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Abstract

Building up and sustaining the motivation for tasks where short-term convenience has to be traded for greater long-term benefit is notoriously difficult. In a world of increasing obesity, stress and other unhealthy practices, new technological capabilities play an important role in motivating individuals towards behavioural change, especially when aiming for preventive interventions. This type of intervention requires a multi-disciplinary approach that integrates psychological knowledge into the domain of e-health applications. The present document represents the interim motivational and design aspects of the PRECIOUS system and service implementation. It provides information on relevant theories used within the areas of motivation, behaviour change and gamification research, which are used within PRECIOUS. The document also suggests a service design that will enable the translation from a health

risk factor to an intervention strategy. This service is centred on the motivational forces involved when trying to improve and change health-related behaviour.

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List of Acronyms

API	Application Programming Interface
BCT	Behaviour Change Technique
COT	Causality Orientations Theory
EPLOC	External perceived locus of causality
ESM	Experience-Sampling
FI	Food-Intake
FoMO	Fear of Missing Out
GCT	Goal Content Theory
HBM	Health-Belief Model
HP	Harmonious Passion
IPLOC	Internal perceived locus of causality
MI	Motivational Interviewing
OIT	Organismic Integration Theory
OP	Obsessive Passion
PA	Physical Activity
SDT	Self-Determination Theory
TPB	Theory of Planned Behaviour
TRA	Theory of Reasoned Action
TTM	Transtheoretical Model
UI	User Interface
UTAUT	Unified Theory of Acceptance and Use of Technology
VIM	Virtual Individual Model

Executive Summary

This report provides an incremental approach towards a final motivational design regarding the functionality, motivational and design aspects of the PRECIOUS system, which will be implemented throughout the project. The initial creation of a motivational framework involved the review of motivation, behaviour change and gamification theory and background, which has resulted in the identification of a number of useful principles that will be incorporated into the system.

A highly modularised approach has been selected for delivery of an individualised motivational framework. Individual applications, each possessing different intervention methods and behaviour change techniques, will be selected dynamically and recommended to the user depending on selected factors from the Virtual Individual Model (VIM). These applications will operate under a common motivational framework, including a self-efficacy focused goal guidance system and a global, gamified reward system. A recipes module will guarantee full transparency and furthermore enable the user to fully customise the PRECIOUS environment via rules.

This report also presents potential ideas for (gamified) client applications along with conceptual User Interface Designs depicting manifestations of the system in order to better understand the modularisation concept.

Further work is required in order to connect and link the framework illustrated in this report with the technical aspects and implementation of the system. In addition, next steps comprise extensive empirical validation of the onboarding process of users into the system, goal guidance system and other sub-elements of the motivational framework as well as user-interface (UI) usability tests.

1. Introduction

1.1 Motivation & Problem Statement

People are creatures of habit, especially when it comes to health, when the benefits are often not fulfilled for some time. For example, the motivation gained by a New Year's resolution to exercise more often or lose weight is typically lost by the end of January when life returns to normal and previous habits are adopted again. Additionally, high amounts of stress can lead an individual to revert back to maladaptive health behaviours [1]. Since people tend to cultivate an unrealistic optimism about their own susceptibility to health problems [2], these findings are not surprising. Honest and upright motivation is the key to successfully changing one's health behaviour for the better, even when the change of behavioural patterns is lengthy and tough.

External interventions can help individuals through health related behavioural changes, but current health behaviour models, including those applied by e-health applications, do not entirely meet the complex and multidisciplinary demand of users. First of all, the static nature of most models appears to be a poor fit with the challenges of modern lifestyles [3], because they inadequately account for the dynamics behind behaviour change. Whilst most models have also been used to tailor interventions based on pre-determined clinical guidelines and recommendations, the delivered interventions do not always adapt to the individual throughout the intervention. A successful model has to take into account different needs, not only between persons, but also within persons over time. A modern model has to develop tailored mechanisms that use real-time assessments of health behaviour and status to deliver an adapted health intervention with the right content, at the right time.

Even though adaptivity can increase the efficacy of potential interventions, long-term sustainability of behaviour change is not guaranteed if the user is lacking honest and upright motivation for actual change. To solve this, a successful system design has to overcome several problems and challenges.

Firstly, the user is often lacking trust in the privacy and security of health applications. This trust has to be established with transparent communication of the policy on data storage, processing, sharing and deletion. However, conflicting goals of developers or companies and the users can contribute to the complexity of this problem. Where companies may want to monetise the gathered data, users would typically prefer to keep their sensitive data private.

Secondly, all too often health applications do not have a scientific validation for their health interventions. Since the e-health market is booming, even apps that do not utilise any scientific or professional expertise have the potential to become successful, which may lead to users adopting sub-optimal practices.

Third, most health applications are not tailored to the user's individual needs or motivational baselines and only provide a standard solution. Therefore, we argue that professional e-health systems have to centre their attention on the individual user rather than on general strategies in order to sustain motivating effects towards health practices. Users may differ in

their personality, stage of life, socio-economic environment, goal progress, actual goal choice and expectations when using an application.

Finally, decreasing one's own health risk factors requires a multitude of different strategies. In order to acquire the necessary feature set for the desired change, users need to find, test and evaluate different applications to find those most suitable for their needs. Subsequently, these applications operate independently from one another and hence do not pursue a common behaviour change strategy. The market is currently cluttered with a wide variety of different health apps, but a holistic, motivational framework is lacking. The ability to deliver a fully individualised strategy, which combines motivational, behaviour change, health and technical aspects, should enable users to achieve their goals.

1.2 Contribution

Until now psychological theories and technological capabilities for optimally motivating users towards behavioural change have been insufficiently bridged in academia and industry. This deliverable reports the basis for creating the required holistic, motivational framework for e-health by systematically covering essential background literature as well as transferring these insights into guidance for optimising the user interaction and user experience. We then focus our attention on the areas of food-intake (FI), physical activity (PA), stress and sleep quality.

Building up and sustaining sufficient levels of motivation, to maintain and support health lifestyles in the long-term, is one of the most challenging tasks for systems, services and apps in the area of health and well-being.

We will construct an interim motivational framework, keeping in mind both psychological and technical constraints, by targeting the following three primary contribution blocks:

- Firstly, this report will deliver an overview of the scientific background of existing theories in the field and subsequently derive a number of empirically validated principles and guidelines in order to design a framework capable of bridging the areas of motivational theories, behavioural science, as well as gamification aspects, which will be used as a basis for the system and intervention design.

- Secondly, as the aspect of tailoring and individualisation has been strongly emphasised in health behaviour interventions, a working motivational framework has to be built upon the individual. Therefore, part of this report highlights the challenges involved when dealing with users with different backgrounds, cultural values, demographical variables and different baseline motivations

- Thirdly, the report presents a proposal for a unified system design, where individual apps can work seamlessly together under a single motivational umbrella to jointly work towards health improvement, thus giving maximal attention to the individualisation aspect. Furthermore, a conceptual UI design is presented leveraging the principles that have been discovered thus far. Starting from a goal guidance system, this report describes the processes involved when interventions are suggested to the users, including a number of concrete ideas for gamified client

applications, which can be embedded within a single framework. This also comprises a modularisation of behavioural change techniques, as well as a standardised global reward system, which will be used to attribute achievements of the user depending on various factors. Furthermore, the goal was to create the motivational and intervention design in a fully transparent way to the user, which is propounded in the form of a fully customisable recipes module.

In the light of above, the goal of this report is to depict the interim big picture of the motivational design of the PRECIOUS system, including aspects from both system and UI design. The outcomes will serve as inputs for the technical realisations in WP4 and economic considerations in WP2.

This interim report presents work in progress, which will require subsequent iterations and empirical validation, in order to result in the final motivational framework. Currently, the collection of multiple inter-disciplinary viewpoints has been in focus, in order to derive a from the ground-up solid motivational system.

2. Relevant Work and Background

2.1 Introduction

This section of the report serves as a starting point for the development of a motivational framework, comprising the theoretical underpinnings of relevant psychological motivation and change behaviour theories in the context of both health domains as well as gaming and gamification related fields. More precisely, it aims to provide a fundamental comprehension of the background of various theories, which are relevant in the context of this project. This is important in order to understand the benefits that can be derived when implementing client-specific applications, which take into account not only usability and functionality, but also the potential psychological elements. This approach is designed to facilitate the final goal of changing and maintaining a desired health behaviour.

The recent development of the so-called "quantified self", or personal informatics [4], has started a new area in mobile health technologies, enabling people to explore and reflect on information regarding their own health data. Some health or well-being applications take this concept a step further and introduce game-like presentation of this information [5][6], along with virtual rewards and incentives. This can increase the user's motivation to start and maintain healthy behaviour, but also improve integration of the services offered within the user's daily life; thus locking them onto platforms. These often-conflicting goals from a user and developer perspective have often received substantial criticism, particularly within gamification related research [7].

Nevertheless, one of the biggest problems of available applications and services is the lack of understanding for, or the integration of, both motivational and behavioural change theories. A recent study [8] has shown that of 167 applications found on popular mobile app-marketplaces only included, on average, 4 potential behaviour change techniques (range of 1-13) out of the 40 proposed in a taxonomy [9].

It is therefore important to include a psychological perspective when designing a tailored, individualised system like PRECIOUS. This will enable the system to deal with a variety of different users and interests, as well as identifying those instruments capable of achieving long-term and sustained health behaviour change, as compared to short-term behaviour change [10]. In addition this will enhance understanding of why certain interventions that are delivered by apps and games work better than others.

From a scientific point of view, various studies have found evidence for psychological benefits derived from game experiences, such as a sense of efficacy and power over one's environment [11], improvements in learning [12][13] as well as play and sport in general [14]. Intrinsic motivation, as covered in Chapter 2.2.1, is the core type of motivation underlying the fun aspects of a potential service design because they are intrinsically satisfying [15] or what is often referred to as autotelic [16][17]. Furthermore, games have been found to increase people's intrinsic motivation to engage with contexts that have educational material embedded [18]. Therefore, PRECIOUS could also shape behaviour through knowledge about risk factors with regards to FI, PA, sleep and stress.

Research has shown that in various health domains, satisfaction of psychological needs is associated with self-initiated forms of motivation and, for instance, greater participation in PA [19][20][21], improved mental health, health-conductive behaviours and improved physical health [22] as well as adaptive self-regulation of healthy behaviours [23].

Promoting sustained behaviour change represents one of the most difficult challenges facing health care professionals, behavioural and motivational scientists, and the individuals who are trying to make lifestyle changes towards a more healthy behaviour [24].

Thus, as a first step, it is important to understand the reasons for successful behaviour change or failure, and subsequently strengthened or weakened personal motivations for change [64]. This chapter will explain a multitude of different theories from the areas of motivational psychology, behaviour change and gamification. To some extent, each of these theories could be used and integrated within PRECIOUS as they represent complementary approaches [24] with both advantages and disadvantages.

2.2 Motivational Theories

2.2.1 Self-Determination Theory

Self-determination theory (SDT) is one of today's most influential motivational theories. It suggests that it is part of human design to engage in interesting activities, to exercise capacities, to pursue connectedness in social groups, and to integrate intra-psychical and interpersonal experiences into a relative unity, referred to as the concept of self [25] [17].

In contrast to empirically based personality theories, which investigate needs and tend to view them as learned [26], following Maslow's theory of the hierarchy of human needs [27], The SDT considers these psychological needs as innate, reflecting the humans' fundamental trajectory towards vitality, integration and health. It has been postulated that there is a set of universal psychological needs that must be satisfied and which are directly related to the effective functioning of the human being, as well as its psychological health [28]. In return, these needs give peoples' goals their psychological potency and influence which regulatory processes direct their goal pursuits [17].

These basic universal needs have been named **Autonomy**, **Competence** and **Relatedness**.

- **Autonomy** describes the organismic desire to self-organise experience and behaviour, to have activity that is concordant with one's integrated sense of self and to gain as much autonomy as possible over its activities and decisions.
- **Competence** reflects the human's need to seek to control over outcomes and to experience mastery.
- **Relatedness** is the desire to feel connected to others, reflecting the fact that a large number of daily activities happen within a social context.

Cultural differences are, for instance, not explained by a difference in strengths for either of these psychological needs, but instead result from the degree to which these needs have been fulfilled versus thwarted [28]. Recent studies have confirmed the universal importance of SDT need satisfaction in several cultures [29].

SDT as a formal theory defines different types of motivation. It differentiates between **amotivation**, **extrinsic motivation** and **intrinsic motivation**, the most central distinction being the difference in autonomous versus controlled motivation [28]. Whereas intrinsic motivation is regulated internally, extrinsic motivation is regulated externally. Amotivation on the other hand describes the state of lacking an intention to act [28].

Intrinsically motivated behaviours are based on people's need to feel competent and self-determined. It concerns active engagement with tasks people find interesting, which in turn promotes internal growth. Intrinsic motivation is the core type of motivation underlying play and sport [14], because these types of activities are typically executed because they are intrinsically satisfying [15] or what is often referred to as autotelic [16] [17].

There has been a wide debate on which factors, particularly in social contexts, trigger variability in intrinsic motivation. Notably the effect of rewards on intrinsic motivation has been discussed and studied [30]. Cognitive Evaluation Theory, as one of the sub-theories of SDT, aims to explain these factors by different need satisfaction with regards to the basic psychological needs. Within this theory, it is argued that interpersonal events, and structures that evoke feelings of competence during an activity or action, can enhance intrinsic motivation when accompanied by a sense of autonomy [28]. Thus, the individual must have the feeling that their experience is self-determined. This is also often referred to as *internal perceived locus of causality* (IPLOC), a term originally introduced by De Charms et al. [31].

Whereas intrinsic motivation is generally defined as carrying out an activity for its inherent satisfactions, rather than for some separable consequence, extrinsic motivation is a construct that pertains whenever an activity is done in order to attain some separable outcome [32]. The degree to which extrinsic motivation is autonomous can be highly different in every context. This problem is described within SDT in terms of fostering the internalisation and integration of values and behavioural regulations [25].

Internalisation is a central process in socialisation that describes an active, natural process in which individuals attempt to transform socially sanctioned rules or requests into personally endorsed values and self-regulations [17]. Individuals are then self-determined while enacting them, as they are fully accepted as their own within their integrated sense of self.

Different types and degrees of regulation result in different internalisation behaviours. The degree to which internalisation works, is in large part a function of the degree to which fulfilment of the basic psychological needs is supported when engaging in the relevant behaviours. Within the so-called *Organismic Integration Theory* (OIT), another sub-theory of SDT, different forms of extrinsic motivations are detailed along with the contextual factors promoting or hindering the internalisation process.

This taxonomy however represents a continuum rather than a dichotomy [33][34][21]. Generally speaking, with increasing internalisation and its associated sense of personal commitment, greater persistence and more positive self-perceptions, a better quality of engagement can be achieved [25].

Whereas other theories treat motivation as a unitary concept [35] describing an individual as amotivated or motivated, this theory describes four types of motivational regulations,

reflecting differing degrees of autonomy or self-determination [28], or to what degree individuals experience an *external perceived locus of causality* (EPLOC) [31].

External Regulation represents the least autonomous form of regulation and refers to behaviours purely satisfying external demand or imposed reward contingency [28]. Activities or actions resulting from this type of regulation are typically experienced as controlled or alienated and have been subject to study by the well-known operant theories [36][37].

Introjection is a second type of extrinsic motivation and refers to behaviours acting to maintain self-esteem, to avoid guilt or anxiety, or because of ego-involvement or pride. This type of regulation is still controlling, as even though the regulation is internal to the individual, introjected behaviours are not experienced as full part of the self, and thus still have an EPLOC [28].

Identification represents a more autonomous and self-determined form of extrinsic motivation, which relies on conscious valuing of a behavioural goal. The individual has thus identified with the importance of behaviour and accepted the regulation as their own [28].

Integration is the most autonomous form of extrinsic motivation and occurs when identified regulations have been completely assimilated into one's self through self-examination and when these regulations have been fully brought to harmony with one's values and needs. Thus, this type of motivation is very similar to intrinsic motivation. However, behaviour motivated by integrated regulation is primarily explained by its presumed instrumental value rather than the enjoyment of the action itself.

One can initially adopt a new behavioural regulation at any point along this regulative continuum, depending upon personal experiences as well as situational factors with regards to the context in which the behaviour takes place. Therefore there is no necessary sequence with regards to how certain regulation types are internalised.

Even fully internalised extrinsic motivation typically does not become intrinsic motivation. It remains extrinsic motivation because, even though fully volitional, it is instrumental rather than autotelic [17].

Causality Orientations

Causality orientation is part of the *Causality Orientations Theory* (COT) and describes that the degree to which individuals experience self-determinacy in their acting or behaviour ,differs inter-individually [38]. This approach examines an individual's differences towards **autonomous**, **controlled** and **impersonal** causality in the regulation of behaviour.

These three orientations are subsequently representative of general tendencies towards intrinsic motivation and well-integrated extrinsic motivation, external and introjected regulation, and amotivation [17]. In short, causality orientation affects the influence of external events on intrinsic motivation.

Autonomy orientation was found to be related positively to self-actualisation, self-esteem, ego development and other indicators of well-being [17]. People are more likely to act according to their own interests, and thus interpret external events as informational rather than controlled, which results from on-going satisfaction of all three basic needs [28].

Nevertheless, autonomy orientation does not necessarily require the individual to be separate from, or independent of, others.

On the other hand, control oriented individuals act due to external or internal demands and thus perceive external regulating events as controlled, which in turn affects the internalisation process differently when compared to more autonomy-oriented people. Development of a strong controlled orientation results from some satisfaction of the competence and relatedness needs but a thwarting of the need for autonomy [28].

Strong thwarting of all three basic needs satisfaction can result in impersonal orientations reflecting an individual's tendency to view external events as beyond their control, and thus are often associated with helplessness, poor functioning and symptoms of ill-being, such as self-derogation and lack of vitality [28].

According to SDT, people have some level of each of the three orientations, and one or more of these can be used to make predictions about various psychological or behavioural outcomes [28].

Intrinsic vs. Extrinsic Aspirations

Another sub-theory of SDT, the *Goal Content Theory* (GCT), accounts for the fact that attainment of some life goals may provide greater satisfaction of the basic psychological needs than the pursuit and attainment of others, and that those providing greater satisfaction would be associated with greater well-being. Thus, it is concerned with long-term goals that people use to guide their everyday activities. These goals have been found to fall into two categories, namely intrinsic and extrinsic aspirations [39].

Intrinsic aspirations describe community feelings, affiliation, health, and self-development and are distinguished from extrinsic aspirations such as image, financial success, and appearing physically attractive [40].

In general it can be said that some goals are more closely related to basic or intrinsic need satisfaction than others [28]. Within SDT, aspirations are understood to be acquired as a function of the degree to which the basic needs for competence, relatedness, and autonomy have been satisfied versus thwarted over time. Thus attainment of intrinsic versus extrinsic aspirations is also differentially associated with well-being [28].

Some of the avenues to basic need satisfaction may differ from culture to culture. When investigating issues related to basic needs in different cultures, it is necessary to take a dynamic perspective, to find links between underlying needs and phenotypic behaviours that are different between cultures. In particular, specific goal contents will not necessarily have the same meaning or function in different cultures [28].

However, numerous studies have shown that a personal focus on intrinsic goals, relative to extrinsic goals, is generally related to greater health, well-being, and performance [41].

Findings and Take-Aways

Empirical work based on SDT within the health domain has taken several forms, such as survey research, experimental studies and clinical trials and typically examined relations

between SDT-based constructs and quantified outcomes related physical or mental health [19].

Two basic types of research with regards to SDT can be differentiated: studies concerning the link between exercise and general physical health and basic psychological needs as outlined within the OIT, and studies examining the motivational role of goal contents within exercise [42].

In general, SDT holds considerable appeal for understanding both initiation and persistence issues in PA and exercise [42] given that this theory specifies the nature and function of motivation, along with the contextual factors that foster motivational development.

The first general distinction to be made is the difference between health behaviour change and maintenance [10]. An emerging body of research provides empirical support [33] for the role of the SDT process in behaviour maintenance [43].

However, with regards to PA for instance, previous studies have shown that particularly introjected regulation appears to be associated with PA in the short-term, but not in the long-term [44][45].

Even though introjected regulation seems to be correlated with higher self-determination [21] [46], studies suggest that fulfilment of basic psychological needs within exercise over time is dynamic [42]. Observed changes in need fulfilment have been found to predict well-being in exercisers [47], thus it is important to facilitate the internalisation process throughout the whole intervention period via adaptive sociocontextual factors tailored to the individual. Edmunds et al. [47] showed that satisfaction of three needs as in the SDT can generally be associated with life satisfaction, subjective vitality, positive affect, and levels of exercise among overweight individuals in the long-term [19].

Intrinsic motivation in general is enhanced by positive reinforcement, and undermined by negative reinforcement, with additional evidence supporting the mediating effect of perceived competence on the feedback-intrinsic motivation relationship [48] [42].

A recent meta-study has outlined the implication that self-determined extrinsic motives may be as important as intrinsic regulation in terms of understanding patterns of behavioural variation in exercise [42]. Thus, well-internalised extrinsic motives can be very useful for behavioural regulation when the target behaviour is not inherently self-rewarding.

Gourlan et al. [49] studied the relationship between basic psychological needs and obesity with regards to PA. They found a significant relationship between the satisfaction of both the need for autonomy and relatedness and intrinsic motivation towards PA.

Another study [33] found that interest and enjoyment, as well as competence motives, predicted the number of hours per week spent on PA [14]. Those who have more autonomous reasons for exercising are more willing to initiate PA and report more positive PA experiences [50]. Individuals who experience greater need support for PA demonstrate greater autonomous self-regulation and better attendance in an intervention programme [51]. Studies in adults also showed that the increase in autonomous motivation towards PA is one of the strongest predictors of long-term weight loss [52] [53] [54].

This confirms the necessity for individuals to feel free in their choices, in order to experience an inherent interest in the activities they participated in. Additionally, intrinsic motivation is more likely to thrive in a social context that is characterised by secure and strong relationships with others. In general, the lower the levels of self-efficacy and perceived autonomy, the more people tend to be only motivated towards PA because of external regulation rather than identification. Self-determined forms of motivation towards PA can actually predict the progression of individuals towards the various stages of change [55]. Verloigne et al. [21] showed that a high composite score of relative autonomy, identified, introjected and intrinsic regulation were related to higher amounts of total PA and sports participation.

Generally, Gourlan et al. [49] found that PA is more positively associated with identified regulation rather than intrinsic motivation, which suggests that this type of activity is performed due to the perceived benefits (separable outcome) of PA, such as well being and health, rather than being an autotelic activity. Nevertheless, participation in PA plays an important role in the long-term maintenance of PA [52].

2.2.2   Flow-Theory

Flow describes a state of mind, which is characterised by full immersion and a high focus on the current activity. It is "the holistic experience that people feel when they act with total involvement" [56][57]. While being in this state, the current activity is being highly enjoyed and perceived as fulfilling and the individual thus operates at full capacity [58]. Schaffer [59] describes flow as "the fun of enjoying doing something for its own sake".

In his work, Csikszentmihalyi [57] states that people are happiest when they reach the state of flow. Thus flow depicts the perfect state of intrinsic motivation where nothing else seems to matter to the subject. As opposed to everyday life, flow provides the ability to operate at the limits of one's potential [60], without being bored or unpleasantly stimulated.

Csikszentmihalyi [56] originally named four flow components (control, attention, curiosity, intrinsic interest), but later identified eight distinct dimensions of the flow experience [60]:

- Clear goals
- Opportunities for acting decisively are relatively high
- Action and awareness merge, one-pointedness of mind
- Concentration on the task at hand
- A sense of potential control
- Loss of self-consciousness, transcendence of ego boundaries
- Altered sense of time
- Experience becomes autotelic

If several of the previous conditions are present, actions become autotelic, or worth doing for their own sake. Necessary in this case are *clear goals* and *unambiguous feedback*, so that participants know at any given time whether their actions are appropriate or not. Also crucial in this case is a good balance between perceived challenges and perceived skills [61]. If

challenges and skill don't match, then anxiety, apathy or boredom will result. Sports, games, artistic performances or religious rituals provide flow instantly and thus are intrinsically motivating.

Most often the skill used or the goal to be reached serve no other purpose than using and refining this skill. Because the motivation is intrinsic, money or other external motivational factors aren't necessary.

Flow opens up the entire world as a source of new challenges and an arena for creativity. Due to its immersive nature, flow provides a distraction from everyday worries and problems. Participants report that they forget their troubles and even neglect basic needs for FI and sleep when experiencing flow.

The choice of activities for flow experience varies from person to person. While one person experiences flow during rock climbing, another one gets their immersion by playing chess. Csikszentmihalyi has different speculations for activity choices; they can be based on interest, disguised release for suppressed desires or endorphin stimulation [60].

Csikszentmihalyi also states several positive outcomes for flow [60]: creativity, peak performance, talent development, productivity, self-esteem, stress reduction and help in clinical situations. Additionally, Schaffer [59] names seven flow conditions, which are required to get into flow:

- High perceived challenges
- High perceived skills
- Knowing what to do
- Knowing how to do it
- Knowing how well you are doing
- Knowing where to go (where navigation is involved)
- Freedom from distractions

By measuring these factors designs or interfaces can be tested with respect to how and to what degree they facilitate the flow experience.

Most flow research uses experience-sampling (ESM) techniques to **measure flow**. Experience sampling methods try to capture people's thoughts and feelings as they occur in real time, for example by setting a pre-programmed alarm for filling out a brief questionnaire or pre-structured diary page. Other techniques include qualitative (semi structured) interviews and questionnaires [58]. Schaffer also developed the Flow Condition Questionnaire (FCQ) [59].

Flow is one of the main reasons why people play **video games** and can be called the essence of games [62]. As a part of game design the question is not whether flow is important but for how long you can keep your players in flow. Since flow is about creating intrinsic motivation during an activity it can be seen as a part of the principle of readiness of the Laws of Learning [63]. While in flow state, the subject is concentrated, ready and eager to learn, which leads to an optimal gaming experience and thus enjoyment [64].

2.2.3 Health-Belief Model

The Health-Belief Model (HBM) is a model for explaining and predicting acceptance of health and medical care recommendations. It is used as a conceptual formulation for understanding why individuals do or don't engage in a wide variety of health-related actions [65]. It was developed in the early 1950s by a group of social psychologists at the U.S. Public Health Service in order to understand why people refused to accept disease preventives or preventive screening tests [66]. It was later applied to patients' responses to certain symptoms and to compliance with prescribed medical regimens. Since it was created by social psychologists the model is based on the assumption that perception of reality and personal beliefs influence individuals' actions rather than objective reality [67]. It also aims at avoiding illnesses rather than achieving health [66]. It is currently the most commonly used theory in health education and health promotion [67].

The model itself is derived from the various models of psychological and behavioural theory, which mainly depend on two variables: 1) the value of a particular goal to the individual and 2) the perceived likelihood that an action of the individual will achieve that goal. In health-related domains these variables translate into 1) the desire to avoid illness and 2) the perceived likelihood that a given action will prevent illness.

The HBM consists of the following dimensions [66] (depending on social demographics as **modifying variables** the perception of these dimensions can vary):

- **Perceived susceptibility**: The perceived risk of contracting an illness.
- **Perceived severity**: Perceived seriousness of contracting an illness.
- **Perceived benefits**: Perceived benefits of taking action to prevent contraction.
- **Perceived barriers**: Perceived potential negative aspects of particular health actions. Within the individual a cost-benefit evaluates the significance of the expected unpleasantness (side effects, costs, etc.) of the action against the perceived benefits.

Perceived susceptibility and perceived severity are combined into perceived threat. It creates a pressure to act but does not determine how the individual will act. The way the individuals act depends on perceived benefits and perceived barriers, which calculates the cost and benefit for each possibility.

The model states that internal (e.g. symptoms) or external stimuli (e.g. suggestions from a doctor, advertisement in mass media) are necessary for the individual to actually act in consequence, the so-called "**cues to action**". Those can be events, people or things that move individuals to change their behaviour [67].

In 1998, **self-efficacy** was added to the original four dimensions of the HBM, which was taken from Social Learning Theory, which represents the expectancies of an individual about their own competence to perform the behaviour needed to influence outcomes [68]. Self-efficacy was not incorporated in the early version of the model since in the early stages mostly circumscribed preventive actions with low thresholds, such as vaccinations, were being researched. When dealing with suggested actions like quitting smoking or making fundamental dietary changes, the model doesn't account for the individual's expectancy for their own competence to do so.

2.2.4   Theory of Planned Behaviour

The TPB was proposed by Icek Ajzen in order to enhance the Theory of Reasoned Action (TRA) [70], a model for the prediction of behavioural intention (see Figure 1). Through adding the variable of perceived behavioural control the TPB was supposed to improve the predictive power of the TRA. It has emerged as a major framework for understanding, predicting and changing human social behaviour [71].

The theory states that **behavioural intention** is the immediate antecedent of **behaviour**, while intention itself is a function of **attitude toward behaviour**, **subjective norm** and **perceived behavioural control**.

- **Attitude toward behaviour**: The degree to which performance of the behaviour is positively or negatively valued. Attitude toward behaviour therefore reflects an individual's evaluation of self-performance of the behaviour.
- **Subjective norm**: Perceived social pressure to perform or not to perform a certain action. It is determined by the total set of readily accessible normative beliefs
- **Perceived behavioural control**: Belief that a certain behaviour can be performed. Very similar to the concept of self-efficacy [72].
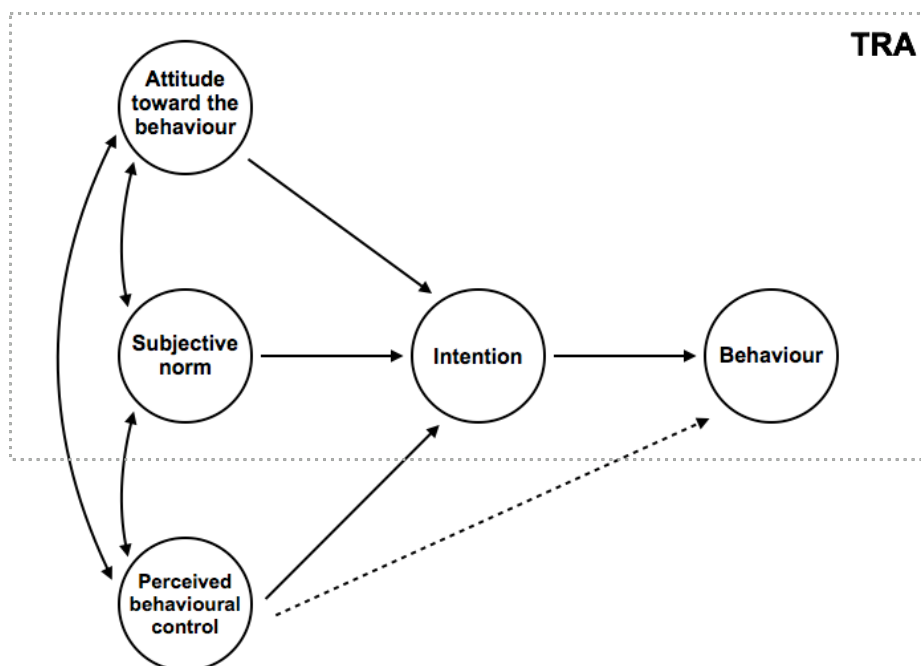
Figure 1 – *The TPB from Ajzen [70]*

Ajzen later refined the model by stating that attitude toward behaviour is the sum of all behavioural beliefs, subjective norm is the sum of all normative beliefs and perceived behavioural control is the sum of all control beliefs.

Research has shown that the TPB is able to predict intentions and behaviour as well as to show that changes in behavioural, normative and control beliefs can produce changes in intention, which can be reflected in subsequent behaviour. The TPB has improved the

predictability of intention in various health-related fields [73], and is said to be one of the most predictive persuasion theories.

However, studies have also shown that TPB has a very limited influence when it comes to the design of actual interventions for behavioural change [74]. Effectiveness of persuasive messages on behavioural change is very limited. Also small changes do not necessarily lead to behavioural changes, let alone changes to the initial beliefs. Theories explicitly incorporating behaviour change techniques would be more useful for intervention design [75].

When comparing the HBM and Theory of Planned Behaviour (TPB) with respect to the prediction of health behavioural change, the TPB outweighs the HBM [69]. However, while the TPB is a more general model regarding behaviour, the HBM is more specific in terms of how risk in information is processed in decision-making. Thus, a simple, abstract comparison is not necessarily possible due to the inclusion of two entirely different concepts.

2.2.5   Transtheoretical Model

During the 1980s the Transtheoretical model (TTM) of change was developed [76]. TTM stages, usually represented by a wheel design, were very useful for clinicians to identify the stage of change of their clients. It was described primarily using the example of smokers. The authors found that a smoker needed going through this wheel an average of seven times before quitting smoking. The TTM of change describes six different consecutive stages that can be identified in every process of change: pre-contemplation, contemplation, preparation, action, maintenance and relapse. The pre-contemplation is the first level of change, when the person does not find any problem is his/her behaviour and no solution is looked for. The contemplation stage states that the person considers their behaviour to be a problem but at the same time is ambivalent to solve it. In the preparation stage, the person starts to be ready to change. The behaviour change actually starts at the action stage and when it is maintained for at least six months, this is the maintenance stage. From this stage the person can exit the wheel or re-enter if they relapse; thus starting the process again.

The now familiar TTM stages of change [77] highlighted the need for the clinicians to be flexible, using methods appropriate to the client's current level of readiness for change. Most cognitive-behavioural therapies were designed for the action stage, when the client is ready to change. However, clients at the earlier stages, such as pre-contemplation, contemplation and preparation, impose other challenges and different approaches or techniques should be considered.

Lately, the TTM has been criticised for three main reasons: 1) the complexity of behaviour, 2) the lack of validated staging algorithms and 3) the possibility that the real determinants of the behaviour change are not included in the TTM [78]. However, there is no doubt that the TTM provides a helpful and intuitive approach for clinicians to identify readiness to change. As a model of health behaviour, the TTM potentially offers a mechanism to identify and describe processes that are able to motivate, to prepare and assist individuals in realising behaviour change [79].

Motivational Interviewing (MI) (see Section 2.3.1) is linked with TTM because it is a clinical tool conceptualised for clients who are less ready to change and to provide clinical interventions according to the stage(s) at which they might be most applicable [80].

Findings and Take-Aways

The TTM has general implications for all aspects of intervention development and implementation [81]. In summary, the five areas or relevance are: recruitment, retention, progress, process, and outcome.

▸ The TTM is an appropriate model for the *recruitment* of an entire population. Traditional interventions often assume that individuals are ready for an immediate and permanent behaviour change. In contrast, the TTM makes no assumptions about how ready individuals are to change.

▸ The TTM can result in high *retention* rates. Traditional interventions often have very high dropout rates. In contrast, the TTM is designed to develop interventions that are matched to the specific needs of the individual.

▸ The TTM can provide sensitive measures of *progress*. The TTM includes a set of outcome measures that are sensitive to a full range of cognitive, emotional, and behavioural changes and recognise and reinforce smaller steps than traditional action-oriented approaches.

▸ The TTM can facilitate an analysis of the *meditational mechanisms*.

▸ The TTM can support a more appropriate assessment of *outcome*.

Recent meta-analyses, by Noar et al. [82], of 57 studies demonstrated greater effects in programmes that are tailored on each of the TTM constructs. Specifically, programmes that are tailored by stage, pros and cons, self-efficacy and processes of change do better than those that do not. There are however findings on certain dependencies regarding the outcome as well as the desired behaviour change and context. This indicates that for instance each stage within the TTM model has different requirements for behaviour change techniques.

2.2.6   The Unified Theory of Acceptance and Use of Technology

Venkatesh et al. [83] developed the Unified Theory of Acceptance and Use of Technology (UTAUT) by consolidating eight models for explaining the usage behaviour of information systems, i.e. the TPB. Today the UTAUT is one of the most commonly used models to explain intentions to use an information system and subsequent usage behaviour. Venkatesh's initial study showed that the model accounted for 70% of the behavioural intention's variance and 50% of that of the actual use [83].

The consolidated dimensions of the UTAUT are:

• **Performance expectancy**: Degree to which an individual believes that using the system will help him or her to attain gains in performance. It is the strongest predictor of intention.

• **Effort expectancy**: Degree of ease associated with the use of the system.

- **Social influence**: Degree to which an individual perceives that important others believe he or she should use the new system.
- **Facilitating conditions**: Degree to which an individual believes that an (organisational and technical) infrastructure exists to support use of the system.

These variables are influenced by different moderating variables - namely gender, age, experience and voluntariness of use – and lead to behavioural intention. Behavioural intention itself leads to the actual use behaviour (see Figure 2).
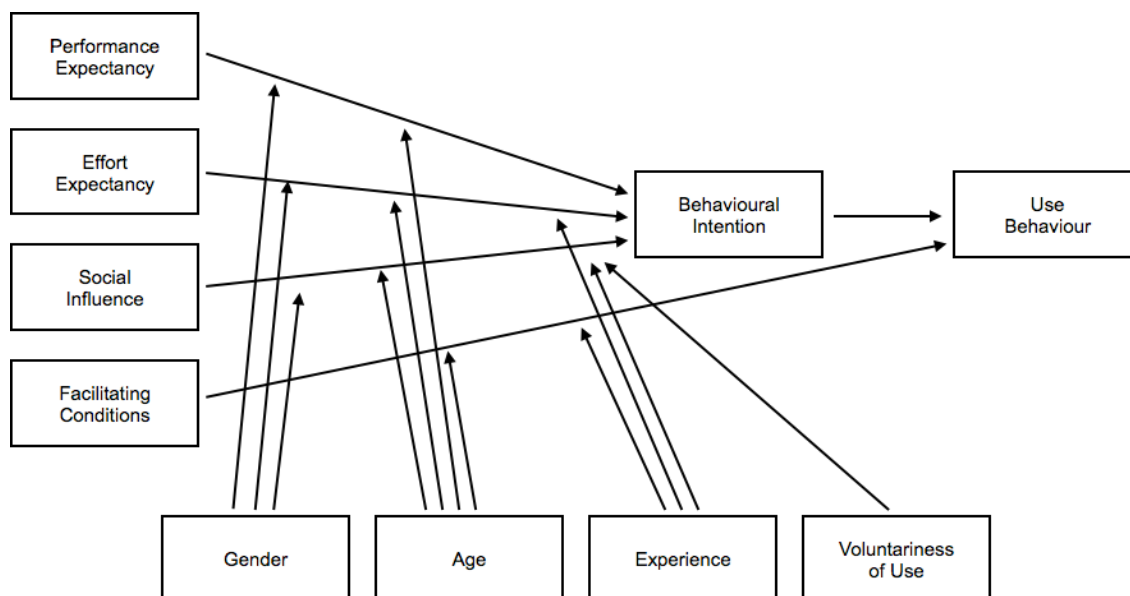
Figure 2 – *The UTAUT Model [83]*

In 2012, Venkatesh extended the original UTAUT model into the revised version UTAUT2, which focused on the domain of consumer electronics [84]. Adaption to this domain necessitated some modifications to the original models: e.g. three new constructs (hedonic motivation, price value and habit) were incorporated, and voluntariness of use was dropped.

- **Hedonic motivation**: Fun or pleasure derived from using a technology.
- **Price value**: In contrast to organisational settings consumers have to bear the costs of private electronics themselves. Costs may have a serious impact on acceptance.
- **Habit**: The extent to which people tend to perform behaviours automatically because of learning.

In his study Venkatesh et al. found that hedonic motivation is a critical determinant of behavioural intention in this case and was found to be a more important driver than performance expectancy is in a non-organisational context. He also stated that future work could examine the role of key constructs of certain domains and how they can improve the model when applied to this specific domain. Another study combined UTAUT with the Flow model by adding the two flow dimensions: perceived enjoyment and attention focus [85]. The results indicated that perceived enjoyment had strong effects on satisfaction and continuance of use.

Therefore, considering the user experience of an informational system, could further enhance the predictive quality of the UTAUT model.

2.3 Behavioural Change Theories and Taxonomies

2.3.1 Motivational Interviewing

MI is a refined form of guiding a conversation focused on change that evokes and strengthens personal motivation in a person-centred, autonomy-honouring way using specific skills in certain ways towards a particular change goal that is attuned and guided by client speech. MI has demonstrated efficacy in different clinical and social settings and it is relatively brief [86].

MI emerged in the context of addiction treatment in the 1990s and it involved a change of the paradigm in the management of the denial and defensiveness of those people. The highly authoritarian, confrontational, even demeaning approach of a heavily directing style of counselling was seen the main reason for the resistance to quit addictive behaviour. Instead of that, the use of a collaborative style (listening carefully to the client, learning from them and trying to understand their dilemma), led to people becoming more open and motivated to change their behaviour. MI involves counselling in a way that evokes people's own motivation to change rather than putting them on the defense. A simple principle that emerges is to have the client, not the counsellor, voice the reasons for change. As it turned out, the directing style is not the exclusive property of addiction treatment and MI has found today applications in other fields such as health care and social work.

MI is a **guiding style** of conversation located between "directing style", in which the helper is providing information, instruction and advice, and "following style", in which the helper just listens and tries to understand the clients perspective. Imagine going to another country and hiring a guide to help you; it is not the guide's job to dictate where you go and what you do. Rather, a good guide offers you an expert vision of the surroundings and takes into account your preferences. Guiding style means to assist, to collaborate, to encourage, to inspire, to look after and to motivate [87]

Ambivalence is a key concept in MI. Ambivalence is a universal and normal feeling among people considering change. They see both reasons to change and reasons not to. They want to change and they don't want to, all at the same time. It is a normal human experience and it is an ordinary part of the change process [88]. If you are ambivalent you are one step closer to change. MI is mainly focused on helping people to solve their own ambivalence. Some people need to make a change, at least in the opinion of others, but they see little or no reason to do so. For them, developing ambivalence about change will be the first step forward. Some other people are well aware of the downside of their behaviour. For example, most people with diabetes know the consequences of poor glucose control, and they also know the benefits of a healthy diet and exercise. Ambivalence is simultaneously wanting and not wanting something, or wanting both of two incompatible things. In this case, if you are arguing for change and your client is arguing against it, you have got it exactly backward. People are more likely to be persuaded by their own expressed reasons; in this way MI works by helping people to understand and express their own reasons to change.

The underlying spirit of MI is based on four key interrelated elements: 1) partnership, 2) acceptance, 3) compassion and 4) evocation.

Partnership means that when the goal is for another person to change, the counsellor can't do it alone. MI is not a way of tricking people into change but is a way of activating their own intrinsic motivation and resources for change. Activation of that expertise is crucial [89].

Acceptance means that you accept the person's values, although you do not necessarily approve of them. Acceptance contains four aspects: absolute worth, accurate empathy, autonomy support and affirmation. *Absolute worth* is related to respect of the person and has its origins in Carl Rogers' work [90]; when peoples' experiences are accepted as they are and they are free to change. The opposite of this is to have a judgement attitude about who deserves respect and who does not. *Accurate empathy* is an active interest and effort to understand the other's internal perspective. The opposite attitude is to impose our own perspective as counsellors. *Autonomy support* means the respect of the person's right and capacity of self-direction [91] - this principle establishes an important link between MI and SDT as explained above. The opposite attitude is to make or to coerce people to do things. *Affirmation* is to acknowledge the person's strengths and efforts.

Compassion is a motivation that draws people into helping professions, meaning to actively promote and prioritise the other's welfare and needs.

Evocation means that the task of the counsellor is to evoke, rather than inspire, motivation from the user. From this perspective it is considered that people already have within them much of what is needed to change their behaviour, and the counsellors task will be to call it forth. This means that most people have their own positive motivations to change and the task would be evoke and strengthen these motivations that are already present.

MI is developed in four sequential and recursive processes: 1) engaging, 2) focusing, 3) evoking and 4) planning. They can be represented as stair steps, where it is necessary to climb one by one, without missing previous steps.

Engaging is the process by which both parties establish a helpful connection, involving much more than simply being nice and friendly with a client. Engaging tends to predict retention and outcome [92]. Engaging is a challenge that can be solved by highlighting the following three aspects [93]: establishment of a trusting and respectful working relationship, agreement on change goals and collaboration on a mutually negotiated task to reach these goals.

There are several factors influencing engagement that might be explored, such as desires or goals, importance of change, self-confidence, positivity, expectations and hope.

Focusing helps to clarify the direction of movement and to establish the goals for change. It is possible to be engaged with someone, but without any clear direction. Focusing in MI is a process of maintaining direction. The focus can arise from client, context or counsellor and could be quite clear or not. In this case agenda mapping, tolerating uncertainty and sharing control is useful.

Evoking involves eliciting the client's own motivations for change. The evoking process helps people to resolve ambivalence in the direction to change, carrying them from *preparatory* change talk (e.g. desires, abilities, reasons and needs) to *mobilising* change talk (e.g. commitment, activation and taking steps). During this process it is necessary to evoke the importance and confidence of the person. People are reluctant to commit to a change unless they have some confidence that it is possible. Clients with high importance and low confidence need a different approach from those with low importance and high confidence.

Planning is the process where people are ready to change and begin building a realistic and affordable plan about when and how to change. In this process acknowledgement of signs of readiness is crucial. With sufficient readiness, developing a change plan improves outcome [94]. However, when a change plan is designed without the user being ready, you may undo whatever progress was made before.

The practice of MI involves a strategic and flexible use of core micro-skills shared with other forms of person-centred approach counselling [95]. These micro-skills can be used throughout the four processes described above. The micro-skills are the following: asking open questions, affirming, reflective listening, summarising, informing and advising. An ***open question*** is like an open door, whereas closed questions, although sometimes useful, provide very little information about user preferences. ***Affirming*** is to accentuate the positive side of user behaviour; it reduces defensiveness and promotes engagement. It is to recognise and acknowledge, as well as support and encourage, the client's strengths and efforts. Affirmation is not the same as praise; in general, it is recommended to avoid affirmations that begins with the word "I", because these are focused more on you rather on your client. Instead it is preferred to begin with "you" ("you really tried hard this week!"). ***Reflective listening*** consists of giving a response that makes a guess about the person means. There are three stages of communication that can go wrong: encoding, hearing and decoding. The reflective listener forms a reasonable guess as to what the original meaning was in the form of statement. It is preferable to respond with a statement rather with an open question because the latter can increase defensiveness. A question requires a response and places a demand on the other person. Reflective listening can be quite simple or complex and provide a direction in the conversation depending what was reflected or ignored. ***Summarising*** consists on pulling together several things that a person has told you and can be collecting, linking and transitional. ***Informing*** and ***advising*** in MI has the purpose to foster change rather than deliver simple advice and follows these principles; the counsellor has some expertise but the clients are experts on themselves, the counsellor finds out what information the client wants and needs, while the counsellor matches information to the client needs and strengths, clients can tell the counsellor what kind of information is useful, and finally, advice that champions clients needs and autonomy is helpful. Information and advice in MI is always offered with client permission in a sequence of eliciting-providing-eliciting that honours the client's expertise and autonomy.

MI is a broad strategy, which emerged from clinical experience that generated a testable hypothesis. Nowadays, there are more than two hundred randomised control trials using MI in different clinical settings. Although the effectiveness of MI varies widely across counsellors

and studies, there are several meta-analyses which demonstrate its efficacy when compared with other psychological approaches [96][97][98][99][100][101][102][103].

MI delivery through new technologies deserves more attention as there are small but fruitful experiences using MI strategies in web services, telephones and apps [104][105][106].

Findings and Take-Aways

MI is a collaborative person-centred approach for strengthening a **person's own motivation and commitment to change**. It is a structured, brief and practical method that integrates elements from other psychological theories like CBT, SDT, TTM and Carl Rogers's Client-Centred Therapy [90]. In this sense, an MI style is compatible with a wide range of other clinical practices [107][108]. Furthermore, MI provides from a theorist's point of view, an understandable picture about the underlying motivations for behaviour change, and from its practical side, is based on evidence-based experience. It is a learnable method to guide clinicians in helping their clients to change behaviours and to acquire healthier lifestyles.

To MI, **ambivalence** is a normal part of preparing for change and a phase where a person can remain blocked for some time. The overall style of MI is guiding, which lies between and incorporates elements of directing and following styles depending on the client's ambivalence. When the helper uses a directing style and argues for change with a person who is ambivalent, it naturally brings out the person's opposite arguments. In the same case, if the helper is just using a following style (listening without direction), the helper and client will walk blindly together without finding a solution for the dilemma.

Four key aspects of the underlying spirit of MI are **partnership**, **acceptance**, **compassion** and **evocation**. Providing accurate empathy, autonomy support and encouraging self-efficacy are key points in the process of change. As people are more likely to be persuaded by hearing themselves talking about change, using *OARS* (Open questions, Affirmation, Reflections and Summaries) and Eliciting Change Talk will conduct people to change. Change talk, in opposite to sustain talk is any client speech that favours movement toward a particular change goal. There are two types of change talk depending of the level of mobilisation toward change; the **preparatory change talk** (DARN: desire, ability, reason and need) and **mobilising change talk** (CAT: commitment, activation and taking steps). A client's balance of change talk and sustain talk predicts change, and is substantially influenced by the interviewer [109].

MI is about evoking the strength, which is already present in people, not installing what is missing. Change rulers, usually rating scales (0-10), will provide information about how the client rates the importance of making a particular change (importance ruler) and how the client rates the level of confidence in their ability to make a particular change (confidence ruler).

However, when the client and clinician have different goals and aspirations an ethical dilemma can appear. In a traditional clinical approach, the counsellor is the expert and directs the client towards the potential best solution for him (righting reflex or directing style) [216]. At the opposite level, with Carl Rogers' [217] client-centred counselling approach, the client determines the content, direction and goals for treatment and the counsellor provides a

non-judgmental support (following style). In between, MI provides a client-centred guiding toward the change behaviour. Nevertheless, sometimes there are clinical situations in which it is obvious that a professional helper should not favour a particular direction in which to move people, for example to sign a consent form, adopt children or donate one of their kidneys. There are other situations (e.g. heavy exercise after a heart attack) where the healer might unconsciously try to convince the client to forget the idea. Ethical concerns arise in situations where the clinician or the institution has an aspiration for change that the client does not (yet) share. There are four key ethical considerations in such situations which include non-maleficence, beneficence, autonomy (a respect for human freedom and dignity, the client decides whether and how to pursue change, and that choice cannot be taken away) and justice (equitable access to the benefits and protections against the risks.

Neutrality or "equipoise" is not a counsellor characteristic but rather a conscious decision to avoid influencing the direction in which ambivalence is resolved. Decisional balance is an appropriate strategy to use when one chooses to counsel with neutrality rather than encouraging change in a particular direction. Sometimes, the direction is toward making a decision regardless what decision is.

In health promotion, **effective health communication** and **tailored feedback** is a prerequisite for initiating, changing and sustaining healthy behaviour. An understanding of how the individual perceives the content of health information is critical for enhancing behaviour change. Some individuals have a tendency to avoid information that they find threatening or distressing [219]. Thus, it is important that relevant and suitable suggestions and feedback are provided [220]. Tailoring of health information could increase the possibility that this content is processed and accepted by the receiver to enhance healthy behaviour [221]. A previous study with a pre-diabetic sample of individuals showed that those whose physical health status was poor wished to receive tailored information on nutrition and PA more frequently than the healthier ones [222]. For optimal results in tailoring health information, the style of presenting the health message content should be carefully considered [223]. One strategy is the use of emotional appeals, which could range from humour to sympathy [224]. Another message strategy, feedback, involves presenting individuals with information about themselves, obtained during assessment or elsewhere [225]. There are very different approaches to provide feedback, the most common are; descriptive (factual), evaluative, normative, ipsative and theoretically driven.

In summary, there are four key processes in MI; **engaging** (establishing a helpful connection and a fruitful relationship), **focusing** (development and maintenance of a specific direction towards change), **evoking** (eliciting the client's own motivations for change) and **planning** (process which encompasses both developing commitment to change and formulating a concrete plan of action) [110].

2.3.2   Taxonomies and Tools

It has been a long-lasting challenge for researchers to define the effective psychological determinants that make people engage in healthy behaviours [111]. Interventions often led

to change in behaviours but not in the supposed underlying psychological determinants [111]. Reliable evidence was previously hard to accumulate as interventions were generally poorly reported. In the past years, these determinants have been drawn to the centre of the discussion in the overall behavioural sciences in order to increase replicability [9]. Therefore, comprehensive listings of behaviour change techniques have been collected and classified in order to standardise the techniques used in interventions and thus enable further comparison and analysis (see e.g. [112][113][114][9] or [115]). Thus, a growing number of meta-analyses and literature reviews explain the mechanisms that lead to action.

Health behaviour targeting interventions are often complex and include several simultaneous, often interacting elements [9].

In order to increase replicability and evidence syntheses when reporting behaviour change techniques in PRECIOUS, we have chosen to refer to the taxonomies that standardise health psychological terminology. The two most relevant taxonomies are 1) the CALO-RE taxonomy of [9] which lists 40 behaviour change techniques related to PA and healthy eating, and 2) a new behaviour change technique taxonomy (v1) of 93 hierarchically clustered techniques, building an international consensus for the reporting of behaviour change interventions [116].

Work with taxonomies has led to observations that certain techniques are more effective in achieving behaviour change. In a review and meta-regression of healthy eating and PA interventions [115], self-monitoring (comparing actual performance to behavioural goal) was found to be the most effective technique, especially when combined with other techniques derived from Control Theory [117][118]. As behaviour change techniques associated with control theory have a strong evidence-base in behaviour change research [115], a simplified model of the theory will be presented here.

The basic principle of the Control Theory is a discrepancy reduction loop in which individuals aim to decrease the difference between their actual behaviour and their behavioural goal. If a discrepancy is found, individuals adjust by behavioural or internal changes [119]. This change is triggered by *setting or modifying a behavioural goal* and by *action planning*. Possible environmental interferences are avoided with *coping planning*, which involves finding solutions for possible difficulties. Planning is a key technique for overcoming hurdles between good intentions and action [120][121][122].

Self-monitoring is a natural technique for PRECIOUS as it can be conducted with technical devices such as pedometers or mobile applications to record amount of activity or track dietary habits. Self-monitoring is also used in health care specifically when breaking established habits [114]. Self-monitoring has been found to be a successful strategy in increasing physical exercise [123][122] and for weight control [124].

Behaviour change is often divided into qualitatively different, consecutive stages [125][126][127][128][129][130]. A common structure between all these theories can be found, and Schüz et al. [130] identified it as three-stage structure that is supported by strong evidence. The stages are pre-intention (before forming intention to act), intention (having a specific intention for a target behaviour) and action (preforming the behaviour). Moving from one stage to another happens through two critical transitions [130]. In PRECIOUS, we need to

refine methods that recognise the state of the user and guide them toward the transitions. Following the stage theory, this may happen by first guiding the user towards forming an explicit behavioural intention and next, acting according to the intention. Behavioural sciences widely acknowledge a gap between intention and actual behaviour [131]. Therefore, the service may be most useful in presenting and advising the user behaviour change techniques that are proximal factors of behaviour and thus help the user to reach their targets [132][133]. The use of these strategies or behaviour change techniques is strongly affected by the users' motivational status' that reach from amotivation to controlled and autonomous forms of motivation. This quality of motivation largely contributes to the users' intention to act and to the use of self-regulation strategies.

The intention stage may be triggered for instance by risk awareness, and affected by positive and negative outcome expectancies [133]. Lack of appropriate self-regulatory strategies may lead to failure to implement intention [134]. These strategies are crucial as intentions have been found to explain only about 20-30% of behaviour (see of e.g. [135]).

2.4 Theories in the Context of Games & Gamification

2.4.1 Definition, Concepts & Criticism

During the last few years, gamification, or *the use of game design elements in non-game contexts [136]*, has been widely and successfully used to provide motivating experiences in a variety of different situations. In general, it has been highlighted that the role of gamification in conventional services is to invoke experiences that are usually linked to computer games, thus enhancing these services with motivational affordances in order to create value for a user [137].

In short, the underlying assumption of the concept of gamification is that the inclusion of game-elements would make tasks in the health domain, such as tracking of FI data, increasing levels of PA, improvement in sleep quality or reduction of stress through given tasks more enjoyable [5].

Given the increasing popularity of gamification since its definition, gamification has even been proposed as a general design pattern in persuasive systems, particularly in the area of social interaction and social influence [138].

Formally, structures underlying gamification have been drawn from common definitions of games and gameplay. Generally, a game is composed of one or more potentially interconnected challenges which the user is trying to master by taking actions to reach certain goals, with rules making the achievement of the goal difficult to a varying degree [139]. Challenges require a specific kind of skill and non-trivial effort to overcome, and are at the heart of designing a gameful experience [140].

At the heart of these gameful experiences is the fact that games can provide basic psychological need satisfaction [141], for instance competence need satisfaction by overcoming challenges, autonomy need satisfaction by being able to direct the game in terms of choices to make and thus acting highly self-determinedly, or the relatedness need satisfaction through virtual collaborations or combats. When these needs are satisfied,

intrinsic motivation is enhanced. On the other hand, the reverse effect will take place when they are thwarted according to SDT [25].

Non-trivial challenges further require focus, binding attention and cognition, thus limiting the users' capacity to deal with unpleasant thoughts or memories [140][142]. This state has already been referred to within this report as Flow [57] (see 2.2.2).

One of the most commonly leveraged frameworks in game design is referred to as the MDA [143][144] framework:

- **Mechanics** – rules specifying player actions
- **Dynamics** – run-time behaviour of the mechanics acting on the users choices
- **Aesthetics** – desirable emotion responses evoked in the player

This framework helps to use system-thinking to describe a game and its elements as well as the interaction with the user.

Nevertheless, gamification as a concept has also received substantial criticism. Deterding [7] lists the following reasons to explain why existing gamified solutions have received criticism:

- **Not systemic:** dynamic user interaction is required with all system components
- **Reward oriented:** focus on extrinsic rather than intrinsic motivation
- **Not user-centric:** often conflicting developer versus user goals
- **Pattern-bound:** often limited to small set of interface design patterns rather than gameful experiences

In a system trying to integrate gamification as a core concept in a user-friendly and user-centred way, these factors need to be taken into consideration when designing components of the service, which will be visible to the final user.

2.4.2 Motivational Mechanisms & Game Mechanics

The mechanics of a game or gamified system are made up from a series of tools, which will be described in this chapter.

Rewards

Rewards are tangible or intangible incentives given following a desired response in an attempt to reinforce the response [5]. In general, external rewards have been found to reduce intrinsic motivation [17]. In addition, a gamified system offering virtual rewards for instance is not necessarily free of consequence, thus potentially thwarting perceived autonomy. Various studies have emphasised, though, that findings regarding this implication were inconclusive, often underlining that the combination of rewards and a meaningful framing yielded the best results [5]. Thus, rewards have to be in congruence with one's own goals and needs and are highly contextually specific.

- Points & Coins

Points or coins are usually collectible items rewarded immediately following a certain action of the user. Five different point palettes can be differentiated from a conceptual point of view [143]:

o Experience Points

Experience points typically do not serve as any type of currency within a system, but rather determine how a user is ranked in terms of gameplay within a system. They usually do not expire and are not redeemable. Every activity within the system has assigned Experience Points and can thus control long-term objectives. Goal loops can also be triggered based on these type of points. Users can often infinitely accumulate Experience Points and thus give an impression of how advanced the user is in the system as well as how long the user has already been engaged with it.

o Redeemable Points

Redeemable Points are often used in exchange for items within a game or for real-world items. They can be earned depending on a metric designed by the game's creator and often can be monitored, managed and traded. They are closely linked to virtual economies, and thus can underlie the same economic principles.

o Skill Points

Skill points are similar to Experience Points but more targeted at specific activities of the system. They are used to direct behaviour into certain directions in order to complete key tasks and sub-goals.

o Karma Points

Karma points are a measure of creating altruism and user reward with the system, gained through collaborative tasks or simply by letting the user issue Karma Points by themselves. They are a great way to increase social interaction within a system.

o Reputation Points

Reputation points deal with issues of trust within a system and thus have to be particularly meaningful, integer and consistent. It is complex to achieve, as users have to be able to immediately associate levels of trust with elements of the system, or other entities, depending on a more or less virtual number of points.

• Virtual currencies

Virtual currencies incentivise broad behaviours across a system via points or coins, and for instance, can be treated similarly to currencies in real life. Large communities have been successfully established using this principle; however, they have legal and regulatory issues that are complex to deal with. In the MMO game "Eve Online" for instance, a battle between 2.700 players has resulted in a damage of an estimated 240.000 EUR[1].

• Badges, Trophies, Limited-Edition Items

Antin and Churchill [145] have suggested five individual and social functions for badges [5]: goal setting, instruction, reputation, status/affirmation, and group identification. Collecting in general is a powerful drive in human nature and well-designed badges or trophies can be compelling for a variety of reasons, if not only for purely aesthetic reasons.

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[1] http://derstandard.at/1389858475911/Eve-Online-Unbezahlte-Rechnung-loest-Massenschlacht-im-All-aus

The function of a specific badge or a trophy thus depends on the nature of the activity that rewards it as well as contextual dependencies. They are often also rewarded for completion of goals and progress within the system.

- Customisation Objects, Easter eggs, hidden objects

Customisation is tool in games that can offer users another layer of choice within the system. It can come in a multitude of different forms, i.e. ranging from avatar customisation with different clothing, to customising the interaction type with the system. Customisation with a reward function serves the purpose of achieving a visible outcome related to a goal, which constantly reminds the user of their achievement.

However, the relationship between choice and well-being is complicated [146]. Simply increasing the number of choices in terms of customisation for instance will probably not contribute to the game's experience; however, small, carefully chosen and well-placed customisation options can demonstrate the user's commitment [143].

- Collectible virtual objects

Collectible virtual objects are often closely related to the game's context and are rewards for extensive users of a game, i.e. objects placed in hidden places such as treasures etc. They serve the purpose of being an unexpected reward, in contrast to rewards, which are expected in regular intervals or for the completion of certain tasks.

- Heroism

The concept of heroism is often deeply integrated into game concepts and can also be considered as a type of reward. While earlier games were based on a simple rescue-the-maiden concept, today's games include this concept in a more diffuse and social way [143]. It is in most cases closely related to the narrative of the game or service and thus linked to one or more tasks that need to be accomplished in order to allow the user to be pictured as a hero. This can be a particularly useful tool for social interaction, i.e. when users are required to "play the hero" for other users and thus follow more altruistic motives.

- Micro-Goals, Macro-Goals & Pre-defined Paths

Depending on the implemented challenge that needs to be overcome in order to achieve a goal, goals generally promote self-efficacy [147] and thus can serve as rewards themselves.

A distinction of game-related goals can be made in terms of time-proximity; while proximal goals or micro-goals are usually set for smaller set of tasks and subtasks, global or macro-goals are related to fulfilling a purpose within the game. The effect of achieving a goal can have a powerful influence on the perceived levels of competence and autonomy when the goal is perceived as important and challenging [148].

- (Activity) Banking

Achieving goals and thus getting respective rewards require time, effort and resourcefulness. Banking (see for instance [149]) is a term related to achievement of long-term behavioural change in the games context, and describes the ability of users to accumulate rewards over

time. Collecting coins, badges or trophies over time can be powerful tools for users to increase engagement with the system.

Challenge

- Levels and Progression of Difficulty

Levels generally indicate progress within a game, and typically level difficulty increases, if not linearly, with advancement in levels. The goal is to create clear and seamless paths for the user to gradually gain confidence and experience, while on the other hand encountering challenges that are balanced relative to the player's perceived current ability, so that "it appears neither to hard as too induce anxiety, or easy that it creates no uncertainty before nor competence upon overcoming it" [140].

- Ghost-Version

The ghost-version is an interesting tool in order to challenge the user. Simply put, the user is shown, in some way, a previous achievement of themself and is requested to challenge this achievement in order to improve. Thus, the user actually competes with themself. Previous user actions can be shown dynamically during the task in order to let the user know about previous performance at all times.

- Continuous Quests

Continuous quests give users a direction within a game and an idea of the goals and fundamental drives of its narrative. The idea of a continuous quest is to constantly remind the user of both micro and macro goals and to ensure that there are always available challenges for the player to take on the intended path.

- Nurturing and Growing

Nurturing and growing is a well-known concept from virtual pet games, the most famous example being the Tamagotchi. However, not every individual is equally predisposed to this concept [143]. Gamified experiences can make use of this concept due to the often existing similarity between given tasks, such as growing a business or improving one's health status, and the virtual environment provided which is often tailored to the real-life case, thus creating an immediate link between the virtual and real environment.

- Expiration of Points

Often systems require regular interaction or completion of tasks in order to maintain for instance points. This represents a different form of challenge where the user is tried to be stronger locked in into the system by capturing the user's interest when not being active on the actual platform.

Social Context

- Leaderboard

The simple purpose of a leaderboard is comparison with others through a ranking system. By being able to judge one's own performance as compared to the performance of others,

users are able to see and improve their behaviour in order to perform better. Two kinds of leaderboards are used largely today [143]:

- o No-Disincentive Leaderboard
- o Infinite Leaderboard

In the no-disincentive leaderboard, the user is always compared to the closest best and worse performing others and subsequently placed in the middle. In the infinite leaderboard, every user has an absolute place and rank given within the system.

Due to the increasing user numbers for instance on mobile platforms, multi-layered leaderboards have also gained tremendous popularity. In this case, users are compared to other users based on geographical proximity, time and level of skills or certain social groups.

- • Virtual Avatar

Virtual avatars are manifestations of someone's identity in a virtual environment. People can try out alternative identities or project some private aspect of themselves onto their avatar and thus create a visual representation of themselves [150]. It is a powerful motivational tool to be able to "live" through an alternative version of one's self, and has been successfully used for instance in MMOs or virtual worlds such as Second Life. Przybylski et al. [151] investigated for instance the effect of putting users in touch with ideal aspects of themselves and found evidence for increasing levels of intrinsic motivation.

- • Collaborative Tasks

Cooperative or collaborative quests are tasks that require user interaction from others and thus depend on a community of players. As it is often up to the user to find collaborators, it requires even more effort to complete this type of quest. These are socially powerful tools to increase user engagement, but are also challenging to implement due to the requirement of having enough people already using the system. However, sometimes even just awarding rewards in a group setting can be enough to trigger a similar response.

- • Virtual Economies and Secondary Markets

Virtual economies allow creation of a macroeconomic frame for currencies in a virtual environment, with often potential direct and costless manipulation of the system's rules [152]. A well-designed virtual economy will allow creation of further incentives for the user to engage with the system, such as promotional tools or even exchange for tangible goods.

Aesthetics

- • User-Interface (UI)

The UI of a system is the first and central point of contact with the user, and thus one of the most important elements.

Related work suggests a multitude of different UI Design principles for developing mobile or web applications. Some include [153]

1. Compatibility: design must fit the user, the task and the product and thus start with understanding the needs of the user

2. Configurability: permitting easy personalisation and configuration enhances sense of control and encourages an active role in understanding the system

Colour for instance can have an important, context-specific influence on behaviour and achievement, and certain colours have been shown to be associated with positive content, openness and peace (blue) or calmness and success (green) [154], a fact often also used by marketers and advertisers. Furthermore, certain colours have very different meanings in different cultures. Thus, the right colour selection can contribute to the overall user-experience within the system. An individualised, theme-based approach of dynamically selecting colour-sets according to the user's preferences thus can enhance task engagements in a subtle, non-conscious fashion [155].

Another crucial factor is language. Even though most applications nowadays are held entirely in English, this could potentially represent a barrier for certain users (e.g. elderly people). The PRECIOUS team will consider internalisation of the provided services in terms of translations.

3. Consistency: the system should have components which a similar look, similar uses and similar operation and interaction modes
4. Control: the user most control the interaction and should match the user's skills and experiences
5. Directness: a direct way to accomplish tasks should given if possible, with visible available alternatives and effect of actions
6. Efficiency: Eye and hand movements should be minimised, needs and wants should be anticipated whenever possible
7. Predictability: the user should be able to anticipate natural progression of each task
8. Safety: trying to protect the user from mistakes via visual clues, reminders etc.
9. Simplicity: obvious visual hierarchies, defaults, provide uniformity and consistency
10. Transparency: user should not deal with the mechanics of the interface

- Onboarding

Bringing a novice into the system is a challenging task and should never be underestimated. The onboarding process should focus on the experience rather than informational processes and under all circumstances avoid presenting too much information. The complexity of the system needs to be revealed slowly, and optimally accompanied by optional tours and helping features (also see Section 5.2 in this topic).

- Dashboards

Dashboards are one-page views of an often large amount of information, with the goal of presenting information in a structured way without overwhelming or confusing the user. Once the user is familiar with the structure and data points of the dashboard, they can immediately assess game status, achievements and rewards.

- Story and Narrative

Successful games or gamified environments have good background stories. Narratives guide action, organise character roles, rewards and group action and thus provide a frame

for immersion within the system. Stories have the advantage of helping to keep people engaged [156], whether through simple narrative visualisation [157] or a complex background storyline guiding through a full service experience.

2.4.3 Games, Gamification and Psychological Theories

Przybylski et al. [141] investigated the relationship between video game engagement and motivational theories and frameworks. They generally found that it can effectively be studied and understood through a motivational lens.

SDT for instance has been found to be a promising bridge between the motivational and gaming domain [158], as fun and engagement with games have been found to facilitate and deepen basic intrinsic need satisfactions. Thus, this theory is particularly useful in understanding the motivational aspects of games and gamification. The broad appeal of games is based on the psychological need satisfaction they can provide and applies across game genres and content.

Immersion in virtual contexts such as games has been found to serve as a key moderating variable amplifying the actual effects of the virtual content on goals and decision making [151], and has also been found to enhance self-exploration [159] and more rapid goal adoption [160].

Ryan et al. [161] conducted a series of studies on how well self-determination theory applies to the context of gaming in order to determine the relationship between the satisfaction of basic psychological needs and the short-term impact of game play on psychological well-being. The aim was to explain both a user's game choice, as well as the motivation of a player within a particular game context. They found that autonomy and competence satisfaction provide significant accounts of player motivation and enjoyment in solitary game play, and all of the three needs in multiplayer environments. Furthermore, they found that intuitive controls facilitate players' experiences of in-game competence as well as in-game autonomy.

Users who evidenced less satisfaction of basic psychological needs also reported higher levels of Fear of Missing Out (FoMO), a phenomenon grappled with particularly by younger people "describing an apprehension that others might be having rewarding experiences from which one is absent" [162]. FoMO is a key indicator in explaining game and for instance social media engagement in terms of elevation of negative social and emotional states.

Another dimension, in which people playing games differ, is passion profiles. Ryan et al. [163] tried to identify subgroups of people with distinctive passion profiles on self-determined regulations and engagement time in gaming. The authors differentiated two types of passion helping to understand motivation in digital gaming based on a duality model proposed by Vallerand et al. [164]; Harmonious passion (HP) and Obsessive passion (OP).

Findings suggest that HP leads to greater positive affect as compared to OP in gaming activity. HP generally had higher associations with the flow state, identified and intrinsic regulation while OP had closer relations to external and introjected regulations. It was found that people with stronger HP derive their sense of achievement from self-determined game goals, as compared to OP-type gamers, who prefer goals decided for them [163].

Thus, differentiating users with different passion profiles [163] can be useful to determine the users' relationship to a service and react accordingly and to understand motivational processes in digital gaming experiences [165], as controlled forms of internalisation usually do not contribute for the need fulfilment of competence, autonomy and relatedness. Hence, OP types should not be encouraged, while HP is highly desirable to achieve need fulfilment.

A study by Przybylski et al. [166] applied this dualistic passion model to gain a better picture of causes and consequences of players' unhealthy feeling that they have to, instead of want to, play video games. They found that HP contributed to enhancing experiences of play related to game enjoyment; however, did not uniquely relate to the amount of play. Thus, OP cannot be detected only by the amount of time people are engaging with the system. Other factors also have to be considered in order for the system to be able to determine OP relationships. Findings also suggest that OP can be considered as a consequence of need thwarting.

In addition, related work places an emphasis on the relationship between gamified learning environments and SDT constructs. By creating environments where both individual and collaborative goals are pursued within a gamified context, it has been found that both internalisation of learning and framing of activity in general are facilitated [158]. In turn, explicit support of autonomy and competency has been found to in turn positively affect for instance students' self-determination to learn online [167]. Thus, focusing on the learning aspect of behavioural change in the health context could be one potentially successful road. Even though such gamified learning environments tried to increase motivation by providing extrinsic recognition and reward for completing activities, already highly intrinsically motivated persons can be demotivated by such rewards [168][169]. Hence, determining the initial level of task-specific motivation is also crucial for the contextual setting of the reward system.

Another study by Przybylski et al. [151] investigated how video games are capable of putting users in touch with ideal aspects of themselves. Experience of ideal self-characteristics during play has been found to be associated with increased intrinsic motivation to play video games as well as enjoyment of play and positive shifts in affect. Games were most intrinsically motivating to users who felt a wide distance between who they were and who they would like to be. This finding also extends previous research suggesting that the use of media in general can be motivated by the desire to avoid awareness of discrepant self-concepts (i.e. in a TV setting [170][171]).

Serious games in the health context have been found to be particularly motivating when individuals have fully endorsed behavioural goals to the extent that they facilitate satisfaction of the basic psychological SDT needs. Given this requirement, efforts will more likely result in actual behaviour change and maintenance [24]. It should be emphasised that too strong a focus on immediate rewards, and thus trying to influence people's cognitions in a gamified environment can lead to ignorance of important elements associated with the process involved in adapting behaviours, such as developing genuine interest in exercise or PA tasks. In the worst case, rewards can even undermine this process.

2.5 Questionnaires, Tests & Methods

Complementing this survey of related theories, in this section, we provide a short list of potential questionnaires that could be used, further compressed and integrated within the PRECIOUS system. This list is not final and is likely to change over the project's duration.

- Relative autonomy Index (RAI) [34][172]
- General Causality Orientations Scale [173]
- Aspiration Index [39]
- Player Experience of Need Satisfaction (PENS) [161]
- Treatment Self-Regulation Questionnaire (TSRQ) [34]
- Perceived Competence Scale (PCS) [174]
- Health Care Climate Questionnaire (HCCQ) [23]
- Perceived Competence for Exercise Scale (PCES) [23]
- Leisure Time Exercise Questionnaire (GLTEQ) [175]
- PA Questionnaire for Adolescents (PAQ-A) [176]
- Behavioural Regulation Exercise Questionnaire (BREQ-2) [177]
- Fear of Missing Out (FoMO) [162]
- The passion scale [178][164]
- Flemish PA Questionnaire [179]
- Psychological Need Satisfaction in Exercise Scale [180]
- PWB scale (Self-realisation) [181]
- Positive Affect Negative Affect Scale (PANAS)
- Dispositional Flow Scale (DFS-2) [182]
- Physical Self Description Questionnaire PSDQ-S [183]
- Readiness to change questionnaire (RTC) 12 items [184]
- Readiness and Motivations questionnaire [185]
- YACS 50-item [186]
- The Client Evaluation of MI (CEMI) [187]
- Client Satisfaction Questionnaire (CSQ) [188][189]
- The University of Rhode Island Change Assessment Scale (URICA) [190]

The list of these questionnaires will undergo further evaluation and will be used within PRECIOUS particularly within the onboarding process in order to determine various baselines with regards to the individual.

However, during this process, the system will need to account for bias and feelings of shame. For instance, obese adolescents who feel ashamed of their figure and weight will try to avoid these feelings [191], thus potential questionnaire items will need to differentiate whether it is guilt answering or true behaviour. Feelings of shame and guilt need to be distinguished given their different antecedents and consequences [21].

2.6 Key Take-Aways

Having discussed a variety of findings with regards to psychological theories, gamification and health related issues; a large number of principles can be derived from these findings in order to facilitate a potential service design that incorporates requirements and

recommendations for long-term behaviour change. The following table provides an overview of these findings, which will be used to design the PRECIOUS service, which incorporates a motivational framework.

Take-Away	Theory	Literature
Sociocontextual support via an adaptive environment can contribute to overall feelings of eudemonic well-being and health	**SDT**	[42]
Money, contingent tangible rewards, threats, surveillance, evaluation and deadlines generally *undermine intrinsic motivation*, and thus should not be the primary factor driving motivation to alter health behaviour	**SDT**	[17]
Providing choice and acknowledging feelings can enhance the sense of self-initiation, generally positive feedback increases intrinsic motivation by conveying effectiveness *when the individual feels responsible for the competent performance*	**SDT**	[17] [49] [19] [192] [193] [21]
Experience of freedom from rejection by others in a social context, *indicators of incompetence* and *excessive pressures*, *judgement and control* are requirements for achieving intrinsically motivated behaviour	**SDT**	[17] [33]
A meaningful rationale such that the individual understands why the target behaviour is important, *acknowledgement and acceptance of negative feelings* for non-interesting and arduous activities, an *emphasis on choice rather than control*, an informational, relevant and *autonomy-supportive language* style (e.g. "may" and "could" rather than "should" and "must") and the *support of own initiatives* are factors that facilitate internalisation	**SDT**	[17] [49] [192] [192] [21]
Long-term behaviour change for instance in PA levels are often not associated with introjected regulation, thus a *persistent emphasis on the pleasure and personal benefits* associated with the behaviour change is necessary to prevent a dominant internal obligation for the change, which in turn of often related to higher levels of autonomous motivation. Generally, it is important to *differentiate between initial and sustained service participatio*n and to design interventions and measures accordingly	**SDT**	[44] [45] [21][47] [51] [42]
Suggested activities or interventions need to be tailored to the capabilities along with *sufficient instructions and positive feedback* in order to obtain a sense of competence and thus	**SDT**	[21] [51] [194] [195]

increase intrinsic motivation by *making the individual feel optimally challenged*		
Quality of motivational messages and feedback is more important than quantity	**SDT**	[179] [21]
Empathic, unambiguous autonomy support and realistic feedback from friends and perceived leaders can greatly enhance sense of competence by acknowledgement that behavioural change is demanding from the individual's perspective	**SDT**	[42]
A focus on *intrinsic relative to extrinsic PA goals* encourages autonomous motivation	**SDT**	[195]
Providing *clear goals* for a task, a good balance between perceived challenge and perceived skills, a maximum focus on interventions for which the individual already *has inherent interests* and *freedom from distractions* by suggesting interventions with strong contextual dependencies are necessary for achieving the desired flow state of the user	**Flow**	[60] [56] [61] [59]
Individuals act with regard to a suggested intervention depending on perceived benefits and perceived barriers, thus it is imperative to *visualise and emphasise benefits* and *taking into account potential barriers* for the completion of an intervention	**HBM**	[67] [66]
Changes in *behavioural, normative and control beliefs* can produce significant changes in behavioural intention, which can be reflected in subsequent behaviour.	**TPB**	[73]
Hedonic motivation is one of the most critical determinants of behavioural intention next to performance expectancy, thus *including gamification aspects as well as visualising gains in performance* through suggested interventions is crucial to achieve intention for behaviour change.	**UTAUT**	[83] [84]
The TTM is a model of *intentional change*. It is a model that focuses on the *decision making of the individual* (decisional balance of pros and cons).	**TTM**	[76] [196] [197]
The TTM construes change as a process involving progress through a series of *five stages*: Pre-contemplation, Contemplation, Preparation, Action & Maintenance, with a common more general structure being *preintention, intention and action*. Each stage has *different requirements* in terms of how to address behaviour change.	**TTM**	[76] [196] [197]

MI is a client-centred counselling style for helping people to explore and resolve their *ambivalence* to change.	**MI**	[109] [86]
By expressing *accurate empathy, supporting autonomy, evoking client personal resources and encouraging self-efficacy*, change can be achieved by MI guidance styles.	**MI**	[109] [86]
OARS and Elicit Change Talk (DARN-CAT) along the four key processes (engaging, focusing, evoking, planning) are key tools for change.	**MI**	[109] [86]
Using change rulers for updates and a *regular check on the client importance of change* and *the level of confidence of their ability* to make a particular change (importance/confidence ruler) are interactions that facilitate the change process.	**MI**	[109] [86]
BCT taxonomies can be a useful tool to identify techniques that can be included in health interventions	**BCT**	[73]
Certain BCT techniques can *initiate discrepancy reduction loops*, in which individuals aim to decrease the difference between their actual behaviour and their behavioural goal	**BCT**	[119]
Self-monitoring has been found to be a successful strategy in increasing physical exercise and for weight control	**BCT**	[123] [122] [124]
Inclusion of game and gamification elements can make enduring tasks like increasing levels of PA *more enjoyable* by providing basic need satisfaction and by *limiting the users' capacity to deal with unpleasant thoughts or memories*	**Games**	[5] [140] [142]
Virtual environments (as in games for instance) that allow individuals to *experience ideal aspects of themselves* can have positive effects on emotions and intrinsic motivation	**SDT/ Games**	[151]
Supporting basic needs for competence, autonomy and relatedness can improve well-being within video game contexts and help *protect against disordered or unsatisfying game engagement* associated with obsessive passion, which has close relations to external regulations and thus is an undesirable state	**SDT/ Games**	[166] [164]

Table 1 – *Key Take Aways from Related Work*

3. Target Groups

3.1 Introduction

The differentiation of target groups is crucial not only from a functional and usability point of view, but also in terms of psychological influence and potential behaviour change techniques. Various studies have examined the effects of intervention programs within the framework of psychological and behavioural theories with regards to specific target groups, segmented by demographic, educational or psychological aspects.

Thus, in a first step, it is of utmost importance to assess the individual subjects' usage of an intervention program. From the point of view of the SDT, differences in strength for basic psychological needs strongly depend on the individual [17], thus the degree to which individuals experience, or have experienced, need satisfaction in different social, game and health contexts needs to be examined.

3.2 Target Group Differentiation

Potential users of PRECIOUS have been specified in Deliverable 2.1 (List of usage scenarios and user requirements), resulting in four example user groups (student, young professional, family and retired couple), which will be the main entry point in terms of differentiation and segmentation of users.

According to Frederick [198], both intrinsic and extrinsic motivations are linked with each other and unfortunately decreasing with age. Fortunately, the fitness motives themselves do not show the same tendency. This not only gives rise to an age-specific handling of target groups, but also expresses the difficulty of sustaining the motivation-process when customers become older. PRECIOUS may have to consider a longer term perspective including transitioning from one motivation scheme to another one.

- **Family Unit**

Amongst others, one's role in families may influence the efficacy of individual motivational techniques, e.g. Kassler et al. [199] have illustrated that uninvolved controlled parenting facilitates the preference for extrinsic motivations of children, while intrinsic motivations are more effective when involved autonomy-supportive parenting is used.

The size of the family has a significant influence on children's achievement motivation (cf. [200]), increasing with the size of the family, which on the other hand expresses the importance of considering group effects. A family represents a very (emotionally) closely related group, which may be even closer if the size is rather small. A long-term study has also shown that the probability for becoming obese increases drastically when a family member became obese within a given interval [201].

Both perspectives underline the "leadership role" of parents and their high influence on children. This is also reflected in Baker et al.'s [202] assessment on reading motivation where the authors claim that a parents' desire to a read books is passed on to their children. Similar effects may also be expected in the health domain where healthy (e.g. sporty)

parents may provide a perfect role model for their children. In terms of preventively reaching out to young people, the necessary lifestyle change of parents (when they may be started to be treated on physical problems) may be a good opportunity to also immediately stretch towards the younger and even more motivated users. Following the broad agreement[2] positioning e.g. obesity as a family problem, PRECIOUS has to target preventively **treating the entire family** whenever possible.

The roles of families may also be influenced or determined by socio-economic bounds, i.e., social classes [200].

- **Student**

Also see socioeconomic aspects.

Students typically have a substantially different lifestyle to classical families. Many students live on their own and a high number of students will be solitary or in a short-term relationship. Financial dependency on parents or other family members may still exist. The food may often be consumed on the go from one class to another, while the evenings may be used for learning or social activities. The group concept of students may thus be regarded to be somehow looser, while of course their integration in their family, circle of friends and fellow students is important. Motivational techniques may aim at combining healthy practices with social activities, e.g. social cooking.

- **Young, single working Professional**

Also see socioeconomic aspects.

This is a more heterogeneous group than students due to various kind of educational, professional and way of living backgrounds. While the monetary dependencies and constraints may be lowered due to their own income, career entrants may have trouble making ends meet due to below-average starting salaries. Thus, PRECIOUS should be usable with limited monetary expenditure and may make use of extrinsic motivation stimuli for attracting their attention in the first place.

- **Retired Couple**

For the retired couple, a loosening of the family concept to adult children and other family members may be regarded to be typical. It is also often claimed that the group of retired persons is highly heterogeneous. According to Woodward & Berry [203][204], the motivation for exercising is dominated by barriers to exercise. Strategies to overcome barriers (e.g. physical limited activities, difficult access to resources, etc.), thus, need to be integrated in our motivational framework supporting the transition towards a healthier lifestyle.

Following the results of Guinn [205], not only the degree of life satisfaction is critical for the intrinsic motivation of elderly people, but also a correlation to leisure valuation exists, i.e., highly satisfied users have more joy in leisure activities. Intrinsic motivation, thus, needs to be built up for elderly people by targeting measures to improve life satisfaction.

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[2] http://health.usnews.com/health-news/family-health/brain-and-behavior/articles/2008/12/10/obesity-is-a-family-affair

With rising age the problem of insufficient FI increases in importance, which may be treated by increased physical exercise (to enhance appetite) [207]. Thus, motivational strategies and apps that target both healthier FI and exercise at the same time may have to be considered for this target group.

Socioeconomic Aspects

Educational aspects, as one dimension of socioeconomic aspects, have been found to be relevant in this context. Less educated people have lower perceived competence to produce desired outcomes such as *PA* behaviour [208], most likely because they are provided with less relevant information about how to change their behaviour and because of restricted access to resources and sports facilities [21]. Thus, a stronger knowledge-focus could be a decisive supporting factor in a tailored strategy to change behaviour with regards to this target group.

Cultural Aspects of Target Groups

Cultural aspects are relevant because, for instance, specific goal contents will not necessarily have the same meaning or function in different cultures [17]. However, it is important to assess cultural orientations individually or through the perception of the participant [209] and not to generalise on levels of endorsement of certain country-specific cultural dimensions, particularly when designing a system highly-tailored to an individual. Nevertheless, full assimilation of cultural values has been generally found to be correlated with higher levels of autonomy in the context of SDT, even though there is evidence that vertical orientations or practices in terms of culture are potentially more difficult to internalise as others [209]. Hofstede's well-known cultural dimensions [210] could provide a good starting point for a cultural assessment during the onboarding process within the system.

While many theories such as the SDT do not recognise any gender-specific differences, works like [211][212] have been able to illustrate that cultural factors may nevertheless impact the motives for doing sports. Males were more strongly focused on the competence motive, while females showed higher results for physical attractiveness and appearance motives. For example, when we envision a motivational mechanism in PRECIOUS that strongly focuses on visualising appearance improvements, the activity results may not be gender-balanced. Thus, different kinds of motives may need to be covered in order to broadly address (future) users.

Delivery Vehicles and Usage Patterns

Ex ante identification of belief and attitude changes can assist proactive planning of intervention mechanisms when IT-products are used in the long-term [213]. It is emphasised that disconfirmation and satisfaction with technology usage should be tracked, and sources of any negative disconfirmation or dissatisfaction should be identified. Thus, the system should intervene before eventual service discontinuance.

Based on penetration figures [214] we can conclude that smartphones can be regarded as a mainstream technology, which is broadly used by minors and adults. However, the figures [214] also illustrate the low smartphone adoption rate by elderly people, i.e., in 2012 only 13% of people aged above 65 years used a smartphone, which is substantially below the average 60% of the entire population. Comparably, the Internet subscription rates in western

countries are typically close to 100% of the population or even above[3], i.e., individuals have more than one Internet subscription. More than 70% of all households in the OECD had access to the Internet in 2011 [215]. In the Internet usage statistics[4] we can, however, still reveal age differences; while the group of below 65 years old people converges towards an Internet usage of 100% (i.e., everyone is using the Internet), the elderly have an adoption rate of 57%. For the generation above 65 years we have nevertheless found evidence in [214] that once elderly people start to use the Internet they also begin integrating it into their daily life routines. Thus, we can conclude that the Internet may still be an excellent delivery vehicle for reaching out to a broad range of preventive care users. Considering the smartphone penetration growth rates it seems preferable to focus on smartphone services instead of primarily creating applications for tablets[5] or other kind of computers with lower penetration rates.

A highly different picture is produced when comparing TV usages by age group[6]: Elderly people (65+ years) seem to watch TV twice (around 55 hours/week) per week, as long as teenagers. While the consumption rate of elderly people is stable or even growing, every studied group below 50 years has rather stagnating or falling consumption behaviour. In particular, the young adults group with (18-24 years) has shown a clear degradation over time. Thus, we may conclude that TV as a medium may only be valuable for elderly users. Due to the increasing penetration of more modern media and the natural ageing of tech-savvy users, smartphones (with Internet usage) will soon outgrow TV on a general basis. Note that the limited interactivity of classical TVs (rather than smart TVs) may provide limited hooks for establishing modern kinds of interactions with e-health preventive care systems as envisioned by PRECIOUS.

In general, as mentioned in Deliverable 3.1 (Interim report on behavioural representation and virtual individual modelling) in Section 3.2.2, the PRECIOUS system will use the specified Technological Affinity Index in order to account for differences with regards to previous experiences with devices, and subsequently change or alter the introduction process dynamically. A potential categorisation can be found in Deliverable 3.1, along with suggestions for questionnaires in order to determine technological affinity from a conceptual point of view.

3.3 Cultural Factors

Preventing physical inactivity (PA) and poor diet quality is highly important as an active life style and a balanced diet have been associated with higher quality of life, increased life expectancy and lower risk of developing illnesses such as cardiovascular diseases and type 2 diabetes [226]. Therefore, PA and diet are the two target behaviours for the PRECIOUS system.

Food patterns and food habits vary between the European countries, although there are some similarities, including a high intake of red meat, dairy and processed food. Culture is

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[3] http://www.oecd.org/sti/broadband/broadband-statistics-update.htm
[4] http://www.statista.com/statistics/266587/percentage-of-internet-users-by-age-groups-in-the-us/
[5] http://www.statista.com/statistics/272191/distribution-of-tablet-computer-user-in-the-united-kingdom-uk-by-age/
[6] http://www.marketingcharts.com/television/are-young-people-watching-less-tv-24817/

defined as the unique set of shared values, attitudes, beliefs and practices of a group, which affect the individual behaviours (diet and PA). The influence of cultural factors is reflected in different national food guidelines across Europe. PRECIOUS won't measure the cultural values and attitudes; however, the group practices are important and have to be considered when designing the system. At a general level, the system should increase the fruit, vegetable and fibre intake and decrease fat, sugar and salt consumption.

Culture influences for instance the content of the three most important meals. Breakfast, lunch and dinner vary across the European countries, and in some cases from region to region and province to province. Although to some extent food habits are determined by the location of the country (food accessibility, prices), cultural factors and practices play a significant role. For example, regardless of the location, there are cultures (social norms, habits) that promote or encourage sweeter breakfasts, whereas other cultures promote a breakfast with salty items. Lunch is the most important meal across many cultures; however, there are again some differences with regard to the food intake (consumption) and time. Although the content of the meal is significantly affected by the location, the availability of the products and the prices, the timing is more culturally determined. In this regard, southern Europeans consume more fruits and vegetables (availability, price) and have lunch and dinner much later than northern Europeans. In some cultures the meal is a social event and culture can also influence portions and quantity.

In the same way that culture can influence the eating habits, cultural factors affect the individual PA habits and patterns. Across the European countries PA is considered important and in general people are aware that reduced or limited PA increases the risks to develop obesity, heart diseases and diabetes. When designing the system we have to be aware that PA patterns differ between countries as a result of the culture. There are cultures and social norms that encourage people to exercise only after work, late in the afternoon/evening, whereas other cultures tend to promote and encourage people to be physically active regardless the time or gender. Some differences exist with regard to the motives behind engaging in PA. PA is strongly linked to beauty and attractiveness is some cultures. On the other hand, some cultures underline the link between PA, health and well-being. In addition, some PA and sports are categorised as male sports in some cultures, preventing female or male to participate in some physical activities or sports. These and other cultural differences have to be understood.

Having said so, the effectiveness of the PRECIOUS system depends on the flexibility of the system to adapt to the culture of the targeted groups. In other words, the system has to be culturally sensitive to some extent.

4. Case Studies from Industry

In this chapter, a short review of apps and ecosystems will be presented which are related to health, well-being or behaviour change. Each description will include a summary or list of motivational element considered important and thus potentially useful for the creation of the PRECIOUS system.

My Pocket Coach:

My Pocket Coach is a mobile app that focuses on helping individuals to reach their goals. A coach guides the users to create and maintain good habits related to both physical and psychological domains (exercise, diet, sleep, stress, humour, etc.). My Pocket Coach serves to 1) identify or choose the habit the user wants to create or change, 2) to record, track the progress and export statistics, 3) to design reminders, motivational messages and rewards and 4) to stick with it and celebrate goals accomplished.

It includes several motivational elements such as:

- Visual feedback, always available,
- Avatars and customisation,
- Freedom and autonomy regarding breaking/changing habits and customisation of the service,
- Motivational messages,
- Tailored recommendations and 6. Possibility to share statistics/achievements.

Runtastic:

Runtastic is a mobile app that tracks diverse parameters (e.g. distance, duration, speed, elevation change, calories burned, etc.) of sport and PA practice (e.g. running, jogging, biking and walking). It utilises GPS technology to help map and monitor the workouts in real-time.

Several motivational elements are included:

- Personal training diary,
- Rich variety of statistics (graphs, bars, rates, etc.) related to different parameters (e.g. pace, speed, heart rate, etc.),
- Possibility of customisation of the service (e.g. display preferred statistics, reminders, etc.),
- Tailored feedback: voice coach (audio feedback based on the user's preferences) and specific recommendations after the training,
- Real-time monitoring and tracking (it gives the possibility to share location, receive messages from others, etc.),
- Periodic challenges against oneself or against other users,
- Specific and personalised goal setting (the user can choose desired heart rate zone, total calories to burn, etc.), 8. It gives the possibility to integrate the music player and to take photos during the workout, 9. It gives the possibility to share statistics.

Jawbone Up:

Jawbone Up (and Up24) is an activity (primary function), sleep and FI tracker being synchronised with dedicated mobile client applications. The activity tracker is designed as an aesthetically pleasing wristband that can precisely recognise and temporarily store steps. The step count in the cloud is updated whenever a Bluetooth-enabled device using the Jawbone application is in proximity. On the basis of the step count and a prior calibration phase, the distance is estimated (above 95% accuracy reported) and may be forwarded to other applications or services via an API. For example, runners may calibrate their step size for jogging and may upload their data to platform for runners.

The motivational elements included are:

- **Statistics** (numbers and graphs) and scores for step count allowing a direct comparison of exercise or sleep data with previous days
- **Daily goals (goal selection) & challenges**: The application suggests the user to select daily goals (e.g. 10 000 steps per day) for which the progress is visually tracked on the home screen. Dynamic challenges are further included where users may be asked to beat their average activity values of the last few days (progress is again tracked).
- Input of **mood information** via simple emoticons-based slider input
- **Social** (aggregate) **comparison** with peers of your gender and age, e.g. the application may users about their recent above-average activity values within the user's gender and age group
- **Inactivity alarms** (vibrating wristband) are issued whenever users are inactive for a defined period of time – i.e. a feature being tailored to the needs of office workers
- **Reminders** to record food & intake
- **Educative elements**: On the home screen users are informed about the recommend daily intake of e.g. water. The food catalogue, primarily placed for recording FI, also serves the learning of nutritional facts about our foods.

The wristband has been shown to entice users to increase PA by intentionally taking detours, as well as to go to bed on time. The wristband has been less efficient for FI where the data input is difficult and cumbersome (while meals from chains like McDonald's are easy to enter, self-made food is difficult to be represented).

ZombieRun

ZombieRun (slogan: "run for your life") is one of the gamified approaches to target e-health. In particular, the user plays a game where he/she has to build up a base by collecting required sources while being chased by zombies. The storyline is communicated to the runners via their smartphone's headsets – more information like states or running routes can be seen on the screen. After the run collected items can be assigned to the base, which carries the gameplay on to more inactive phases (i.e. phases of rest). Thus, motivational elements include the following:

- **Gamification**: Storyline including challenges ("missions" in the game like collecting medicine for the base)

- **Statistics**
- **Interaction** with the community (social responsibility to build up the base; support for other players)
- **Customisation** (users can contribute to the storyline; users can select specific items etc.) and **individualisation** (e.g. individually select the playlist for the run) and motivational comments and messages.

GymPact

GymPact, in contrast to prior approaches, primarily acts upon extrinsic motivation via a rewarding scheme. Users make their weekly pact with the community to increase their level of exercise or to improve their FI habits (e.g. eating more vegetables). Whenever they meet their goals the community rewards them monetarily, while otherwise the user pays other members. GymPact collects health data via its own application and external applications using the provided data API (e.g. Jawbone Up), upon which the goal satisfaction can be evaluated. Motivational elements include statistics, exchange with the community, own commitment, but especially extrinsic stimuli. Thus, GymPact may be especially suitable for beginners who have to take the first hurdle to start exercising.

mySugr

Keeping track of blood sugar levels and FI with regards to bread exchange units in an active lifestyle (e.g. exercising) is a difficult task, which is even more difficult for children. mySugr aims at assisting and motivating diabetes patients to cope with their illness. Amongst others, mySugr allows the easy integration of blood sugar measurement data and helps to ease the FI recording process. A "monster" is supposed to remind users of blood sugar level measurements and the proper entry of their FI. Whenever the monster is happy or satisfied, the user is doing a good progress (compare to Tamagotchi-like games). The variant specifically designed for children ("junior") provides gamified UI elements to simplify the complexity of their illness and gamify the learning of important facts about diabetes. By receiving access to FI statistics of their children, but also by direct communication (children can requests assistance for recording their FI by sending a picture of their meal to their parents), parents can assist their children. mySugar thus makes use of the following motivational elements; gamification, with especially using the concept of avatars (a monster's mood reflects the health status of the user), target groups, reminders and statistics, motivating messages, and reward schemes (e.g. collected points).

Withings

Around the Withings brand a series of e-health products such as activity trackers or smart scales exist. Especially of interest is the smart scale, which provides high precision weight feedback, which can be paired with further means of analysis. Withings also aims at educating users by integrating air quality, body fat mass and heart rate levels. Withings mainly focuses on providing statistics to the users.

Summary

Especially for the area of activity tracking and exercising, applications exist that make use of a series of motivational elements to increase their impact. Successful applications have demonstrated creative ideas in order to introduce such elements in a natural way for specific kinds of users (target groups etc.), while at the same supporting the endeavours of users to become healthier. Only a few motivational elements such as statistics on the user's progress have been shared across application, which underlines the required tailoring to the application context.

We believe that even more variety will be needed to address more kinds of users (e.g. elderly users) that have so far been left out of focus, as well as to even more successfully transfer motivational elements to the food intake, sleep and other health domains.

We have also observed the lack of integration of individual health applications (tailored to specific needs and contexts) into a general framework (unified interface, data basis etc.) that goes beyond certain degree of API access to data. Thus, PRECIOUS will have to focus on both measures for supporting greater variety of health applications and the creation of an integrative health framework that harmonizes data access, storage and protection, as well as interfaces.

5. Towards a Motivational Framework

5.1 Guidelines & Principles

The PRECIOUS system will provide a motivational framework tailored to the individual and their lifestyle on a variety of different levels, with a strong emphasis on positive enforcement. The overall goal of the motivational system is to facilitate sustained internalisation of healthier behaviour over time, the core of the system consisting of goals (what behaviours to change), self-monitoring (sensoring, see Deliverable 3.1) and feedback (rewards etc.).

From a conceptual point of view, the framework can be thus split into four different parts:

- **Understanding**

The individual's motivation, interests and (previous) activities will be quantified within the Virtual Individual Model in form of different, aggregated variables from psychological theories in order to create a link between the individual, a suggested action or intervention and a response, cumulating in classifications in forms of for instance changes of change. A list of potential variables can be found in the report Deliverable 3.1. Empirical evidence as well as recommendations and guidelines from studies will serve as a starting point in order to suggest interventions and applications relevant to the individual, and the quality of these relationships will increase over time due to the system's capability of learning by checking on how the user responded to suggestions. Including psychological variables into this process is an entirely new concept that could potentially enhance an individual's motivation for actual behaviour change.

- **Behavioural Change**

Starting from the Virtual Individual Model's parameters, suggestions in terms of behavioural change techniques can be made that are contextually (location, weather, etc.) relevant, best fitting to the motivational status of the user and closest to the user's specified goals. This also enables the system to identify potential conflicts in terms of time requirements and other factors for interventions, and thus do not suggest health measures unsuitable for the users current situation.

Therefore, the system will focus on these techniques, encapsulated within a number of creative applications the PRECIOUS team will deliver, which potentially work best based on a previous classification and quantification of both psychological and health variables. In this way, all apps created, including those implemented by external developers, will necessarily use of the motivational system provided by PRECIOUS.

Given the PRECIOUS sensoring system, the system will be capable to learn over time which apps and subsequently interventions were successfully delivered and thus further adjust its parameters by identifying the discrepancy between suggestion and actual action.

- **Self-initiative and Choice**

In order to support basic psychological needs for autonomy, PRECIOUS will provide extensive features within the system for individualisation, including a modularised app system where users can feely choose apps they like and dislike, an extensive goal guidance system leading users towards their goals (see Section 5.3) as well as module called "recipes" (see Section 5.7) which will enable the user to create own context-based rules for interaction and feedback. Thus, feedback preferences can be fully customised, starting from simple phone vibration to the activation of specified actuators at home. The goal here is to let the users increasingly regulate their own behaviour over time based on which metrics are provided to them.

- **Gamification**

PRECIOUS will implement as standardised reward system across all applications in order to make achievements and progress comparable among apps and individuals, where tangible and contingent rewards will be kept to a minimum and primarily serve as an extrinsically motivating tool during the onboarding process, thus trying to incrementally showing the value of the system to the user. A so-called Gamification API will be implemented giving access to all the tools, functionalities and principles gathered in a simple and standardised way to apps.

5.2 Onboarding & User Assessment

Onboarding is the act of bringing a new user into the system. The first time that the user engages with the system is crucial, because this is the moment when first impressions are made by the user regarding the system [143]. Typically, the first minute within the system should not be part of the explaining process, but instead about experiencing the core behaviour of the service; therefore, immediately showing value to the user [143].

However, this step can already be used to gather understanding of the user. For instance, if the user is walking, steps could be measured, or the front-face camera of the smartphone could be used to determine the user's heart rate. Thus, within PRECIOUS, various ways will be found to combine fun aspects with information gathering at the same time.

The next step of the onboarding process is the actual user assessment and allowing users to quickly understand the basics of the system and thus move on to higher levels as efficiently as possible. Simultaneously, the system will obtain basic data from the user. The right amount of information input has to be determined. On the one hand, more information enables the system to make better suggestions right from the start; on the other hand, overwhelming a novice user with questions can lead to immediately decreasing interest in the system. Asking meaningful questions however, also informs the system about the user's true and on-going engagement with the health topic. Several theories have proven that behaviour change happens through qualitatively different stages, with a common structure being pre-intention, intention and action [130]. As the transitions between different stages is critical in terms of intervention suggestion, an initial assessment of the users stage is important to tailor the service. These factors will be evaluated during the onboarding process, where we aim to make this process more interesting by also including funny and challenging UI-features, potentially even mini-games yet to be specified, instead of simple

questionnaires – see for instance Playable Data [227]. It is important at this stage is that the user should not be able to fail on their very first interaction.

Within the onboarding process, it is also important to clarify the features and functionalities of the system. After the first engagement, the user should be able to understand what the platform can do, but also what it can't. This is particularly important in order to avoid disappointment and frustration with the system in later stages. Second, the complexity of the system needs to be revealed slowly. This will be achieved by an introduction tour through the system explaining features and functionalities.

In general, the onboarding process should be tailored to the individual to some extent. This can be done using factors already entered by the user, such as demographical variables or even psychological traits or goals. While some users might want to see potential progress on a virtual avatar depending on selected goals, other might be more strongly motivated by seeing success stories of other users or before/after comparisons of other people or friends who managed to change towards a healthier behaviour. These factors need to be examined empirically in order to improve the onboarding process, but can also be further adjusted and derived through machine learning of other users' behaviour.

In order to prevent usage conflicts with the system, a basic questionnaire regarding diseases, operations or other medical conditions needs to be included in order to be able to suggest the right interventions.

Finally, an immediate feedback about the initial user assessment should be shown in the form of risk factors and areas with room for improvement, ideally with choices for further adjustment and modification.

By designing the onboarding process in this way, PRECIOUS will also try to gain the trust of the user starting from the very first interaction. Thus, the right mix between fun elements and elements perceived as professional, or recommended professional physicians, has to be found. Furthermore, data privacy issues also need to be clarified at the beginning.

5.3 Goal Setting

The PRECIOUS goal guidance system within the motivational framework will consist of several steps aiming at facilitating the process of goal achievement, such as for instance maximising self-efficacy, which is central for the actualisation of behavioural goals [228].

Creating awareness & Increase Knowledge

The first step towards self-efficacy is to create awareness of the user's current status in terms of potential risk factors, in addition to previously shown behaviour. This will be part of the onboarding process of the system, which will visibly display pros and cons of the user's behaviour, thus subsequently increasing the user's knowledge level about general health recommendations through their own experiences.

Assessment of Readiness to Change

In order to be able to suggest health goals, a conceptual differentiation needs to be made between 1) not yet having formed any intention for behavioural change, 2) having formed an explicit behavioural intention or 3) actually acting in order to achieve the formed behavioural intention [130]. This greatly influences for instance the goal choice and affects the levels at which self-formulated goals are typically set [229].

Goal Formulation & Choice

Depending on the risk and psychological factors determined within the onboarding process, the users should then be able to formulate goals relevant for behavioural change. The emphasis will be placed on guiding the user towards well-specified health national guidelines or type-2 diabetes prevention goals.

The process could begin with a list of both reasonable and achievable wishes to make a first distinction between global health goals. Following this stage, concrete health goals will be formulated by the user. They should generally be SMART; specific, measurable, achievable, relevant and timed [230]. In particularly, the user should be able to self-monitor the goals over time, which has found to be an effective tool among healthy FI and PA interventions [115] next to given feedback. Discrepancies between the behavioural goal and actual behaviour typically initiates a discrepancy reduction loop in which the individual aims to adjust either behaviour or environmental factors [119]. Goal progress and importance are generally strong predictors of feelings of success and well-being. Aiding the formulation of self-set goals will be key tools, phrases and features from Motivational Interviewing [107], which resembles as "person-centred counselling style".

Goal choice in general has been subject to a variety of different studies, with several outcomes regarding requirements and suggestions. First, studies have shown that hard goals generally lead to a higher level of task performance as compared to easier or vague goals [229]. Nevertheless, high goals must not be perceived as a threat but rather as a challenge. Three basic requirements have to be met in order for the individual to be self-satisfied with performance later on; a certain level of commitment to the goal, the ability to attain it and having no other conflicting goals. Second, with regards to knowledge-based goals, which will also play a crucial role in PRECIOUS, goals can also function to store task-relevant knowledge or to motivate the user to search for new knowledge [229]. By increasing knowledge about health behaviours, awareness could potentially be raised, thus affecting the desired lifestyle change. Thirdly, goals have also been found to be effective under certain circumstances when coming from different sources, such as friends, family members or other social contacts. Others can simply assign them, or they can be created jointly or through participation. Social influences tend to affect the level at which goals are set, thus this is an important factor when formulating or suggesting goals. Even though group goals add another layer of complexity to the system, it has been shown that high personal goals, which are compatible with group goals, greatly enhance group performance [229].

Furthermore, the scope of the goals set is also important. Past performance has been found to be a strong indicator for the levels at which goals are set, hence setting multiple goals with

different scopes, i.e. short-term, long-term or even macro goals valid for the whole PRECIOUS platform, could be a tool to increase long-term motivation.

Personality traits have also been found to influence goal setting through general goal orientation. For instance, people with extrinsic goal aspirations [39], i.e. people focused more strongly on image, financial success or appearing physically attractive, rather than attainment of life goals, community feelings or self-development, tend to chose tasks in which they can look good in the eyes of others [231]. This is often also referred to as performance goal orientation. In extreme cases ("amotivated condition"), this can result in goal-avoidance motivation and substantially lower goal levels.

Finally, the system will provide tools to rate goals in order of importance of change behaviour and confidence in achieving it. This selection along with the complexity of the tasks and goals formulated with both user and the system needs to be selected carefully according to the personality of the user in order to prevent for instance obsessive behaviour. Complex tasks can also lead to tunnel vision, i.e. too much focus on the short-term rather than the long-term goal leading to converse health effects or even injuries.

Action and Coping Planning

After having formulated and chosen health goals, the next step will be planning, which is a core component of self-regulation of behaviours for overcoming hurdles between good intentions and action (see for instance [131]). Planning is typically divided into two different areas:

Action Planning

Action planning deals with the question of when, how, where and how often interventions will be performed in order to achieve goals and thus behaviour change. Here, it is imperative to include situational, contextual and environmental factors of the user in order to suggest suitable interventions. A potential measure would be to show different scenarios to the user in terms of interventions from which the user can pick, thus at the same time further learning about interests.

Coping Planning

Coping planning is preparing for setbacks when the individual is facing difficulties through "if-then" rules. Coping planning has been associated with effective maintenance of the new life style [232].

After the goal formulation phase, the user will start using the system and enter engagement-loops within the system and subsequently provide feedback to track progress, which is a key moderator of goal setting [229].

Self-monitoring

Self-monitoring is the last crucial component as it provides information to the user on her or his goal attainment [233], optimally leading the individual to adjust strategies or effort over

time based on the feedback given by the goals set, which at the same time enhances self-efficacy [234]. The global reward system (see Section 5.6) will then take care of providing self-reward for goal attainment, or else new or revised goals for attainment can be formulated. Through the continuous display of a health status as well as visual presentation of coins & activities (see Section 5.6.1), the user can track the difference in attainment between goals and actual behaviour.

5.4 Engagement Loops and Requests

Life is always very dynamic and things may change more quickly than any automatism or system may be able to respond. Thus, we envision a motivational interaction system with three kinds of **possible interactions**:

- **Automatism / Push request**: The health status of each user is continuously monitored. Activities are actively suggested ("pushed" to the user) whenever relevant abnormalities are detected or the health status drops below a certain threshold. The automatic interactions should be tailored as much as possible to the individual circumstances of life in order to avoid annoying interaction requests or overambitious suggestions. We, thus, target automatism that natural integrate in the users' lives and assist the internalisation of healthy practices.

- **User-driven Action / Pull request**: Users may feel the need to engage themselves, e.g. to improve their health status or to just feel better. In this case, the user can at any time call the system and start an interaction (the user "pulls" activities from our system). This activity is of course monitored and thus feeds the automatic push loop.

- **User-driven Lookup / Soft pull request:** Many users may frequently check their status, statistics or news on the system's dashboard (comparable to checking the status in social media). Despite the possibility that users may have started the application without any direct intention to become active themselves, we regard this behaviour as a window of opportunity for considerately placing interventions. In other words, the user expresses interest in health topics by opening the application and is now just one click away from being actively involved (or even the commitment to new health goal). We assume that the mental cost of change might be lower in this case than in a classical push scenario. We will later on regard this kind of activity to be a "soft pull" request by users, which has to be treated with outmost care being followed by considerate activity suggestions and interaction modes.

Generally speaking, the interactions listed above result in three kinds of system-wide interaction loops: **Engagement loops**, **Progression loops** [235] and **Estimation Loops**.

On the one hand, an **engagement loop**, depending on the interaction type, is an experience that a user enters and cycles through iteratively that offers incentives and dynamic, positive reinforcement mechanisms. It operates at micro level, from user to action. The engagement loop pulls the user in, incentivises an action, and rewards the user for completion of the

action by offering another incentive to take an additional action. Engagement loops can be started either by user-driven actions or push-requests. Self-monitoring for instance is part of a typical user-driven engagement loop, where the user compares her or his goal attainment and subsequently engages with the system in order to make adjustments if necessary.

Generally, the typical elements in an engagement loop are:

1. **Motivation**: the system gives the user some reason to be motivated and to actuate. If this motivation is strong enough, the user will take an action to overcome a challenge. If not, the loop dies and another motivator arises to provide the same effect through a push-request.
2. **Action**: the user performs the action to accomplish the goal.
3. **Feedback:** the key of engagement loops is feedback. It must be clear, immediate and meaningful and related to the action performed.

Our system will keep this process going continuously (either by push or pull request) so that each piece reinforces other pieces. Additionally, a well-structured progression loop will take the user from early stages that are easy to learn, up to harder stages of mastery that allow to progress through the system.

Progression loops operate at macro level in broader structures of activity throughout the PRECIOUS system. Instead of getting the users to move in one big leap, which seems overwhelming, the process is split into multiple smaller progressive steps within individual interventions. Intermediate steps must be balanced in an effective way so that the user has a sense of mastery and self-efficacy [235]. However, as research has demonstrated [236], self-efficacy is not enough to predict behaviour change. Only if the person is really convinced about the potential negative effects of their risky behaviour (e.g. unbalanced diet, being sedentary, etc.), will behaviour change be prompted.

Estimation loops are system-internal processes designed to further adjust the system after engagement loops. They consist of four general parts, namely estimating, analysing, suggesting and reacting.

Figure 3 – *Estimation Loops*

Estimation loops are responsible for push requests to the user, as well as adjustments, which take place within the Virtual Individual Model. Some psychological variables cannot be directly estimated from sensor input; thus, one way to estimate them is to measure the discrepancy between suggestion and reaction of the user. Estimation loops are also responsible for detection of health thresholds for instance, and are thus continuously running in the background without being visible to the user.

5.5 Behavioural Change Techniques

As mentioned in Section 2.3.2, related work has proposed a taxonomy for behaviour change techniques [9]. This list of techniques will be extensively used within PRECIOUS in different ways. Due to the modularised app approach being pursued (see Sections 5.6.2 and 6.1), one potential selection criterion for apps are behaviour change techniques themselves. Thus, some behaviour change techniques will be globally included within the system for instance in the goal guidance system, while others will be implemented by apps or external developers.

Hence, next to contextual and situational requirements like time, weather, mood etc., another factor for intervention suggestions can be behaviour change techniques. Over time, the system will be capable of connecting VIM parameters to behaviour change techniques in apps that have actually led to modified behaviour and therefore learn to link these two aspects, which can then be used globally in the system.
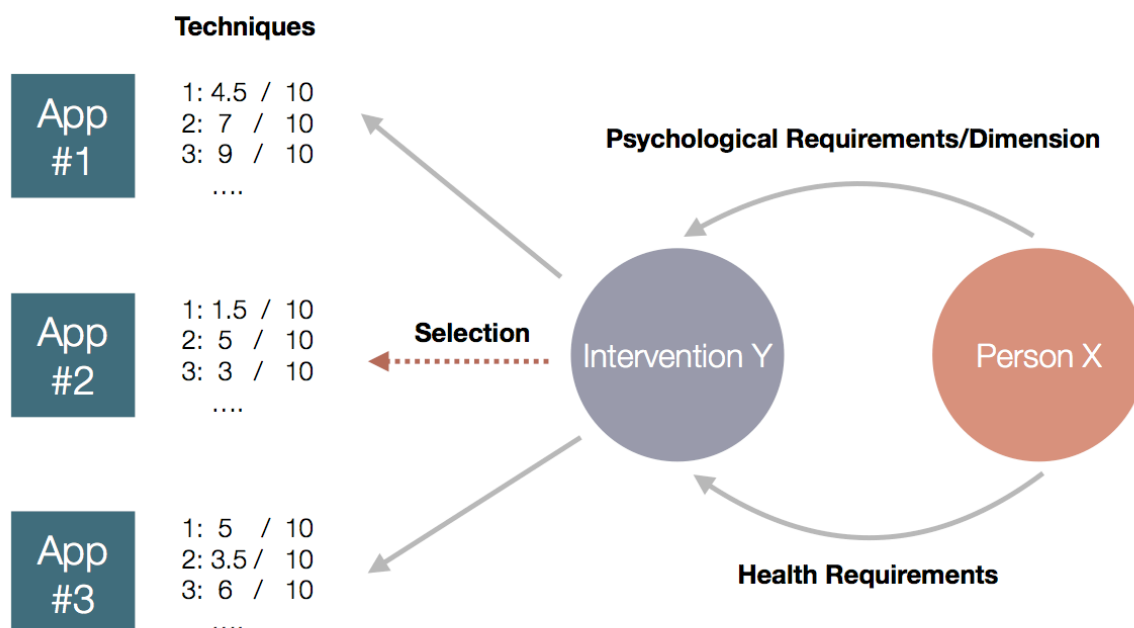
Figure 4 – *BCT Dynamic Intervention Approach*

As seen in the graphic above, one potential approach would be to initially rate interventions and apps based on how strongly different behavioural change techniques are included. These ratings are then stored within the Marketplace module (see 6.4), and can be used to estimate the best working app and intervention in terms of rated behaviour change techniques given user-specific parameters. External developers for instance could be required to beta test their application before submitting and let users themselves rate the inclusion of behaviour change techniques in order to have a starting point for the system.

5.6 Gamification

5.6.1   Global Reward System

In order to facilitate and standardise some of the gamification aspects of the system, a global reward system will be implemented that distributes a variety of rewards consistently independent of the actual app the individual is using. The actual distribution process is briefly mentioned in Section 6.3, but still has to be concretely specified. In general, the aim is to achieve a systemic integration of these gamification aspects, such that achievement and progress are 1) comparable between persons, friends and family members, 2) comparable between different applications, so the actual behavioural change and motivational status of each application is quantifiable to some extent. Furthermore, it should be emphasised that the reward system is not pattern-bound, thus it is included dynamically to achieve a single gameful experience even though the user is dealing with a number of different applications, potentially from different developers.

- **Activity Coins**

Activity coins are the primary metric measuring micro-goals within the system. They are immediately awarded for different kinds of health activities and thus should serve as a feedback tool. Different applications can have different subtypes of activity coins, and it is still to be specified whether activity coins are going to be split by areas of progress, such as FI or PA. Activity coins are non-redeemable and also serve the function of giving a compressed overview of the individual's health status in order to measure self-progress. Optimally, the user should learn to associate certain levels of activity coins with actual and experienced (lifestyle) changes.

- **Karma Coins**

Karma coins are, like activity coins, non-redeemable and are awarded for social activities, collaborative tasks or quests and generally speaking which require any kind of interaction with other users of the system. Thus, they serve primarily as a tool for achieving intrinsic motivation through relatedness to other people. People can actually see Karma Coins of other people provided the privacy settings allow this feature, and thus actively search for people to collaborate with in order to improve their own health status.

- **Health Coins**

Health coins are redeemable coins and awarded based on multiple factors, most importantly the users own health goals as well as potential combinations of activity and Karma Coins. Thus, they will play a crucial role within the onboarding process due to the fact that they service primarily as an extrinsically motivating tool. They can also be used as tool for health maintenance, i.e. when the interest curve of the user is declining, offers, discounts or extras can be offered. In general, one of the most important functions of Health Coins is to achieve motivation for the users to further invest in sensors and health-monitoring devices, so the health status can be recorded more accurately and thus the systems recommendations can be more accurate. Therefore they can potentially be compared to a PRECIOUS-specific health currency that could under special circumstances even be tradable.

- **Activity Level**

Activity Levels are awarded for accumulation of Activity coins and thus measure medium to long-term progress. Given that Activity Coins do not expire over time, Activity Levels should typically increase with system usage over time. The system will differentiate between different activity levels in terms of reachability, thus while during the initial phase it is easier to progress to advanced levels, it will get increasingly harder to achieve higher levels. Certain activity levels can also be used for developers in order to unlock objectives, upgrades, quests and tasks and furthermore can be used as a quick health indicator in order to determine the intensity levels of the individual's usage of the system.

- **Reputation Level**

Reputation Levels are awarded fro accumulation of Karma Coins and therefore measure, similar to Activity Levels, medium to long-term progress in terms of social aspects of the system. The implementation will follow a similar approach to Activity Levels, with the difference being that a Reputation Level indicates levels of social interactions with others rather than actual health progress – potentially even how the individual has helped other users' health status.

- **Experience Level**

Experience Levels are awarded for accumulation of Health Coins and thus fall into the category of being redeemable. Again, progress in Experience Levels will increase in difficulty over time similar to the other two Level measures mentioned above. Experience Levels will be used to unlock tangible items such as being able to invest Health Coins in health-related devices.

- **Health Status**

Along with Coins and Levels, users will be able improve their health status in forms of medals, which can be bronze, silver or gold. Depending on how many Activity Coins for instance users managed to collect within a certain period of time, the user's health status can either for instance get better from bronze to silver status or decrease from silver to bronze status. Another possibility is a traffic light like system, or a rating based system where users additionally can have an outlook on their status (indicated for instance in a similar way to credit ratings, e.g. AAA+). Thus, the user always has an overview of her or his current status in a simple, quantified form.

Leaderboards

PRECIOUS will automatically create Leaderboards capturing the different Coins and Levels. Generally, no-disincentive Leaderboards will be used, where the user's status is only compared to a peer group with similar health values gathered from the VIM. Nevertheless, the option will be given to switch to infinite Leaderboards. Furthermore, Leaderboards will also be available for given friends & family members, as well as specified by geographical distance in order to be able to potentially contact intensive health users of the PRECIOUS system to achieve common goals.

- **Badges and Trophies**

In order to account for different types of activities and interventions, Badges and Trophies will be awarded when the user reaches certain levels of activity, reputation or experience. Each app can include own badges and trophies here and can make in-game progress dependent on these elements.

As mentioned in Deliverable 2.4 (Ethical and privacy guidelines for PRECIOUS system implementation) in Section 2.2.2, all the measures mentioned above will continuously be tracked for obsessive usage of the system, i.e. unnatural and unhealthily fast progress in

terms of coins or levels in order to prevent both misusage and obsessive usage. This will result in temporary infinitely difficult progress in coins or levels accompanied by warnings and notifications.

5.6.2 Modularisation through Apps

PRECIOUS has chosen a modular approach for integrating different apps with different purposes under a single system. From a psychological point of view, this has multiple reasons, for example one intention is to avoid letting the user form habits.

The human brain is specialised to respond to novel events which provide new information, a variety of experiences with elements of surprise and creativity spread out over time thus have a higher chance to success in keeping the user motivated over long time periods [237].

Secondly, by creating a number of gamified applications, it is intended that the user will seek out flow experiences [16] more often, with a total involvement within a task, quest or challenge.

Each of the client applications will consist of two aspects in terms of gamification:

- Usage of the global reward and gamification system via the Gamification API (Application Programming Interface)
- Individual gamified elements within applications

Each application can have individual game-based elements providing fun experiences (see Section 6.5 for ideas regarding client applications), however, having a unified reward scheme enables the system to have a game-like experience when using the system, even though it is composed of very different modules potentially implemented by external developers.

5.6.3 Gamification API

The Gamification API will be the central entrance point for applications in order to access features with regard to gamification, individualisation and motivation. We want to emphasise that at this stage, the list of features is not final and will probably be enhanced when more and more features are added to PRECIOUS.

- **Amounts of Coins, Current Levels, Badges and Leaderboards**

Apps can always access the users' current status in terms of Coins or Levels as well as accessing badges, trophies and the users' place in Leaderboards and thus make in-app progress dependent on the users' health status, which can of course also be improved via other apps. Thus, apps can generally contribute to progress in other apps if desired by the developer.

- **Transformation of Activities and in-app Tasks, Quests or Challenges into Rewards**

A metric will be defined translating measured activities and in-app progress into rewards contributing to the global reward system. Apps can access this information for instance to

inform the user about potential progress in terms of rewards when a certain intervention is suggested to the user. Furthermore, as all users react differently to rewards, the moment when rewards are awarded can also vary across users. While some users expect rewards in a certain interval, others prefer unexpected and surprising rewards. This fact will be included within the API when potentially issuing Coins, as unexpected feedback has been found to increase intrinsic motivation (see Section 2.6).

- **Define progress**

Apps can have their own badges and trophies, which can be made dependent on aspects and factors decided by the developer.

- **Access friends & family**

If allowed by the user, developers can easily access settings and rewards of friends and family members in order to tailor their service. This can for instance be used to send and receive motivational messages from friends, family members or other linked contacts.

- **Create (Collaborative) Tasks & Quests**

Apps can have their own tasks and quests, which will be specified in form of interventions. There will be a standardised way to do this via the API, also when for instance creating social interaction with other users by making task goals etc. depending on other users.

- **Addressing the user**

Depending on the environmental context of the user, the Gamification API will provide the best way to currently address the user via different means, i.e. vibration, notification, sound.

- **Adaptive Aesthetics**

Apps can dynamically modify the appearance of their content depending on the settings of the user. This can include colour themes, chart types, and interaction types but also writing style, where prewritten text in funny, informal or informational language style can be used to address the user with standardised messages.

- **External Developers**

Another potentially interesting feature is to make this API accessible for real-life video and mobile games. Thus, external developers operating outside the platform can make their game content depending on the health status within the PRECIOUS system (e.g. Angry Birds Levels only playable when user has gathered Activity Level 12).

5.7 Recipes

Another motivational tool of the PRECIOUS system will be called Recipes. PRECIOUS will create a maximum autonomy supportive environment where users can fully and transparently control how and why interventions are suggested, and subsequently manipulate these connections to their own desire. This aligns well with the principles derived

in Section 2.6, namely providing choice, meaningful rationales and tailoring to capabilities. Users will be able to design "if-this-then-that" or "if-this-then-don't" rules in an easy and understandable way in order to connect their own behaviour to certain actions, similar to the IFTTT[7] platform. In this way, users are able to create their own interventions to some extent. For instance, an office-worker used to long working hours could implement a rule warning them to drink a glass of water when sitting in front of the computer for longer than three hours. On the other hand, users can alter and modify rules of already existing interventions, for instance cancelling all notifications regarding PA when rain is expected in the area. The complexity of this tool is still to be determined, but it could have great potential also for the formulation of user's own goals.

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[7] https://ifttt.com/

6. System Design and Approach

6.1 A Unified System Design

More and more e-health applications like Jawbone Up have recently emerged and enjoy increasing popularity. Most applications individually collect and process the data and in some cases also provide APIs for exchanging some kind of data with other platforms or apps. These applications nowadays still represent island solutions where users have to trust every individual developer. For example if someone is using a PA tracker that exchanges some kind of data with a platform for runners, he/she has to trust both data collectors. This trust issue is also continued in the User Interface (UI) where users have to gain confidence in using each application, i.e., a learning curve for every used UI element exists. The learning of understanding and trusting an application is an effort, which may hamper the innovation of e-health applications in several ways:

- Users may not be willing to switch to newer services once they have settled with a service they are now familiar with, i.e., the cost of change may be too high to justify the transitioning to a new service (whether due to the effort of getting used to other kinds of interfaces or to the effort of understanding the trustworthiness and professionalism of developers).
- Only a limited number of applications/services and their developers can be continuously monitored for their trustworthiness. Thus, users may limit their application usage to a few known applications.
- The possibility of untrustworthy applications (or applications of low quality) may reduce the perceived value of newly introduced services – this kind of phenomenon is typically referred to as "market for lemons" [238].

In this light, PRECIOUS will for the first time provide a systematic and unified motivational framework and platform that allows the interaction with potentially untrusted developers via a secure and trusted interface. This will be realised by hosting individual applications on a unified platform that allows the sandboxed-execution of developers' code. The applications by developer will be tailored to the needs and wishes of users, while the underlying PRECIOUS platform will remain level-headed by assisting users to protect their privacy. Consequently, both user and developer communities are important stakeholders of this concept.

Hence, once a trust relationship between the user and the PRECIOUS platform has been established, critical data (personal information, raw health data from sensors, etc.) can be considerably protected and moderated in order to liberally allow the users to benefit from a multitude of service offers but on the other hand to avoid the handing over of any critical information to developers. For the end users PRECIOUS can create an environment where they can freely and easily experiment with applications fitting best to their context, while running no dangers of interacting with unknown developers. While this kind of design may seem to primarily benefit users, also application developers can profit from the PRECIOUS' simplified cross-application interaction. This may lower the costs for developing high quality

applications, which again may positively affect the service offer, i.e., a two-sided market where user and developer satisfaction are interrelated.

In order to avoid steep learning curves when for the first time interacting with newly installed applications, PRECIOUS' UI guidelines will simplify the user's transition from one application to another– i.e., known UI elements will appear in every application, which will easily be recognised by users and will thus help to shift the attention towards the unique contents and details of every application.

In summary, PRECIOUS is able to establish a single trusted point of interaction for any kind of e-health application, whereby equally integrating applications from trusted and untrusted developers. Additionally, the high standard of integrating medical and psychological expertise as well as review opportunities (allowing the users to express their experiences) may positively affect the feedback being provided to users (e.g. when communicating to the user whether a PA has been sufficient today), which is intended to contribute to the satisfaction of users and a healthier society.

6.2 VIM & Behavioural and Motivational Representation

As further documented in report D3.1, the Virtual Individual Model will contain several parameters and variables capturing the users state, also in terms of behavioural and motivational aspects. The list provided here is in a preliminary state and is subject to further discussion among the partners.

- Technological affinity
- Health-related knowledge
- Social network & family system
- Health-related values & preferences
- Mood & well-being
- Psychological distress
- Substance consumption
- Health-related goals and desired changes
- Level of motivation and desire to change
- Readiness to change

Further potential variables, deducted from this report, could include:

- Goal Aspirations

Tailoring the service strongly depends on the goals set by the user in accordance with the suggestions provided by the system. Intrinsic goal aspirations, such as attainment of life goals, community feelings, affiliation, self-development require different actions and rewards as for instance extrinsic goal aspirations such as image, financial success or appearing physically attractive.

- Passion Tendency

While harmonious passion type of users gather sense of achievement stronger from self-determined goals, obsessive passion type users are stronger motivated when goals are decided by others. This fact could potentially be leveraged within the goal guidance system.

- Control orientation

Types and timing of rewards issued for instances highly depends on the users control orientation. While autonomously controlled persons prefer self-initiation, activity seeking and take greater responsibility for behaviour, persons with higher control orientation can by influenced by rewards, deadlines, ego-involvements and structure.

- State of Flow

When the user is engaged with the system, determining the level of relaxation versus anxiety could give further information on whether the user is performing an activity wholeheartedly and for intrinsic purposes or not. If the system fails to deliver this state, different measures will be needed to provide motivation.

6.3 Attributing Achievements

Following the goal guidance system in Section 5.3, this section serves to further illustrate how rewards could be issued when achievements or goals are met.

In general, there exist two kinds of achievement categories:
1. Current achievement (relative to prior iterations; short term)
2. Absolute achievement level (long term)

The current achievement is modelled via a **dedicated goal setting and goal achievement mechanism**, which is described in the subsequent section.

The **absolute achievement** level, however, provides a longer-term perspective on the personal evolvement. Thus, it has to be able to break down the user's health in meaningful subcomponents for which the tracked activity is recorded.

Common categories could be sleep, FI, PA, stress etc. for which levels of achievements could be indicated through accumulation of Activity Coins (see Section 5.6.1), e.g. gold status for FI. Even through users will keep their Activity Coins and Activity Levels, they can still loose their health status due to inactivity, as healthy behaviour should be encouraged to be sustained. Thus, whenever a user becomes inactive (whether forgetting to track activities or actually inactive) the status may start to continuously drop. This may render the impression to the users that they are running the risk of a certain loss.

Due to the subsequent design of the goal setting engine but also due to the possibility of only exchanging the user status (e.g. gold) instead of absolute numbers with others, a direct comparison on absolute numbers (e.g. distance covered) is avoided. As a result, the personal progress is presented more relevant than the absolute achievement, which is absolutely in line with PRECIOUS's endeavours for facilitating the behavioural change rather than training professional athletes.
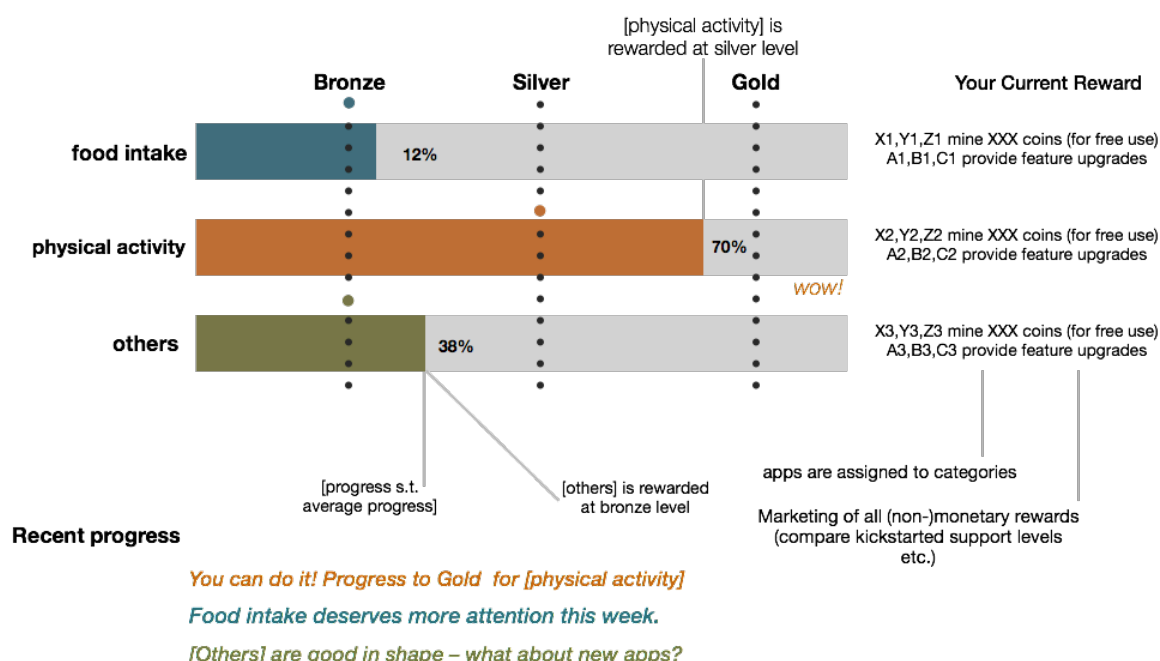
Figure 5 – *Achievement Attribution*

Goal Setting

The goal setting mechanism plays a crucial role in the motivational framework design in e-health, as it has to trigger and sustain healthy activities without overstraining users. For this reason, choice can be a very important concept for moderating such process within PRECIOUS. This chapter focuses on the continuous goal setting and adjustment process rather than the onboarding process as described in Section 5.3.

Whenever users in lieu of force have the possibility to actively select their target for the next iteration (e.g. day or week), their degree of commitment may be increased. Under an active target selection the non-achievement of a goal comes with contradictory cognitions that may lead to some degree of discomfort. To avoid this kind of discomfort, a certain level of extra commitment may be yielded, which should not be overstrained in the long run. On the other hand, the constant non-achievement of overly ambitions goals may disrupt the process of internalising healthy practices into daily routines, i.e., the effect may not be sustained. Thus, it is important to provide meaningful and ambitious default values around which a certain degree of choice allows an optimal fitting to the user's current needs, condition, self-confidence, and motivation. As a result, the goal setting will take an important role in our motivational framework, where choice around clever suggestions should be enabled.

Beyond that, the framework has to further consider meaningful bounds for the context of PRECIOUS: It may not be rational to use such a framework to even more motivate professional athletes, while it may also be unbeneficial to give justifying goals for inactivity, i.e., absolutely minimal activities, which represent no progress over prior iterations, may not help to install a more healthier way of living.

Concept

We envision a concept consisting of five health states (quintuple), two of which are hidden (extreme values) and three are offered to the user. The goal in the middle of the scale will be the calculated optimum that would be best suitable for the user from a theoretic point of view. Thus, by the design of the scale a defaulting (priming) towards the theoretically optimal choice is given – i.e., libertarian paternalism [239] –, while alternatives may provide means for optimally adjusting to circumstances of life (level of motivation, mood, physical condition, schedule, etc.). This provides the user with the free choice, an active commitment to health goals, and a corresponding assessment of the own achievements in the upcoming iteration.

For the later analysis, six achievement states can be created around the five targets. These achievement states are designed to provide means for further avoiding the absolute comparison of achievement values (to prior weeks or with others; indirect awarding scheme), the support for record seeking endeavours (e.g. professional sports) and the over-interpretation of normal fluctuations across measurement iterations (e.g. due to minor schedule variations etc.).

Based on the degree of achievement, e.g. the goal engine was using too ambitious goals; the goal design of subsequent iterations will be influenced.

The process of setting goals consists of the following seven envisioned steps:

1. Data collection by the platform and all connected sensors, which feed the VIM of each user
2. Extrapolation of activity trends, frequency of opening apps etc.
3. User-individual creation of target quintuple from "very ambitious" to "less ambitious" (see below) – targets are relative to prior achievements, the current health data and the current level of interaction with the application
4. Free target selection by the user out of the three central goals in the quintuple – the other two targets are hidden and only serve further analysis reasons (see details below)
5. Monitoring of goals and continuous motivation to achieve the own goals
6. Final achievement figures (based on achievement states relative to the chosen goals), which will feed subsequent iterations
7. Rewards such as Activity Coins or Health Coins are awarded

Interaction Design

Based on our framework the goal setting should be straightforward and comfortable for users. Users have no awareness of the defined states and any hidden additional target levels. Users can only select the 3 most relevant target levels and will only see their achievement state around these levels rather than the entire range.

The "very unambitious" and "very ambitious" extremes are introduced as boundary cases. Boundary cases on the one hand limit the degree of over- and underachievement to a realistic spectrum, but the even more provide feedback on the inadequacy of the current goal setting. So, whenever an extreme is reached (several times) the app may not be suitable for this user or the target suggestions may be inadequate.
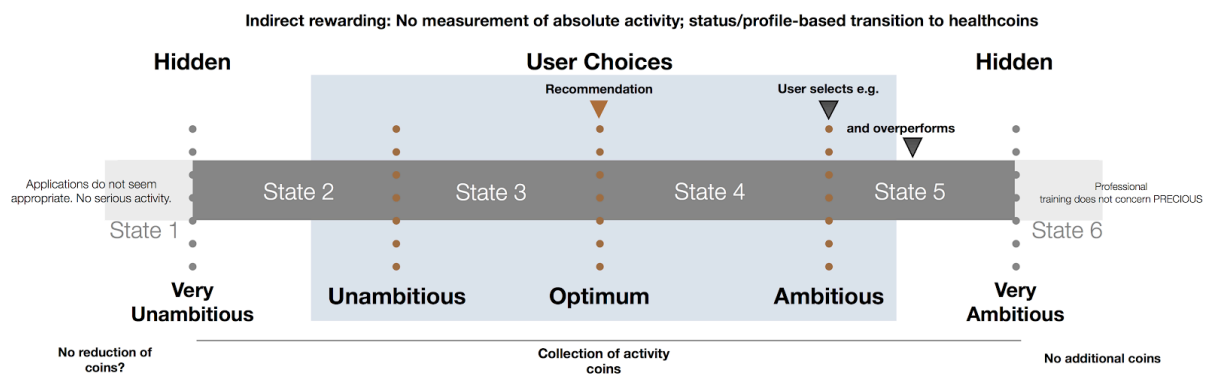

Indirect rewarding: No measurement of absolute activity; status/profile-based transition to healthcoins

Hidden	**User Choices**		**Hidden**
	Recommendation	User selects e.g.	
		and overperforms	
Applications do not seem appropriate. No serious activity.	State 2	State 3	State 4	State 5	Professional training does not concern PRECIOUS
State 1			State 6
Very Unambitious	**Unambitious**	**Optimum**	**Ambitious**	**Very Ambitious**
No reduction of coins?	Collection of activity coins		No additional coins

Figure 6 – *Interaction Design with Goal Continuum*

Please take note that also the labelling of targets, e.g. "Optimum" or "Recommendation", when presenting them to the user may essentially influence the user's choice or the perceived freedom of choice, which needs to be further studied with later design mock-ups.

Apart from that, the sketched states will provide a more relative and fair issuing of Activity and Health Coins. For an almost professional athlete, the achievement of long distance runs may not be as challenging and thus surprising as the very short run of a very untrained novel user. For more details on the concept of Health Coins and related tangible elements we kindly refer to WP2 deliverables.

Quality Control

Due to the difficulty of considering app-specifics, sports-specifics, etc. in a general goal-setting engine, we recognise the benefits of integrating the expertise of the application creator. For example, every application may design five goals for every user based on the data provided from PRECIOUS (health status, trends, etc.), the guidelines and assistance

tools for goal setting and the domain-specific / app-specific requirements instead of globally calculating goals on a pure data basis.

This may, however, lead to unpredictable achievement figures, e.g. many users may overachieve if the application sets too low targets, which may also actively be used for rational business advantages (cheating). We will, thus, briefly review four means to avoid such problems:

- Reviews for the fairness and adequacy of the goal setting mechanism – reviews may, however, not be able to avoid the overachievement (too much praise, too many points, too high game/app level, etc.), but only unfair distributions.
- Issuing of achievement levels and activity coins (or comparable metrics) based on the final distribution of user achievement. So, when calculating the medium degree of achievement (e.g. in terms of obtained state), the activity metric (and later on Health Coins) may be issued relative to this point. This, however, may appear to be inconsistent as personal achievements may seem to be decoupled from the global point of view. Reviews may provide the correcting hand, which positively or negatively rates the correlation between global and personal achievements.
- Automatic analysis of achievement statistics around the defined goals in order to provide feedback to the developers to optimise their algorithms. Whenever a constant misuse of the goal setting mechanism is detected, the application will be suspended from the market in order to avoid negative user experiences or the creation of misleading expectations by the personal success.
- Externally set goals based on achievement distributions of prior iterations without the inclusion of app- or domain-specifics.

6.4 Adaptive Interventions

The following diagram gives a big picture of the PRECIOUS system, along with a potential flow starting from the VIM to the actual intervention on a user device.
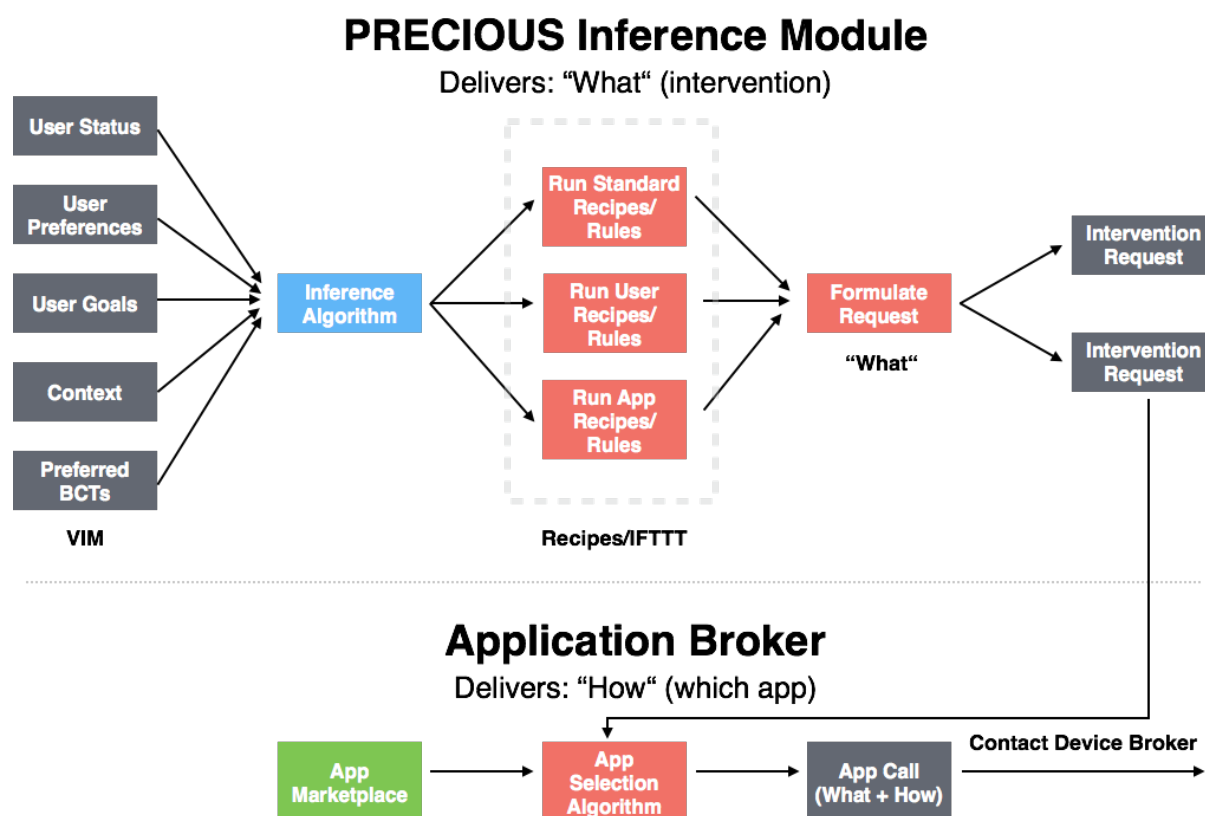
PRECIOUS Inference Module

Delivers: "What" (intervention)

Figure 7 – *PRECIOUS Inference Module*

As already mentioned within this report, the PRECIOUS system will be highly modular, meaning that different apps will be brought together within a motivational framework. Starting from the Virtual Individual Model, the user's health status and previous behaviour will be analysed, resulting in a general user health status, preferences regarding for instance devices, apps, etc., set goals, the current environmental context and preferred behavioural change techniques which could have already been adjusted within a cyclic learning process. This information is fit into an inference algorithm merging and adjusting this information.

In the next step, this information is run through a set of recipes (see Section 5.7), which can be standard recipes set by the PRECIOUS team based on general health guidelines issued for instance by public institutions, user-based rules or rules created dynamically by apps and developers. After the rules have been run, a request is formulated containing the information on what health behaviour should be targeted with an intervention. This information for instance also includes important contextual information, such as whether the user currently has time to perform an activity, the weather outside, the current mood of the user (if available), baseline-levels of activities, geographical requirements in terms of proximity and goal-fit of the required task.

Subsequently, an app selection algorithm matches apps and their specified interventions with the request. Apps can register interventions based on a metric to be provided. An

example would be a running activity for instance available within an app, which has a time requirement of 0.5 hours, should be optimally performed during good weather, after a good night's sleep, etc. In addition, interventions of apps have registered behaviour change techniques (BCT), so higher matches with previously successfully used BCTs are ranked higher in the algorithm.

Next, a list of potential applications and their interventions is sent to the device broker, which checks for available devices and actuators of the user. A number of technical factors however have to be considered when implementing this model in order not to undermine motivational factors in terms of usability, such as connectivity (and what to do when no internet connection is available), memory space of the device in use or potentially app pricing.

6.5 User Interface and Interaction

This section is supposed to present initial, conceptual designs for the PRECIOUS User Interface as well as interactions with the system. We will only deal with the smartphone case in this report, although the concept could potentially be ported to several other platforms.
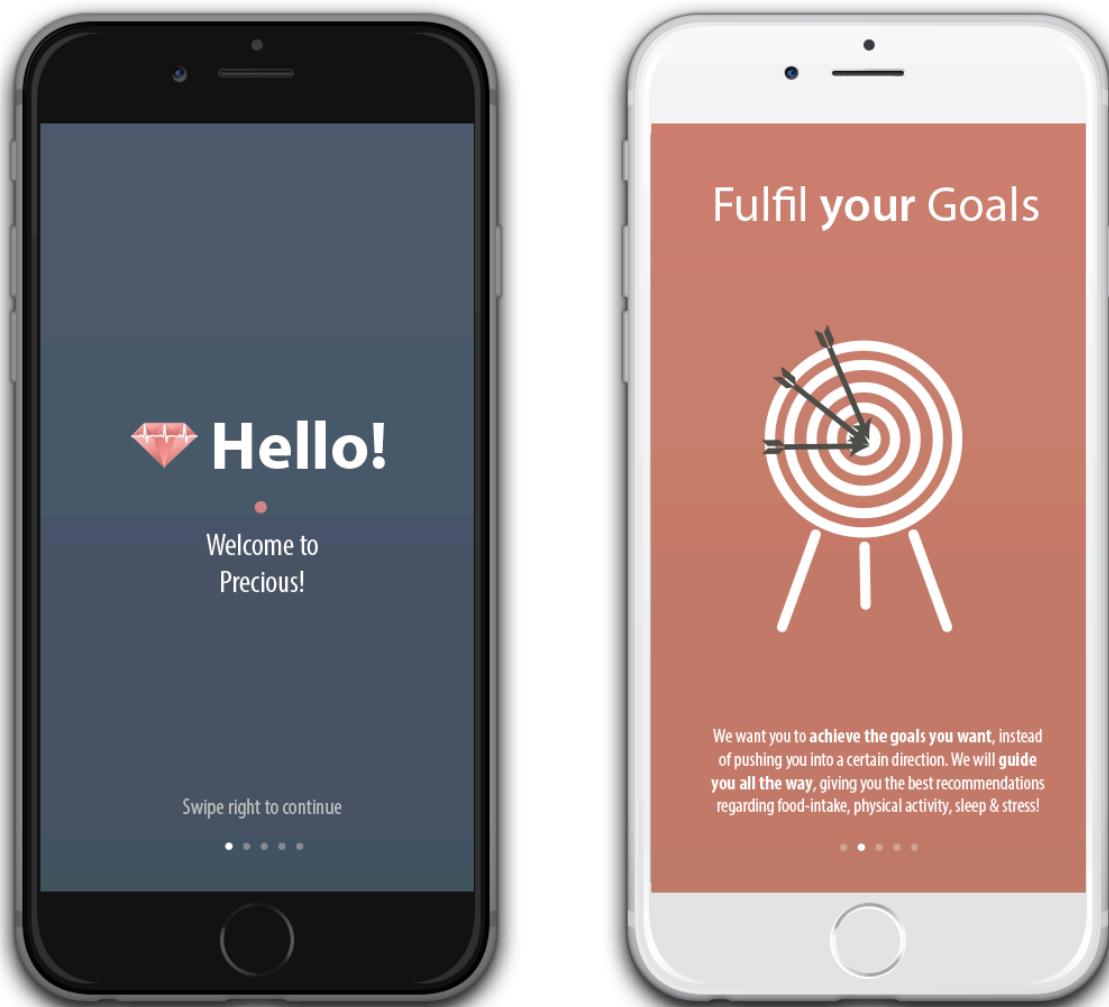
Onboarding

Figure 7 - *PRECIOUS Welcome Screen (a) and Initial Messages (b)*

In Figure 7, a potential welcome screen is shown together with the initial messages conveyed to the user. This will be the first point of contact with the system, and it is important to immediately clarify the functions of PRECIOUS. This will be accomplished via five animated single page views graphically describing the features and functionalities of the system from abstract point of view. In this way, later user disappointment with regards to different expectations can be avoided.

Next in the onboarding process will be, as mentioned in Section 5.2, about experiencing the core behaviour of the system. It is still to be determined whether a small introduction game will be created, how this can be individualised at this early stage of the onboarding process as well as how this can be used in order to already start gathering information.

Subsequently, the user will start the personalisation process by creating an account, his personal settings as well as connections to social platforms and devices already in possession of the user.
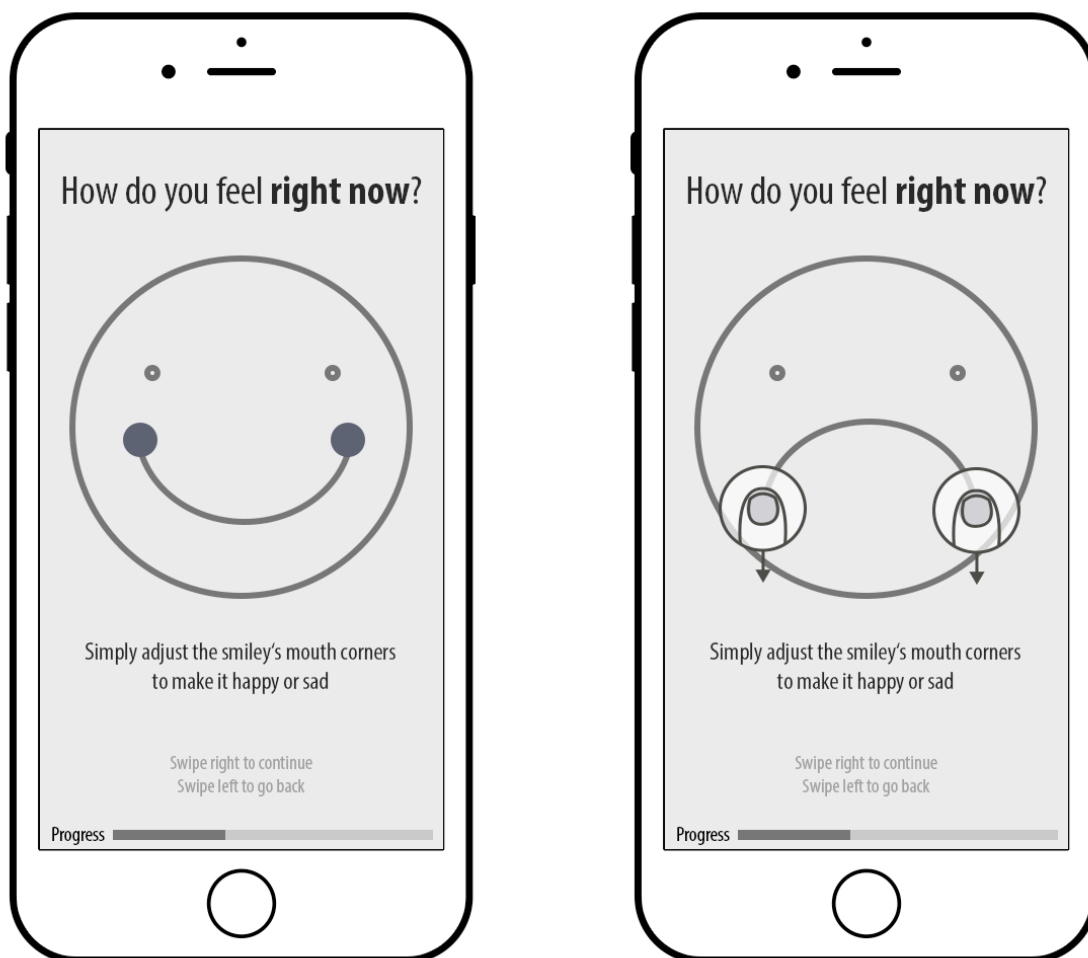

Figure 8 - *Example Question within the Onboarding Process*

Subsequently, the user will have to fill out several questionnaires in order to create a baseline level profile. The PRECIOUS team will try to make this process as short as possible and with as much interesting and fun elements as possible, for instance by adjusting figures or pictograms (see graphic above, where a smiley can be adjusted by touch gestures).

After having finished the registration and individualisation process, the onboarding part of the system will be completed with an optional tour of the features explaining navigation and other aspects.

Figure 9 - *App-Stream (a) and Scrolling (b)*

In Figure 9, the App Stream (a) on the left and scrolling through the App Stream (b) on the right can be seen. The App Stream represents apps and interventions that have been selected on purpose by the user and which have been determined by the app selection algorithm as described in Section 6.4. The size (the bigger the more important) and rank (the further to the top, the more important) of the app view within the App stream is determined depending on the match of an app intervention with the formulated request of the PRECIOUS inference module. Each application can display any type of information within the App stream, but adherence to design guidelines will be necessary in order to create consistency across apps. The App Stream will implement lazy loading to maximise performance, i.e. further App modules are dynamically loaded as the user scrolls downwards via an upward swipe gesture (see Figure 9 (b)).
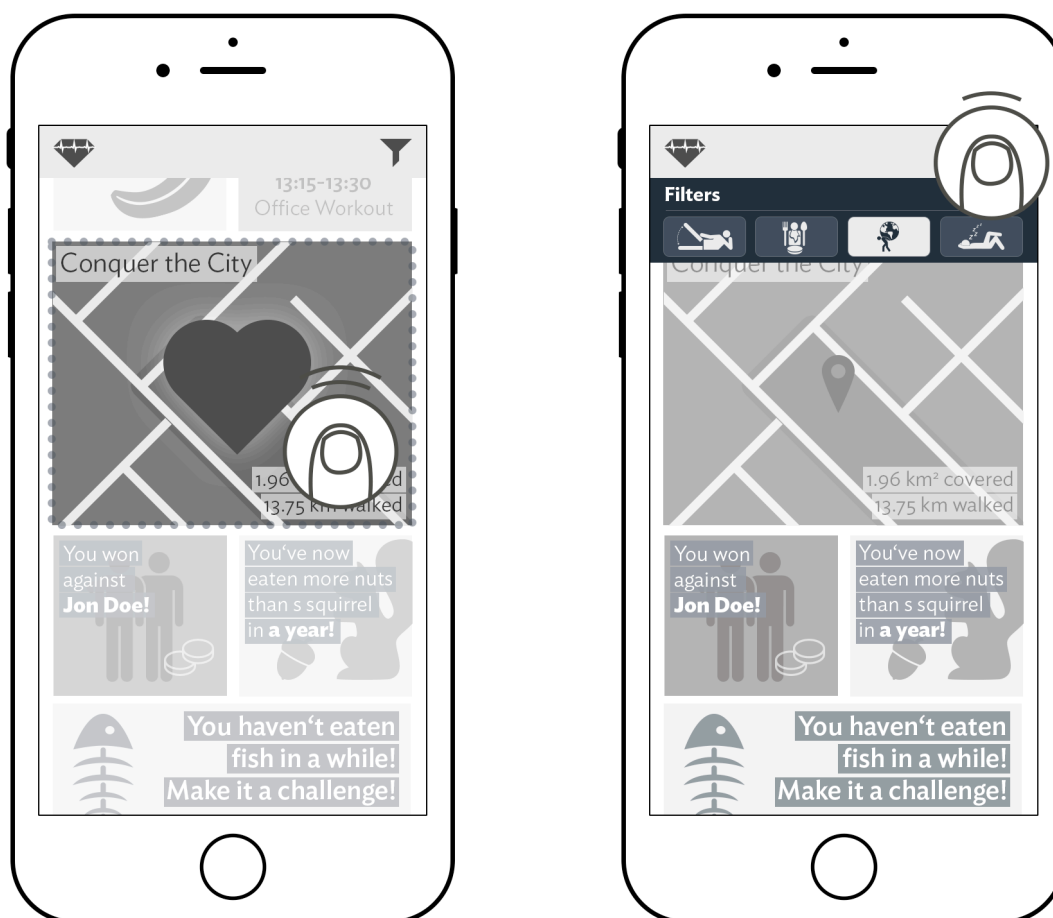
Figure 10 - *Liking (a) and Filtering (b)*

Users have access to several functionalities directly from the App stream. The first and most obvious function is to select an App, which is done by simple tapping on the app. In Figure 10, two more functions are depicted: Liking (a) an app intervention on the left and filtering app interventions on the right (b). Users can immediately like an app by double tapping on the respective app in the App stream and thus ensure that more interventions will be displayed from this application in the future. Furthermore, users can filter interventions based on the four areas PRECIOUS is focused on: PA, FI, stress and sleep. Filtering can be achieved by single-tapping on the filter icon on the top-right corner of the App Stream view.
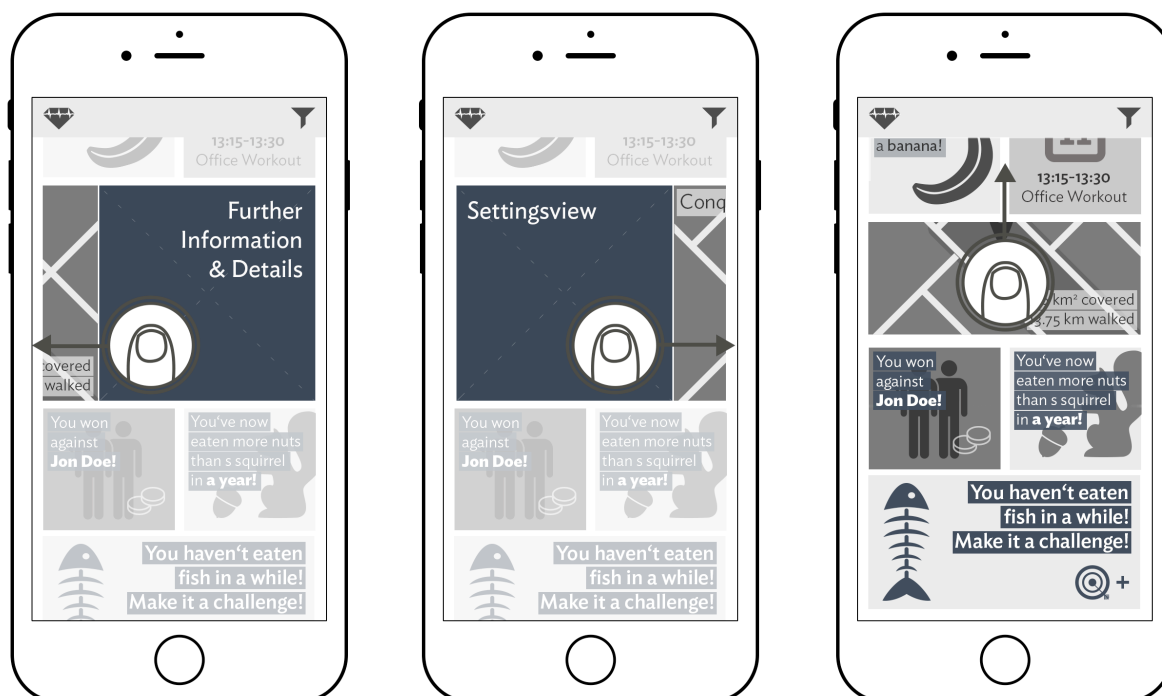
Figure 11 - *(a) Detailsview, (b) Settingsview, (c) Hide Function*

Users don't necessarily need to fully open an app by tapping on it. If they prefer to quickly view more information about the respective intervention, they can open the Detailsview as in Figure 11 (a) on the left. The Detailsview is activated by long-pressing on the App view within the App stream and then swiping to the left. Apps themselves have access to this view and thus external developers can put additional content in this view. Similar to the Detailsview is the Settingsview (Figure 11 (b)). It is activated by long-pressing and subsequently swiping to the right. Here users can quickly adjust settings of the app, such as privacy settings or other individualisation settings. If users do not want to get a specific app displayed any more, they can hide an app by long-pressing and swiping upwards (Figure 11 (c)). In this way, no more interventions from this app will be shown by the system.
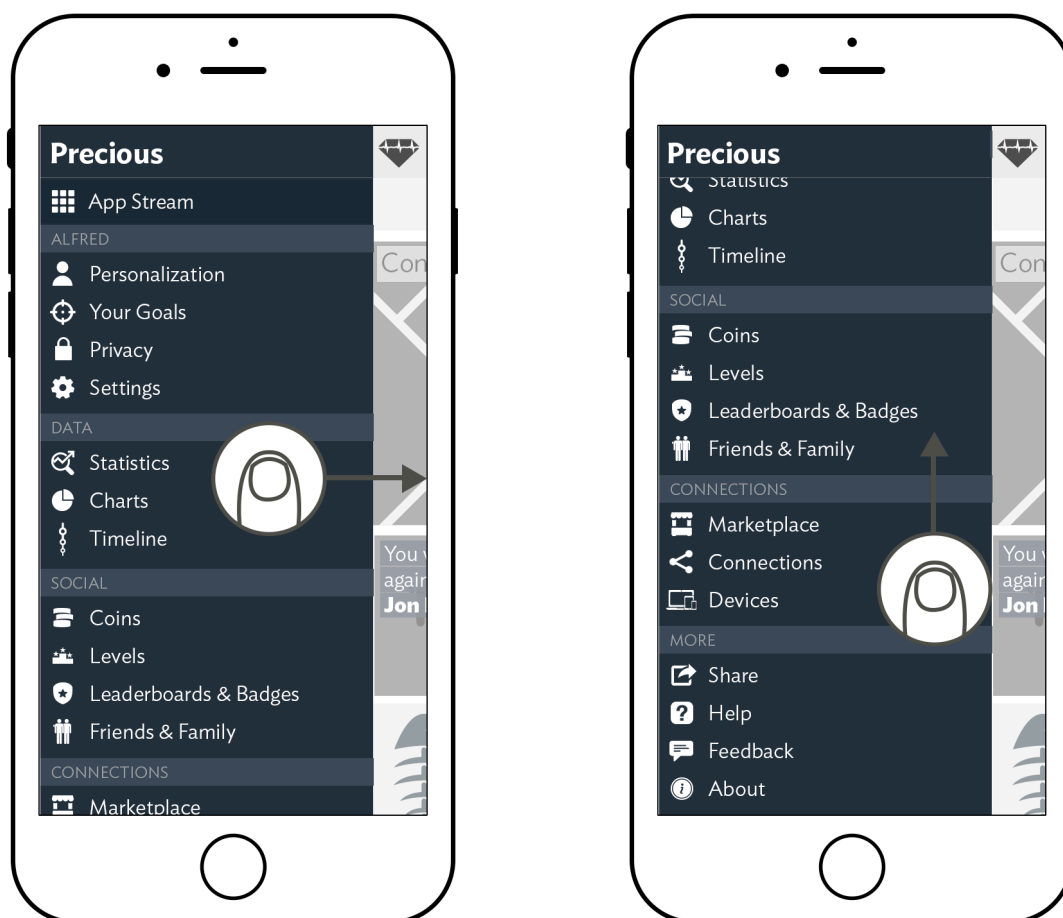
Figure 12 - *Settings Opening (a) and Settings Scrolling (b)*

Further functionality of the system, which is not yet designed, will be reachable through the settings view. It is consistently reachable via a swipe right gesture (Figure 12 (a)) and can be scrolled through by swiping upwards and downwards (Figure 12 (b)). A preliminary arrangement of settings has been found to include the following:

- Personalisation (Themes, Sounds, Colours, etc.)
- Privacy (Passcode Protection, Friends Visibility, App Access to Data, etc.)
- Your Goals (Goal Guidance System and Overview)
- Settings (Notification Types & Frequencies, etc.)
- Statistics (Steps taken, etc.)
- Charts (Visually appearing representation of health data)
- Timeline (of personal activity and of friends and family)
- Coins (Activity Coins, etc.)
- Levels (Reputation Level, Experience Level, etc.)
- Leaderboards (App Badges, Global, Local Leaderboards, Friends Leaderboards)
- Friends & Family (Overview of Contacts and others' achievements)
- Marketplace (all Apps, Reviews, etc.)

- Connections & Devices (FB/Twitter, Gmail, Runkeeper, MyFitnessPal, Nike+, BodyMedia, Withings, Runtastic, etc.)

Last in this UI preview is the recipes module, as described in Section 5.7, which will be consistently reachable through a swipe right gesture. Here, users can quickly browse for other users recipes, add new recipes, as well as activating and deactivating recipes specified by themselves, developers or the PRECIOUS team (Figure 13).

Figure 13 - *Recipes*

6.6 Client Applications

By applying the technique of a consortium-wide client application competition (presented in Vienna in Sept 2014), we have targeted the identification of interesting concepts for client applications assisting those which are already on the market. These applications will all have own specified intervention and behavioural change techniques and thus be visible within the App stream as separate views. They will be selected dynamically by the PRECIOUS inference module.

Below we will briefly sketch some of discussed ideas to give some indications on the variety of required motivational stimuli being reflected in a multitude of client applications.

PRECIOUS Time Finder

Organising a family, being successful in the work and finding the time to reconcile different aspects of life makes it a difficult decision to start practicing. There is a clear trade-off when

investing precious time that could be spent with one's family on doing exercising. Thus, the PRECIOUS Time application will focus on aligning the exercising needs of several family members in a way that time can be spent together but healthy goals are not neglected. The process starts with identifying overlapping gaps in the calendar. In association with typical workout preferences, the geographical distances from each other, the availability of exercising equipment and suitable workout locations, an exercising meeting is automatically suggested by the application. When at least two of the invited family members (or two friends) agree on the exercising suggestion, the meeting will be arranged. Thus, the social environment plays a very important role for the PRECIOUS Time Finder application. Apart from that, the application also allows the manual suggestion of social workouts by users (the users can send invitations to others) as well as the alteration of automatic suggestions. Hence, this app utilises geolocation-based information and the access to the calendar, to improve the work-life balance and to facilitate a healthier lifestyle.

Health-a-Gotchi

In the past there has been a very successful game called Tamagotchi, which positions the user in the role of being responsible for an avatar that needs to be taken care of (FI, sleep, entertainment etc.). This principle is transferred by health-a-Gotchi to the domain of preventive health care. The avatar in the game is kept alive and physically and mentally in good shape whenever the player treats its body healthily (and diligently records the data). As in the original game, the avatar can even die or becomes very unhappy when it is not treated with the expected care. In our case, the system thus rather represents a mirror of the user's body where the consequences of unhealthy behaviour are exaggerated and visualised. Thus, this application provides useful gamified feedback to players while at the same time encouraging them to become more active to change their lives.

Health-a-Gotchi may comparable to Tamagotchi represent the avatar like a chick or may use a representation of the user (specifically designed filters using the front-facing camera of the smartphone or modifying an uploaded picture).

Conquer the City

This geolocation-based game idea is about motivating users to avoid the shortest path when walking somewhere - e.g. to the office - and to generally encourage them to walk. Users have to conquer their city in collaboration and competition with other players. Players can conquer and protect a building or area for some time when circling it. The more often the same building has been circled, the better will be the protection against attackers. Speeds above 15-20 km/h and too great distances being covered are ignored to avoid cheating. The bigger the occupied area by a player, the higher is the score in the game.

The game can also include missions and challenges that are unlocked in the course of time, e.g. capturing landmarks or police stations may trigger specific missions for which players can earn extra points. Rent in the form of points is also collected for occupied buildings. Random events like disasters may destroy those buildings, which have to be rebuilt by users for collecting the entire rent again. The collected points can be invested in upgrades of the protection for occupied buildings.

Depending on the covered area, the user can overtake important roles in the city area, e.g. mayor or even emperor.

Walk the Last Mile

With this game concept we target the utilisation of augmented realities in order to encourage players to walk or run. Players can collect activity coins by following a path shown on the screen. Every few metres they can pick up a single coin - visually represented on the screen. The distance and distribution of coins is varied according to the air pollution, traffic, noise and green space in the area in order to motivate users to exercise at healthy locations. Recommendations of attractive places nearby are pushed to the device. Whenever the activity level of the player could currently be higher, the app sends suggestions to the user.

Impulse Purchase

Everyone has experienced the temptation when standing in line at the register and being confronted with attractive but unhealthy or expensive offers. The Impulse Purchase app is created for such situations and forces the user to reconsider the quick purchase. When users attempt to quickly purchase something unhealthy the contactless payment system may first refuse the payment. In this situation the user receives a second chance to question the current impulse purchase in order to rationalise the decision process, which may positively influence the current or subsequent purchases. Of course, when the user would like to continue with the purchase, the second payment attempt will not be rejected.

Exercise Class

For sedentary people the idea of an exercise class, the gym or going jogging may be daunting or at least unpleasant. In many cases office workers would even like to become more active but cannot easily leave their desks for long periods. So, instead of overwhelming users with unrealistic suggestions, this app concept aims to educate users about small changes.

During the day the application sends push recommendations to the users (based on inactivity measures or just on schedule) in order to suggest some small office exercises. Whenever users are stuck in meetings, the app may use fake calls to help users to leave the room for some moments. Additionally, the application tries to understand and ask the user where they are in order to not only optimise the current exercise suggestion based on the user's health status but also based on the environment, e.g. a single-person office, an open space office (with or without presence of colleagues), the toilet, the canteen etc.

Users receive points and motivations such as congratulatory messages when becoming active. Over time, users may become "office athletes" in the application in order to reflect their progress, which can be shared with other players.

The Social Canteen

Healthy meal choices are difficult, especially when eating externally. When eating in a canteen, the food choices are already limited when entering. In the canteen, decisions have

to be made quickly when standing in line with many others. Thus, users require prior knowledge (quality, appearance, healthiness, etc.) about daily dishes at close-by restaurants and cafeterias. Such information cannot always be provided by online menus, which typically only allow finding facts for individual restaurants (offered dishes, prices, and potentially nutritional information). In addition, many restaurants do not have a precise online coverage.

In this light, the social canteen concept is proposed, which allows the community to provide missing information and adequate recommendations. Users can upload pictures (optional description, price and quality rating) of the dishes they have ordered, eaten or just seen and all users of the community can start rating the size of the dish (nutritional value) and the nutritional balance (proteins, fats, carbs etc.) by simple slider mechanisms. Once a few ratings for a restaurant have been collected, (push) recommendations can be given to users that are currently looking for a place to eat or are already entering the same canteen. Each user can then record their choice with the application and will receive activity coins for healthy picks or the avoidance of the unhealthiest dish. Bonus points will be granted for recommendations to other users and uploads of new dishes. Educational introductory tutorials – where the app teaches users to make healthy choices – will further provide users with relevant knowledge on FI, which can be applied and tested during the social rating of dishes.

7. Conclusions and Next Steps

The motivational framework proposed in this report is based on principles and guidelines, which are derived from an interdisciplinary approach to this topic, ranging from the areas of behavioural science to games and gamification, and thus merge a multitude of different viewpoints on this rather complex topic.

The SDT has been found to be highly applicable within the PRECIOUS context, providing a large number of principles deduced from empirical validations, which can be used to facilitate support for basic psychological needs and, in turn improve psychological well being. Furthermore, differentiation in stages of change during the service usage over time, as in variations of the TTM, can have a substantial benefit in terms of tuning and adjusting the above-mentioned support. On the other hand, the BCT taxonomy as described in Section 2.3.2 provides a useful approach for both evaluation and differentiation of applications, which will be used to further tailor the service to the user regarding suggestions and recommendations. Finally, MI has been found to be an interesting and relatively new approach to guide the user towards a certain health goal, whose concepts could facilitate the transition between motivational stages towards a decrease of health risk factors.

In the present report, these findings have been translated into a motivational framework and subsequently into a concrete, interim system design. In summary, we have specified the onboarding process of the user into the system and described the goal setting system, which possesses a strong emphasis on maximising self-efficacy through several steps, such as letting the user formulate their own goals along with action and coping planning. Additionally, a common global reward system is proposed which is separated into Activity, Health and Karma Coins, which account for a user's status both on short and long-term.

Finally, we have formulated our vision on a fully modularised, user-centred and unified system. This provides a maximum level of variety in terms of ideas and tailoring to individual user demands, while at the same time giving intervention-level granularity of suggestions and recommendations that are consolidated within user-set goals, rewards and achievements. Within this vision all applications, including those developed by external service providers, work together under a joint motivational umbrella to create an individualised strategy that enables the user to achieve their goals. The conceptual UI designs included in this report provide a first step towards a manifestation of the final system, which will translate a user's health risk factors from a clinical aim into a concrete intervention strategy, in addition to considering motivational aspects and barriers the individual might encounter.

Next steps include further discussion, iterations and improvements of the motivational framework mentioned in this report, along with alternative suggestions for UI designs, reward systems and other factors potentially influencing the goal guidance system for instance, which all need to be evaluated empirically once prototypes are ready. This report represents an interim stage of the motivational aspects of this project, thus a lot of decisions still have to be made.

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