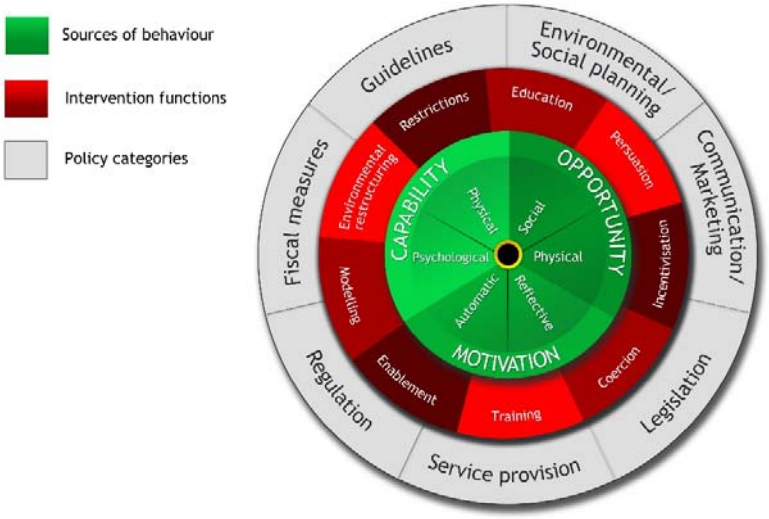



**Figure 3 Behavior Change Wheel. Retrieved June 21, 2017 from http://www.behaviourchangewheel.com**

**Michie and colleagues (2011)** examined 19 existing frameworks in order to create the BCW. From their comprehensive theory-based approach, they saw the need to create a framework to describe behavior change in which a clear distinction was made between the source of behavior, the intervention functions and the policy category. The most inner ring describes the elements that make behavior change possible, being capability, opportunity and motivation. Around this are the nine intervention functions, which can be employed to

address the deficits in the above mentioned. If for example a person is lacking physical capability, one could support them by facilitating training. The outer ring of the BCW lists the policy categories, which change facilitators could use to support behavior change. Some of them are more tangible and actionable for designers, such as “communication/ marketing” or “service provision”, others are less accessible to directly apply. For example, fiscal measures could be employed to support training which will address a lack of physical capability support. The format of a wheel was chosen because there are almost endless ways to combine these three levels of behavior change. As in our example the lack of physical capability could be addressed by training, by education, by intensification or by any combination of these. In addition, the combination of interventions could be facilitated by any form of policy in any of the policy categories. This framework helps designers and change facilitators structure the way in which behavior change is being facilitated.
A major limitation of the Behavior change Wheel is the lengthy process of applying it in detail. The multiple steps of intervention development for a medication management solution **(Sinnott, 2015)** took from the beginning of a systematic review to the final refinements of the intervention almost three years, even though **Sinnott and colleagues (2015)** skipped the last step. Such a prolonged course must be factored in by those pursuing and funding evidence-based intervention development.

### *2.4.2 COMputerized Behavior Intervention (COMBI) model*

Overlap exists between existing theories of behavior change, with many of the theories using similar constructs. Therefore, the COMBI (COMputerized Behavior Intervention) model aims at integrating existing theories into one holistic representation (**Klein et al., 2011**; see Figure 4), also describing the interaction between the different construct. It was originally developed as a basis for an intelligent support system that creates intervention messages. The COMBI model was based on the TTM, social cognitive theory (**Bandura, 1977**), self-regulation theory, attitude formation theory (**Smith & Mackie, 2000**), the health belief model (**Janz & Becker, 1984**), the relapse prevention model (**Marlatt & Gordon, 1980**), and the TPB. The application of this model to a coaching system shows how one ultimately can implement behavior change theories in design for behavior change.
The model differentiates between internal and external determinants of behavior, with the external factors being depicted beyond the dotted line in Figure 4. Definitions of the different constructs can be found in Table 1. All internal factors that determine the stage of change of an individual consist of three layers, showing a causal dependency between them (e.g. awareness is determined by perceived cues and threats, the latter of which is influenced, in turn, by susceptibility and severity). In case the value of one construct exceeds a predefined threshold, it transitions to another construct. **Klein and colleagues (2011, 2014)** describe that the COMBI model has been successfully applied to a coaching system (eMate) that attempts to enhance therapy adherence for patients suffering from Diabetes Mellitus type II or HIV.
A limitation of the COMBI model is the level of detail required in applying it practically. For example, the determinants are linked through pathways that specify how the stage of change can be influenced. The question arises which determinants need to be applied in an intervention component: only the most specific determinant (e.g. ‘emotions’ is more specific than ‘attitude’), or also all determinants on the pathway from the stage of change to that determinant (e.g. motivation, attitude, emotions).

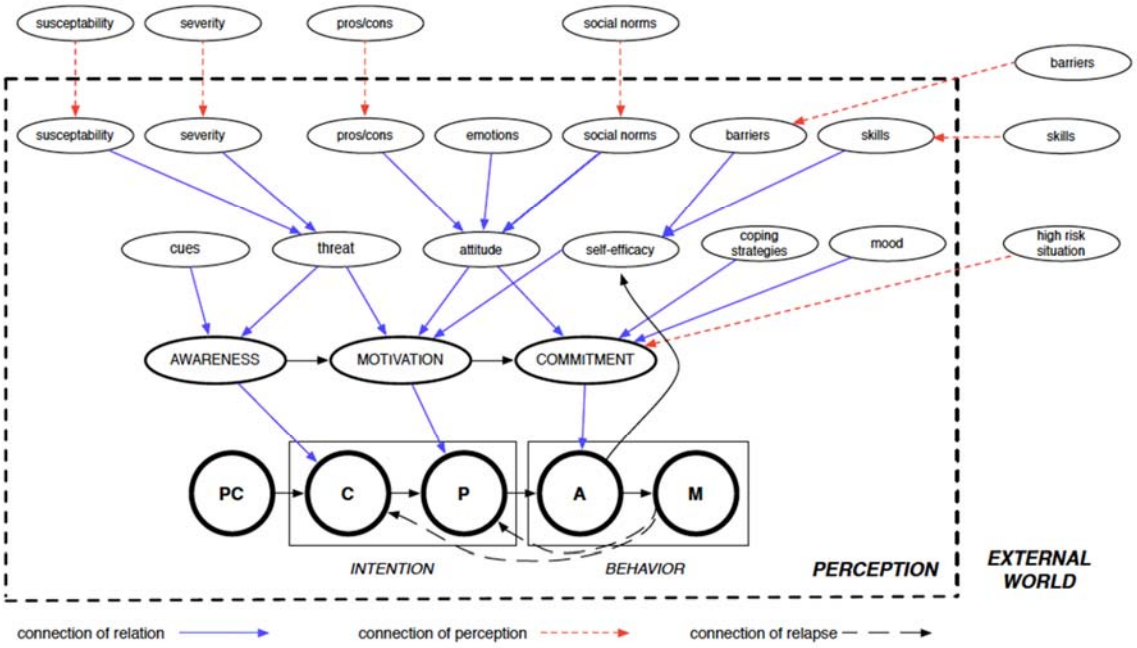



**Figure 4 The integrated model of behavior change COMBI. Reprinted from Klein et al. 2014**

**Table 1** ***The behavior determinants and related theories of the COMBI model. Reprinted from Klein et al. 2014***

TABLE 1
The model's behavior determinants and the related theories.

| Construct | Description | Related theory |
|---|---|---|
| Susceptibility | The likelihood of being affected by the behavior's consequences | Health belief model |
| Severity | The severity of the behavior's consequences | Health belief model |
| Pros/cons | Beliefs about the importance of behavior change | Theory of planned behavior<br>Attitude formation<br>Health belief model |
| Emotions | Feelings and cognitive appraisal related to the behavior change | Social cognitive theory<br>Attitude formation |
| Social norms | The influence of a person's culture and environment | Theory of planned behavior<br>Attitude formation |
| Barriers | Practical obstacles that prevent behavior change | Health belief model |
| Skills | Experiences and capabilities to overcome barriers | Theory of planned behavior<br>Social cognitive theory |
| Cues | Environmental or physical stimuli | Health belief model |
| Threat | Perceived risk of continuing to perform the behavior | Health belief model |
| Attitude | A mental state involving beliefs, emotions, and dispositions | Theory of planned behavior<br>Attitude formation |
| Self-efficacy | Perceived behavioral control | Relapse prevention model<br>Social cognitive theory<br>Theory of planned behavior |
| Coping strategies | The ability to deal with tempting situations and cues | Self-regulation theories<br>Relapse prevention model |
| Mood | A temporary state of mind defined by feelings and dispositions | Theory of planned behavior |
| High-risk situations | Contexts and environments that influence a person's behavior | Relapse prevention model |
| Awareness | Conscious knowledge of your condition and the threat and influence of current behavior | Transtheoretical model |
| Motivation | Incentives to perform goal-directed actions | Health belief model<br>Transtheoretical model |
| Commitment | An intellectual or emotional binding to a course of action | Transtheoretical model |

## 2.5 Overview 3 – design models

### *2.5.1 Regulatory Focus Theory (RFT)*

**Bruckner and Higgins'** Regulatory Focus Theory (RFT; **2001**) describes how people's intrinsic motivation differs. The RFT allows designers a way to profile users as either promotion or prevention focused and claims that acknowledging the user's regulatory focus provides designers insight into how these users can be moved and motivated toward a particular target behavior, which is the reason why we found this a valuable theory to include here.

The RFT claims people either have a promotion or prevention regulatory focus and that what motivates each of these types of people is inherently different. This theory suggests that people with a promotion regulatory focus are driven by their need for growth and development while people with a prevention oriented regulatory focus are driven by their need for security. People with a promotion regulatory focus are naturally motivated to move toward achieving the best version of themselves. People with a prevention oriented regulator focus are naturally motivated to achieve the version of themselves they feel they should achieve, fulfilling either their own expectations, or those of others. This theory describes what motivates people to act. This can be illustrated in the example of a physical education workshop in which participants are encouraged to run as many laps a possible. In this competitive setting, the promotion focused participant would aim to achieve their personal best in number of laps or try to surpass as many people as possible, while a prevention focused person will aim to prevent failure, which could mean avoiding having the least number laps or not achieving the same number of laps as their friend. Both participants might run the same number of laps, but the underlying motivation that moves them to do so is different. **Bruckner and Higgins (2001)** go on to describe that promotion focused people's emotions vary on a cheerful-dejected scale while those of prevention focused people vary along a quiescent-agitated scale. Understanding these distinctions can be a valuable step for designers to address their users more effectively.

What regulatory focus theory does not offer is a simple rubric for predicting how users will react to feedback in real clinical settings. The reasons for this complexity include both the important influences of other factors, such as credibility, on receptivity to feedback, and the nature of the tasks that comprise the context and may compete for the attention of the user **(Watling et al., 2012)**.

**Neruda and colleagues (2015)** found in their participants that tested apps for running lead to higher perceptions of "feeling right" in the case of a fit between individual orientation and tool orientation than in a non-fit. The test of participants' effort in using the tool showed a significant individual goal orientation x tool orientation interaction. The effort the individuals spent on their running routines under fit conditions was significantly higher than effort in non-fit conditions. Hence applying the promotion and prevention focus scale items in the design of physical activity behavior designs sounds promising, but must be explored further for the target user group of elderly people in the REACH project.

### *2.5.2 BJ Fogg's Behavior Model*

**Fogg**'s Behavior Model (FBM; **2009**) can be helpful for designers and researchers to understand why a behavior change intervention is currently not (yet) working. FBM describes three factors necessary for behavior change; for any behavior (B) to occur, we need motivation (M), ability (A) and a trigger (T). These crucial elements are plotted on a graph; ability on the X-axis and motivation on the Y-axis (see Figure 5). Triggers are placed on this two-by-two according to the user's level of ability and motivation (**Fogg, 2009**). On this same graph, Fogg's action line describes the minimum level of motivation an individual

must have in relation to their ability to react to a trigger in order to respond positively. If the individual is motivated (i.e. has a desire to take action), but does not have the ability to complete a task, even a well-timed trigger will not move a person to react and perform the targeted behavior. Conversely, if a task is very easy to complete but there is very little to no motivation to do it then, still there will be no response to a trigger. Goal of designing with FBM in mind is to let the end-user perform a behavior, when motivation, ability and trigger come together at the same moment.

Fogg's model triggers exemplary investigations for researchers and designers to ask the following questions in the evaluation of an existing intervention and when being in the actual design process:

1. Are users lacking motivation?

   Core motivators are (1) seeking pleasure and avoiding pain (as an immediate motivator), (2) seeking hope and avoiding fear (as an anticipation of an outcome) and (3) seeking social acceptance and avoiding rejection (i.e. the need for relatedness; see also the Self-determination theory).

2. Is the behavior too difficult to perform?

   To enhance the user's ability, designers can make use of design simplicity. **Fogg (2009)** defines simplicity as "a function of a person's scarcest resource at the moment a behavior is triggered" and explains further that "in general, persuasive design succeeds faster when we focus on making the behavior simpler instead of trying to pile on motivation. Because people often resist attempts at motivation, but we humans naturally love simplicity." To increase simplicity in designs, Fogg distinguishes between 6 core abilities of end users: time, money, physical effort, cognitive effort ("brain cycles"), whether it easily fits current routines of behavior, and social deviance. Having these well in place will enhance simplicity. In addition, people are generally resistant to teaching and training because it requires effort. Minimizing this effort can be helpful and make behavior change be perceived simpler as well.

3. Is the intervention not triggering the behavior appropriately?

   To provide effective triggers (e.g. prompts, cues, calls to action, etc. something that tells people to perform a behavior now), different approaches can be taken, depending on the motivation and ability of the user.

   1. Spark as a trigger: when a person lacks motivation to perform a target behavior, a trigger can be designed in tandem with a motivational element. Examples of sparks can range from text that highlights fear to videos that inspire hope.
   2. Facilitator as a trigger: appropriate for users that have high motivation but lack ability. The goal of a facilitator is to trigger the behavior while also making the behavior easier to do. For example, software updates often use facilitators to gain compliance by implying that one click can get the job done.
   3. Signal as trigger: works best when people have both the ability and the motivation to perform the target behavior, it just serves as a reminder. A simple example of a signal is a traffic light that turns red or green.

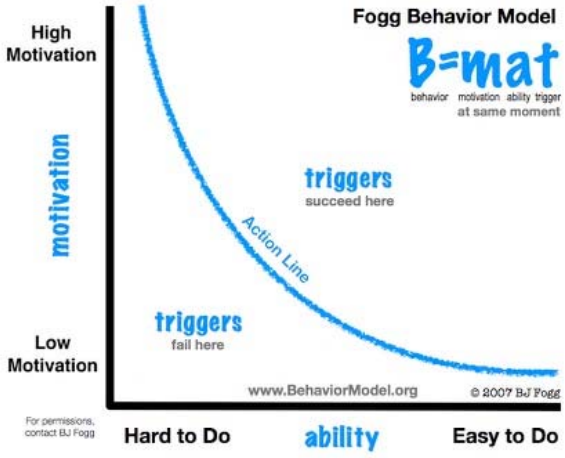



**Figure 5 The Fogg Behavior Model. Retrieved June 21, 2017, from http://www.behaviormodel.org.**

**Fogg (2009)** challenged himself whether persuasive technologies might be, in general, ineffective for the decrease or cessation of behaviors, mentioning one of the limitations of his model. Most examples of the FBM have been tested with software and social networks such as Facebook. Furthermore, the time component, to which extent the model applies to short, mid and long-term behavior changes that are required are not well described by Fogg.

### *2.5.3 The Hook model*

Because habit formation is one of the ultimate goals of designing for behavior change, we have included the Hook Model (**Eyal, 2014**) as an example of a theory on habit formation (see e.g. **Duhigg, 2014; Wood, 2014** for other habit theories). Habits are formed by consistently and repeatedly performing the same behavior in response to the same trigger, although the frequency can be variable (e.g. the frequency of checking Facebook daily and trimming the garden yearly obviously differ, although both behaviors can be considered habits). The Hook Model describes the design of an experience that connect the user's problem to a solution frequently enough to form a habit. It is partially inspired by Fogg's Model of Behavior, reinterpreting parts of it, while introducing investment and variable reward.

According to Eyal, a "hook" has four parts: trigger, action, reward and investment (see Figure 6). Each pass through the hook helps shape users' preferences and attitudes and with enough frequency, a habit is formed. How frequent means "enough" is not defined in detail.


**Figure 6 Hook Model. Retrieved June 21, 2017, from https://genius.com/Nir-eyal-hooked-how-to-build-habit-forming-products-annotated**

### *Triggers*

Triggers come in two types: external and internal. External triggers are a call to action from the environment of the user (e.g. billboards, tweets, messages, reminders, a link on a web site, or the app icon on a phone). For external triggers, the information on what the user should do next is within the trigger itself and often the desired behavior is made explicitly clear (see Figure 7 for an example). **Eyal (2014)** distinguishes between four different types of external triggers; paid triggers (e.g. advertising, marketing); earned triggers (e.g. high company/product ratings); relationship triggers (e.g. word of mouth; Facebook shares); and owned triggers (e.g. a newsletter the user signed up for). The first three types of external triggers can stimulate new user acquisition, while the latter can be a driver of long-term user engagement.

Internal triggers are created when the product becomes directly associated with a specific thought, feeling, emotion or preexisting routine of the user. For example, feeling lonely or having the need to socially belong, can automatically trigger the tendency to open Facebook or WhatsApp, to satisfy this need and relieve the discomforting feeling. Especially negative emotions (e.g. boredom, loneliness, frustration), stemming from general human needs, are powerful internal triggers. In this type of trigger, the information on what the user should do next is formed through an association in the user's memory. Soon users are internally triggered every time they feel a certain way to use the same product, which is the ultimate goal for most companies. The internal trigger becomes part of the person's routine behavior and the habit is formed. So, to form habits over time, the user will always be alerted to a new product by an external trigger. Then, once he has gone through several hooks, external triggers may switch to internal ones, related to internal associations the user has made with the product/solution (see also Figure 7).

### *Variable rewards*

Variable rewards fulfill the user's needs of the "tribe", the "hunt", and the "self". Email, for example, is addictive because it provides all three reward types at random intervals. First, we feel we have a social obligation to answer our emails (the tribe). We are also conditioned

to know that an email may tell us information about a potential business opportunity (the hunt). And finally, our email seems to call for us to complete the task of removing the unopened item notification in a sort of challenge to gain control over it (the self).

### *Investment*

This phase has two main goals. The first is to increase the likelihood that the user will make another pass through the Hook when presented with the next trigger. Second, once the user is anticipating reward from the previous phase, it is time for asking for investment, which implies an action that improves the system, product or service for the next cycle of the user. Inviting friends to Facebook, uploading new pictures to Instagram, stating preferences, or learning to use new features are all investments that improve the experience for the user longer term. These can be leveraged to make the trigger more engaging, the action easier, and the reward more exciting with every pass through the Hook. This is also the last stage before users will start automatically associating their feelings with the product.

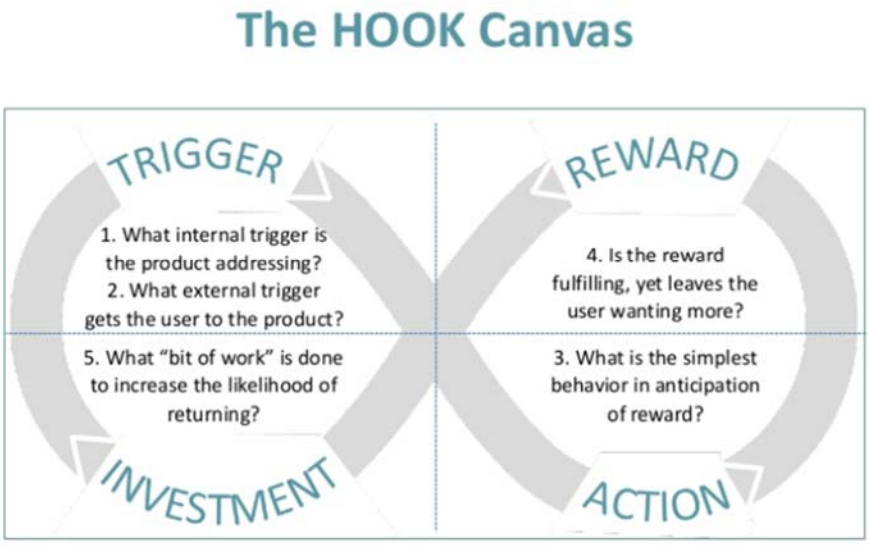



**Figure 7 The Hook model with questions for the different steps. Retrieved June 21, 2017, from https://dailybitsof.com/courses/hooked/posts/the-hook-model-a-summary**

A limitation of the Hook model is its focus on techniques to build technology for frequent use or habitual (app) usage (**Kosner, 2014**), rather than for technology that supports broader behavior change or habit formation.

#### *2.5.4 Cialdini's six principles of persuasive design*

Plentifully used in marketing and advertisement, **Cialdini**'s six principles of persuasive design (**1984**) can also be applied to designing for behavior change, as they focus on mental 'short cuts' that everybody uses in deciding for their own behavior.

### *Reciprocation*

The first of Cialdini's principles outlines reciprocity, or the rule that we should try to return a favor that was provided by somebody else. When a request is made by someone the receiver feels in debt to, the latter is more inclined to respond positively to the request. Interestingly, also uninvited favors (that were never asked for) trigger the reciprocation rule.

In addition, small initial favors often stimulate larger return favors. For example, being offered a food sample in the supermarket often results in feeling obliged to buy the product.

### *Commitment and consistency*

People have a need to be seen as consistent, or in other words, to do as they said they would. Being consistent is associated with mental stability and high levels of intelligence. Being *in*consistent in terms of feelings or deeds creates an uncomfortable feeling of cognitive dissonance. Therefore, if a persuasive request aligns with previous behavior, people are more inclined to comply.

### *Social proof*

Also seen in other theories and a factor that should never be underestimated while designing a solution: People do as other people do. Canned laughter causes an audience to laugh longer. This means that people are more inclined to comply to a request, when they know that others have done so as well. A product's star ratings and Facebook likes are examples of social proof.

### *Liking*

People prefer to say 'yes' to people they like. How attractive someone is directly taps into whether we like him or not (the halo effect: one positive characteristic of a person transfers to other characteristics as well). Providing a background story on your company/product, such as the company in Figure 8 does, can help in increase liking (and thus sales). Also, the 'invite friends and receive a discount' strategies of companies such as Uber are based on the liking rule (Figure 9).


**Figure 8 Liking illustrated by company O My Bag. Retrieved June 21, 2017 from https://www.omybag.nl**

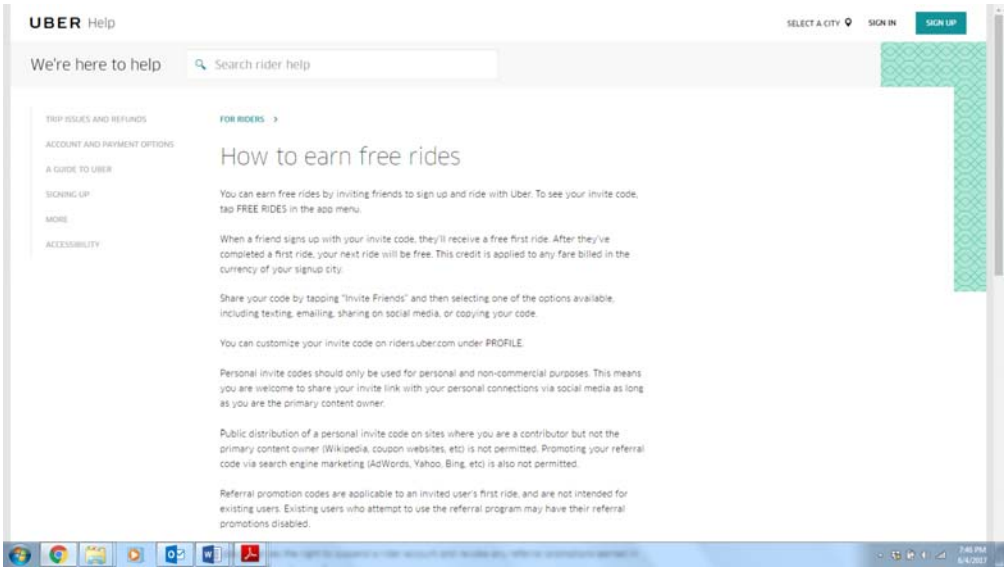



**Figure 9 'Invite friends and receive a discount' strategies of Uber. Retrieved 21. June 2017 from http://uber.com**

### *Authority*

If the person who is trying to persuade you into buying a new type of tooth brush wears a white dentist coat (i.e. is mimicking a legitimate authority figure), you will be more inclined to find this information credible and follow through on the purchase.

### *Scarcity*

People tend to impose more value on scarce products, compared to products that exist in abundance, and are more likely to buy them. The 'there are only X rooms left' statements on booking sites are a great example of the application of scarcity.
A limiting factor when taking these six principles into account, is that individual differences in attitude, personality or mood have an impact on what the most effective principle is to increase compliance to a persuasive request (**Kaptein, 2009**).

## 2.6 Summary of the behavior change models

In the psychological theories (Trans-Theoretical Model, Theory of planned behavior, Implementation intentions, Dual (or trial) process models, Self-determination theory), changing behavior is seen as something that can happen throughout different stages, that becomes more efficient when the individual takes situational context factors into account and that behavior is driven by the core psychological needs of autonomy, competence and relatedness.
In order to create holistic frameworks, the models mentioned in Chapter 2 (Behavior change wheel and COMputerized Behavior Intervention) are resulting from an analysis of 19 (BCW) and six (COMBI model) existing ones. With this approach, the BCW made a clear distinction between the source of behavior, the intervention functions and the policy category. It describes the elements that make behavior change possible, being capability, opportunity and motivation. In addition, nine intervention functions are listed. The COMBI model provides a differentiation between internal and external determinants of behavior.
The designs models (Regulatory Focus Theory, Fogg's Behavior Model, the Hook Model and Cialdini's six principles of persuasive design) provide designers ways how to profile their

users, how to dissect an interaction and to best analyze the situation at stake to design elements that can help change it and give some advice on how to form habits.

# 3 Behavior Change Strategies (Philips)

In this section, we will focus on practical behavior change strategies that have been derived from the theories mentioned above. The aim of these strategies is to bridge the gap between psychological/psychosocial behavior change models (see previous chapter) and their application to design. How these strategies have been applied to the REACH touchpoints will be subsequently described in Chapter 4. To provide relevant examples for each of the strategies, we will be referring to work done in the industrial and academic settings of the partners contributing to this report, leverage examples from another EU project on behavior change, and focus on (design) literature such as the Design with Intent toolkit by Dan **Lockton (2010)**. Many examples listed will stem from the digital domain, often in the format of mobile applications. The strategies that we are providing below come with a word of caution: they all focus on different (but interrelated) parts of designing for behavior change, while behavior change solutions tend to work best when taking several angles into account, not concentrating on one alone.

## 3.1 End user - Know the person who will be using your product

Knowledge of the target users should be the starting point of developing any product, not only those targeted at behavior change. We feel it is worthwhile to mention here as well, because it will make the application of the other behavior change strategies outlined below much easier. We recommend doing user research to find out as much as possible about your targeted user. Highly effective approaches to learn more about your target user are field visits such as contextual inquiries (i.e. observing the user's normal activities in their own context and interviewing them about these activities), diary studies (i.e. have users fill out a diary on the targeted behavior during several days or weeks), focus groups (i.e. interviewing a group of people and triggering discussions with them) and individual interviews (e.g. **Goodman, Kuniavsky, & Moed, 2012**). To communicate the findings and to aid the product development process, the gathered data could be represented by personas (i.e. fictive representations of your target users, see Figure 10), scenarios (i.e. stories that describe how a user behaves or thinks), or customer journeys or experience flows (i.e. mapping the user's experience during all potential interactions with your product; Figure 11; see also **Kalbach, 2016**). These, in turn, could lead to user requirements that are key to your (future) product or solution. Unfortunately, it is beyond the scope of this paper to detail out all approaches towards doing user research, please refer to the literature mentioned.


**Figure 10 An exemplary Persona. Retrieved June 21, 2017 from https://fakecrow.com/free-persona-template/**


**Figure 11 Experience Flow creation by multidisciplinary team. Retrieved June 21, 2017 from http://www.usa.philips.com/healthcare/consulting/strategic-design**

## 3.2 Personalization - Personalize and allow for customization as much as possible

Personalization is done by the system that is being used (see e.g. **Schade, 2016**), while in contrast, customization is carried out by the user. A solution can be personalized to a user's preferences, abilities (physical, education level), context factors and many other aspects. It can be done by adjusting tone of voice, wording, visual elements like shape and colors, style and material. By personalizing a product, a feeling of familiarity and similarity can be created (see the Coca Cola example below), which in turn results in a positive attitude towards the product and eventually using the product more often (see also **Andrews, Van Leeuwen, & Van Baarsen, 2013**). Customizing a product towards a user's preferences and constraints (see the Hue app and Real Plan examples) should in itself enhance the user experience. In

addition, allowing the user to customize the product generates a sense of autonomy in the user, creating the feeling that he can control the product, which should improve user experience as well.

### *Examples*

Coca Cola had a campaign where they put first names on their bottles, so that individual customers could identify themselves better with the brand. People have an automatic (positive) response to their own name and names of the people they know and like, which increases liking of the product.


**Figure 12 Coca Cola and first names on bottles. Retrieved June 21, 2017 from http://www.websalespromotion.com/social-media/4-social-media-marketing-strategies-to-increase-engagement/**

An example of customization is the Philips Hue mobile app that is connected to the Hue lamps. Through the app the user can adjust his lighting environment at home according to his preferences, for example decreasing brightness during evening hours, using white ambiance light for reading, or connecting the lamps with a game the user is playing.

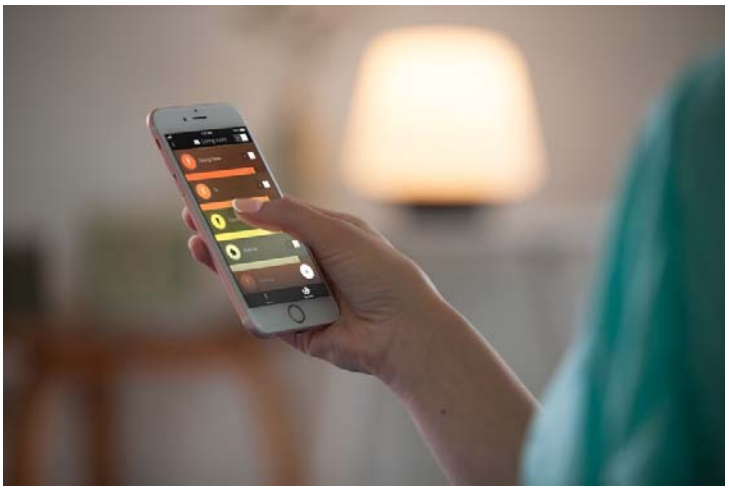


**Figure 13 Hue app, user adjusting the personal environment to own preferences. Retrieved June 21, 2017 from https://techcrunch.com/2016/04/28/philips-launches-new-hue-app-with-much-improved-design/**

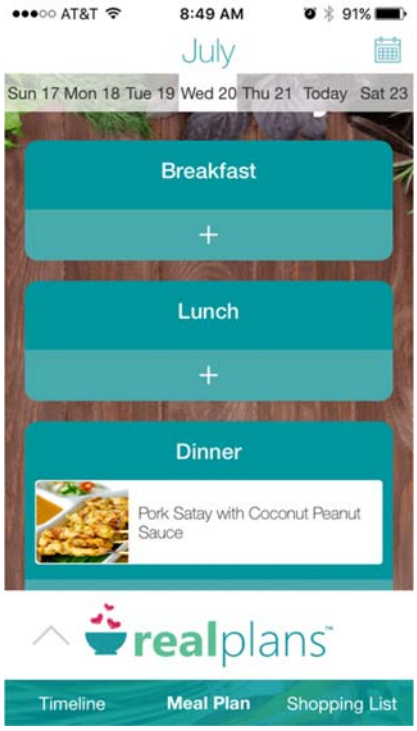



**Figure 14 Real plans app, allowing the user to create a custom plan suiting one's family's size, available cooking and prepping time, and dietary restraints. Retrieved June 21, 2017 from https://realplans.com**

## 3.3 Triggers - Make use of different triggers at the appropriate times

Triggers or cues are mentioned in several of the theoretical frameworks for behavior change (see for example the Hook model, B.J. Fogg's model, Behavior change Wheel) and can "nudge" users into the direction of the target behavior (**Thaler, Sunstein, 2008**). Triggers can be internal, for example emotional, or external, environment based. To include triggers during a customer's behavior, change journey, it helps to do some customer journey mapping beforehand (see e.g. **Kalbach, 2016**). Especially if the ultimate goal is to have people use the product following an internal trigger (e.g. a negative emotion), knowing which initial feelings or emotions could lead to usage of your product, and when, can help in creating the correct external triggers. What could be users' internal triggers regarding your product? (I.e. what discomfort do they want to solve?) **Eyal (2014)** recommends creating a narrative of how users use the product, their associated emotional status and the context in which it's used. He states that one often finds that people's declared preferences – what they say they want – are far different from their revealed preferences – what they actually do. A method of diving deeper into user's internal triggers he suggests using therefore is asking 'why?' five times (see Figure 15 for an example).

1. **"Why did the robot stop?"**
   The circuit has overloaded, causing a fuse to blow.
2. **"Why is the circuit overloaded?"**
   There was insufficient lubrication on the bearings, so they locked up.
3. **"Why was there insufficient lubrication on the bearings?"**
   The oil pump on the robot is not circulating sufficient oil.
4. **"Why is the pump not circulating sufficient oil?"**
   The pump intake is clogged with metal shavings.
5. **"Why is the intake clogged with metal shavings?"**
   Because there is no filter on the pump.

**Figure 15 Five why's example by Toyota's Ohno Taiichi from the 1950's, getting to the root causes of a problem. Retrieved June 21, 2017 from https://open.buffer.com/5-whys-process/**

When users are not familiar with a product (yet), external triggers or cues are first needed to get their attention and prompt them into action. These could range from adds (paid trigger; Figure 17), to good reviews (earned trigger; Figure 18), or a Facebook share (relationship trigger). Triggers can be non-digital, too (Figure 19). Again, knowledge about the target user will help in identifying the correct initial external triggers. Which websites, blogs or social media will they visit regularly? Which magazines or newspapers do they read? What and when do they watch TV? Which shops do they visit?
When users are already using the product, a different type of external trigger may be warranted to prompt them to maintain their usage. This could be, for example, a reminder on their mobile phone (Figure 20). The coach.me app (formerly called Lift), for example, sends daily reminders for the goals the user has set for himself on moments the user has selected. Tapping it takes the user into the coach.me app, where the met targets are shown (weekly stats – see also Chapter 3.5 on providing feedback) and how many people are participating (which is an example of social proof, see section 2.5.4).

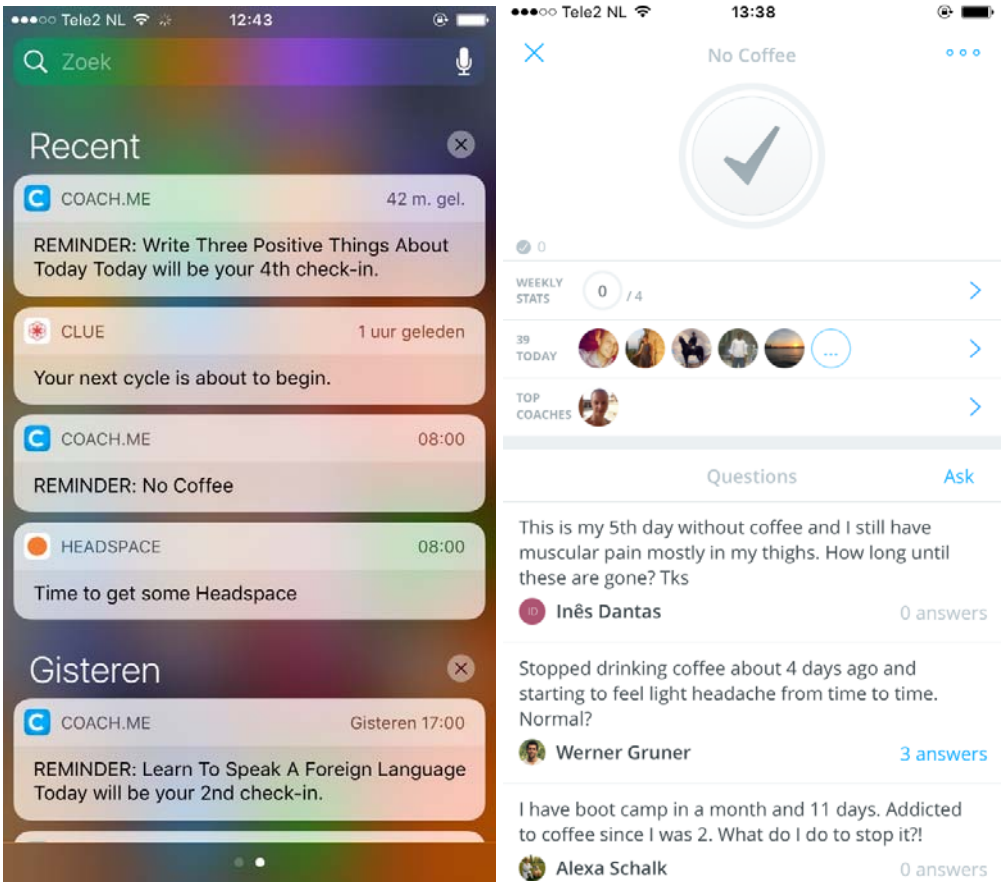



**Figure 16 Reminders for behavior change from various apps, screenshot from personal mobile phone.**

### *Other examples*

It is worth mentioning that cues or triggers do not have to be digital. It can also be the note on the fridge to buy fruit, or the fly in the men's urinals to help them aim and decrease spillage (Figure 19). The order in food display in cafeterias can already change pattern of consumption by 25%: putting fruit at eye level increases the likelihood people will buy and eat it (**Thaler & Sunstein, 2008**).

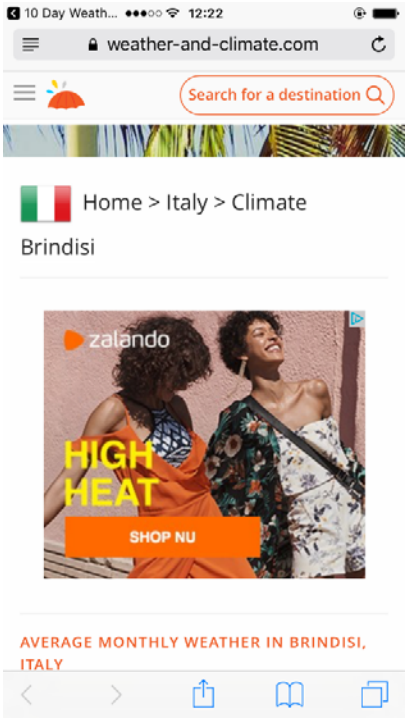



**Figure 17 Paid add by Zalando in a weather website. Retrieved from June 21, 2017 weather-and-climate.com**


**Figure 18 Reviews on Amazon, illustrating an external trigger to buy. Retrieved from amazon.com**

**Figure 19 A fly on men's room urinals, illustrating a non-digital trigger to avoid spillage. Retrieved June 21, 2017 from *https://worksthatwork.com/1/urinal-fly***

## 3.4 Goal Setting - Facilitate setting quantifiable, realistic goals

Allowing the user to set quantifiable goals helps the reflective mind (the Rider) to organize (see Chapter 2.3.4). The motivational strategy of goal-setting is also part of the preparation

stage in the Trans-Theoretical Model and should facilitate users transferring into the action stage (Chapter 2.3.1). Research has shown that when a person sets goals himself, he is more inclined to achieve those goals (**Siegert, 2014**). If possible, it is advised to also help the user to set realistic goals, together with an explanation of *why* this is a realistic goal. In addition, it can help to provide an advised goal to the user, for example based on normative behavior for that particular behavior, so that he can use it as an anchor (e.g., for persons with a similar height and gender have the following weight loss trajectory is advised). Goal-directed behavior both involves education as well as training (see the REACH **D2** report for more information).

### *Examples*

The Runkeeper app urges its users into setting specific goals with their 'Goal Coach'. People answer several questions related to the goal they selected (e.g. Get fit) and Goal Coach puts suggested end goals together based on these (see Figure 20). This helps the user to break down his end goal into smaller goals or targets and should facilitate him to start doing the desired behavior, to eventually reach his final goal.
The CBT-i Coach app was designed to provide cognitive behavioral therapy to people with insomnia. The app will guide users through the process of learning about sleep, developing positive sleep routines, and improving their sleep, by setting helping them to set smaller behavioral goals, such as caffeine reduction or providing ways to relax and wind down (Figure 21).

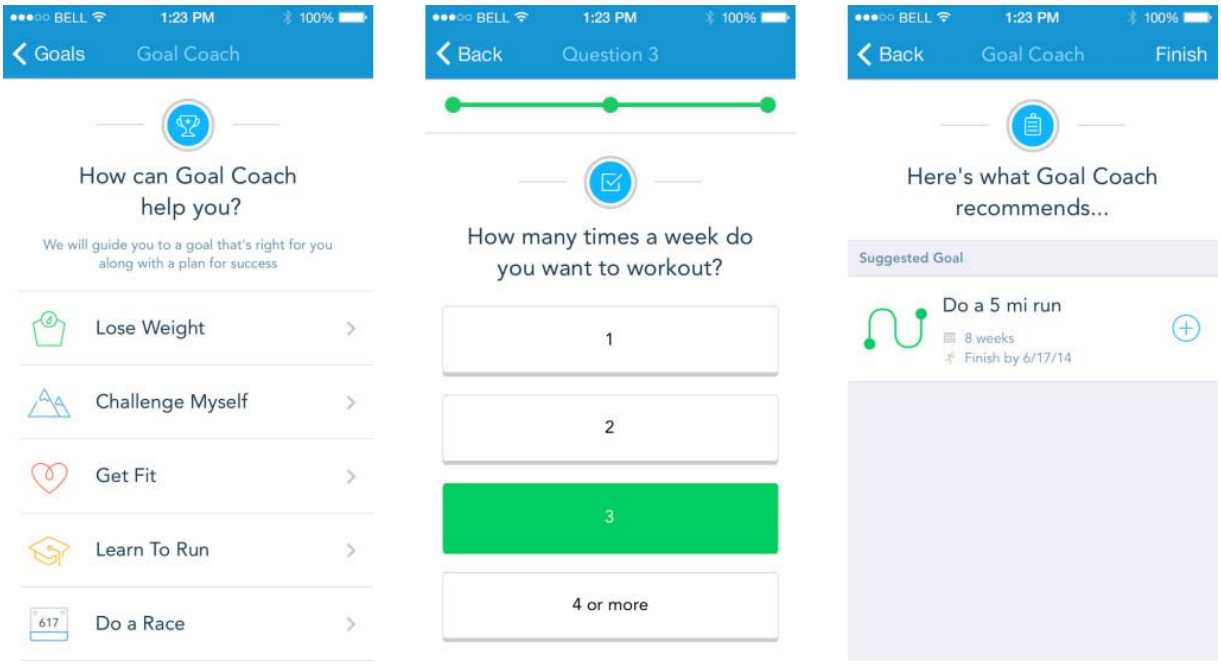



**Figure 20 GoalCoach app, illustrating goal setting for physical activity. Retrieved June 21, 2017 from https://blog.runkeeper.com/1638/weve-got-a-big-runkeeper-update-on-ios-introducing-the-all-new-goal-coach/**

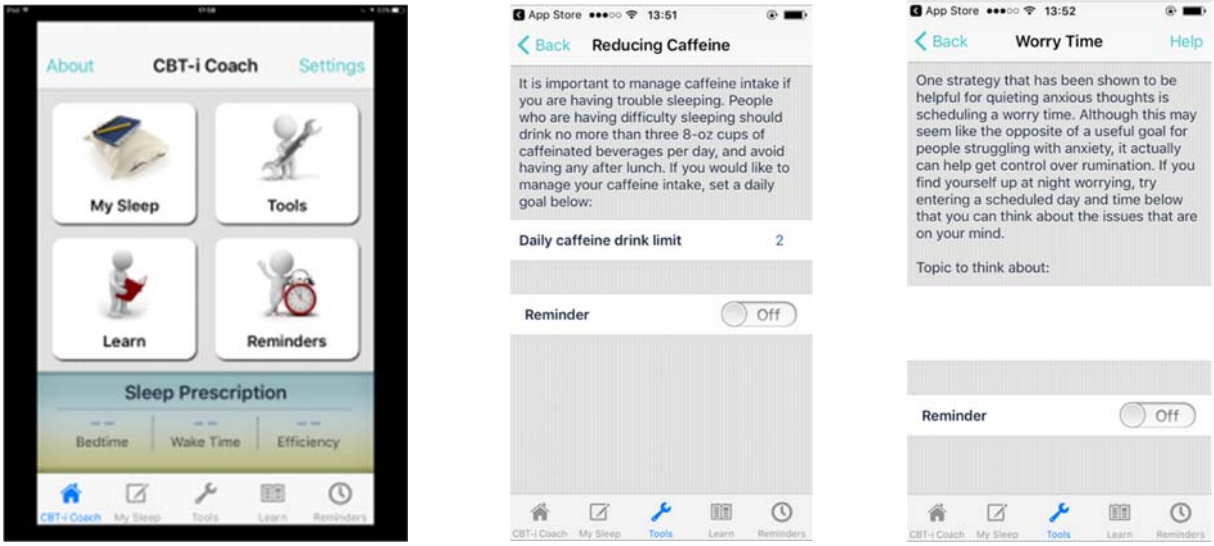



**Figure 21 CBT-i app, illustrating goal setting. Retrieved June 21, 2017 from https://play.google.com/store/apps/details?id=com.t2.cbti**

## 3.5 Feedback - Provide performance feedback (based) on your user's behavior

Often, products focusing on health-promoting solutions will provide performance feedback to their users about their behavior. Providing feedback provides users the opportunity to understand how they are doing in terms of weight loss, physical activity or what the attained behavior may be. **Fogg (2003)** introduced feedback into his model, as this allows people to obtain insight into their own behavior and to increase their involvement and motivation to change this behavior. In addition, it provides users with a baseline to start their behavior change process from. Feedback can be considered most meaningful if it relates to a previously identified goal. **Marcus (2015)** states that "goal setting is necessary to give meaning to feedback and to optimize its effectiveness". Simply stated, if the initial goal to sleep better does not exist, then providing feedback on sleeping behavior becomes meaningless. Feedback can range from simply monitoring behavior and reporting what has been monitored (e.g., a pedometer reporting on steps) up to actionable feedback on how to improve certain behaviors (e.g., coaching the user to start a particular exercise). Ideally, the feedback is followed up by actionable advice, so that the user is guided to options on what to do with the feedback (see the example of the Lark app).
In the growing field of Persuasive Technology, for feedback (**Lockton, 2010**), there are some of the most common design elements of interfaces where users' interactions with the system affect how their behavior is influenced. These include feedback through form; partial completion; peer feedback; progress bar and real-time feedback. When using feedback through form, the form of the object itself is used to provide feedback or suggestive cues (Figure 24; e.g. Royal VKB's balancing bowls tilt when they have been filled with a particular portion). For partial completion feedback, users are shown that the first stage of a process has been completed already, to give them confidence to do the next. For peer feedback, users' feedback on their behavior is provided by other users of the system, equal in status to themselves. Progress bars let users know their progress towards achieving a goal. The preferred approach is to let systems provide feedback to their users real-time.

### *Examples*

A review by **Darby (2006)** found that showing consumers feedback about their household's energy consumption reduced the use of energy with 5-10%. It makes the abstract concept of energy more visible and allowed users to better understand and control their energy consumption. Two examples of applying this knowledge are Greenchoice (a Dutch energy provider) and the Green Machine (**Marcus, 2015**).


**Figure 22 A user's energy use per month, compared to the average energy use of a similar household (the curved line). Retrieved June 21 2017 from https://www.greenchoice.nl/app/**

Lark, a coaching app, provides actionable feedback in terms of behavioral activity, in combination with showing the actual physical activity recorded. In case the user has not been active enough, he is provided with an actionable suggestion that would increase physical activity (e.g., taking a quick lap around the building). Lark gives an additional reason to take this quick lap (get some fresh air), which may add to the motivation of the user to actually execute the behavior.

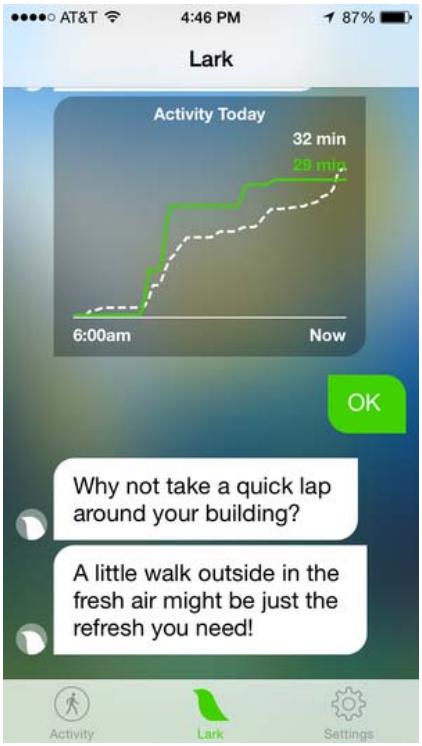



**Figure 23 Lark app, illustrating actionable feedback based on user data. Retrieved June 21, 2017 from https://itunes.apple.com/gb/app/lark-personal-health-weight-loss-coach/id912530754?mt=8**


**Figure 24 Example for feedback through form. Royal VKB's 100g/250g Balancing Bowls are weighted so they tilt noticeably and audibly when the 'portion size' is reached when filling. Adapted from Lockton, 2011.**

## 3.6 Implementation intentions - Help your user to formulate 'if… then' plans

Helping users to recognize critical cues regarding their desired behavior (e.g. a good opportunity, a specific time, an anticipated barrier, a difficult situation) is the first step towards defining very specific 'If-then plans' (implementation intentions; **Gollwitzer, 1993**). 'If-then' plans can come in various formats; suppression oriented, specifying a replacement behavior or ignoring the critical cue (with the two latter ones being the ones most successful). 'If-then' plans make potential behavior change cues more concrete and automate the response with the desired behavior, promoting goal attainment.

### *Examples*

If my colleague approaches me offering a snack, then…
… I will not take the snack (suppression oriented)
… I will eat an apple instead (specifying a replacement behavior)
… I will ignore his offer (ignoring the critical cue).

## 3.7 Tiny habits - Help your user to set up a tiny habit

A variation on the 'if… then' plans can be found in Fogg's tiny habits approach. Fogg states that there are two ways to achieve long-term, systematic changes in behavior: changing the environment, which is generally difficult, and doing plenty of very tiny behavior changes. Those tiny behaviors (e.g., walking up and down the street; cleaning up one item from the living room) should follow an already existing behavior to anchor the new behavior to. The tiny habit format that follows is: 'After I <existing behavior>, I will <new tiny behavior>. For example: after I <watch the evening news at 8 pm>, I will <do one yoga pose>. Including a small reward (e.g. telling yourself you're awesome) also helps in keeping it up. Interestingly, according to Fogg, motivation and willpower do not play a significant role in long-term behavior change. While the 'if… then' plans focus more on identifying difficult situations and barriers to change behavior, tiny habits use existing behaviors to connect the new behavior to.

### *Examples*

The tiny habits app, developed by the same B.J. Fogg, allows the user to do exactly this: define a new tiny habit and practice it (Figure 25).


**Figure 25 Tiny Habits app, illustrating setting up tiny habits. Retrieved June 21 from https://itunes.apple.com/gb/app/tiny-habits-by-dr-bj-fogg/id817653907?mt=8**

## 3.8 Variable rewards - Provide your user small, variable rewards for their efforts

Rewards play a large role in several of the above-mentioned theoretical frameworks (e.g. the Hook model). The basic idea is that users should not get a negative association with your product in any way, and therefore, you may not want to leave his efforts going unrewarded. It's best to keep your rewards variable, always leaving room for wanting more

(which is one of the reasons why gambling is so addictive). Different types of rewards have been identified: rewards of the 'tribe' (e.g., gratification from others, empathetic joy, competition, partnership, recognition, cooperation); rewards of the 'hunt' (e.g., things, money or information), and rewards of the self (e.g., mastery, completion, competency, consistency).

### *Examples*

Rewards come in different shapes and sizes. The *swoosh* sound after sending an email via Outlook on an iOS device can be considered a reward for the user, applying to a reward of the 'self' (i.e. completion). Similarly, the *done* sound of the Wunderlist mobile application each time the user checks a task to done (Figure 26) results in a pleasurable feeling (rewards of the self), as well as each received 'like' on a Facebook post (reward of the tribe).

Another example of a product that uses variable rewards consistently is DuoLingo, a mobile application that helps users to learn a new language (see Figure 27). After each successful small exercise the user hears a bright, check-mark-like sound and receives a visual notification that he is correct (which applies directly to the reward of the 'self'; mastery/completion). After a full lesson, the user receives another 'victory' sound, a visual notification ('Lesson complete'). After learning a new skill yet another reward screen is shown, together with another victory-like sound, as well as the earning of new 'gems'. The gems allow the user to gain more benefits (e.g. pausing the streak to remain in place for 1 day of inactivity). In addition, the user can get his additional rewards by choosing from 3 treasure boxes (Figure 28) with variable results.

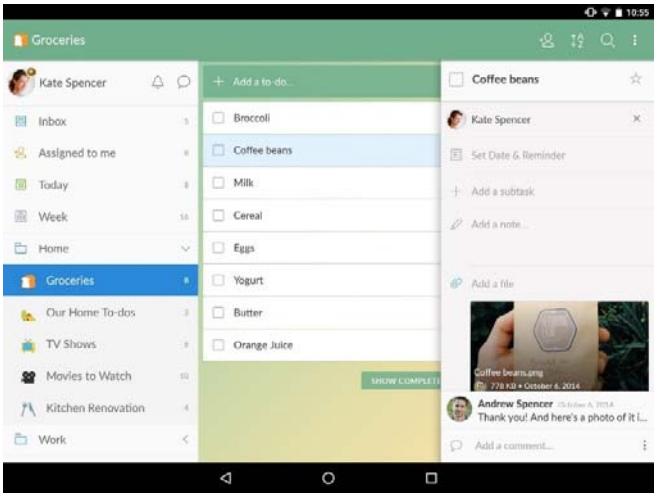



**Figure 26 The Wunderlist app allows its users to check tasks to done, providing a 'check' sound with it. Retrieved June 29 from https://play.google.com/store/apps/**

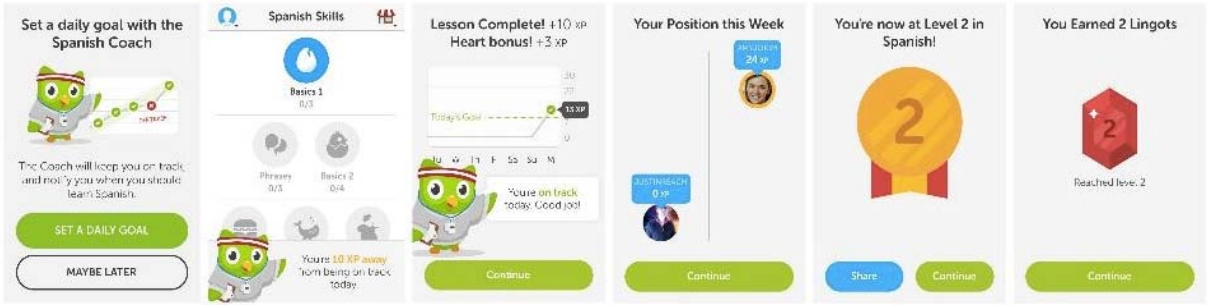



**Figure 27 Duo Lingo app, illustrating small variable rewards (and gamification). Retrieved June 21, 2017 from https://www.duolingo.com**

It can be valuable to apply the Hook model to your product, as this is the model in which rewards are detailed out mostly. Can you identify the kind of reward(s) a user receives (if any)? Is this reward always the same or is it variable? Is the reward fulfilling, yet does it leave the user wanting more? Brainstorming can help to identify more ways users could receive variable rewards.

## 3.9 Gamification - Apply gamification to enhance user engagement

Gamification, or applying game-like technology in a non-gaming context (**Huotari & Hamari, 2012; Deterding et al., 2011**) to reinforce positive behavior can be fun. The idea is that a game stimulates people to achieve a particular behavior (change), for example to enhance their physical activity levels. Although rewards are an important element of games and gamified products, just adding rewards does not gamify a product. Instead, gamification has been shown to be a combination of persuasion, education and incentivisation (see the REACH **D2** report). The game-elements should also apply to the needs or internal motivation of the user. **Bartle (1996)** distinguished between 4 different player types that relate to these needs: achievers (want to collect points and complete levels; the self-need), explorers (want to explore and find secrets; the hunt need), socializers (want to get to know other people; the tribe need), killers (want to win and increase their self-esteem; the self-need).

### *Examples*

The Duo Lingo app again applies game-like elements to learning a new language (see section 3.8 on rewards).

Also, the mobile application Lark is a great example for a playful engaging Behavior change solution, based on a chat bot interaction. It coaches the user around physical activity, sleep and diet. The way it is set up, using a dialogue-like interface (i.e. conversational UI) and fun tone of voice, is surprising and engaging to the user. Also, the app rewards the user for actions he has been taking just after they happened (Figure 27), and it challenges the user on competing with himself, by comparing past activity and average activity over a week with the most recent one. Lark engages the user in an ongoing conversation, guiding the user, but keeping him in control at the same time (need for autonomy).

Another example is Zombies, Run, a gamified app to increase running activity (Figure 28). The story behind the app is that players are trying to survive a zombie apocalypse. By carrying out different missions (i.e. actually running!) they can collect items and supplies that help them survive.

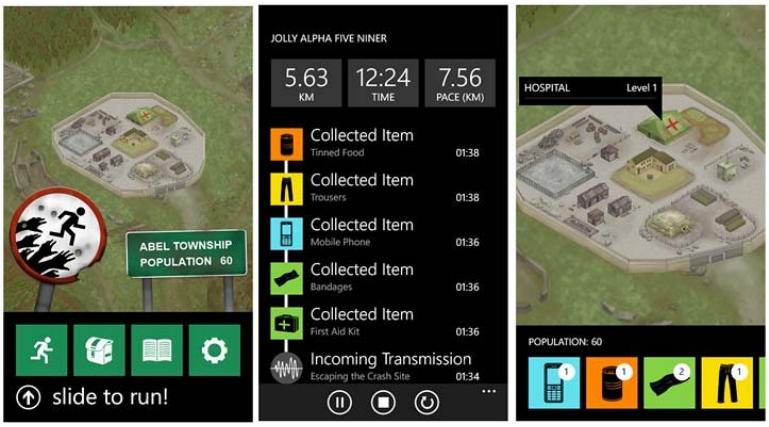



**Figure 28 Zombies Run app. Retrieved June 21 2017 from https://www.windowscentral.com/tag/zombies-run**

## 3.10 Education - Inform your user to enhance awareness and capability

Increasing a user's awareness of the necessity for behavior change can be done by educating them. Providing information about why a (primary) behavior change can be beneficial for the user could lead to increased user awareness. In the TTM, consciousness raising is the first step towards changing behavior (precontemplation stage).
Providing information not only enhances awareness, but also supports the development of knowledge and skills on how to practice a desired health behavior. In other words, informing the user can increase his psychological capability (Behavior change Wheel). This is an important precursor to behavior change because it also contributes to self-efficacy (i.e. the extent to which a user's trusts that he is able to reach a particular behavior change goal; COMBI model). In turn, self-efficacy facilitates the formation of intentions to be physically active (**Conroy et al., 2014**).

According to **Rothman and Salovey (1997)** there are two ways for delivering an educational message.

1. Loss frame: Approaching from the negative side (e.g. examining skin for cancer), informing about the potential threats and negative consequences
2. Gain frame: Delivering message in terms of ways for preventing the current good state of health to deteriorate further (e.g. using a sun crème).

Overall emphasis on negative consequences does not seem to be a successful method; people stop listening to the messages if they contain several fear formulations (**Peters et al., 2014**). Hence, it is recommended to avoid an overload of fear inducing suggestions and messages in educational material.
It should be mentioned though that disruption, the introduction of an unexpected (often shocking) element can be applied to break someone's routine or stable mindset (also see **Andrews et al., 2013**). This causes people to be more open up to new information and increases awareness. The unexpected element disables the rational mind for a short instance (system 2; dual process theories), making it easier to change a user's perception to a situation. An example is an experiment the France government did with unaware pedestrians. If they ignored a red light to cross the street, they would hear the squeaking sound of a car hitting the brakes. Their picture was then shown on a large billboard (see Figure 29), with the text: 'Don't take the risk of looking death in the face. Follow the traffic lights when crossing the street.'


**Figure 29** ***Campaign to avoid street accidents of pedestrians. Retrieved June 21, 2017 from http://www.serviceplan.com/en/news-detailed/virtual-crash-billboard.html***

### *Other examples*

An example of an intervention aimed at early stages of change that evoked consciousness raising is the game 'Na-aapje' (literally translated as 'little-copy-monkey') that was developed by the Dutch Voedingscentrum (Centre for Food). Na-aapje is a children's game that is designed to raise awareness with children that fruit and vegetables are healthy diet choices. The monkey in the game has to collect fruits and vegetables and the child scores high by collecting many fruits and vegetables (**Niederrer et al., 2016**).


**Figure 30 Na-aapje', illustrating education (and gamification). Retrieved June 21, 2017 from http://www.voedingscentrum.nl/na-aapje (in Dutch).**

Governments (see Figure 31) and health organizations are promoting physical activity, for example by using information graphics and by running campaigns. These type of campaigns

are more successful if the information they contain is tailored to the audience in terms of complexity, tone of voice, level of being actionable. For instance, providing information to an elderly person with limited mobility about heavy physical activity can be frustrating and even become demotivating to move at least a little.

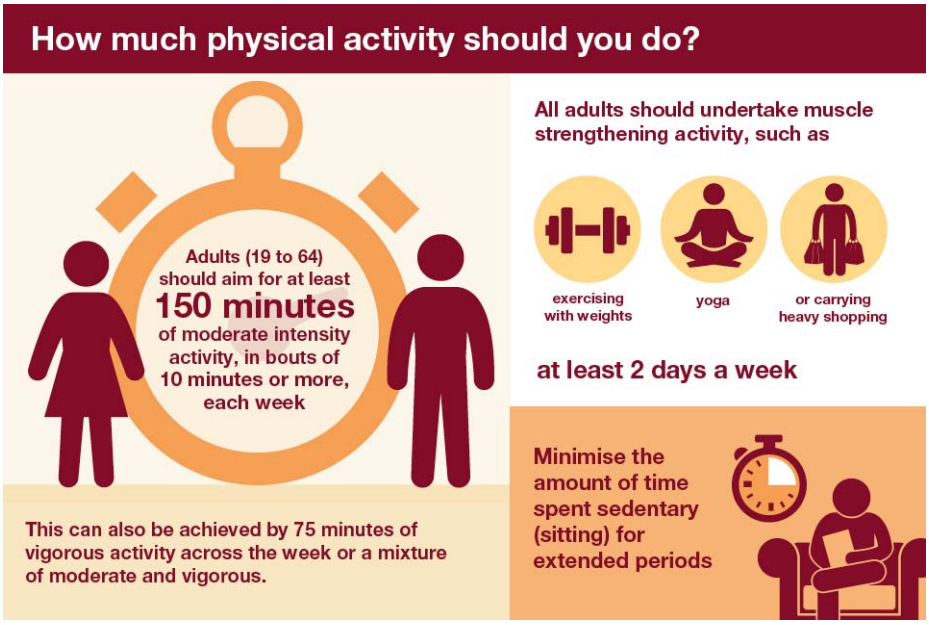



**Figure 31 Excerpt from guidance "Health matters: getting every adult active every day by UK government (Public Health England) to make the general public move more, illustrating education (and gamification). Retrieved June 21, 2017 from https://www.gov.uk/government/publications/health-matters-getting-every-adult-active-every-day/health-matters-getting-every-adult-active-every-day.**

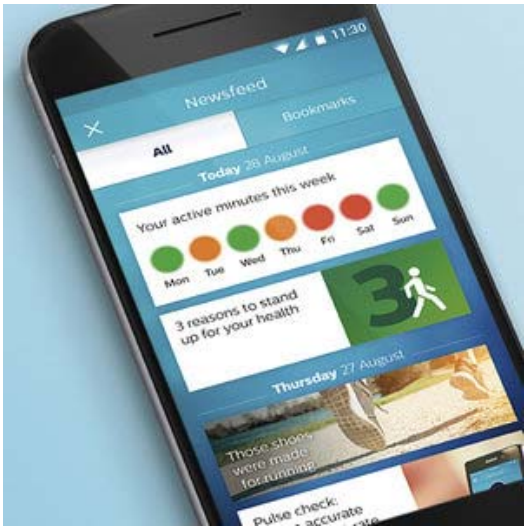



**Figure 32 Philips Health app, illustrating providing reasons to become physically active and triggers to learn more about what can be done to improve. Retrieved June 21, 2017 from http://www.philips.co.uk/c-m-hs/health-programs/healthsuite-health-app**

## 3.11 Connectedness - Make use of social influence and support

Social incentives come at different levels in trying to achieve behavior change. The most basic level is the social proof effect (see e.g., **Cialdini, 1984**; BJ **Fogg**'s Behavior Model, **2009**): people will do things that they see other people are doing. In addition, one of the core human needs and thus a strong motivator for behavior is the need for social acceptance (need of the tribe). Social support on exercise behavior in older adults has shown to strengthen self-efficacy and outcome expectations related to exercise (**Resnick et al., 2002**). In the TTM, "helping relationships" is one of the processes that support a user in the action stage. It is described as being open and trusting about problems with someone who cares. Also, social inclusion has been shown to be of benefit, which includes persuasion, incentivization (approval), coercion (disapproval) and modelling (observational learning) (see **D2** report).

### *Examples*

Social network platforms such as Facebook and Instagram are used mainly because of the need to be socially accepted. Each like or shared post reinforces this need for social acceptance and thus results in a short boost of rewarding feelings. More frequent use of a social media platform results in stronger connections with the associated feelings of reward, which makes users want to keep using the tool (see also the Hook model).
Social patient groups such as PatientsLikeMe allow users to connect with others who have the same disease. Patient companions can share their experiences and provide social support for decision making during treatment and for coping with living with a disease.
Pacer is a pedometer, blood pressure tracker, and a BMI and weight management tool all in one. It aims at helping users getting active, losing weight and lowering their blood pressure. One of the motivational tools included is to check out friends' steps and to create walking groups to compare daily steps in real-time, evoking social support for walking.
Runkeeper encourages its users to create running groups with friends with one of its features (called challenges; see Figure 33). In this way, social support from a group helps in achieving a pre-set running goal.

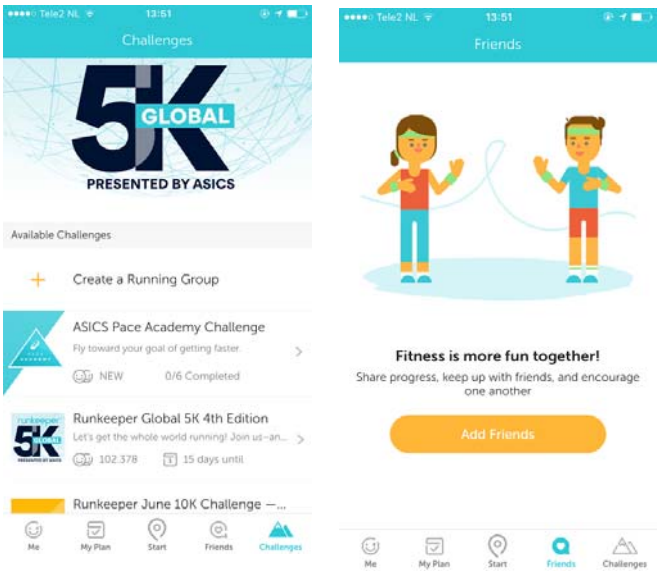



**Figure 33 RunKeeper app, illustrating social support. Retrieved June 21, 2017 from https://blog.runkeeper.com/1638/weve-got-a-big-runkeeper-update-on-ios-introducing-the-all-new-goal-coach/**

The Runkeeper app invites users to set up running groups with friends and to share progress with others; examples of the application of social support. Retrieved June 30 from Runkeepers app on personal mobile phone.

HealthyTogether (Figure 34) is a mobile social app that helps dyads to exercise and reach a common goal together. The user is able to set a common steps/stairs goal, see the number of steps and stairs of his partner, encourage or taunt him through the app and look at the dyad ranking in the community.

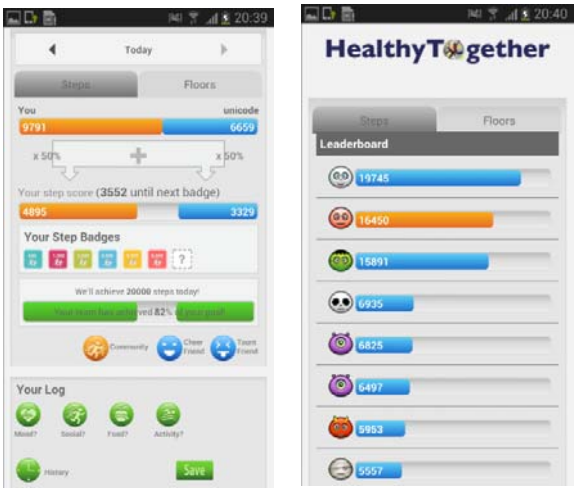



**Figure 34 HealthyTogether (Social Incentives in Pervasive Fitness Apps for Obese and Diabetic patients – In Proc of CSCW '16 Companion. 2016)**

## 3.12 Case examples of interventions using full models

### *3.12.1 Applying the Hook model to designing for behavior change*

The Hook Model can be applied in different ways. An example is the application of sticky habits that have four components working together: Trigger, Action, Variable Reward, and Investment. These components are present in both healthy and unhealthy habits. When using this model, one needs to first identify a Key Habit (the main desired habit) related to the Action.

For example, Lisa's (0) Key Habit is the aim to go running three times a week. She often feels restless during the day and wants to improve her fitness levels. During her lunch break, she is (1) Triggered to go by an external trigger (because her colleagues are also going for a run), and she does the (2) Action of running. She gets her (3) Variable Reward in the form of a feeling of accomplishment while running, variable amounts of endorphin release, and refreshing energy when she's done. Over time, she sees her (4) Investment of running several times per week pay off, because she is more fit, and less restless. Over time, Lisa learns that feeling restless can be rehabilitated by going for a run. She does not need external triggers anymore to start her run, feeling restless is enough to trigger her to start (scheduling) running.
Since habits already work this way, we can use the Hook framework to design products that become habit-forming themselves. In essence, the product needs to accommodate these four habit components, to make Lisa actually run habitually. Applied in an app, the model is illustrated here with a case example:

1 Trigger: Lisa would get an external trigger, such as a push notification or a reminder card to remind her to go running.
2 Action: Her run gets monitored with the sensors in her Health Watch and maybe also her smartphone.
3 Variable Reward: When she has finished the run, the app shows her sensor data about her run, providing her with interesting feedback. The app could also congratulate Lisa (variably), provide 'bonus points' or allow Lisa to share her results with friends (social incentive).
4 Investment: The app captures Lisa's investment by populating charts with her data and by filling up her Timeline, so she can get an intuitive sense of how she is progressing over time. More importantly, Lisa senses this investment outside of the app as she gets more energetic and less restless, which were the reasons to start using the app in the first place. This also loads her next trigger, and eventually she won't need reminders to run anymore.

### *3.12.2 Using the TTM in designing interventions for behavior change*

Inspired by the TTM, **Ludden and Hekkert (2014)** created a 'design for healthy behavior framework', which contains four different design strategies that can be divided over multiple stages in the TTM: 'raising awareness' (pre-contemplation and contemplation phase), 'enabling' (preparation and action phase), 'motivating' (action and maintenance phase) and 'fading out' (termination phase).


**Figure 35** ***Preliminary framework for stage-matched design interventions, inspired by the TTM. Reprinted from Hekkert & Ludden, 2014.***

**Ludden and Offringa (2015)** designed a sequence of products that aimed to help people to diminish their intake of sugar-containing beverages. These are described as three separate case examples in the paragraphs below.
For many people, their daily intake of sugar is too high, which has a negative effect on their general health and wellbeing. Limiting the intake of sugar-containing beverages can be a solution to this problem and was explored as a design case study to explore sequential interventions. It is of high importance not to simply stop at the trigger but to design a sequence of interventions that are connected. Following the 'design for healthy behaviour framework' three different products were designed for three different phases of behavioural change. The first product was designed to match the motivational state of people in early stages of behaviour change.
In early stages, users do not want to change their behavior yet and the threshold of getting engaged into the product use is very high. Users are not motivated to buy a product that supports behavioral change yet. Hence a publically available solution that raises general awareness can be of assistance: an example is a cooling sleeve that displays the amount of sugar contained in a bottle. In this phase, people should be supported to move from raised

awareness to actually acting on a desired behaviour change. Second, a free mobile application that helped people to keep track of the number of sugar-containing beverages that they consumed was created for the enabling phase. Thirdly, a water bottle containing an hourglass was developed that reminded people to drink enough water instead of sugar-containing beverages for the “maintenance” stage (see Figure 34).


**Figure 36 Three products designed for three different stages of change. Adapted from Niederer et al. (2014).**

**Table 2 Overview of connection between behavior change models, strategies, and applications/examples. Inspired by Prochaska & Velicer (1997) and Hekkert & Ludden (2014)**

| TTM Stage | Stage definition | Process (or strategy) | Process definition | Behavior change designs / applicable examples |
|---|---|---|---|---|
| **Pre-contemplation**<br><br>→ Design strategies aimed at raising awareness | Prior to start of design process/ pre-design stage (not stage of change) | **Know the person who will be using your product (REACH)** | Helpful materials before and alongside conceptualization design & product development. E.g. customer journey maps, personas, service blue prints etc. | Pre-requisite for good BC Design, no specific examples |
| | Individual is unaware of problem; No intention to change behaviour in foreseeable future | **Inform your user to enhance awareness and capability (REACH)** | Increasing information about self and problem | **Information campaigns, designs that uncover facts about a problem in positive ways or even through shock**, e.g. cooling sleeve that displays the amount of sugar contained in a bottle for diabetics |

| | | | | |
|---|---|---|---|---|
| | | | | (Ludden & Offringa, 2015) |
| | | **Dramatic relief (TTM)** | Experiencing and expressing feelings about one's problems and solutions | **Experience installations or virtual reality solutions** "Into D'mentia" in a truck for caregivers to experience their loved one's problems. Virtual reality glasses "Oculus Rift" for Anorexia patients. |
| | | **Environmental re-evaluation (TTM) / Provide performance feedback (based) on your user's behavior (REACH)** | Assessing how one's problem affects physical environment | **Energy meters** can allow house-holders with real time feedback to see which appliances use the most electricity, and how much this is costing. |
| **Contemplation**<br><br>→ Design strategies aimed at raising awareness | Individual is aware of problem; Serious consideration of change in behaviour | **Self-reevaluation (TTM) / Provide performance feedback (based) on your user's behavior (REACH)** | Assessing how one feels and thinks about oneself with respect to a problem | **Questionnaires, assessments & feedback on results** (e.g. in Optimism app findingoptimism.com), user would not search or fill them in if not being aware of a potential problem at first. |
| Preparation<br>→ Design strategies aimed at enabling and preparing | Individual is intending to take action and taking the necessary preparation steps | **Self-liberation (TTM)** | Choosing and commitment to act or belief in ability to change | **Monitoring and tracking**, e.g. free mobile application that helps people to keep track of the number of sugar-containing beverages that they consume (Ludden & Offringa, 2015) |
| | | **Help your user to formulate 'if…then' plans (REACH) / Help your user to set up a tiny habit (REACH)** | Helping the user to set implementation intentions | **The experiment by Milne et al. (2002) showed that implementation intentions help in becoming more active** |
| | | **Facilitate setting quantifiable, realistic goals (REACH)** | Setting a quantifiable goal that is also realistic increases motivation to act upon these goals | **The goal coach by the Runkeeper app** |
| Action<br>→ Design strategies aimed at enabling & at motivation | Individuals modify their behaviour, experiences and/or environment in order to overcome problem | **Counter-conditioning (TTM) / Help your user to formulate 'if…then' plans (REACH)** | Substituting alternatives for problem behaviors (can also be done by 'if then' plans) | Headspace, a meditation app that comes with **reminders and gives educational videos** on how and when to implement the short 10 min practices. |
| | | **Stimulus control (TTM) / Help your user to formulate 'if…then' plans (REACH)** | Avoiding or countering stimuli that elicit problem behaviours | Restructuring one's environment (e.g., removing alcohol or fattening foods), avoiding high risk cues, fading techniques |
| | | **Helping relationships (TTM) / Make use of social influence and support (REACH)** | Being open and trusting about problems with someone who cares | **Social support, self-help groups**, e.g. Patientslikeme |

| | | | | |
|---|---|---|---|---|
| | | **Reinforcement management (TTM) / Make use of social influence and support (REACH) / Provide your user small, variable rewards for their efforts (REACH)** | Rewarding oneself or being rewarded by others or the product/solution for making changes | **Social network apps** in which others can monitor and celebrate own progress with a user such as Instagram and Facebook, creating a 'running group' in Runkeeper (called a challenge), friends in coach.me. |
| | | **Make use of different triggers at appropriate times (REACH)** | Providing triggers (e.g. mobile notifications) to remind the user of taking action | Headspace allows its users to set their own time for a **notification** to 'take some headspace' (i.e. do a meditation session). |
| Maintenance → Design strategies aimed at motivation | Individual works to prevent relapse and consolidate gains. | **Social liberation (TTM)** | Changing social norms that support a positive behavior change | **Reminders**, e.g. water bottle containing an hour glass that reminds people to drink enough water instead of sugar-containing beverages (Ludden & Offringa, 2015) |
| | | **Make use of different triggers at appropriate times (REACH)** | Providing triggers (e.g. mobile notifications) to remind the user of taking action | Headspace allows its users to set their own time for a **notification** to 'take some headspace' (i.e. do a meditation session). |
| | | **Apply gamification and gamified elements to enhance user engagement (REACH)** | Making products and solutions fun to use enhances engagement | The **gamified app environment** of DuoLingo. The **surprising interaction** in conversational-UI with the Lark app. |
| Termination → Design strategies aimed at fading out | Not every Behavior change is needed for forever | **Fading out (TTM)** | Once goal or connected behavior are not relevant anymore, let maintenance go down until stop and potentially substitution with other behavior | |

# 4 Applications to the touchpoints

In this section, we will address the relevant strategies and their practical applications for each of the touchpoints. Additionally, applied examples will be provided to illustrate the behavior change strategies and to enliven the behavior change theories and models. Although the focus here will be on motivational strategies used in each of the touchpoints, Table 3 gives an overview of the complete scheme for each touchpoint, including the early detection, the motivational techniques and the programmed interventions.

**Table 3 Touchpoints description (from REACH deliverable D3)**

| **Touchpoint** | | **Testing Instances** | | |
|---|---|---|---|---|
| **Name** | **Theme** | **Early detection** | **Motivational Techniques** | **Programmed Interventions** |
| TP1 Personal Mobility Device | Frailty and risk of falls | Signs of frailty person under risk of falls Evolutionary approach: early detection will be done only with the sensors; when then risks of falls or signs of frailty are detected the mobility device comes in as a safe activation and training device. The mobility device optimally follows (and can modularly be adapted to) the person throughout the patient journey through different care stages. | Goal must be to motivate the elderly (e.g. through gamification) to use the equipment to train a) themselves, b) or in a community (e.g. a ZZ), or c) together with care personnel in an institution to achieve a better level of mobility. At best, this results in an improved mobility, e.g. in terms of distances walked (also without using the equipment). | The mobility device functions as a kind of medical home or indoor fitness device. A screen and motion sensor allows for an interactive scenario where the users can play games or follow mobility training instructions. Like in a fitness device in a fitness studio, our device should contain some basic (and modularly separable) physiological sensors on board that allow to monitor the training progress and outcomes. |
| TP2 Active Environment | Mobility | Early detect and prevent decrease of (micro) mobility in a care environment. Therefore measure/monitor performance levels: positioning problems, balance/falls. Measure/monitor mood: Track mood based on the physiological measurement + track mood by clinical professionals e.g. by | Engage in activity in patient and therapy rooms. Motivate to participate in and adhere to therapies/scheduled trainings/interventions and. | A combination and integration of “furniture” components (bed + bed periphery + mobility device (iStander) + toileting support) to a seamless in-house “transfer and mobility chain” should facilitate a significant increase of mobility in the patient room. Both the personal mobility device (TP1) and the Playware tiles based “gaming and training” system (TP4) may later on be used as additional interventions. |

| | | | | |
|---|---|---|---|---|
| | | depression questionnaire (and correlate/match both). | | |
| TP3 Socializing and Nutrition | Social interaction and nutrition | Physical activity in relation to eating habits. Inputs my come from self-reporting, doctor assessments, sensors, and/or other Touchpoints. | Find out what motivates specific elderly to eat what they should eat, stick to eating recommendations, etc. Develop motivational strategies that facilitate the physical activity levels within the context of socializing and nutritional intake. Measures: measure impact of socializing, measure improvement in terms nutritional intake | Personal advice on food intake in combination with physical activity recommendation. The food nutrition, recipes, recommendations should make them active (go shopping to get ingredients, meet with others to cook, etc.). Facilitation of socializing and nutritional intake should enhance the physical activity level. |
| TP4 Gaming and Training | General physical and cognitive ability | Changes in physical activity > infer from these changes in physical ability. Use of Philip's back end server (dashboard) to explore the by DTU collected data sets to identify what (probably signals or trends) to early detect. Playware tiles themselves and/or sensors may be used as early detection tools. | Playware tiles are seen as a tool/means to explore and test a variety behavior change tactics. Produce knowledge about what training and gaming can mean as an activity promoter. | Playware tiles themselves (plus associated games and training procedures) may be seen as an intervention. In case the tiles themselves are rather used as a detection means, additional services (e.g. by care professionals, etc.) may be seen as intervention. At ZZ/Tu/e: make use of an RTC trial to draw conclusions about effects of engagement/training. |
| TP5 Wearables | General physical and cognitive ability | Detect changes in activity, i.e. deviations from normal activity; this has two dimensions: Micro changes: changes in micro activity patterns (within hours or minutes) Macro changes: variations cross days/weeks | Development of approaches for wearables that enhance willingness and adherence to wearing them. In that context: find the right balance between perceived safety gains and privacy aspects/ concerns | Development of clustering algorithms to identify intrapersonal behavior patterns and infer from this intervention profiles. In that context, the success of a variety of interventions (i.e. intervention alternatives and/or motivational techniques) for specific persons or cohorts shall be predicted. Feedback of information/recommendations/interventions through a) (Interfaces) on the wearables and b) other Touchpoints (and/or services tied to them) |

## 4.1 Description per touchpoint

### *4.1.1 Personal mobility device (Alreh Medical)*

#### *Motivational Challenge*

In the REACH project Personal Mobility Device Cluster, an activation programme is addressed to those elderly people whose activity levels decreased for some reasons (including hospitalisation after one event), resulting in a negative feedback loop: fear of physical activity leads to less activity which further increases the sense of fear of falling during an activity. The solution for this group of seniors is to create such an activating device that will provide the possibility of complementary motor training as well as activating mental processes at home. The designed device is intended to enable senior citizens to continue their normal daily activities by building their strength and fitness through training.

There are a number of scientific reports on high efficiency combination of these two forms of activities. **Erickson et al. (2011)** showed in their trial with 120 older adults that exercise training increases the size of anterior hippocampus which is important for spatial memory. Important findings are that regular physical exercises effectively reverse hippocampal volume loss which is connected to improved memory function. Additionally, training of cognitive function in combination with task oriented physical activity can reduce the risk of falls among older adults. Combination of motor and cognitive therapy is highlighted as an effective solution for enabling the elderlies move safer with reduced risk of falls. Dual-tasking exercises are considered as a critical health care need for improving balance and gait (**Silsupadol et al. 2009**).

Motivation for regular exercise comes from a number of sources: strengthening of a sense of self-reliance and independence of seniors, attractiveness of games created especially for seniors, fear of progressive dementia, fear of falling and associated pain, medical knowledge recommending increasing relative intensity of training due to aging to rebuild lost muscle mass and impact of emotionally close ones who will encourage seniors to take care of their own health. **Bherer et al. (2013)** highlighted that physical activity is a significant moderator of age-related cognitive decline. Frail patients and persons with mild cognitive impairment were discussed. The results suggest that physical activity is a promising non-pharmaceutical intervention for preventing of age-related cognitive decline. Physical inactivity is also considered as a major risk of frailty.

#### *Related Motivational Strategies*

**Gamification / gamified element -** The element of activating training programmes in a form of computer games is significant while motivating seniors to activity. The games need to be engaging for elderlies in performing certain actions. Exercises with the use of computer games should be a pleasure and fun and not a necessity for seniors.

**Social influence and social support -** Sharing goals and achievements is an important way to involve elderlies into a social network and to motivate them to be more active in everyday life. Social interactions can be an intervention trigger point and enable to show others “best practise” which can be for senior who starts to be active a model to follow.

**Goal-directed behaviour (set realistic goals + set tiny habits + feedback on user’s performance/behaviour) -** Goal-setting approach is motivating people to exercise more. In case of gaming exercises, achieving higher and higher levels in games allows to see the

progression of certain skills. The goal could be also to be active every day for longer time which can be easily measured by activity tracker.

**Self-reflection/Self-efficacy (enabling awareness + feedback on user's performance/behaviour) -** Involving activity monitoring device is an effective tool for motivate people to be active by showing their activity level every day. Self-efficacy has a positive influence on being more physically active among older adults. It is also a good early-detection for seniors and their relatives to monitor the daily activity of the elderly and respond accordingly in case of progressive inactivity.

**Personalization and customization** – Adapting the enabling device to the elderly's condition will enhance the ability in Fogg model, inducing a better acceptance of the solution. Proposing a personalized gamified program depending on the user's improvement or regression would also have a positive impact on elderly's motivation.

### *Case Example*

We are in the early stage of creating a concept solution to motivate elderlies to be active in everyday life. The **TP1** personal mobility concept should contain an early detection part and case-oriented intervention process. An early-detection part is a very important element in the design of the solution, which will monitor the daily activity of the elderly and respond accordingly in the event of a fall. Due to early detection of changes at the level of daily activity, an individual intervention programme can be quickly implemented to protect the elderly against progressive inactivity, and allow them to stay at home for as long as possible, protecting against unwanted hospitalisation.

It would be perfect to create a solution that will allow for a continuous process of activating seniors in a variety of forms depending on an individual's ability as the ageing process progresses. For the patients who were active before hospitalisation, the designed device will allow for a quick process to adapt to daily physical activity already in hospital. The selection of appropriate modules of the device by physiotherapeutic staff of the hospital will allow to educate a patient how to operate it and develop personal training programmes. For this reason, a patient will have a good opportunity to continue training at home.

The **TP1** cluster focusses on the development of a personal mobility device that is able to prevent, mitigate, and reverse functional loss associated with immobility. The activeLife device concept would be an activation device consisting of indoor gym. It could be used in the area of prevention for all elderly people endangered by mental disorders (Alzheimer disease, dementia) and under the risk of falls.

The device is able to activate elderly and motivate them to get out of the bed and out in their environment, and conduct a variety of tasks. The device will be highly adaptive to individual users, emphasize the fun and activity aspect of mobility, and will be equipped with a variety of sensors (equipment embedded sensors + SC sensor) for feedback on different levels (device, user, care givers, etc.) and combination of vital data and usage/mobility data will allow proactive, predictive insights. The goal for further development of activeLife inside Reach framework is more about a combination of mental and physical activation. In Figure 37, a visible scenario, demonstrating how the different modules of the **TP1** system could look like.

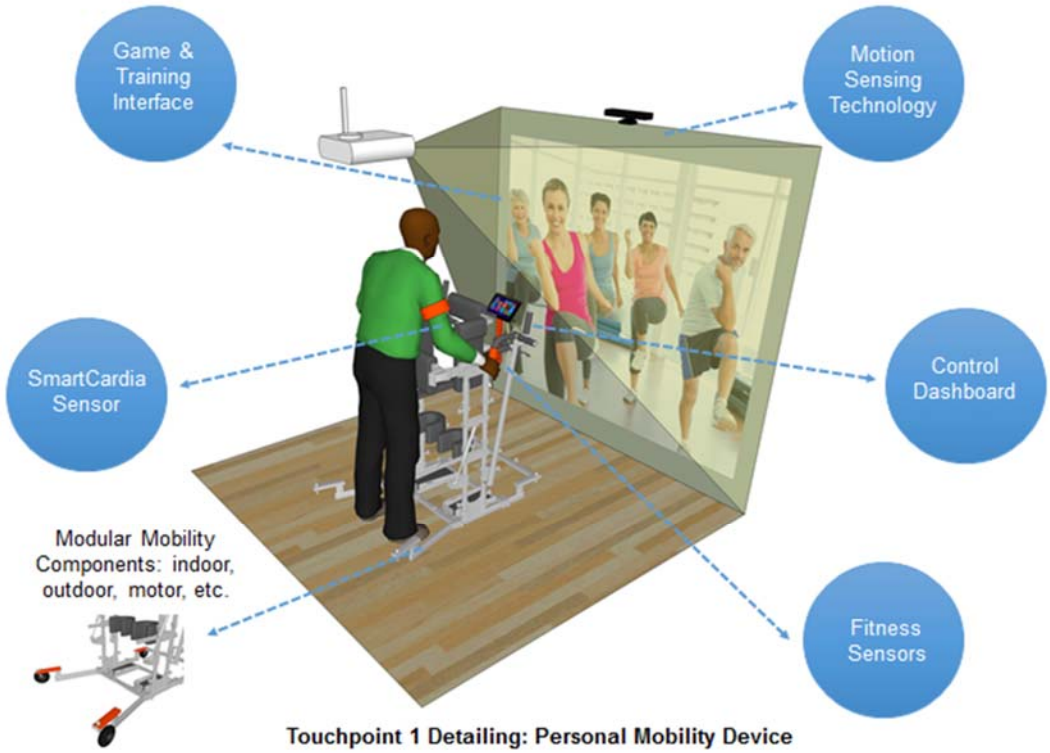



**Figure 37 Touchpoint 1 Detailing: Personal Mobility Device**

### *4.1.2 Active environment (TUM)*

***Motivational challenge***

The REACH System will consist of several modules cooperating with each other (Personal Mobility Device, Active Environment, Socializing & Intervention, Gaming & Training, Wearables and REACH Engine) when possible. The REACH system aims to support the elderly in their daily activities such as being physically, socially and mentally active through mobility, group cooking and intellectual games. Furthermore, the REACH system will use an unobtrusive approach for monitoring physical health criteria. This system will use active modules (e.g. handles, robots, mobile support etc.), as well as passive modules (e.g. unobtrusive implemented sensors for vital data tracking, wearables etc.). However, the more surrounded the elderly are with technology, the more difficult it is for them to use the system, since it is more difficult for the highly aged to use new technologies than younger generations (**Roupa et al., 2010; Michel et al., 2015**).

If the system triggers the feel of observation (e.g. the sensors are too obviously implemented into the environment), or changes the environment dramatically, (e.g. looking too much like a laboratory or hospital due to heavy use of displays, sensors and buttons), the system will be inconvenient. Therefore, it is important that the user have one interface for the entire system, in order to avoid user rejection. On the contrary, a well-developed user interface (on software and hardware level) is able to motivate the user to stay active by using the proposed REACH system. Additionally, a main user interface supports the system to add later additional modules via plug and play.

Therefore, the user interface should be as much as possible intuitive. In previously investigated projects, several user interface possibilities arose such as gesture recognition, touchscreens, speech recognition and remote controller (e.g. at a smart TV). However, the problem with speech recognition is that someone has to pronounce clearly. Depending on diseases and different accents, this can be difficult. Therefore, the elderly face more problems with speech recognition systems, compared to younger generations (**Michel et al., 2015**). A better solution, according to (**Alaoui & Lwekowicz, 2013**), is a Smart TV. However, the end user needs to get used to the remote controller, when a smart TV is used as the main interface. Furthermore, in the solution of **Alaoui and Lwekowicz (2013)** also an additional tablet computer is considered, which increases the user interface functionality, but also the complexity. Alternatively, studies like from (**Findlater, Froehlich, Fattal, Wobbrock, & Dastyar, 2013**), describe the touchscreen as a usable user interface, which is quite intuitive for the elderly. On the other hand, tablet computers and smartphones, have mostly too small displays for the elderly, which makes it difficult for them to read or interact with these devices. Therefore, (**Nicolau & Jorge, 2012**) demand solutions that are more effective for the elderly regarding touch screens, after testing the text-entry performance of the elderly via touchscreens of mobile phones and tablet PCs. Furthermore, these devices are developed in order to be portable, whereas the user interface of REACH, is aiming to mobilize the user and to motivate him to stay active by using the REACH system.

Therefore, an interactive table with an optical touchscreen concept seems to be more intuitive as a user interface for the REACH system, because a table surface offers enough space to increase the button and label sizes so that even the elderly with symptoms like tremor or weak eyes, can easily operate the user interface.

***Relevant strategies***

Accordingly, a pre-prototype of a smart table has been developed already, which is using an HD ultra-short distance beamer, as well as depth cameras (Kinect V2) to create an interactive table (out of any ordinary table). The prototype differs from existing solutions like the Microsoft PixelSense (**Schäfer, Acevedo, & Hansson, 2013**) in so far that the sensitive technology is placed above the table. Therefore, this proposed solution is much more robust regarding accidents (spilling water, fall of objects on the table surface etc.). Since this interactive table will operate on an optical principal, in contrast with capacitive touchscreens, it will be compatible with prosthesis, gloves or other objects (i.e. there is no direct skin contact necessary).

Depending on the design of the Graphical User Interface (GUI) on the software level, the user can be using simple gestures, to steer the different GUIs intuitively. Thereby the user is able to control the active modules of REACH, as well as display the data of the passive modules (i.e. ambient sensor of **TP2** or from the Wearables of **TP5**), guided by a large scaled GUI surface. This allows an intuitive and easy use which encourages the user to move (with the arms and upper body) actively, in order to “press” the buttons of the GUI. The software has also a modular architecture, which allows to include other programs like games for supporting (additional to the physical activity because of the gesture recognition) the mental activity of the user, e.g. Puzzle, Dominos, Solitaire (**Mitzner, Charness, & Rogers, 2015**) etc. Therefore, one use case of **TP4** which is “Gaming and Training” is addressed and will be implemented in this strategy.

Since the table is thought to become the main user interface of the REACH system (whereas this is not excluding other interface options like PC, tablets, smartphones etc.), different

layers of the GUI will be developed in close cooperation with REACH partners of **TP3**. The GUI needs to be intuitive, simple, self-declaring and large scaled regarding text and buttons. This means the entire operation system surface has to be designed for the needs of the elderly, based on the offered functions of the REACH system. In addition, the physical design of the interactive table needs to be properly addressed (regarding functionality and design).

The already aforementioned pre-prototype considers in its design the possibility to upgrade any existing table to a smart table. Especially for the elderly, this allows to upgrade their existing environment, instead of exchanging it completely. Nevertheless, only a smart table is not sufficient enough as the main user interface for the REACH system, e.g., because with a pure touchscreen interface not all training aspects of the REACH system can be considered. Therefore, a special design of the new interactive table has been developed (depicted in Figure 37), which represents a “Personalized Interior Intelligent Unit” (PI²U).

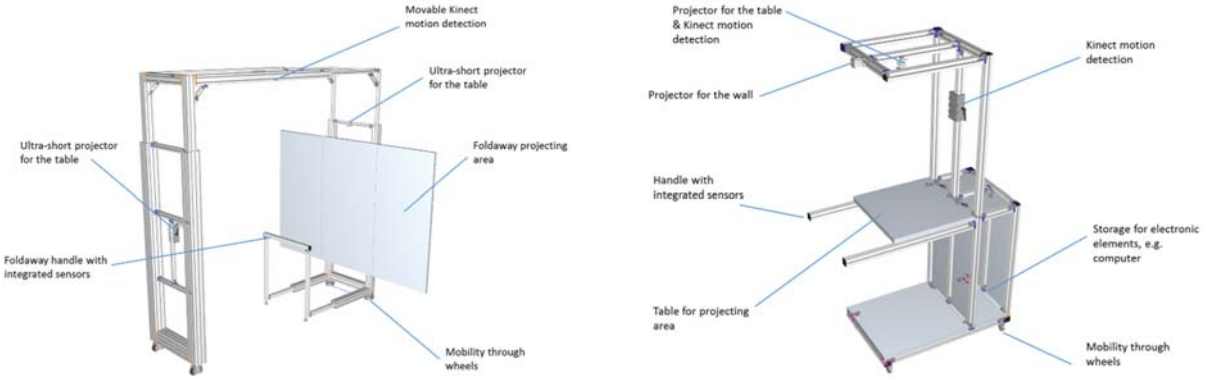



**Figure 38 Initial design concepts of the interactive table PI²U, aiming to extend the functionality from pure table surface, to wall and floor mode. Left) A concept with large display options, which needs be customized depending on the room dimensions. Right) A very first concept of a lightweight version.**

These designs (in Figure 37) contain additional functionalities (compared to the existing pre-prototype), which allows to display information not only on a table surface (with touch screen function), but also on the floor surface, as well as on the wall, in order to enable guided training (e.g. via tele presence or games). The aim of these structures is to offer space to implement the different depth cameras (for gesture recognition) and beamer (for information display).

Figure 38 demonstrates solutions of the very first iteration developments, focusing on the physical functionality. Thereby, it is possible to develop very early different GUIs for the final demonstrator. With both designs of Figure 37, laboratory tests can be executed in order to receive valuable input, which will be used to design the final demonstrator. The use of the Kinect sensor, depending on the beamer and frame costs, allows a relatively low-cost solution compared to solutions like the Microsoft Surface interactive table.

### *Case example*

In Figure 39, a scenario is visible, demonstrating how the different modules of the REACH system could look like.

**Figure 39 Possible scenario of the first proposed PI²U, represented by the improved interactive table, interfaced to the MOTO tiles. Supporting sports, telepresence, as well as serves as an interactive table including recipe displaying.**

The interface to the MOTO tiles, from the Centre of Playware (**Lund, 2016**), allows the user to play the games also with their hand at the table plate via gesture recognition, in case that they are bound on a wheel chair. In a similar way, also the STATIC PLUS from Alreh Medical (**Alreh Medical, n.d.**) (belonging to **TP1**), will be extended by the REACH system, i.e. enabling the user to steer rehabilitation training by the feet.

Although the frame is quite large, it allows upgrading the apartment with the service functions. This approach allows the user to stay in the current environment (e.g. home, home care institute etc.) as it is, enjoying the additional services of the REACH system such as socializing and mobility enhancement (demonstrated in Figure 38). Additionally, this approach offers a platform for implementations like telepresence, cooking guides via displayed recipes, or a REACH store, where the different service module can be bought later on. Thereby, the modular design of the system leads the elderly to adapt to this system/GUI very easily, to satisfy their needs more than before and to support them financially through step-by-step purchases on the REACH store.

Furthermore, additional PI²Us are under development, with focus on other living environments of an apartment (e.g. bedroom), where unobtrusively sensor can be installed, aiming to capture health relevant data, which will be transferred to the proposed interactive table module offering an interface to **TP2**.

### *4.1.3 Socializing and nutrition (TU/e + Biozoon)*

***Motivational challenge***

In the United States 40% of nursing home residents and 50% of hospitalized elderly patients are malnourished (**Chen et al., 2001**). In Europe 37% of institutionalised elderly are already malnourished (**Manders et al., 2009**) and another 30% of elderly adults are at the risk of malnutrition and undernourishment (**Chung & Chung, 2014**), in which malnourishment is characterized by all deviations of the nutritional status. In contrast, being undernourished describes the undersupply of dietary energy (**Shetty, 2003**). **Nieuwenhuizen et al. (2010)**

reported that the numbers of malnourished elderly in long-term care home residents are 85%. Because of the increasing number of the elderly population malnourishment is going to be a more important topic in elderly care **(Chen et al., 2001).**
To understand the eating behaviour of elderly, it is important to differentiate two types of eating drivers in our brains: homeostatic and hedonic control of eating **(Saper et al., 2002).** Homeostatic control of eating is concerned primarily with regulation of energy balance: how much should be taken to maintain an energy balance of the body. This control of eating is a rational act and can be sometimes considered tedious as eating is considered as surviving. Hedonic control of eating, on the other hand, focuses on the reward associated with food intake. It is very much an emotional eating act and driven by the satisfaction and enjoyment that food can bring. In the case of elderly malnourishment, both homeostatic and hedonic control of eating is important to stimulate better food intake.

Elderly malnourishment can be caused by three different reasons, namely psychological factors, physiological factors and pathological factors (**Donini et al., 2003**). *Pathological factors* are those related to the loss of appetite due to taking several medications (**Donini et al., 2003; Chandra, 1991**), chronic diseases (**Amarantos et al., 2001**), and age related hormonal regulation (**Donini et al., 2003**). These factors regulate the homeostatic control of eating and reduce the desire of the elderly to acquire the sufficient amount of food intake. *Physiological factors* relate to impaired physiologic functions such as the ability to chew, to swallow, to smell and to taste (**de Groot et al., 1999, Donini et al., 2003; Chichero, 2013**). Many advanced food technologies have been developed to deal with for example the chewing and swallowing challenges. However, the unattractive appearance, modified texture and lacking taste of pureed food can actually demotivate the food intake (**Mertz Garcia, & Chambers, 2010; Wright et al., 2005**). These factors prevent elderly receiving the food stimuli to trigger hedonic control of eating. *Psychological factors* are those related to the emotion of the elderly. Generally speaking the more positive the emotions are, the higher is the energy intake (**Paquet et al., 2003**). Negative emotions can come from loneliness, a low self-esteem, intolerance of the new environment, hospitalization or retirement in a nursing home and the loss of important people to them. 30% less energy is acquired when elderly eat alone, rather than in company of others (**Donini et al., 2003; Chen et al., 2001**). Specifically many of institutionalized elderly used to cook for years in the past but are now completely dependent on supplies (**Donini et al., 2003**). The dependency at the different meals for these elderly can lead to a motivational loss as well (**Chen et al., 2001**). Furthermore, lack of education can also be a reason for inadequate food intake. Many elderly patients are lacking the knowledge for healthy nutrition and what may happen when they are malnourished (**Soederberg, Miller, & Cassady, 2012; Chandra et al., 1991**). It should be noted that people who can't take normal meals due to pathological and physiological factors often feel isolated and don't want to eat in groups which can intensify the psychological factors explained above. These psychological factors limit both homeostatic and hedonic control of eating.

### *Related motivational strategies*

In the report of REACH **WP 1.2**, four categories of motivation strategies have been identified: Gamification, social incentives, goal-directed behaviour and self-reflection/self-efficacy (See REACH Deliverable **D2**, 2017, pg. 45-46). In Chapter 3 of this report, motivational strategies were further unfolded. More concrete and actionable strategies were derived and identified using real life examples. For example, gamification can be designed by creating rewards, social incentives can be realized through social support, goal-directed behaviour can be achieved by means of triggers, quantifiable realistic goals, tiny habits, performance feedback

and formulate plans and self-reflection/Self-efficacy can be enabled by developing capability and education and focusing on personal attributes and habit information. Apparently when dealing with elderly malnourishment, gamification and social incentives try to stimulate hedonic control of eating while goal-directed behaviour and self-reflection/self-efficacy try to re-establish the homeostatic control of eating. We conducted literature review on which strategies could be useful when dealing with the elderly malnourishment problem.
Gamification can be applied to make food intake a fun and interesting activity to trigger hedonic control of eating. **Donini et al. (2003)** and **Nieuwenhuizen et al. (2010)** pointed out that the energy intake is much higher when the elderly have a variety of food, especially with different sensory qualities like tastes, flavours and colours. **Mertz, Garcia, and Chambers (2010)** expounded the motivational aspects of using moulded pureed food into their original shapes and colours and increased flavours. **Donini et al. (2003)** and **Marcus and Berry (1998)** suggest changing small things in the environment during mealtime such as changing the atmosphere (e.g. music), providing the favourite meals or feeding assistance during the meals can stimulate better food intake. In the US, a serious video game was successfully used to improve the intake of fruits and vegetables by children, thanks to the promotion aspect of the game **(Cullen et al., 2016)**. MyPlate.gov is a nutrition programme of the United States department of agriculture (USDA). Since 2011 it serves as visualization on groceries in retail, as before, the food pyramid or other information, for healthy and smart food choices. It contains recommendations and special needs of different target groups like children, students, adults (men/woman; moms/ moms-to-be and older adults) and families. MyPlate.gov is reminding them for smart food choices, includes prescription for cooking, is monitoring weight and contains also quizzes to every food group (dairy, fruit, grains, protein and vegetables).


**Figure 40 "MyPlate"- symbol from USDA (www.choosemyplate.gov)**

For the group of children, a lot of games are also available, which can be used either online or via app. For example "Food detectives" deals with the hygiene of food, "Track and Field" contains quizzes and in "Blastoff" the children have to fill the "Myplate" with only smart food. This kind of games could also be applied to the elderly population choosing, using e.g. a more sophisticated, less childish appearance (USDA: https://www.choosemyplate.gov/,03.07.2017)

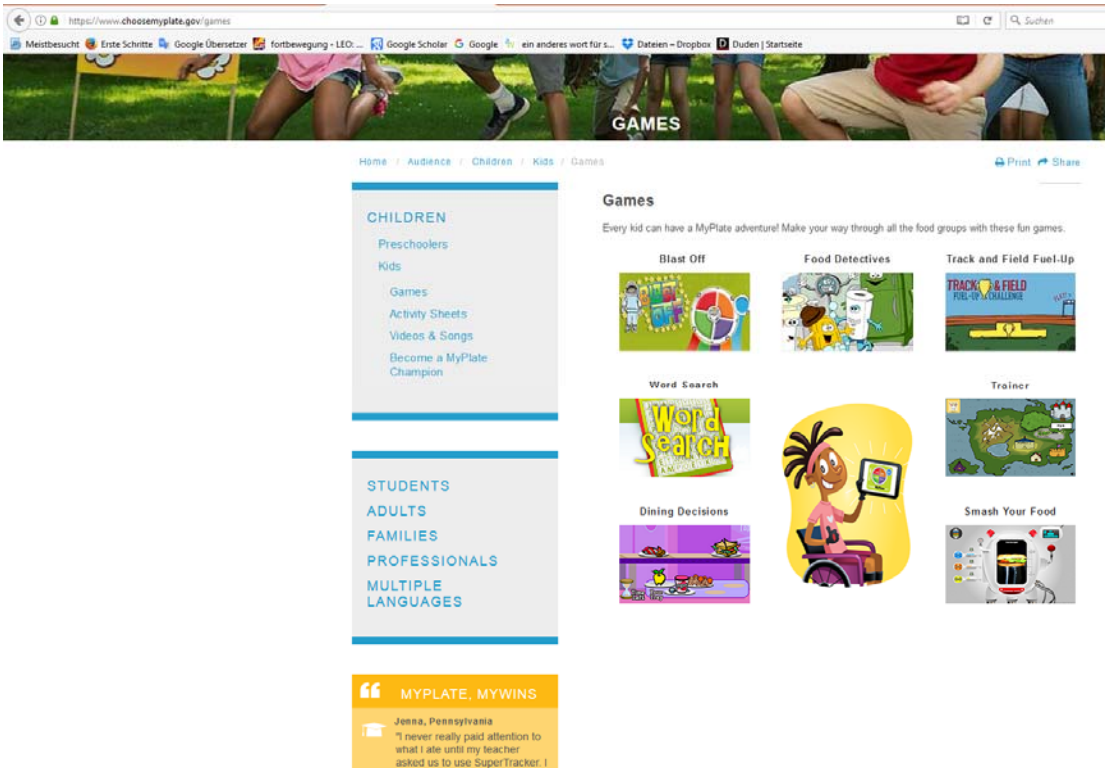



**Figure 41 "Myplate" online page with games to nutritional topics**

Social incentives can be a very useful strategy to be applied, for example, by influencing how the food is made, served and consumed, also on hedonic control of eating. **Donini et al. (2001)** described that the elimination of loneliness may help and friendships may have a positive effect to appetite and nutrient intake as well as social company while eating. It was also reported that more attention should be paid to the elderly and assist them during the mealtime by staff members as well as dieticians and social workers (**Marcus & Berry, 1998**). Social robots have been successfully used as a companion at nursing homes, which may also enhance food intake (**Gallego-Perez et al., 2013**).

Goal directed behaviour could be useful here to break the food intake into a number of smaller tasks in order to support elderly in reaching their food intake goal to re-establish the homeostatic control of eating. To support the elderly to take sufficient amount of food with required nutritional value, **Farsjø and Moen (2017)** proposed to use the recipes with a higher energy or a higher amount of protein e.g. with yet small portion. **Nieuwenhuizen et al. (2010)** suggested providing more frequent but smaller meals, which includes their favourite food as well as adding a lot of snacks throughout the day. This resulted in an increase of 600 kcal and 12g of protein in the daily intake of elderly patients. **Alibhai and colleagues (2006)** pointed out that high-energy food and smaller meals may be very helpful to support elderly maintaining a healthy amount of food intake.

Self-reflection/self-efficacy can be useful here to provide awareness and feedback to the elderly people about their food intake to support them to re-establish homeostatic control of eating. **Chung and Chung (2014)** developed a nutritional education program. In their opinion elderly have to learn about adequate nutrients and what is healthy eating especially focusing on what is within reach of their budget. Teaching cooking skills is also included in their program to learn more about cooking and the usage of another variation of food, which means to choose also unfamiliar food. At the beginning of the program 70% of the

participants were at risk of malnutrition. Six months after the education program the number of participants at risk of malnutrition decreased.

***Case example***

We are in the earlier process of creating the touchpoint concept to stimulate healthy food intake through socializing eating and monitoring. One of the earlier concepts is called SMAAK (i.e. Dutch for 'taste') created by bachelor student Laura Power from TU/e based on a series of interviews and workshops conducted with elderly people from an activity centre together with other TU/e students (**Power, 2017**). Social incentives and self-reflection/self-efficacy are applied in this concept to promote healthy eating behaviour among elderly. SMAAK is a temporary service intervention to rekindle an interest in food among senior citizens. SMAAK stimulates seniors to make and share recipes and introduce new foods into their diet and lifestyle, addressing the growing problem of malnutrition among seniors. Firstly, seniors enjoy a social, fun and educational tasting experience at their local community or activity center. Each tasting experience revolves around a theme. Here seniors try small food samples, which have nutritious ingredients they are not accustomed to. These food samples adhere to at least one of nine guidelines, which were co-created with the dieticians in the project and aim to make eating more attractive and incorporate nutritional components, such as high in fiber, high in protein, high in vitamins and minerals, no (or low) salt, 3 or more colors, high in taste (herbs/spices), strong smelling ingredients, 30 minutes or less to prepare and variety of recipe types (sweet, savory, etc.), which seniors often lack. Whilst trying these samples, organizers of the activity, such as healthcare students, teach seniors about the health benefits of ingredients and food types. Seniors also take part in playful quizzes and rate each food sample by choosing a happy, straight or sad face. The event is relaxed and participatory for all seniors involved (see figure 42: social support in the SMAAK concept). During the tasting experience, organizers create a profile for seniors on the platform, SMAAK (Figure 42. Smaak platform). Each senior is talked through the platform and asked about their food, dish, cooking style, time and difficulty-to-cook, preferences as well as any allergies or health conditions. The organizer inputs the data into the platform and uploads the information to a SMAAK-card which is then personalized to that senior. This information can be updated or edited at the following tasting experience one month later. After the tasting experience, seniors take home their SMAAK-card as well as a compact multi-purpose printer. Seniors swipe their card on the printer at home to receive personalized recipes depending on their preferences and information. If a senior does not swipe their card, a recipe will automatically print as a trigger every few days. Once the senior has made a recipe, they take a photo of their food creation using the printer's camera. A light will flash green and the photo will automatically print on paper. This information is automatically uploaded to the SMAAK platform and intelligently combines the recipe and photo to generate a senior cookbook. If photos are not being uploaded the platform, an organizer will call the senior to chat about their progress and provide encouragement and support. One month later at the next tasting experience, the printed cookbook including all seniors' recipe creations is available in physical form to take home and share. The social interaction around the tasting experience is one of the many initial motivations to explore new foods, developing into an intrinsic motivation to feel good within oneself. The touchpoint partners agreed to further explore the potential of this concept together.

In the meantime, based on the literature review on motivational strategies, Biozoon will conduct interviews with elderly living in nursing homes. Interviews in nursing homes are targeting the identification of user insights with relation to food. The analysis of the

information collected will provide a strong fundament for the motivational strategies to be adopted (for increasing food intake in elderly) and will be shown in the following WPs.

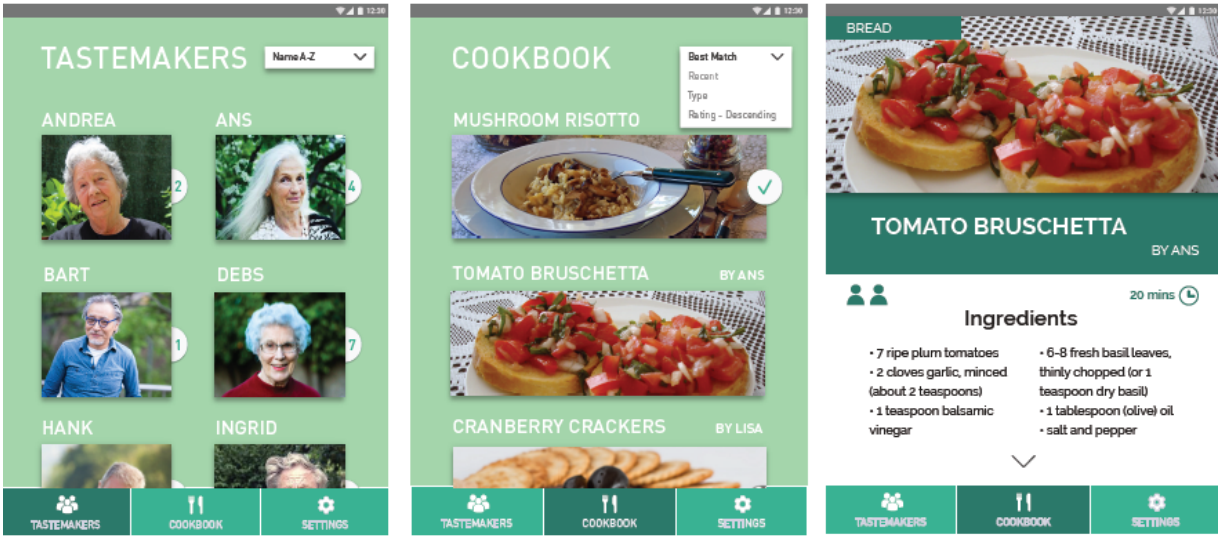



**Figure 42 SMAAK platform (Power, 2017)**


**Figure 43 Social support in the SMAAK concept (Power, 2017)**

### *4.1.4 Gaming and training system (DTU + TU/e)*

***Motivational challenge***

With Playware, we aim to create playful products, but we also design the play in ways where we gain certain benefits. In the example of the MOTO tiles (Figure 44) we designed a playful product that engages people in order make them move more and make movements that improves their balance, but movements they normally would tend to avoid. We can see that the elderly people participating tend to move as little as possible and very stiff when they move. So, the design challenge was to motivate elderly to move more while getting out of their comfort zone and bringing them into a state of flow (**Nakamura & Csikszentmihalyi, 2014**).

**Figure 44 Moto Tiles used by elderly lady**

***Relevant strategies**:*

Gamification, immediate feedback (light off/on), social influence and splitting the challenge into baby tasks (instead of showing the path from the beginning and enlightening a sequence of tiles, showing the light one by one) are the relevant strategies chosen. To achieve the outcome we hoped for, we used play. Play is known as a voluntary action that we participate in solely for the fun we get out of it. Thus, we engage in playful activities, because they are fun, but when we design Playware we make sure to design the play activity in ways that creates the needed outcome i.e. more movement and getting out of the comfort zone.

When we play, we forget about time and place, and this is the reason we can get people to do things they would otherwise not do. The concept of Flow **(Nakamura and Csikszentmihalyi, 2014)** and related research was developed to understand a phenomenon of intrinsically motivated, or autotelic, activity: activity rewarding in and of itself no matter what its end product or any extrinsic good that might result from this activity. It means that the created motivation lies in the created activity experiences, i.e. in the flow. Although many different motivational strategies such as rewarding, feedback can be applied when creating the activity experiences, the resulted intrinsic motivation is a perception and subjective experience of the activity. Playfulness as intrinsic motivation was found dependent on the status of flow and personal traits **(Woszczynski et al., 2002)**.

Part of the play activity is drawn on other motivational aspects, such as challenging people to do more, rewarding them with small rewards in the form of feedback. But also, the point that people want to "progress" is vital. With the MOTO tiles we created different games, that utilizes different motivations, but all with the main aspect being to create playful interaction. This is important, as we clearly believe in an understanding of motivation as not something you can just "add" to a product, because then the motivation is detached from the actual praxis, here exercise. If the motivation is detached from the product it's a matter of trying to convince people to change their behaviour (e.g. move more) using different strategies (e.g. gamification, social incentives, goal directed behaviour and/or self-reflection), while Playware is focused on creating technologies that allow people to exercise their natural affinity for play.

**Case example**:
In the scenario that we believe is a prototypical example of the use of the tiles, we have four elderly people from the municipality nearby the university placed around a set of tiles and a game (called Color Race) is started on the tiles. The game is fairly simple, the players have to press the tile that lights up. When pressed another tile lights up, and the player must move over and press that one. The game continues for one minute, and the number of tiles that is pressed during that minute is the amount of point the player gets.
The game is calling for the player to step on the tiles. In our observations, we have seen this time after time. New players or observers cannot resist trying to press the tiles to see what happens. The physical design of the tiles on the floor, the size of a foot, and the colorful light invites the player to step on them. They function as trigger points. We can describe it as follows: The player must press a tile and catch as many lights as possible within a limited time frame. The game is created so the color jumps to another tile almost instantly and this creates the feeling of running after the colors, thus the name "Color Race". The movement of the light to another tile "forces" the player to act as prescribed be the game.

### *4.1.5 Wearables – An early test with the Mi-Band (TU/e)*

***Motivational challenge***
In order to prepare for field testing with future REACH concepts, TU/e and care organisation ZuidZorg (ZZ) teamed up to set up an early test to experiment with the use of the Mi-Band with the elderly guests at the ZZ 'Meet and Greet Centre'. ZZ is a care organization in The Netherlands, which provides home care. ZZ also runs a community centre, called the 'Meet and Greet Centre', via ZZ Extra. In this Meet and Greet Centre social gatherings between elderly people are facilitated by volunteers and employees at ZZ Extra. The related

motivational challenge discussed here is ‘How to motivate elderly to adopt the use of the wearables (Mi Band)?’

***Relevant strategies***

The relevant strategies are feedback on user’s behavior (activity), gamification and social support. Given the context of the REACH project in ZZ, it was decided to use social support as the main strategy to set up the experiment and to sustain the usage of the wearables during the experiment. Next to wearing the Mi Band, the elderly participants were also requested to fill up a diary book on daily basis. This test lasted three months including a one-week pilot test. A bi-weekly workshop was organised by the researchers and involved students from TU/e to give feedback on their performance and reflect together with the elderly participants about their test experience and their diary in the last two weeks. The bi-weekly interaction between the participants, researchers and students served as the social support strategy to drive the participants to continue the experiment. Social motivation of using wearable activity trackers was also found in other studies as a powerful strategy to encourage self-tracking and monitoring of individual health status **(Chiauzzi, 2015)**.

***Case example***

The social support strategy used in the earlier test was an important drive for most of the elderly to remain participating in this test. Meeting the research team on bi-weekly basis and discussing their findings were considered as a very important social event for them. At the end of the trial many of the elderly expressed the interests to continue the test if necessary. In addition, the experiment revealed that the initial diary book was considered tedious and resulted in a lack of motivation for continuous writing. The researchers therefore created a playful diary book with elements such as “the joke of the day” or “solve a puzzle”. These changes were observed as an important motivating factor to keep the participants interested in continuing the experiment. This is in line with the research finding related to gamification and playfulness in behaviour change. This is an additional insight obtained from the earlier test. It implies that when social support is effective in motivating participation, gamification can be applied to sustain the effect.

### *4.1.6 Summary of application of motivational strategies in touchpoints*

Table 4 provides an overview of behavior change strategies and models applied per touchpoint. Many of these have been named in earlier chapters of this deliverable.

**Table 4 Overview of behavior change strategies and models applied per touchpoint**

| Touchpoint | Short description of experiment/s | Behavior change models & theories used | BC strategies used in experiment/ concept design |
|---|---|---|---|
| Personal mobility device (Alreh Medical) | It will monitor the daily activity of the elderly (plus respond accordingly in the event of a fall or progressing inactivity)<br>An individual intervention programme can be quickly implemented to protect the elderly against progressive inactivity (physical activity/personal mobility device)<br>Result: staying at home for as long as possible, protecting against unwanted hospitalization. | - Fogg<br>- RFT<br>- Trans-Theoretical model (action stage)<br>- BC wheel | - Gamification<br>- Social incentives<br>- Goal directed behavior<br>- Self-reflection/self-efficacy<br>- Persuasion,<br>- Incentivisation,<br>- Training (virtual coach),<br>- Modelling,<br>- Enablement barriers |
| Active environment (TUM)<br>TP2, TP3, TP4 – The user feedback of the elderly will be considered in a second iteration step, aiming to improve the design and functionality. | Testing prototypes by elderly for improving the design and games, to investigate the user acceptance and activity improvement | Putting the user in control, focus on autonomy and competence.<br>- RFT<br>- SDT | - Gamification |
| Socializing and nutrition (TU/e, Biozoon) | No experiment was conducted yet. Only conducted early user research through interviews and first ideation | - Gamification<br>- Social incentives<br>- Goal-directed behaviour<br>- Self-reflection/self-efficacy | - Social incentives,<br>- Self-efficacy |
| Gaming and training system (TU/e, with DTU) | 4 elderly tested a set of Playware tiles and a game (called Color Race) to demonstrate how play facilitates intrinsic motivation of physical movement | - Gamification,<br>- Play,<br>- Intrinsic motivation | - Playfulness<br>- Immediate feedback (light off/on)<br>- Social influence |
| Wearables (TU/e – possibly involve SmartCardia?) | Testing Mi Band with elderly people at activity center to learn how to improve wearable technology adoption by elderly people | - Gamification<br>- Social incentives<br>- Goal-directed behaviour<br>- Self-reflection/self-efficacy | - Social support, gamification |

# 5 Conclusion and next steps

The main aim of the current deliverable was to translate behavior change theories and frameworks into applicable strategies that can be used in the actuation and intervention work done in the REACH project. Conclusions and next steps are described below.

Many design interventions aiming for a behavior change in their users do not (consciously) apply the knowledge from behavior change theories. In other words, practical examples of designs for behavior change are for some behavior change models largely absent (e.g. for the implementation intentions), and this is especially true for offline (non-digital) designs. This limited number of practical design examples impedes bridging the gap between behavior change theories and the application of these theories in designs aimed at behavior change. Therefore, more practical examples of behavior change designs that are rooted in (parts of) behavior change theories are needed. Ideally these examples focus on promoting activity in elderly and are delivered from the REACH context in the future. A challenge that needs to be taken into account there is that many commonly used motivational, specifically self-regulation intervention strategies that are effective for younger adults may not be effective for older adults as **French and colleagues (2014)** concluded.
In addition, the level on which the behavior change strategies are presented could be more granular, specifying details for, for example, usability, effectiveness and reproducibility (reliability; **Henkemans et al., 2015**). As such, the behavior change strategies provided in Chapter 3 are considered a starting point for the theory-to-practice-translation. As this is a working document, new strategies should be added based on new studies and literature, and current strategies should be adapted, improved and contain sub-strategies on a more detailed (e.g., usability) level where necessary, especially applied to the domain of behavior change towards physical activity in elderly.

There is a plethora of behavior change theories and frameworks around and currently limited guidance exists on which elements designers should incorporate to optimally design for behavior change. There is a need for practical guidelines that designers can use to discover which behavior change elements would be relevant for their designs. In the field of exercise promotion, which of the theoretical behavior change variables or elements would be valuable to include in a particular design? If designers are more informed on these relevant variables, they can already incorporate them in what's often the first phase of creating a design: explorative user research. This will help designers to identify the most relevant motivational concepts for their topics of interest, and makes sure that these are not left out in the designs that follow the initial user research.
Additionally, more practical examples of successful behavior change designs, in which a full model (e.g. FBM) or multiple strategies and elements from different models (e.g. triggers, capability, self-efficacy) are included, are needed to better guide the designer (see also Chapter 3).

In their paper "Lost in Persuasion" **Henkemans et al. (2015)** present a guideline that should aid developers in developing technology for behavior change, consisting of six steps:

1. Conducting a needs assessment of the end users;
2. Developing program change objectives and determinants;
3. Selecting theory-based intervention methods and practical strategies for behavioral and environmental change;

4. Producing program components and materials for behavioral and environmental change by pretesting program material with target groups and implementers;
5. Achieving program adoption, implementation and maintenance;
6. Evaluating the proposed program by studying effect and process evaluation outcomes, indicators and measures, and writing an evaluation plan.

If such or related approaches are being pursued in the remaining time of the REACH project, the implementation of the theories and strategies described in this report are helpful. Finally, as **Henkemans et al. (2015)** put it, “to prevent persuasive technology to land on the shelf, it is important to specify the infrastructure, offering, consumers and finances at an early stage”.

It should become standard practice for designers that aim to influence and change their user’s behavior through their designs to have a look at behavior change models and theories before starting their design efforts. On top of what is provided in the current deliverable, we recommend to facilitate designers in doing this by: (1) taking guidelines such as **Henkelmans et al.’s (2015)** into account; (2) translating behavior change frameworks to more practical and applicable motivational design strategies; and (3) showing practical examples of behavior change designs that can inspire and support designers whilst designing for behavior change – tailored to target user groups at stake in the domains of behavior change designers are relating to. For project REACH, these are elderly and physical activity.

This deliverable outputs relevant behavior change strategies that can be applied to the REACH touchpoints. A first attempt to connect these motivational strategies and techniques to the five touchpoints has been done in the document. An additional level of detail will be added while developing and finalizing the different interventions (**D16**, **D17**, **D18**, **D19**, **D20**). In addition, this deliverable **D14** will provide the primary input for deliverable **D15** on the development of the PSS (Product-Service-System) concept on motivational strategies.

The outputs of this deliverable will inform the REACH teams working on the individual touchpoints, and help them understand how they may leverage state-of-the-art knowledge on motivational behavior change strategies in the context of early detection and intervention for these touchpoints. Also, this deliverable provides the REACH project with a shared understanding, terminology, and framework for further discussing and assessing behavior change theory and motivational strategies for promoting activity amongst elderly. Since the current deliverable (**D14**) reports on ongoing tasks (**T4.1** and **T4.2**: M15-M36), it will be updated in accordance with the progress of work. Future work in within these tasks will focus on the practical detailing, implementation, and verification of the identified motivational behavior change strategies.

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