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**Deliverable D7.1: Identification and detailing of personalization strategies and degrees of personalization for all Subsystems 6 (associated with task T 7.1)**

**Abstract:** This deliverable report presents the outcomes of task 7.1. It focuses on the identification and detailing of personalization strategies and degree of personalization for all subsystems. Since in task 1.3 and 1.4 we have created the REACH Touchpoint Engine concepts as the subsystems, the personalization strategies are identified and detailed based on the initial development related to the socialization and nutrition concept Touchpoints. Lyngby's II Study on gamification and early testing in Zuidzorg were also used as cases here. The identified strategies are then generalized to other concepts in the discussion. Attention will be paid to exploring, building upon and substantially expand and facilitate the already successful engagement strategies that are currently used by caregivers to engage the elderly in personalized and sometimes highly individualized activities that promote physical and mental health and wellbeing. The resulted personalized strategies will be then used in task 7.2.

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Partner	Short task description
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DTU	Co-writer of the main chapters, conducting the Lyngby II study
ZZ	Review report, support Touchpoint case socialization and nutrition, early test at ZZ extra

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## Key expressions

### Abbreviations for partners:

**AH:** ArjoHuntleigh

**AM:** Alreh Medical

**CU:** University of Copenhagen

**DTU:** Technical University of Denmark

**EPFL:** École Polytechnique Fédérale of Lausanne, Switzerland

**HUG:** Hôpitaux Universitaires Genève

**PSS:** Product Service System

**SC:** SmartCardia

**SK:** Schön Klinik

**TU/e:** Eindhoven University of Technology

**TUM:** Technical University of Munich

**ZZ:** ZuidZorg

**D:** Deliverable report.

**Early testing:** small user feedback and iteration loops to develop qualitative features

**Engine:** The "Engine" – 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.

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

**Touchpoints/Engine concept:** structures the envisioned REACH product-service-system architecture, into manageable research and development clusters.

**Touchpoints:** The "Touchpoints" will act as "graspable" front end towards the end users (elderly). The Touchpoints will serve as data gathering devices as well as a 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 the system to be adapted both for a certain person or setting as well as for the changing needs over time.

**Use case setting:** Use case setting refers to the four solution operators and this report called them the "use case setting" since they reflect concrete application scenarios.

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

**Hedonic motivation:** refers to the willingness for people to initiate behaviors that enhance the positive experience (pleasant or good) and behaviors that decrease negative experience (Higgins, 2006).

**Homeostatic motivation:** refers to the motivation that is evoked by an internal body state that drives behavior and aimed at maintaining the body's internal environment in its ideal state (Craig, 2003).

**Psychological factor:** has to do with the either positive or negative emotional reaction to the intended behavior.

**Pathological factor:** refers to that can influence intended behavior due to disease, medication, and age-related hormone regulation.

**Physiological factor:** refers to those impaired physiologic functions such as chewing ability, muscle movement and etc. that can affect the intended behavior

**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

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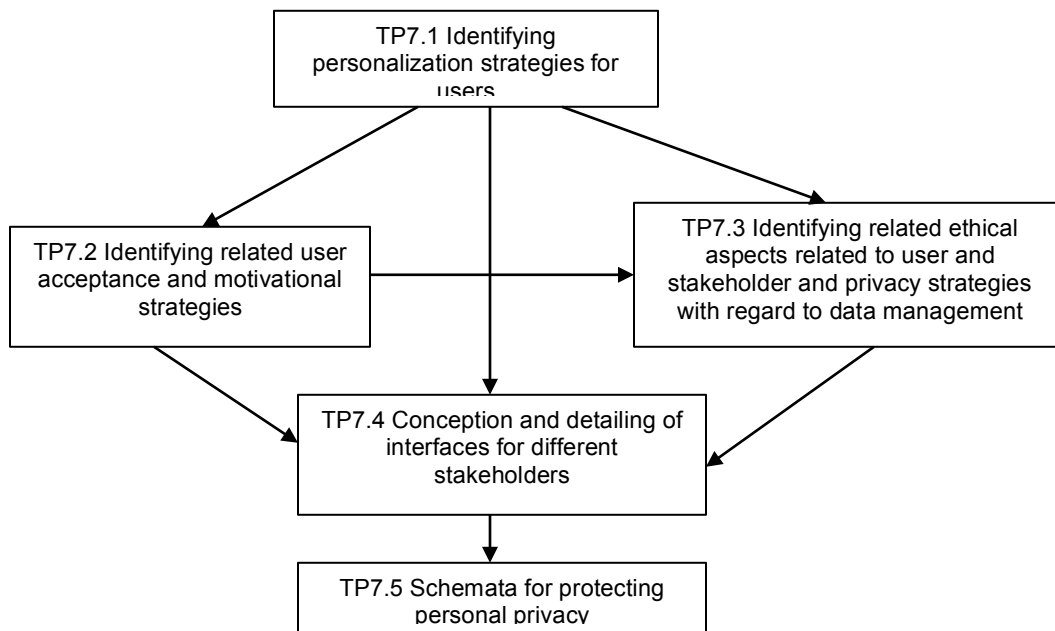
# 1 Background and summary of tasks and activities related to T7.1/D29

In this Section, an overview over **WP7** and **Task T7.1** are provided. First, in **Section 1.1** the relation and interdependencies of tasks in **WP7** are explained and **T7.1** is situated in this particular context. Then in **Section 1.2**, **Task 7.1** with its focus on the coordination of system integration activities, standards research, and testing planning is detailed. In **Section 1.3** the relation to and linking with of **WP7/T7.1** to other WPs is outlined.

## 1.1 Overview WP7: Personalization & user acceptance, motivational strategies, ethical issues, safety, security/data Privacy

In REACH, WP7 contributes to the creation of the personalized Touchpoint and Engine concepts that meet the expectations of the caregivers as well as the elderly users. **TP7.1** focuses on identifying and detailing personalization strategies for the REACH Touchpoint and Engine concepts. **TP7.2** aims at identifying the corresponding motivational strategies for the acceptance of the entire REACH system, not just for the user but also for the caregivers. **TP 7.3** considers the associated ethical aspects, privacy strategies and data management requirements for the REACH Touchpoint and Engine concepts so as to promote user and stakeholder acceptance. Based on the personalized REACH concepts, **TP 7.4** creates concepts of the user interfaces for not just the elderly, but also for formal and informal caregivers, doctors and etc. **TP5** develops schemata to protect personal privacy for these personalized REACH Engine and Touchpoint concepts.

The relation of these subtasks is visualized below in Figure 1.



**Figure 1-1: Relation of tasks within WP7**

## 1.2 Task T7.1: Identification and detailing of personalization strategies and degrees of personalization for all Subsystems 6

**T7.1** focuses on identifying and detailing personalization strategies and the degrees of personalization for the REACH Touchpoint and Engine concepts. At the different use cases in the REACH project, personalization is not a new concept. Each individual elderly person does receive a certain degree of personalized services from the rehabilitation center, hospital, and home care organizations provided by professional caregivers and informal caregivers. Within the REACH project, the ambition is to create a much higher degree of personalization and identify appropriate personalized motivational strategies through continuously sensing and monitoring the behaviors of the individual targeted elderly.

Currently, the REACH project team is focusing on developing the earlier created REACH Touchpoint and Engine concepts. In WP 7.1, a multi-case study approach was applied to demonstrate how personalization strategies can be identified and what are the identified strategies. The development of personalized motivational strategies for Touchpoint concepts: Socialization and nutritious monitoring and intervention, Lygnby study II on game and play, and the early test in ZuidZorg were analyzed to identify a set of hypothesized personalized motivational strategies that can be later generalized to the other REACH Touchpoint and Engine concepts. Observations, diary studies, interviews and quantitative activity tracker are used for data collection.

The report is structured as follows:

- 1) State of art related to personal motivational strategies. In **Chapter 2**, a literature review is conducted on why personalization is needed and the related personalized motivational strategies based on earlier identified motivational strategies.
- 2) Case results and analysis. In **Chapter 3**, three different cases are reported. These cases relate to the ongoing REACH activities related to early testing in ZuidZorg, Touchpoint development on socialization and nutritious monitoring and intervention and Lyngby II Study related to game and play.
- 3) Envisioned personalized motivational strategy model and generalization. In **Chapter 4**, the developed platform is discussed for its generalizability to other Touchpoint concepts.

## 1.3 Relation of WP7/T7.1 to other WPs

WP7/T7.1 is closely linked to Touchpoint/Engine concept developed in **WP1** (see **Deliverable T1.3 and T1.4**) and motivational strategies in WP 4 (see **Deliverable T4.1**) It provides personalized strategies to promote user and stakeholder acceptance. The results of WP7/T1.7 serve as input to other TPs in WP7, also can be seen in Figure 1.

## 2 State of art related to personalized motivational strategies and current practice in use cases

The need to implement persuasive strategies in order to stimulate the elderly to adopt a more active lifestyle is clear from earlier report deliverable of T4.1 and T4.2 (Owusu et al. 2017). Due to the largely varied needs of elderly people, personalization is more important to the elderly population than to the other age groups (Cabrita et al., 2015; LeRouge et al., 2013). Gregor and Newell (2001, 2002) pointed out that not only the diversity among elderly is larger than that among other age groups, but even for the same elderly person, his abilities may vary widely over time. Many researchers (Purpura et al., 2011; LeRouge et al., 2013; Higgins, 1997; Kaptein et al.; 2015) have highlighted the fact that the application of persuasive strategies should be personalized to encourage the adoption of the target behavior. How to create personalized strategies for persuasive or motivational messages to meet the specific and individual needs of the user once a profile has been established remains still an open question although much has been written about the desired of personalized motivational strategies relating to the user's motivational and psychological profile. This chapter discusses some related work on developing personalized motivational strategies for behavior change, especially related to increasing physical activities, already discussed in WP 4.1.

Many personalized motivational strategies have been discussed in works of literature. All the strategies relate very much to tailored strategies for specific profiling on personal traits (Hirsh et al., 2012) and/or behaviors (Prochaska et al., 1992; Rosenstock, 1966; Orji et al., 2013). On the other hand, when discussing motivation towards behavior change, one can talk about intrinsic motivation and extrinsic motivation (Ryan and Deci, 2000). Intrinsic motivation relates to the physical bodies (capabilities) and minds (willingness) of the individuals while extrinsic motivation relates to external cues triggering behavior changes (Ryan and Deci, 2000). In the following, some personalization related motivational strategies are discussed from the intrinsic or extrinsic perspective as well as personal traits or behavior perspective.

Hirsh et al (2012) proposed to apply tailored messages according to individual personal traits to motivate behavior change after examining the message-personal congruence effects by framing the persuasive messages according to the five personality dimensions from Goldberg (1990). Goldberg (1990) explored these possibilities by examining whether message-person congruence effects can be obtained by framing persuasive messages in terms of the widely used Big Five personality dimensions. Hirsh et al (2012) concluded that each of the five personality dimensions reflects variation in a different motivational system: *Extraverts are especially sensitive to rewards and social attention (Lucas, Diener, Grob, Suh, & Shao, 2000); agreeable individuals value communal goals and interpersonal harmony (Graziano & Eisenberg, 1997); conscientious individuals value achievement, order, and efficiency (Roberts, Chernyshenko, Stark, & Goldberg, 2005); neurotic individuals are especially sensitive to threats and uncertainty (Carver, Sutton, & Scheier, 2000; Hirsh & Inzlicht, 2008); and open individuals value creativity, innovation, and intellectual stimulation (McCrae & Costa, 1997)*. These findings suggest that for the individual with different personal traits, different sets of motivational strategies are needed to form both external and internal motivations when desired.

Behavior theories have been used to profiling users when developing interventions, especially in health domain (Prochaska et al., 1992; Rosenstock, 1966; Orji et al., 2013). Transtheoretical Model (Prochaska et al., 1992) considers behavior changes as a process of six different stages through which people move sequentially before and during the behavior change process. Self-determination theory (SDT, Ryan, and Deci, 2000) describes motivation personality and optimal functioning and it addresses various kinds of motivation. The SDT describes three different kinds of motivation respective of three innate needs people have. These three needs are 'competence', referring to the need to have control over one's situation, 'relatedness' referring to the need people

has to feel an emotional bond with others and 'autonomy' referring to the need for free will. Both intrinsic and extrinsic motivations are included here. The former is autonomous motivation, which involves the individual drawing on internal motivation to do a task which is intrinsically satisfying or identified motivation that aligns a task with the individual's internal motivation. The latter is led by external consequences, either punishment or reward, or by introjected motivation, which involves the individual feeling appreciated or rejected due to this action. When creating personalized intrinsic motivation strategies related to self-determination theory, we, therefore, should unfold autonomous motivation even further and understand what are the factors behind. Self-efficacy theory (Bandura, 1977) developed self-determination and cognitive evaluation theories further. It makes use of two constructs the assessment of ability (perception of competence, "I can") and the choice to act (self-determination, "I want"), similar to the "**competence**" and "**autonomy**" constructs from Ryan and Deci (2000). With these two constructs, intrinsic motivation strategies can be created based on a better understanding of a person's belief in his capabilities to produce a desired outcome and desire and confidence in organizing her actions towards meeting a predetermined goal (Bandura, 1977). When addressing personalized extrinsic motivation strategies related to self-determination theory, relatedness should be discussed further. It connects to two important constructs from Ryan and Deci (2000): **structure** and **involvement**. Supportive structures allow a person to control outcomes through the provision of clearly defined expectations and constructive feedback. Involvement is the amount of attentiveness and psychological resources that others provide to a relationship. To create personalized extrinsic motivational strategies, it is important to understand the individual social and environmental resources.

The regulatory focus theory (RFT) introduces another dimension when addressing personalized motivation based on personal traits. It takes into account that people's way to move toward pleasure and avoid pain change depending on the needs they are trying to satisfy, i.e., it can help create personalized motivational strategies from a behavior perspective. The regulatory focus theory "distinguishes between promotion focused motivation and prevention-focused motivation" (Brockner & Higgins, 2001, p. 44), but not absolutely point to either a promotion focus incentive system or a prevention-focused incentive system being more effective to motivate the user. Instead, the RFT explains that which of these incentive systems is more effective depends on the users being design for (Brockner & Higgins, 2001). Socio-cultural context also affects if a person is motivated more by prevention or promotion. The example mentioned in Brockner and Higgins 2001, explains that in an electrical utility company there are very few rewards present and the technicians only get feedback from their clients when the lights do not turn on at night and there is something wrong. Besides this contextual preference for promotion or prevention, people themselves also have personal "dispositional tendency" to focus on promotion or prevention (Higgins, E. T.,1997). This should also be taken into account when designing personalized intervention for users.

Kaptein et al. (2015a) called for methods to estimate the effects of persuasive principles on individual users in order to develop personalized persuasive strategies. They proposed that when measuring the effect of persuasive strategies, designer researchers should map the strategies one by one on with the interventions. This is because personalization should be defined at the persuasive strategy level, but not on the implementation of the intervention level (Kaptein et al., 2015a; Kaptein et al., 2015b).

## 3 Results and analysis

In this chapter, the three case studies are presented and analyzed. As a result, a framework to create personalized strategies is created. In Section 3.1, 3.2 and 3.3 the early test in ZuidZorg, the Touchpoint concepts on Socialization and nutritious monitoring and Lyngby II Study was analyzed to identify the personalized motivational strategies applied. All three cases are different because of their purpose and stage of development, but they do share a common focus on exploring personalized strategies. A personalized motivational strategy is summarized in Section 3.4 based on a cross-case analysis.

### 3.1 Case 1: early test at ZZ

#### 3.1.1 Case description

This early investigation into the user group aims at discovering to what extent profiles can be created from observed traits and motivators indicative of physical activity behavior to inform strategies for personalized interventions which motivate elderly to live a more active lifestyle. TU/e and ZuidZorg collaborated closely to realize this initial test. A further description of this collaboration and test can be found (See REACH report deliverable D1.2 for information related to the early tests in the REACH project).

A Sedentary lifestyle is threatening the health and independence of the growing elderly population in Europe. Sedentary behavior refers to activities which hardly require any excursion and are done sitting or lying down (de Rezende, Rey-López, Matsudo, & Luiz, 2014). Some examples of sedentary behavior include reading while sitting or lying down, watching TV or working on the computer (de Rezende, Rey-López, Matsudo, & Luiz, 2014). As people age, there is a tendency to increasingly engage in sedentary behavior (de Rezende, Rey-López, Matsudo, & Luiz, 2014). Unfortunately, this contributes to symptoms of frailty (U.S. Department of Health and Human Services, 1996) (Lee, et al., 2012), such as muscle weakness, poor balance, and low bone density, which diminish the independence of elderly by decreasing their mobility (Chodzko-Zajko, Schwingel, & Park, 2009) and increasing their need for care. Though physical activity cannot reverse the natural aging process, an increase in physical activity can make the elderly happier and healthier. Physiologically, physical activity has been shown to improve the elderly's physical ability to perform activities of daily living, by maintaining muscle strength and bone density (Bauman, Merom, Bull, Buchner, & Fiatarone Singh, 2016). In addition, an increase in physical activity has been linked to a decreased risk of chronic diseases (Bauman, Merom, Bull, Buchner, & Fiatarone Singh, 2016). Psychologically, physical activity has been shown to have a positive effect on social involvement, self-esteem, stress reduction, and cognitive functions (Bauman, Merom, Bull, Buchner, & Fiatarone Singh, 2016). This overall increase in well-being can prolong the elderly's independence of care (Warburton, Nicol, & Bredin, 2006).

In this early test, we attempt to learn more about the behavior in terms of the level of activity of the elderly in the Netherlands, recorded traits (Hirsh et al., 2012), such as their Regulatory Focus (REACH report 4.1, pp.) (Brockner & Higgins, 2001), and by observing whether they seem to act on intrinsic or extrinsic motivation (Ryan and Deci, 2000). Observations about participant behavior, traits and motivation can be examined to create profiles which can aid innovators in knowing how to address their audience to most likely achieve the target behavior change.

### 3.1.2 *Related motivational strategies and personalized motivational challenges*

For elderly, barriers to engaging in physical activity relate to factors such as their ability, or physical competence, their willingness to engage in physical activity and the lack of external drivers or triggers. For example, difficulty walking or a fear of falling may decrease the likelihood of an elderly person to engage in regular physical activity. Likewise, if there is no external party, for example, a neighbor or pet dog to trigger going for a walk, chances are the elderly will continue reading or watching TV instead of going for a walk. While a lack of these physiological and psychological motivators can become barriers to physical activity, these barriers can also become the motivators of increased physical activity. If there is the external motivation of a pet dog or regular walking club then an elderly person may be triggered to go for a walk. So too, if there is an increased willingness and confidence in one's ability to walk, through use of a walker for example, then it becomes more likely for the elderly to engage in that physical activity.

We used the Regulatory Focus Theory as a simplified version of the 5 personality traits (Hirish et. al., 2012). Hirish et. al. (2012) have provided a questionnaire that can be used to determine whether a person is a prevention or promotion focused person. Using this questionnaire was more efficient than personal interviews to determine each participant's five traits personality.

### 3.1.3 *Approach and method*

We intended to have a random control trial, with 25 people in the control group and 25 people in the intervention group. ZZ extra Greet & Meet center helped us with the recruitment at the two different locations and random selection of the participants. The control group would use the visualization data from the existing Mi Band App to visualize their progress, while the intervention group would receive a newly developed visualization of their progress created by a self-made App by the researchers based on strategies from persuasive system design (Oinas-Kukkonen & Harjumaa, 2009).

The test lasted about three months from Feb 2017 to May 2017. During the test personal trait information was collected including participant age, gender, their perceived age ('what age do you feel?'), perceived health ('how healthy do you feel?' on a five-point scale), participant stage of change and their Regulatory Focus. Data on behavior was collected through a cultural probe in the form of a daily diary (which included a combination of closed and open-ended questions, see Figure 3-1) and step data from a technological probe. In order to collect the data from the technological probe and to gain a richer contextual understanding of the information gathered in the diaries, researchers planned to organize biweekly workshops with the control and intervention groups, respectively at the ZZ Extra Meet & Greet center locations as part of their activities at the centers. These workshops were also planned to deal with lack of smartphone usage and lack of knowledge of using technology probes of this target user group. The Xiaomi Band (Mi Band), a wearable activity tracker, was the technological probe used, tracking activity level in the form of the number of steps per day. For data registration, ZZExtra provided us with a number of smartphones. The number of available phones was however not enough to assign every participant with a phone for both the control groups. We used then AppClone (Rehan, 2016) to connect more than one Mi Band to one phone. The diaries asked participants to list or check a list of their activities to contextualize step data collected from

the technological probe. In addition, the diaries asked participants to reflect on their emotional state and how busy they felt in order to better understand participant’s attitude. In the end, an open-ended question was asked to inform the participants’ attitude and provides room for them to explain their activities and motivations thereof further.

The image shows two pages of a diary form. The left page contains questions 1 through 6, and the right page contains question 7 and a footer.

**Page 1 (Left):**

- 1) Wat zijn de belangrijkste activiteiten die u vandaag gedaan heeft? (meerdere aankruisen mag)**
  - boodschappen
  - commissiewerk
  - wandelen
  - op bezoek geweest
  - hond uitlaten
  - fietsen
  - bezoek ontvangen
  - schoonmaken
  - koken
  - dagje uit
  - oppassen
  - handwerk
  - spel:
  - anders, namelijk:
- 2) Hoe leuk vond u vandaag?**

1 2 3 4 5  
helemaal niet leuk heel erg leuk
- 3) Waarom vond u dat?**
- 4) Hoe druk vond u vandaag?**

1 2 3 4 5  
helemaal niet druk heel erg druk
- 5) Waarom vond u dat?**
- 6) Hoe fysiek inspanned vond u vandaag?**

1 2 3 4 5  
helemaal niet inspanned heel erg inspanned

**Page 2 (Right):**

- 7) Wilt u nog iets delen over uw dag (bvb wat was er bijzonder?)**
- Multiple horizontal lines for writing.
- Footer: RESPONSIVE ENGAGEMENT OF THE ELDERLY PROMOTING ACTIVITY AND CUSTOMIZED HEALTHCARE

Figure 3-1 Example of the contents of the diary book

Given the time available for this report, only an initial analysis was performed and reported here. The analysis was performed in two different steps with the focus on getting a better understanding of the differences in physical activities related to different profiling factors. The data analysis was aided by Nvivo, software for qualitative analysis, to perform a thematic analysis first. The thematic analysis was performed based on a number of pre-defined categories such as extrinsic and intrinsic motivation and behavior (types of physical activities based on their intensities) based on the literature review related to personalized motivational strategies. After that, differences in behavior were analyzed in relation with the other clusters to draw conclusions about the importance of personalization in motivational studies in this context.

### 3.1.4 Results

In this section, we endeavor to report on the results this as yet ongoing analysis has yielded. Initially, 52 people were recruited for the test and planned for the workshop and diary studies. When the test progressed, a number of participants felt too obliged or were ill and did not want to participate anymore. In total 13 participants did not complete the workshop sessions, but we managed to collect diaries from 44 participants. The use of the pairing App AppClone and the unexpected absence of the participants at the planned workshops caused some step data loss in the test. In addition, the unknown bugs in the self-made App caused other data lost with the intervention group. The intended random

control trial analysis was thus not feasible. Eventually, only step data from 15 participants of the control group were collected properly of the entire test period.

Qualitative analysis of collected diaries

Utilizing a word-search function in Nvivo much of the collected qualitative data could rapidly be coded for a thematic analysis. As such the number of instances that certain phrases related to the pre-defined categories were mentioned in diary entrees could be counted. In the table below, an overview of the phrases used in analyzing the data is listed. We just started the analysis, these phrases will be further refined as we progress. Table 3-1 below listed the words and phrases used in the initial word search analysis in Nvivo.

**Table 3-1 Categories used to categorize the qualitative data from the diary study during the early test at ZZ**

Behaviour			Motivation Extrinsic		Motivation Intrinsic	
High Intensity	Moderate Intensity	Low Intensity	Structured activity	Involvement	Dependant on others	Independent living
hometrainer	lopen	tv	groep	man	heeft mij geholpen	strijken
fitness	wandelen	lezen	club	Buurvrouw	hielp	was opvouwen
gym	golf	administratie	gilde	Buuren	"gaat mij helpen"	administratie
Tennis	gelopen	tvkijken	altijd	Buurman	"hebben mij geholpen"	betegeld
fietsen	poetsen	gelezen	clubgenoten	vrienden	hulp	op gepast
fitnesstraining	gepoetst	tv gekeken	vrijwilligerswerk	vriendinnen	"kan ik niet"	overleg
gefietst	schoonmaken	boekje	clubje	vriendinnen	"lukt niet"	gewerkt
getennist	schoongemaakt	zitten		vriend	"hulp nodig"	
fietsen	wandeling	gezeten		alleen		
gedaan	gewandelt	koken		boodschappen		
fitgym	gedaan			familie		
	boodschappen			zoon		
				dochter		
				kleinkinderen		
				vrouw		
				kleinzoon		
				kleindochter		
				schoonzoon		
				schoondochter		
				zus		

Since the analysis is ongoing, we will only report the initial analysis results here. Firstly we will look at the diary study and then move into the Mi Band data.

The table below demonstrates how many times the participants of different genders mentioned physical activities of different levels of intensity they undertook in their diaries.

**Table 3-2. Number of references to physical activities with different level of intensities made by participants with different gender**

	High level	Moderate level	Low level



Male	226	232	341
Female	345	771	936

Since the data does not suggest normality, we applied non-parametric test correlation analysis using Spearman’s rho correlation efficient based on bootstrap. It was found that the female participants tended to undertake more diverse physical activities with different intensity levels than male participants in general (Spearman’s rho=0.878) with 95% confidence. This result suggests that gender is an important factor to differentiate elderly people when considering promoting physical activities. In the table below, the number of references made by participants, who varied in their perception of their health, are compared to the physical activities of different levels of intensity.

**Table 3-3**Number of references to physical activities with different level of intensities made by participants with different perceived health

	High level of intensity	Moderate level of intensity	Low level of intensity
Perceived Health = Not Healthy at all	4	20	10
Perceived Health = Not Healthy	5	35	14
Perceived Health = Reasonably Healthy	257	488	463
Perceived Health = Healthy	175	341	311
Perceived Health = Very Healthy	211	477	309

Since the data does not suggest a normality, we applied non-parametric test correlation analysis using Spearman’s rho correlation efficient based on bootstrap. It was found that participants with higher perceived health tended to undertake more diverse physical activities with different intensity levels than those with lower perceived health (Spearman’s rho=0.698) with 99% confidence. The level of intensity was found insignificant related to the number of phrases made by the participants referring to the physical activities at different levels (Spearman’s rho=0.265 with 99% confidence.). This implies that more active elderly participants did not necessarily engage in activities with a higher level of intensity. This is also understandable since the elderly we worked with were those frail elderly who could not take highly intense physical activities. These results suggest that when aiming at personalization strategies for promoting physical activities among elderly, self-efficacy is an important factor to be considered; frail elderly with high autonomy will engage in more diverse physical activities with not necessarily high level of intensity (competency).

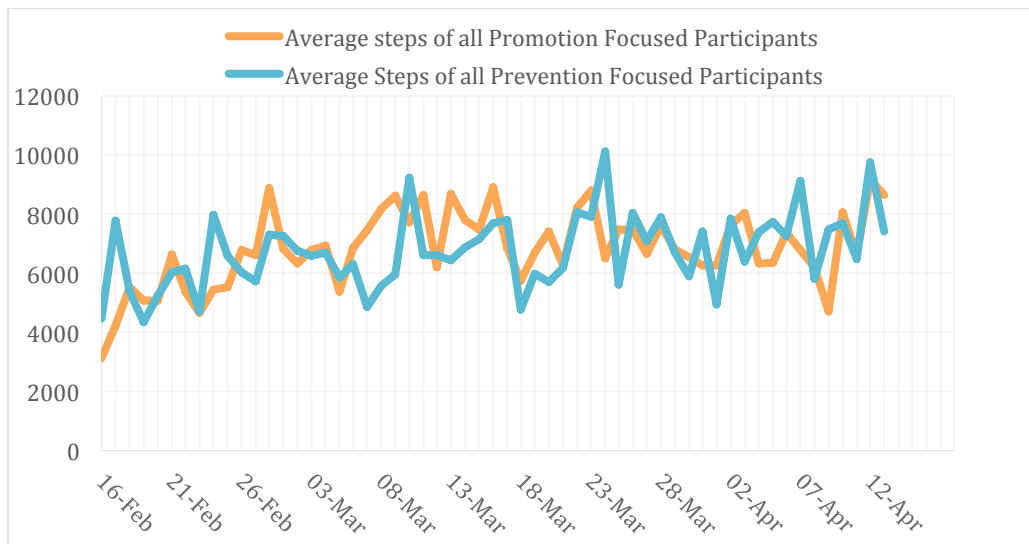
In the table below we listed the number of steps taken by the 15 participants in the control group, with their promotion and prevention focus, and the month when these steps were taken.

**Table 3-4** The average number of steps that promotion-focused participants and prevention-focused participants took during the test

Month	Average steps of all Promotion Focused Participants	Average Steps of all Prevention Focused Participants
Feb-17	3117	4473
Feb-17	4234	7776
Feb-17	5524	5366
Feb-17	5063	4338
Feb-17	5059	5248

Feb-17	6618	6026
Feb-17	5364	6161
Feb-17	4651	4703
Feb-17	5434	7977
Feb-17	5528	6593
Feb-17	6779	6024
Feb-17	6613	5727
Feb-17	8871	7295
Mar-17	6828	7244
Mar-17	6313	6754
Mar-17	6788	6594
Mar-17	6926	6691
Mar-17	5382	5849
Mar-17	6845	6296
Mar-17	7441	4848
Mar-17	8164	5557
Mar-17	8611	5951
Mar-17	7714	9225
Mar-17	8644	6614
Mar-17	6190	6612
Mar-17	8692	6426
Mar-17	7795	6869
Mar-17	7465	7152
Mar-17	8898	7677
Mar-17	6853	7784
Mar-17	5732	4771
Mar-17	6683	5971
Mar-17	7416	5696
Mar-17	6254	6177
Mar-17	8204	8064
Mar-17	8799	7897
Mar-17	6505	10118
Mar-17	7461	5613
Mar-17	7475	8027
Mar-17	6650	7076
Mar-17	7600	7877
Mar-17	6791	6686
Mar-17	6530	5888
Mar-17	6253	7415
Apr-17	6259	4931
Apr-17	7615	7843
Apr-17	8025	6398
Apr-17	6314	7392
Apr-17	6353	7727

Apr-17	7362	7245
Apr-17	6768	9105
Apr-17	6202	5794
Apr-17	4692	7471
Apr-17	8061	7690
Apr-17	6598	6474
Apr-17	9160	9746
Apr-17	8637	7404



**Figure 3-2 Average steps of all promotion and prevention-focused participants measured**

In order to learn whether there is a difference in the number of steps taken by elderly participants with different regulatory focuses (promotion focus vs prevention focus) and at different moments (Feb, March, and April) in the test period, we conducted a linear regression analysis. The resulted ANOVA table below suggested that the linear relation does exist.

**Table 3-5 ANOVA**

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	26081630.292	2	13040815.146	9.273	.000 <sup>b</sup>
	Residual	156103480.699	111	1406337.664		
	Total	182185110.991	113			

The significant test of the coefficients in the linear model below reveals that there was a significant correlation between the number of steps taken and the moment that they were taken. We think this has to do with the fact that more physical activities were taken when the weather condition is improved. It was found that there was no significant influence of the RFT results on the number of steps taken by the participants. This is also understandable since all participants in the ZZ extra Meet & Greet center have a Tilburg Frail Index >5. This result suggests that when the participants have all relatively low physical capabilities, the personal profile related to RFT has limited influence on the number of steps that the participants would take.

**Table 3-6 Coefficient analysis**

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	5487.606	481.189		11.404	.000
	month	705.846	164.454	.377	4.292	.000
	RFT	-78.193	222.138	-.031	-.352	.726

We are still in the process of analyzing the data. These promising early results will encourage us to continue analyzing these findings. The results will be discussed at a later date in a paper that aims to provide advice on how to formulate personalized motivational strategies to inform behavior change. However, we will also bear in mind that there are also limitations related to the data analysis here. The coding of the data may be still inappropriate and incomplete. The number of available quantitative data is still limited. The analysis is not yet comprehensive. We will iterate on this through continuous analysis and in the next test under planning.

### 3.2 Case 2: Touchpoint Socialization and nutritious monitoring and intervention

#### 3.2.1 Case description

This Touchpoint concept aims at creating personalized systems to stimulate healthy eating habits through socializing and nutritious monitoring and intervention. TU/e, BioZoon, ZuidZorg and Philips Design work closely together to develop this Touchpoint concept. The first concept description and related technical structure can be found in report WP 1.3 pg. and WP 1.4 pg.

Malnutrition refers to deficiencies, excesses or imbalances in a person's intake of energy and/or nutrients. The term malnutrition covers 2 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). In this Touchpoint concept, we will address the malnourishment aspect of malnutrition.

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 institutionalized 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). De Groot et al. specified, that 24% of elderly men and 47% of elderly women in Europe have an inadequate food intake (de Groot et al., 1999). Nieuwenhuizen et al. reported that the numbers of malnourished elderly in long-term care home residents are 85% (Nieuwenhuizen et al., 2010). Most of the elderly lose about 10% body weight over 10 years (Donini et al., 2003). Swallowing problems are common among the elderly. 13% of elderly living in residential homes suffer from swallowing difficulty, while among hospitalized individuals this percentage is 25%. The percentage of elderly with swallowing difficulty is huge in nursing home facilities where this percentage is at least 60% (Chichero, 2013). Such swallowing disorders can lead to malnutrition but malnutrition can also lead to

swallowing difficulties (Lieu, et al., 2001). Other conditions which can lead to dysphagia are strokes, motor neurone disease, Parkinson's disease, dementia, head and neck cancer and head injuries (Chichero, 2013). Due to the increasing number of the elderly population, malnourishment is going to become increasingly important (Chen et al., 2001).

### 3.2.2 *Related motivational strategies and personalized motivational challenges*

There are two types of eating drivers in our brains: homeostatic and hedonic control of eating (Saper et al., 2002). Homeostatic control of eating, often referring as reflective eating, relates primarily to the regulation of energy balance: how much should we eat to maintain an energy balance of the body. This control of eating is a cognitive/rational act and can be sometimes considered tedious as eating is considered as surviving. Hedonic control of eating, also known as reflexive eating, on the other hand, focuses on the reward-related 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, understanding of both homeostatic and hedonic control of eating is necessary to stimulate better food intake.

According to Donini (et al., 2003), elderly malnourishment relates very much to three different factors, i.e. pathological factors, physiological factors, and psychological factors. Pathological factors relate very much to the loss of appetite because of medication (Donini et al., 2003; Chandra, 1991), chronic diseases (Amarantos et al., 2001), and age-related hormonal regulation (Donini et al., 2003). Under the influence of medicines, there is lack of desire from the homeostatic control of eating and consequently leads to an insufficient amount of food intake. Physiological factors refer to those 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). In the food technology innovation, many solutions have been developed to deal with for example the chewing and swallowing challenges. However, food intake is not always motivated due to the unattractive appearance, modified texture and lacking taste of pureed food (Mertz Garcia& Chambers, 2010; Wright et al., 2005). The desire from the hedonic control of eating is therefore reduced because of the reduced food stimuli. Psychological factors relate very much to the emotion of the elderly. According to Paguet et al., 2003, people will have a higher calorie intake if they have a positive emotion. Especially when elderly eat alone 30% fewer calories are acquired than in company (Donini et al., 2003; Chen et al., 2001). Besides eating alone a change in their comfortable habits can also cause negative emotions in elderly which may lead to eating less. Specifically, when they move into institutions, they have to give up their own cooking habit and completely rely on supplied food (Donini et al., 2003). Furthermore, lack of knowledge about healthy eating can also be a reason for inadequate food intake (Soederberger Miller & Cassady, 2012; Chandra et al., 1991). These three factors discussed above are highly related. People who can't take normal meals because of pathological and physiological reasons often feel more isolated. They do not want to eat in groups anymore because they are ashamed of their situation and this can lead to worsening of the impact of the psychological factors. These psychological factors can reduce both homeostatic and hedonic control of eating.

In Report of REACH WP1.2, a few motivation strategies have been identified. In the report of REACH WP4.1, these strategies have been further discussed and applied to the Touchpoint development including TP3. It was discussed there, for example, gamification can be applied to turn food intake into a fun and interesting activity so as to stimulate hedonic control of eating. A social incentive is a very useful strategy to be applied, for

example, by influencing how the food is made, served and consumed, on hedonic control of eating. Goal-directed behavior could be applied turn the food intake into a number of smaller tasks. In this way, elderly could reach their food intake goal in a few steps and re-establish the homeostatic control of eating. Self-reflection/self-efficacy can provide awareness and feedback to elderly people about their food intake so that they can re-establish their homeostatic control of eating.

In summary, elderly people with different pathology, physiology and psychology factors related to healthy eating behavior need different motivational strategies in order to deal with different homeostatic and hedonic control of eating at an individual's level accordingly.

### 3.2.3 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, created by bachelor student Laura Power from TU/e together with a group of elderly people in an activity center. This was already reported in the report of WP4.1. We applied social incentives and self-reflection/self-efficacy in this concept to promote healthy eating behavior among elderly. SMAAK is a temporary service intervention to rekindle the interest of elderly people's interest in food. SMAAK stimulates seniors to make and share recipes. It also introduces new foods to fit into their diet and lifestyle, to address the growing problem of malnutrition. Below this concept is explained shortly.

Firstly seniors enjoy a social, fun and educational tasting experience organized by their local community or activity center. Each tasting experience revolves around a theme. Here seniors try samples of healthy food with nutritious ingredients that they are not used to yet. These samples should be made adhering to the guidelines to make eating more attractive and incorporate nutritional components for elderly. Whilst trying these samples, organizers of the activity, such as healthcare students, can teach seniors about the health benefits of ingredients and food types. Seniors also participate in playful quizzes related to the samples and rate each sample by choosing a happy, straight or sad face, for example. The event is relaxed and participatory for all seniors involved. During the tasting experience, organizers can create a profile for seniors on the platform, SMAAK. Each senior is guided through the platform and provides the input about their food, dish, cooking style, time and difficulty preferences as well as any allergies or health conditions. The organizer sends the data to the platform and uploads it to a SMAAK-card that is then personalized to that senior. This information can be updated or edited at the following tasting experience one month later. Elderly could try the recipes at home and share the results photos via the SMAAK-card with the platform and other elderly. During the TP meeting in May 2017, the Touchpoint development team agreed to further explore the potential of this concept together.

In the meantime, based on the literature review on motivational strategies, Biozoon has conducted 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.

### 3.3 Case 3: Lyngby II Study for game and play

In this section, the Lyngby II Study is reported.

#### 3.3.1 *Introduction to the Lyngby II Study*

Information in this section is primarily based on the Lyngby II Study, where 9 older adults equipped with both Fitbits (step and heart rate monitor) and SENS patches (sensors that detect movements) participated in 8 weeks of training on the Moto tiles. The Moto tiles are tiles that light up and react when pressed, they allow for making different kinds of games that require the user to use the body and mind in order to complete.

The project investigated if the training would result in more movement outside of the training and better scores in physical ability tests. Data about motivation was collected from observations during the intervention and post-training questionnaires and semi-structured interviews.

The project builds on the understanding that play can motivate participants in a way that only convincing them about the benefits of training is not able to do. Earlier studies have shown that the participants forget about time and place and there are indications that they make movements they normally try to avoid, strengthening their overall physical abilities.

#### 3.3.2 *Data collection*

The participants of the intervention were interviewed in a semi-structured interview with focus both on their understanding of what it is to be active, what their days look like when they are active (what are they doing), how important equipment, weather and social settings is to how active they are, and how they could be motivated to be more active.

The questionnaire was focused on the intervention, how they judged the outcome, the motivational aspects and issues of privacy and sharing.

The observational data is based on observations of elderly playing on the Moto tiles. How they engaged in the games, how the social aspects influenced the elderly and how they were motivated by the games.

#### 3.3.3 *Results*

The results of the intervention can be divided into interviews, questionnaires, and observations.

##### Questionnaire

The results of the questionnaire show that the participants enjoyed being part of the project (all agree or strongly agree), they found the training fun (8 agree or strongly agree, 1 neither agree or disagree), 6 associated the training with better balance. However, only 2 found that they believed the intervention made them train more than they would otherwise do, and only 2 also believed the games had motivated them to train harder or move more than they would otherwise have done, while 3 found that the intervention had made them more active.

## Interviews

The interview showed that the main reasons for being active outside of the home/garden was shopping. Yet visiting friends and family are also important. Some of them also pointed to nature and cultural events as things that motivated them to move around and be active.

Inside the home, they pointed to tidying-up as a main source of training.

For those that had a garden, this motivated them to get out and be active during the summer.

The interviews also investigated if the participants were interested in reminders that would remind them to move more. The 7 of the participants had a positive attitude towards reminders from e.g. the Fitbit. Two of the participants didn't want this kind of "pressure" to be active, mainly because they believed they were active enough already.

Of special interest was the fact that several of the participants didn't notice any significant change, but several pointed out that friends and family had told them, that they were able to move more freely than before the intervention. This is also in line with the results from the physical abilities test that show improvements above the minimally detectable change score. This must be regarded as an important finding because it indicates that self-reporting about physical improvement is not a credible measurement. The finding is in line with the observations described below

## Observations

During the observations, it was clear that the participants move around in another way than what was observed during the initial screening. The indicators for this was the engagement in the games, where the participants took longer steps, played with less and less assistance (two hands to begin with and only one, in the end, some almost with no help). The play element was also one indication of the fun of the sessions.

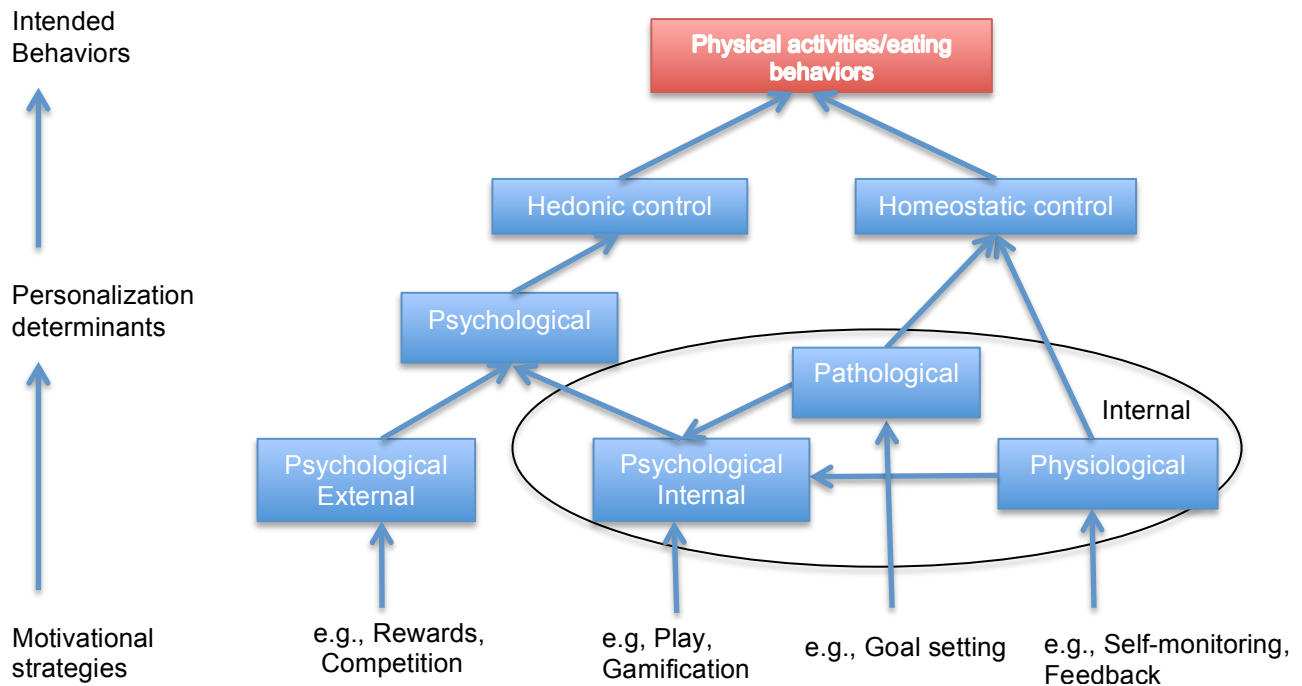
### *3.3.4 Discussion*

The questionnaire data was too small to make any valid conclusion. When combining it with the observation data, the results suggest that fun and play are very important factors to stimulate more physical activities at structured sessions (organized play as in the play). The findings of this study suggest play is an important intrinsic motivational factor and the motto playware tiles were able to create this intrinsic motivation. Unstructured activities such as shopping, visiting friends or family, participating nature and culture events could also stimulate more physical activities. Most of the participants were positive towards the reminders for being active. In the Lyngby I pilot trial reported in WP1.4, it was investigated how performance feedback would affect the participants. The conclusions there was that although there was no increase in the number of steps, but the participant answered that the feedback had a motivating effect.



## 4 Personalized motivational strategy model discussion and generalization

Based on the three cases discussed above, we created to a visualization below to illustrate the envisioned personalization strategies model to promote physical activities and healthy eating behaviors among elderly people.



**Figure 4-1 Visualizing personalized motivational strategies, a proposal**

Hedonic theory or theory of psychological hedonism (Ahtola, 1985) argues that human behavior is motivated by pursuing pleasure and avoiding displeasure. Homeostatic control comes from the concept of homeostasis (Cannon, 1932) and it describes how any person responds to a threat of physiological challenges such as stress or hunger and comes back to a stable equilibrium. These two types of control apparently co-exist in human behaviors related to physical activities (Ekkekakis and Dafermos, 2012) and eating behaviors (Saper et al., 2002). From the cases and literature discussed, we learned that hedonic control is very much influenced by psychological factors including both internal and external factors. For example, the elderly start to eat less when they move into a care home and no longer cook themselves (external) or when they eat alone (internal) (Donini et al., 2003; case 2); the elderly enjoy family visits (external) and go out to cultural events (external) (case 1 and case 3); the elderly enjoy the play and fun very much when engaging in physical activities (case 3). We also learned that homeostatic control is regulated by the ability that a body physically coordinates the process of responding to physiological stresses, coming from pathological and physiological problems. For example, elderly can lose their appetite for food due to certain medications (Donini et al., 2003; Chandra, 1991); elderly participants dropped off the early test at ZuidZorg extra due to health problems (case 1). Literature and our cases suggested using different motivational

strategies for different situations. For example, play and gamification are often applied to make the physical activities more fun to do (case 3) and the pureed food much interesting to take (Mertz Garcia& Chambers, 2010; Wright et al., 2005; case 2). Rewards were used in case 2 as a form of social participation to motivate more physical activity. Food can be arranged in small attractive portions with more frequent meals to accommodate physiological problems (case 2). Elderly can be supported with self-monitoring devices to receive feedback on their progress (case 1 and 3).

The envisioned model for personalized motivational strategies development for REACH needs to be further fine-tuned and evaluated. The early test team in Eindhoven is working a new test plan to further test and develop this model. Its psychological theoretical fundamentals on hedonic and homeostatic control do not relate to specific Touchpoint development, although started from the Touchpoint 3 concept development. This model can be therefore in theory extended to other Touchpoint concepts development. Therefore we made an attempt to apply this model to all other Touchpoint concepts and summarized them below based on Table 4 Overview of behavior change strategies and models applied per Touchpoint, made by the REACH report deliverable D14: Theory-based motivational behavior change strategies for the REACH project on pg. 71. The results are listed below.

**Table 4-1 Envisioned personalized motivational strategies for different Touchpoint experiment/concepts**

Touchpoint	Short description of experiment/concepts	Hedonic /Homeostatic control	Personalization determinants	Motivational 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) An individual intervention programme can be quickly implemented to protect the elderly against progressive inactivity (physical activity/personal mobility device) Result: staying at home for as long as possible, protecting against unwanted hospitalization.	Hedonic	Psychological intrinsic	Gamification	
				Self-reflection/self-efficacy	
				Social incentives	
		Homeostatic	Psychological intrinsic/extrinsic	Barriers removal	
				Psychological extrinsic	Incentivisation
					Persuasion
Homeostatic	Physiological	Pathological	Goal-directed behavior		
		Physiological	Training (virtual coach)		
Active environment (TUM) 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	Hedonic	Psychological intrinsic	Gamification	
				Social incentives	
Socializing and nutrition (TU/e, Biozoon)	No experiment was conducted yet. Only conducted early user research through interviews and first ideation	Hedonic	Psychological intrinsic	Self-efficacy	
				Social incentives	
Gaming and training system (TU/e, with	4 elderly tested a set of Playware tiles and a	Hedonic	Psychological intrinsic	Playfulness	

DTU)	game (called Color Race) to demonstrate how play facilitates intrinsic motivation of physical movement		Psychological extrinsic	Social influence
		Homeostatic	Physiological	Immediate feedback (light off/on)
Wearables (TU/e early trial)	Testing Mi Band with elderly people at activity center to learn how to improve wearable technology adoption by elderly people	Hedonic	Psychological intrinsic	Gamification
			Psychological extrinsic	Social support

For example, for personal mobility Touchpoint concept (See report deliverable WP1.4), we learned that gamefication is used to turn tedious exercises into fun activities so that the patients can overcome the psychological barrier of adopting these exercises. This is a personalization motivational strategy to promote physical activity through hedonic control when there is a physiological challenge. Therefore, this model, according to the lessons learned at the moment, deserves further exploration and validation.

As already known, the strong sensing and monitoring capability enabled by the REACH Engine concept is crucial to provide early detection and warning to unexpected accidents of elderly daily living. Once the behavior data is being collected, the REACH system will be able to identify patterns and predict future behavior; subsequently, interventions provided by REACH touchpoint concepts can then help promoting more physical activities. The continuously collected insights through early detection will support step by step the realization of the motivational strategies for each individual for a sustainable behavior change towards an active lifestyle.

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