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by

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SUPPORTING GROCERY SHOPPING TO ACHIEVE A HEALTHY AND SUSTAINABLE DIET

HOW DEVELOPING A BEHAVIOURAL THEORY INFORMS DYNAMIC SMARTPHONE APPLICATIONS

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1 Contents

Abstract

Health and sustainability are becoming increasingly important in current lifestyles. In this context healthy and sustainable grocery shopping is one key aspect to facilitate a balanced and environmentally friendly diet. Many people are interested in changing their habits to become healthier and to consider their impact on the environment through the choices they make. But many do not consider where a healthy and sustainable diet starts. In other words, people frequently have a vague idea that grocery shopping is an important aspect of a healthy and sustainable lifestyle, but they lack sufficient knowledge and action plans to act accordingly. Therefore, the observable behaviour in many cases shows what is called the intention-action/behaviour gap, the attitude-behaviour gap, or the knowing-doing gap (Ajzen, 2016; Grunert, 2011; Hoek, Pearson, James, Lawrence, & Friel, 2017; de Schutter, 2015; Bailey & Harper, 2015).

To break this deadlock people, who are interested in such a lifestyle change, need the required information and support to create appropriate action plans to lead them through their grocery shopping without incurring excessive cognitive impact. The risk of such cognitive strain is that people give up easily on their good intentions and fall back into old unhealthy or environmentally impacting habits. Smartphones are ubiquitous and therefore could potentially solve many of these problems, but the design of suitable applications is mostly ad-hoc and not based on thorough modelling. On the other hand, existing behavioural models are considered to be too static and not up to the task of dynamically assessing and influencing behaviour as would be required by a smartphone-based intervention (Riley, et al., 2011; Spruijt-Metz & Nilsen, 2014).

To address these problems this work proposes three major contributions: first, a novel comprehensive model of behaviour built on well-established theories used in psychology and the social science. The novelty is the consistent integration of well-proven pre-existing theories into one single comprehensive model that aims to capture the benefits and tries to overcome the limitations of each base theory. Based on this model, the second contribution of this work is the evaluation of motivation and intention to buy healthy and sustainable groceries. It has been found that health is more important than sustainability in this regard, and that health-related goals are easier to act on than sustainability related goals resulting in a bigger intention-action gap for sustainable grocery shopping. To address these issues, the third major contribution of this work is a model-derived design framework for smartphone-based interventions that provides comprehensive guidelines for developing applications to assess and support a specific behaviour, such as grocery shopping, while at the same time aiming at addressing a superordinate issue, such as health and sustainability.

„There is nothing more practical than a good theory“ (Lewin, 1952).

1 Introduction

1.1 Motivation

It is the human nature to try to understand why we are doing what we are doing and how we can influence what we do. To get a better understanding of the human being and his/her motivations behavioural models have been developed to help getting closer to answering these types of questions. So far, no single behavioural theory on its own has solved this problem in its entirety. Many researchers (Barrick & Mount, 1991; Elliot & Thrash, 2002; Judge & Ilies, 2002; Steel & König, 2006) have recognised the fragmentation between and within each discipline, where similar topics have different nomenclature and structure (Steel & König, 2006) making it non-trivial to combine individual approaches. Instead, most behavioural models are developed with a specific application in mind focusing on specific individual parameters while at the same time the concepts are overlapping, and the models exhibit a great level of redundancy (Davis, Campbell, Hildon, Hobbs, & Michie, 2015; Steel & König, 2006).

While for instance Locke and Latham in the context of work motivation and the future of motivational theories argue that "…there is now an urgent need to tie these theories and processes together into an overall model…" (Locke & Latham, 2004), little progress in this direction has been achieved so far. In particular, such pre-existing theories of human behaviour are considered not to be "up to the task" (Riley, et al., 2011) when it comes to the digital world, because most theories are only offering static "snapshots of behaviour" (Spruijt-Metz & Nilsen, 2014). However, Spruijt-Metz also argues that "…we have a rich heritage in theories and constructs that can seed the process of theory development" (Spruijt-Metz & Nilsen, 2014), which this work is aiming to address.

It is noted by Michie et al. (2005; Davis, Campbell, Hildon, Hobbs, & Michie, 2015) that to choose the right theory to develop the right intervention is not that easy, because of the amount of different theories available, which often have the same or overlapping constructs. Davis, et al. (2015) carried out a review of the state of the art looking at theories of behaviour and behavioural change in the context of health interventions. They identified a total of 82 approaches, of which only 4 accounted for 63% of all work and another 4 account for a further 12% of contributions. These 8 most popular behavioural models in descending order are the Transtheoretical Model of Change (TTM) (Prochaska, Redding, & Evers, 2015), the Theory of Planned Behaviour (TPB) (Ajzen, 1985), the Social Cognitive Theory (SCT) (Bandura, 1999), the Information-Motivation-Behavioural-Skills model (IMB) (Fisher & Fisher, 2002), the Health-Belief-Model (HBM) (Strecher & Rosenstock, 1997), the Self-Determination-Theory (SDT) (Ryan & Deci, 2000), the Health-Action-Process approach (HAPA) (Schwarzer, 1992), and the Social-Learning-Theory (SLT) (Miller & Dollard, 1941), which is a pre-cursor model to the SCT.

To improve the evaluation and to enable influencing human behaviour it seems reasonable to use such well-established theoretical models and to combine them to minimise redundancies and to overcome each one's limitations. Many theories are looking at human behaviour and their motivation, but all are also looking at different aspects of predicting behaviour and behaviour change. Depending on the taken perspective they are more or less effective so that an integration into each other would be beneficial for an overall understanding what drives human behaviour and how to influence it in a desired way (Spruijt-Metz & Nilsen, 2014). In other words, different theories work better for different behaviours. The challenge will be to integrate existing theories with new

technologies (mobile phones, wearables, sensors), addressing dynamically the issue that different people show different responses to social and environmental circumstances, because one size does not fit all (Spruijt-Metz & Nilsen, 2014).

Because the mentioned theories are used and evaluated in a variety of areas it can be presumed that models based on such underlying concepts have scientific validity and are applicable to many different subjects. Steel & König (2006) argue, though, that "…there has yet to be a broad, integrated theory of motivation" (and behaviour), and that "any particular theory necessarily deals with only a subset of motivational factors. Although a theory may deal with these factors very well, it potentially will have trouble in intricate, realistic situations". In particular it has been noted that "interventions to change health-related behaviours typically have modest effects and may be more effective if grounded in appropriate theory" (Davis, Campbell, Hildon, Hobbs, & Michie, 2015). To choose the right theory for a particular intervention can be challenging given the fact that while many theories are available, it is often unclear which aspects overlap (Michie, et al., 2005; Davis, Campbell, Hildon, Hobbs, & Michie, 2015) and how to exploit the strengths of any individual theory in a given context. By integrating theories into each other, similarities and differences can be worked out, but terms need to be defined and built towards a common set of terminology.

> *The main research question this work aims to address is, if existing behavioural models and theories can be combined to be suitable for the design and development of dynamic smartphone-based applications?*

To answer this question, the main contribution of this work is the integration of five such well-established theories originating from the field of psychology and the social science with the goal of overcoming each one's limitations and to build a comprehensive model to explain and influence human behaviour. The rationale for choosing which theories to include was based on their respective suitability to be integrated, in particular which concepts are stressed in each and how well these concepts are operationalised, on the broadness of applicability to various areas of interest, combined with popularity and empirical support demonstrated in the field of psychology and behavioural science. Empirical support and applicability to various domains has been demonstrated for the TPB (Biasini, et al., 2021), the SCT (Strong, Parks, Anderson, Winett, & Davy, 2008; Phipps, et al., 2013) and the SDT (Ntoumanis, et al., 2021; Schösler, de Boer, & Boersema, 2014), all three amongst the most important models according to Davis, et al. (2015). In contrast to these, the TTM has been criticised for lacking empirical support (West, 2005; Cahill, Lancaster, & Green, 2010), while the HBM and the HAPA are both very specific to health and the perception of health risks. Therefore, these three, despite being amongst the 8 most popular models in the list compiled by Davis, et al. (2015), are not considered in the following. The final model occurring on this list is the IMB, which whilst establishing the relationship between self-efficacy and motivation, is weak on operationalizability and will therefore be substituted by the High Performance Cycle (HPC) by Locke and Latham (1990a) and the Action-Regulation theory (ART) by Hacker (1986) in the following, who cover this aspect in much more detail and provide better operationalisation while also showing good empirical support (Selden & Brewer, 2000; Borgogni & Dello Russo, 2012; Hörisch, Wulfsberg, & Schaltegger, 2020).

In summary, the theories determined to be most suitable for integrating into a more comprehensive model of behaviour comprise the High Performance Cycle (HPC) by Locke and Latham (1990a), the

Action-Regulation theory (ART) by Hacker (1986) the Social Cognitive Theory (SCT) by Bandura (1999), the Theory of Planed Behaviour (TPB) by Ajzen (1985) and the Self-Determination Theory (SDT) by Ryan and Deci (2000). Each will be discussed in detail in section 2.

1.2 Health and sustainability

Health behaviours have been an important subject of study for many years. Recently, public awareness of sustainability as driver of individual behaviour has gained more and more attention. Both topics intersect in the lifestyle choices relating to food and nutrition, with one of the key behaviours being healthy and sustainable grocery shopping to facilitate such a balanced and environmentally friendly diet. Up until recently, the focus was mainly on supporting and educating people how to follow and maintain a healthy diet. The reason for that was the increase in obesity and noncommunicable diseases, such as cardiovascular diseases, diabetes and hypertension in the world population (World Health Organisation, 2020; Johnston, Fanzo, & Cogill, 2014). In the last couple of years, as the climate emergency is being recognised the impact of food production on the environment is gaining prominence (Nelson, Hamm, Hu, Abrams, & Griffin, 2016). McMichael et al. note that while "food provides energy and nutrients," … "its acquisition requires energy expenditure" (McMichael, Powles, Butler, & Uauy, 2007), therefore a trade-off has to be achieved. Following this development, a new research field developed, taking both aspects health and sustainability into account (Verain M. , Sijtsema, Dagevos, & Antonides, 2017; Hoek, Pearson, James, Lawrence, & Friel, 2017; U.S. Department of Agriculture, 2021).

A healthy and balanced diet is defined by the World Health Organisation as being based on plenty of vegetables and fruit, less fat – in particular the wrong kinds of fat – and limiting the intake of sugars as well as a reduction of salt intake (World Health Organisation, 2020).

For sustainable diets the definitions are often more complex (Jones, et al., 2016). For instance, a sustainable diet has been defined by the Food and Agriculture Organisation of the United Nations as "diets with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe and healthy; while optimising natural and human resources" (Food and Agriculture Organisation of the United Nations, 2010; Dötsch-Klerk, Mela, & Kearney, 2015). This is a very comprehensive definition encompassing many aspects that are difficult to quantify and measure. Therefore, in the following a narrower focus on sustainable diet, which can be understood as reduction of the ecological footprint related to carbon emission, energy use as well as less animal-based and more plant-based diets and seasonal products (Verain M. , Sijtsema, Dagevos, & Antonides, 2017; Hoek, Pearson, James, Lawrence, & Friel, 2017) will be used.

While healthy and sustainable diets can overlap (Donini, et al., 2016) and the co-benefits between the two should be exploited (Cobiac & Scarborough, 2019), this overlap is not always the case (de Schutter, 2015; Dötsch-Klerk, Mela, & Kearney, 2015) as the "Double Pyramid" (Ruini, et al., 2015) based on the Mediterranean diet illustrates (see Figure 1).

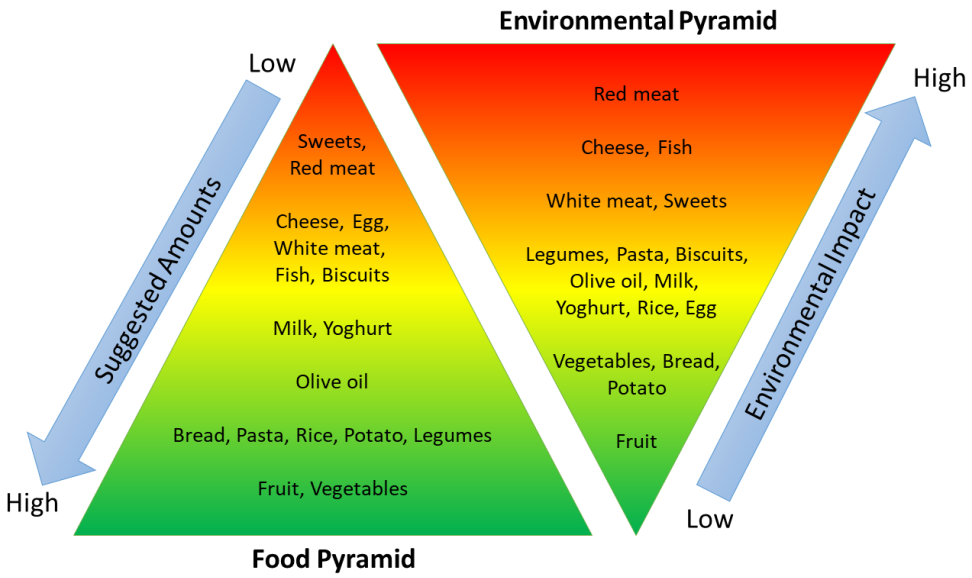


Figure 1 Double pyramid: Healthy food for people, sustainable food for the planet (Ruini, et al., 2015)

A classic example is fish as a source for many healthy nutrients but eating more fish means to endanger the fish stocks (Dötsch-Klerk, Mela, & Kearney, 2015). Vice versa, unhealthy biscuits and cakes do have a modest impact on the environment but a negative impact on health. “Consuming fewer sugary drinks, sweets, cakes and snacks means fewer calories are eaten. This helps to achieve a healthy body weight, which in turn reduces the risk of diabetes, cardiovascular disease, and certain forms of cancer” (de Schutter, 2015). However, there is a significant overlap between the two concepts, as for instance “…reducing meat consumption to healthy diet levels alone would achieve nearly all of the emission reductions needed” (de Schutter, 2015; Johnston, Fanzo, & Cogill, 2014), or adhering to the WHO dietary recommendations could result in a 17% decrease in green-house emissions, when taking the average British diet as reference (Nelson, Hamm, Hu, Abrams, & Griffin, 2016).

So far health aspects are still the driving motivator regarding a balanced diet, but sustainability gains more and more attention (Hoek, Pearson, James, Lawrence, & Friel, 2017; de Schutter, 2015). Food-based dietary guidelines (FBDG) are shifting from solely health oriented towards more sustainable ones (Bechthold, Boeing, Tetens, Schwingshackl, & Nöthlings, 2018). Those changes mean less animal-based and more plant-based diets benefitting both health as well as sustainability (Verain M. , Sijtsema, Dagevos, & Antonides, 2017). Another attempt to bring health and sustainability together in a combined diet has been proposed by Hoek et al. as follows: “(1) reducing over-consumption - not eating more than a person's energy requirement; (2) reducing consumption of low nutrient energy-dense foods, which tend to be highly processed and packaged products, and (3) eating less animal- and more plant-derived foods” (Hoek, Pearson, James, Lawrence, & Friel, 2017).

It has been shown that a joined concept of health and sustainability is perceived as something positive and worth acting accordingly (Hoek, Pearson, James, Lawrence, & Friel, 2017). One of the major issues in this context is that consumers would like to eat healthier and more sustainable, but it seems that knowledge and action plans to translate these intentions into actual behaviour are lacking. Further to that, people often chose products based on price, taste, quality and/or convenience (Verain M. , Sijtsema, Dagevos, & Antonides, 2017) rather than based on sustainability

or health. This is called the intention-action/behaviour gap, attitude-behaviour gap, or knowing-doing gap (Ajzen, 2016; Grunert, 2011; Hoek, Pearson, James, Lawrence, & Friel, 2017; de Schutter, 2015; Bailey & Harper, 2015). It describes the discrepancy that people would like to behave in a certain way, but the actual behaviour does not match the claimed intention.

Three different levels of intervention on consumption-side management can be addressed to support healthy and sustainable grocery shopping behaviour. On the European and national level strategies and policies are being put in place (Flynn, et al., 2012) and implemented through measures such as product labelling schemes (Canio & Martinelli, 2021), education campaigns or taxation, i.e. the reduction of tax on healthy and sustainable products (de Schutter, 2015; Bailey & Harper, 2015; Reisch, Eberle, & Lorek, 2013) and increase of tax on others. On this level it is also possible to influence production-side management, by encouraging the agricultural sector and production chains to implement more sustainable ways of producing food and to ensure the food which is produced is of high nutritional value (Pradhan & Kropp, 2020).

A second aspect of influencing consumers is marketing directly by brands and retailers, which have discovered that focusing on health and sustainability are exploitable characteristics of their products and offerings (White, Habib, & Hardisty, 2019; Kemper & Ballantine, 2019). Up until now, health concerns have had a higher priority for people then sustainability aspects (Verain, Sijtsema, & Antonides, 2016). All actors in the food supply chain have an influence on sustainability as well as health, “however, consumer food choice is a break point in the chain” (Grunert, 2011) when it comes to the types and conditions of food production. Therefore, with sustainability becoming more important for consumer decision making practises (Samsioe & Fuentes, 2021), product information (Stöckigt, Schiebener, & Brand, 2018) and choice architectures (Panzone, Ulph, Hilton, Gortemaker, & Tajudeen, 2021) are adapted to accommodate not only health but also sustainability.

It does not just affect their health but also the environment (Hoek, Pearson, James, Lawrence, & Friel, 2017). Therefore, communicating health as well as sustainability is a major challenge to guide consumers behaviour in a more desired direction (Grunert, 2011; Hoek, Pearson, James, Lawrence, & Friel, 2017). While health delivers a personal benefit, sustainability is a more long-term non-personal benefit, which makes the latter more difficult to address (Hoek, Pearson, James, Lawrence, & Friel, 2017). This is why health is usually prioritised compared to sustainability when it comes to behaviour change (de Schutter, 2015).

The third level of intervention is to focus directly on the individual. Instead of affecting the supply side, i.e. governmental regulations, production and retail, this type of intervention is trying to affect the demand-side behaviour concerning the motivation and choices of consumers (Bailey & Harper, 2015). Shifting behaviour towards more sustainable options (Eker, Reese, & Obersteiner, 2019) has been studied mostly in the context of health (Tilman & Clark, 2014), either focusing on the health aspects in sustainable diets (Mertens, van’t Veer, Hiddink, Steijns, & Kuijsten, 2017) or the sustainability aspects in healthy diets (Reynolds, Buckley, Weinstein, & Boland, 2014).

> *The second research question this work aims to address is, if the motivational drivers and their translation into actual behaviour are different for healthy and for sustainable grocery shopping, and if there is a relationship between the two that can be exploited to improve smartphone-based design?*

To answer this question, the quantitative aspects of the developed integrated behavioural model will be utilised to evaluate how the two subject areas relate to each other with respect to the measurable motivational factors exposed by the models. This analysis contributes to the understanding how supporting healthy and sustainable behaviour of people in grocery shopping situations can be facilitated.

1.3 Personalised interventions

To achieve personalised behavioural support at scale it is necessary to develop methods for communicating with and thereby influencing the choices of consumers based on their individual and current needs and requirements. Smartphones are by now ubiquitous and therefore a good medium to interact with users in their natural environment, particularly when it comes to assess and support certain behaviours. More and more personalised health interventions are therefore smartphone-based applications (Metz, et al., 2000; Lowe, 2003), that enable direct support without interfering too much with the person's activities of daily living.

Mobile technologies particularly in the area of health interventions are rapidly evolving (Riley, et al., 2011) and so is the number of health applications as well as the numbers of users (Rai, Chen, Pye, & Baird, 2013; Amodio, 2008; Fairburn & Rothwell, 2015; Mosa, Yoo, & Sheets, 2012). The WHO uses the term mHealth since 2009 to refer to the use of mobile technologies in addressing the growing health challenges in the world (Codyre, 2014). According to Sama et al. (2014) the most popular types of health applications are fitness/training and diet/calorie intake trackers. However, proper research needs to be conducted to prove the efficacy of mHealth applications (Payne, Lister, West, & Bernhardt, 2015; Charani, Castro-Sánchez, Moore, & Holmes, 2014; Codyre, 2014). Smartphone applications should be simple and easy to use and provide meaningful support of everyday tasks. Furthermore, they should support self-regulation, motivation and reduce cognitive impact (Meule & Vögele, 2017). "The potential of mHealth interventions may be best realised when they can adaptively respond to individuals' actions and states and deliver intervention options that are most needed, when and where they are most needed" (Intille, 2004; Patrick, Griswold, Raab, & Intille, 2008; Klasnja, et al., 2015). To underpin such developments with rigorous theoretical concepts, mobile health interventions could benefit from using behavioural theories and modelling tools, which are already used in the context of classical health interventions. Widely used in this area are the Theory of Planned Behaviour, the Social Cognitive Theory and the Self-Determination Theory (Riley, et al., 2011).

> *The third research question this work aims to address is, if and how the motivational concepts derived from behavioural models and theories can be addressed by smartphone-based interventions and applications to support healthy and sustainable grocery shopping behaviour?*

Up until now grocery shopping is mainly neglected when it comes to supporting a healthy and sustainable diet. It can be very stressful and demanding for many people, because they are confronted with countless temptations and distractors (Aylott & Mitchell, 1999) and intensive performance planning has to take place to address those temptations and to avoid unwanted behaviour patterns. This does not mean that there are not many mobile applications out there, particularly for healthy lifestyles, which offer all kind of support. However, many of these are ad-hoc and neither health interventions (Davis, Campbell, Hildon, Hobbs, & Michie, 2015) nor smartphone

applications (Riley, et al., 2011) are commonly designed with reference to theoretical concepts, or use only isolated components of a behaviour theory (Sama, Eapen, Weinfurt, Shah, & Schulman, 2014), often unintentionally. The main contribution of this work is to build a theoretical model, which combines well known psychological theories from different areas, to facilitate a rigorous approach to the design of personalised support applications in general and for grocery shopping situations in particular.

1.3.1 Introduction of the smartphone application HealthStainable

To demonstrate the concept of translating the behavioural model into a personalised intervention the mobile application case study HealthStainable (Blanke & Beder, 2020a) has been developed. This section will give a brief preview of this application. It will be used in the following both to show how psychological concepts can be translated into the application design process as well as to conduct the use-case study presented in section 3.3. The application is built on the different aspects of the integrated theoretical model, reflected in the various features, which support the user in grocery shopping situations using the different perspectives how human behaviour can be described and influenced provided by each theory.

It can be categorised as just-in-time adaptive intervention (JITAI), which are mHealth and other dynamic intervention technologies supporting the right intervention at the right time in the right location (Klasnja, et al., 2015). Such JITAIs can help to improve health but also sustainable behaviour. It is argued that the behavioural theories which are currently available do not support the development of just-in-time interventions in sufficient ways (Riley, et al., 2011; Spruijt-Metz & Nilsen, 2014; Klasnja, et al., 2015) and that up until now there is a lack of knowledge how to translate abstract theoretical models into technical systems like mobile applications, which support behavioural change approaches. “Behaviour theories in their current form are often not granular enough to guide the design of decision rules for the delivery of intervention components” (Riley, et al., 2011; Spruijt-Metz & Nilsen, 2014; Klasnja, et al., 2015). A major contribution of this work is to build a comprehensive theoretical model, which uses the theories already available, and offers a translation of such concepts into mobile application supported features.

In the following an overview of the functionality of the developed mobile application HealthStainable is provided to put the examples in subsequent sections into context. The application presents itself as a recipe and grocery shopping application (see Figure 2). It is possible to search recipes and ingredients in the database directly through a search field or by category. The application also provides random suggestions for the undecided (see Figure 5, left). This feature enables the application to present a selection of recipes in case someone does not have any ideas what to cook and is used to guide the user towards favourable diet choices.

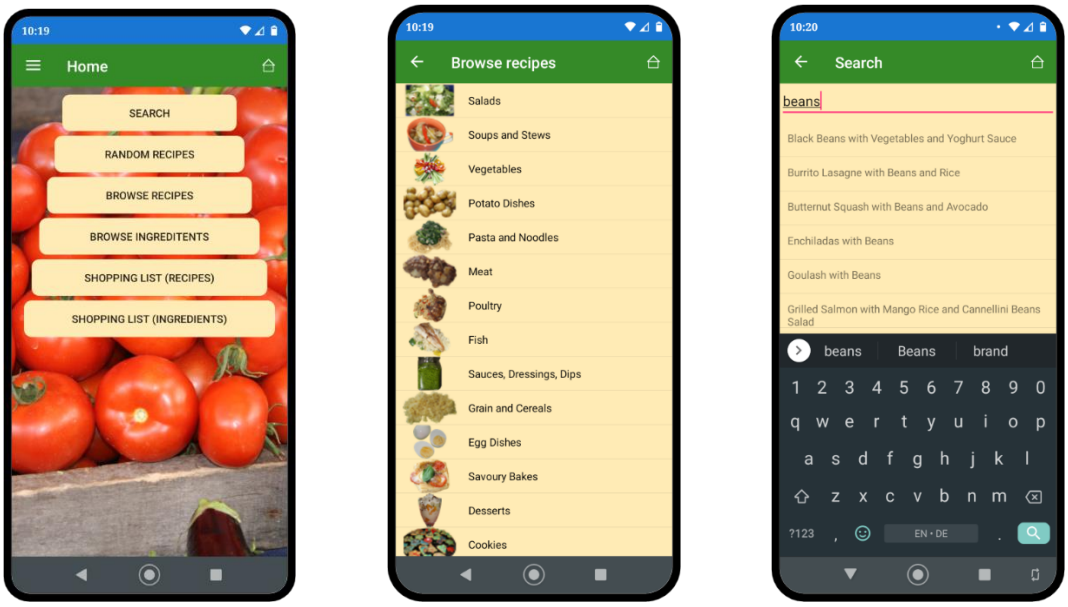


Figure 2 The home screen of the HealthStainable application (left), the browse by category screen (middle), and the recipe and ingredient search page (right).

All recipes are accompanied by additional information on health and sustainability (see Figure 3) derived from the United States Department of Agriculture, Agricultural Research Service USDA Food Composition Databases (U.S. Department of Agriculture, 2021) and the CleanMetrics Food Carbon emissions calculator (2021). The carbon footprint is presented in gCO2e/100kcal, which is a measure to quantify the trade-off between the energy provided by the meal and the environmental impact it creates. The nutritional value is presented using the well-known European food labelling directive (Council of the European Union, 1990) as energy in kcal/100g, and fats, saturates, carbohydrates, sugar, protein as well as salt content in g/100g.

Both aspects are colour coded using an intuitive red/orange/green scheme. The nutritional value coding follows the food labelling guidelines of the UK National Health Service (NHS) (National Health Service, 2021), according to which green stands for low in the four categories fat, saturates, sugar and salt (see Figure 3). Orange indicates a medium content of the nutritional value, while a red label indicates a high value. In this work a similar compatible coding for the sustainability indicator based on gCO2e/100kcal has been devised, with red indicating more than 200gCO2e/100kcal (see Figure 3, right), orange indicating between 50gCO2e/100kcal and 200gCO2e/100kcal (see Figure 3, left and middle), and green indicating less than 50gCO2e/100kcal (see Figure 3, left and middle). These values were determined empirically to achieve a reasonable split across the recipe database used. Such detailed information is unique compared to other recipe applications (see section 3.1), allowing for an informed decision on both health and sustainability aspects. Note, that health and sustainability not always correlate (see Figure 3, middle). More detailed nutritional information for each ingredient can be accessed if desired (see Figure 4, right).

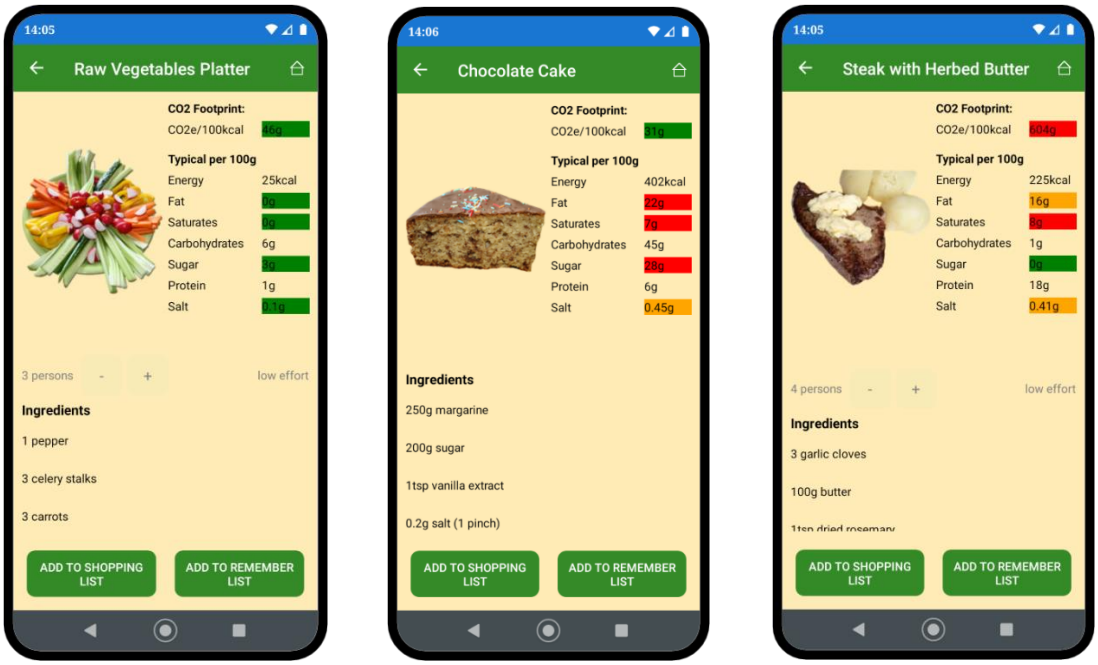


Figure 3 Some sample screenshots of the mobile application's recipe pages. Note the labelling system for CO2 and health indicators, and the effort and adaptable quantities for main dishes (left and right). Also note that health and sustainability are not necessarily correlated (middle).

The required number of servings can be individually adapted (see Figure 3, left and right), with the typical size of a serving per person is calculated at around 500kcal/person. The shopping list is dynamically adapted accordingly and reflects these preferences even if they are altered as late as during grocery shopping. Further to that, recipes are categorised into high, medium and low effort to account for the self-efficacy of the person (see Figure 3, left and right).

The chosen recipes can be placed on either the shopping list or remembered for later, in case grocery shopping is intended to be postponed (see Figure 4, left). The remember list (favourites) is maintained for interesting recipes, which someone likes to cook in the future and can be saved without showing the ingredients on the shopping list. By adding a recipe to the shopping list two things happen: first the recipe will appear on the "Shopping List (Recipe)" (see Figure 4, left). This list helps to maintain an overview and find all the recipes chosen for shopping and cooking later in the process, reflecting the grocery shopping support being integrated into a wider lifestyle context. Second, the ingredients from all selected recipes appear on the "Shopping list (Ingredients)" (see Figure 4, middle). Unlike many other similar applications, HealthStainable works with consistent units and sums up the same ingredients from different recipes accordingly. If for example one recipe contains 100g flour and another references a cup of flour in its ingredient list, then a single item 220g flour is put on the shopping list. This feature frees up cognitive capacity, helping to prevent that people give up easily on their good intentions and fall back into unwanted, old habits. Additionally, the user can add personal products to the shopping list, so that the application is sufficiently flexible and applicable, able to adapt to the individual's needs.

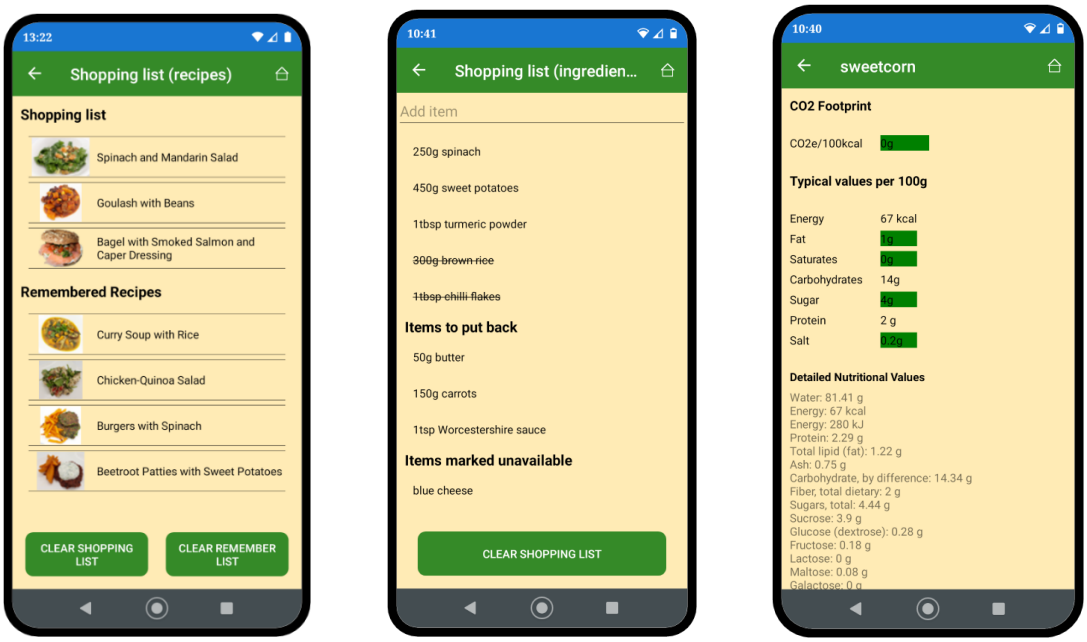


Figure 4 The shopping list screens for planning meals (left) and during grocery shopping (middle). Detailed nutritional and carbon footprint information per ingredient (right).

The “Shopping List (Ingredients)” also provides support when encountering obstacles such as the unavailability of ingredients. As shown by Aylott & Mitchell (1999) “finding that an item on the shopping list is out of stock can be stressful, because of the time and effort needed to find a substitute and the frustration of not achieving the goal”. Therefore, it is not only possible to tick off items from the shopping list, but also to indicate if an item is not available. In this case all recipes containing such an ingredient are no longer valid and need to be substituted by suitable alternatives (see Figure 4, middle). A key strength of a smartphone-based support system is that this action can be taken on the spot and without delay. HealthStainable directly supports this by removing all affected recipes from the shopping list, indicating which items previously ticked off already need to be put back. Alternatives can be selected immediately and added to the shopping list instead. Again, this feature is designed to simplify the cognitive process, automatically indicating what exactly needs to be done in the shop to substitute recipes, which have been discovered to be invalid during shopping. A list of unavailable items is maintained with the possibility of indicating their availability again (see Figure 4, middle).

The mobile application case study HealthStainable also implements the ability to deploy an ecological momentary assessment of behaviour and to continously interact with its users. Regular reminders are sent through the phone’s notification mechanism (see Figure 5, middle) and encourage the participant in the intervention to open the application. This feature is used in two ways: it enables reminders and self-reflection on the topics in question, i.e. healthy and sustainable diet choices (see Figure 5, right), and it also allows to assess the progress on an ongoing basis and in a setting embedded into the daily activities of the application users.

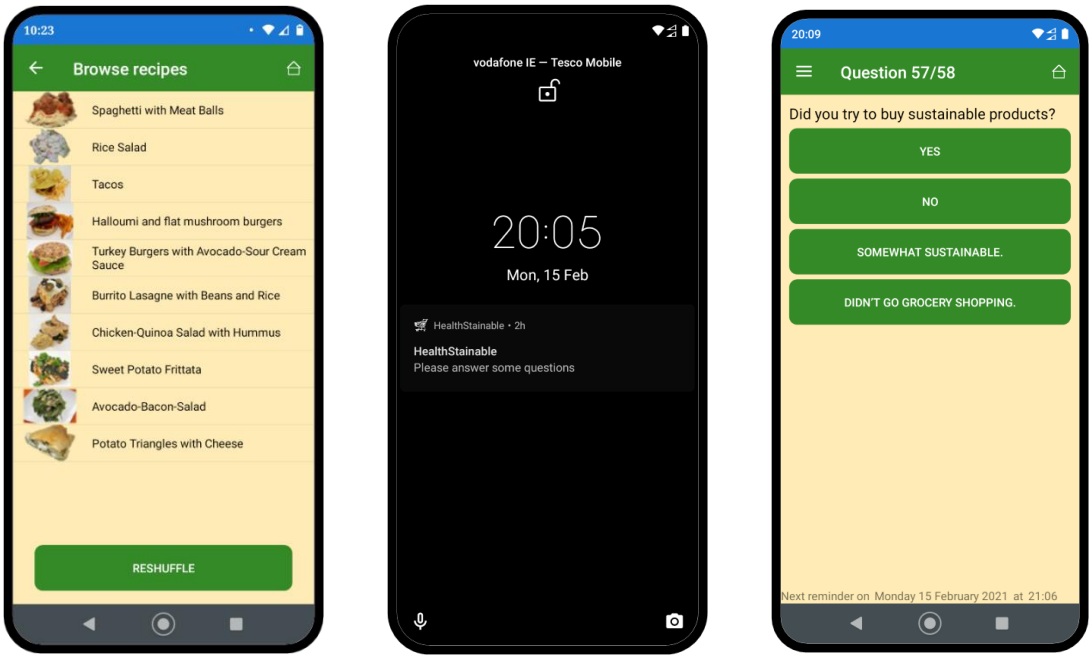


Figure 5 Random pre-selected recipe suggestions (left). Daily reminder notifications (middle). Ecological Momentary Assessment (right).

2 Behavioural models and theories

Theories of behaviour have been proposed to explain, predict and influence human behaviour in a variety of settings. They provide terminology and inventories to assess and describe the processes associated with certain behaviours. Therefore, in order to devise a rigorous approach to supporting and positively influencing behavioural patterns and habits these theories provide the groundwork for designing targeted and personalised interventions. Applying such a model-based approach guarantees that assessing and influencing behaviour is guided by well-defined and structured concepts to avoid misunderstanding and misinterpretation due to vague and arbitrary designs.

Behavioural theories have been developed in various application domains. For instance, in the area of work and organisational psychology these theories have been used to assess work processes and increase productivity; however, they also offer basic models which are applicable to other areas of interest and to achieve other, potentially non-commercial goals such as health and sustainability. A key aspect of most theories that is transferrable between different areas of application is self-regulation, which is defined as "…a dynamic motivational system of setting goals, developing and enacting strategies to achieve those goals, appraising progress, and revising goals and strategies accordingly" (De Ridder & de Wit, 2006). This is directly applicable to health and sustainability goals and the personalised strategies, such as adequate grocery shopping, to achieve improved outcomes under evolving context conditions.

In the following sub-sections, a detailed review of behavioural theories will be presented. The theories were selected to follow the criteria of self-regulatory models (De Ridder & de Wit, 2006):

- Goals are explicitly considered in each theory
- The individual person is considered to actively influence and shape his or her own behaviour
- The achievement of goals is volitional

Across all reviewed theories, goals need to be meaningful for the acting person, have to be favourable and accompanied by expectations to be able to execute the desired behaviour, i.e. support self-efficacy. They also need to facilitate effective action planning and feedback on the process to translate intentions into actual behaviour. In particular, in the presence of obstacles the course of action needs to be adaptable to a changing environment. As part of the concept of self-regulation this can be understood "…as a systematic process that involves conscious effort to influence thoughts, feelings, and behaviours in order to achieve a goal…" (Zeidner, Boekaerts, & Pintrich, 2000; De Ridder & de Wit, 2006).

In addition to this, all reviewed theories have to make the self-regulatory process visible, i.e. explain how set goals are achieved. This will facilitate the integration of the presented approaches into a unified model of behaviour that can draw on the benefits of each individual underlying theory, while at the same time mitigate some of the shortcomings. The presented work will only focus on the individual and the conscious behaviour of the same. Unconscious behaviour and social interactions are an important part of human behaviour but will not be part of this discussion.

Some theories are qualitative, describing concepts and their mutual relation, whereas other are quantitative, describing also measurable inventories for quantifying indicators of the respective variables.

Based on these criteria, the following behavioural theories will be reviewed:

- Qualitative Theories:
  - the High Performance Cycle (HPC) (Locke & Latham, 1990a)
  - the Action-Regulation Theory (ART) (Hacker, 1986)
  - and the Social Cognitive Theory (SCT) (Bandura, 1999)
- Quantitative Theories
  - the Theory of Planed Behaviour (TPB) (Ajzen, 1985)
  - the Self-Determination Theory (SDT) (Ryan & Deci, 2000)

Each of these theories define and elaborate on certain aspects of behaviour. The following Table 1 outlines which concepts are made explicit in each:

	HPC	**ART**	**SCT**	**TPB**	**SDT**
Needs	✓				✓
Values	✓	✓	✓	(✓)	✓
Norms		(✓)	(✓)	✓	(✓)
Demands	✓	(✓)			
Goals	✓	✓	✓	(✓)	✓
Goal-setting	(✓)	✓	✓		
Performance/behaviour/action	✓	✓	✓	✓	(✓)
Motivation	✓	(✓)	(✓)		✓
Intention	✓		(✓)	✓	
Emotions	✓	(✓)	✓		
Moderators	✓				
Self-efficacy	✓		✓	(✓)	
Feedback	✓	✓	✓		(✓)
Mediators	✓				
Redefinition of the task		✓			
Activity		✓			
Environment	(✓)	(✓)	✓	(✓)	(✓)
Knowledge	(✓)		✓		
Observational learning			✓		
Personal factors			✓		
Behavioural intention				✓	
Attitudes				✓	
Beliefs				✓	
Attitudes towards the behaviour		(✓)		✓	
Subjective norms		(✓)		✓	
Perceived behavioural control	(✓)			✓	
Intrinsic motivation					✓
Autonomous motivation					✓
Extrinsic motivation					✓
Controlled motivation					✓
Amotivation					✓

Table 1 Mapping between behavioural theories and concepts

The following sections will elaborate on how these terms and concepts are addressed within the respective theoretical framework and it will be shown, how the concepts can be fused together based on analysing how the concepts match between the models.

2.1 Qualitative Behavioural Theories

2.1.1 The High Performance Cycle

The High Performance Cycle (HPC) is a behavioural theory that was developed in the context of organisation and work performance. It is focused on efficient and humanized work (Locke & Latham, 1990a) with the goal to optimise work processes. Although developed with this particular application in mind, the basic concept of the theory is straightforward to translate into a more general behavioural model applicable to other areas.

The HPC sees the individual as an active person interacting with the environment. Such a perspective was the answer to the principles of behaviourism (Locke & Latham, 1990a). The origin of the HPC lies in the goal-setting theory (Locke & Latham, 1990a), which in a nutshell can be described as stating that people who are trying for specific goals perform better than people who are told to do their best (Locke & Henne, 1986; Locke & Latham, 1990a; Locke & Latham, 2006). Further to that it conjectures, that feedback and goals together have a much better outcome than either one aspect in its own (Locke & Henne, 1986). The approach is understood to be application-oriented and tries to explain motivation concentrating on a relevant sub-set of variables regarding the whole motivational process (Kleinbeck, 1996).

While some motivational theories are content oriented and explicitly address single needs and motives (Fischer & Wiswede, 2014), e.g. Maslow's hierarchy of needs (Zimbardo & Gerrig, 1999; Maslow, 1970), the HPC can be considered a process-oriented approach (Zimbardo & Gerrig, 1999). Process theories are highly abstract and formalised. Sometimes they are also called a-thematical, because in contrast to the content-oriented theories they do not make statements about specific motives. This makes them applicable to a wider range of areas by describing the relations of different variables influencing behaviour and the process of motivation.

2.1.1.1 Definition of concepts

This section will give a detailed overview and definitions of the different terms and variables used in the HPC. They will be the building blocks for the process model outlined in the next sub-section. To illustrate their applicability the definitions are accompanied by examples how the concepts relate to the problem of supporting healthy and sustainable grocery shopping.

Needs

The HPC uses several motivational concepts including needs, values, norms, goals, emotions and cognitions (Locke & Henne, 1986) that will be defined and elaborated next. Although the HPC is a process-oriented approach, most theories including the HPC have some notion of needs, being the most fundamental motivational concept (Locke & Henne, 1986). Physical needs like food, water, sleep etc. but also psychological needs like pleasure, growth and self-esteem are basic for everybody and cause motivation. However, such theories based solely on need are inadequate to explain human action (Locke & Henne, 1986). This is illustrated by the fact that the same needs lead to differences in the chosen action between individuals, showing the limitations of this type of theory. Assuming that needs are inborn they do not provide any information about the individual's tolerance threshold at what point someone starts to act and how, or what kind of behaviour the person choses to satisfy his or her needs (Locke & Henne, 1986). Grocery shopping can be considered to be driven by feeling hungry, however behavioural actions vary between individuals. While some who go shopping feeling hungry are buying too much others are more disciplined in

their actions for example following shopping lists. Others will avoid grocery shopping while being hungry altogether. This shows that needs on their own are not a good predictor for behavioural actions.

Values

In contrast to needs values are actively acquisitioned through experience. Locke and Henne (1986) as well as Locke and Latham (1990b) clearly distinguish between inborn needs and acquired motives and values, which underlie and motivate an action or behaviour. Values can vary between individuals and between social groups. Locke and Henne (1986) state that values can be either conscious or subconscious, hence they can be reflected upon and actively changed. In the context of this work values are linked to environmental consciousness and self-care. Although norms are not explicitly defined in the HPC, it can be assumed that they are closely linked to values. The term includes implicitly the existence of social standards or rules, although the acquisition seems to be passive (Locke & Latham, 1990a). For example, low sugar diets or the reduction of meat products constitute social norms that parts of the population adhere to.

Demands

The HPC defines demands as challenges provided for the individual (Locke & Latham, 1990a). They comprise “high goals on meaningful, growth facilitating tasks or series of tasks” (Locke & Latham, 1990a). Because the HPC was conceived in the context of a work and organisational setting, the original notion behind demands is related to the work tasks given to an employee or manager. In a broader application of the theory that is pursued here, demands can mean any requirement imposed or self-imposed by outside environmental factors on the individual. Demands constitute “standards set by others, such as medical experts and governments” (Bisogni, Jastran, Seligson, & Thompson, 2012), who through policies on public health or climate action impose health and sustainability demands on everyone. A demand is therefore the translation of a broader challenge into an individual challenge. This is not to be confused with a personal goal, which is the alignment of this individual challenge towards a specific end state.

Goals

All these factors described so far influence the individual’s goals, which “… are the mechanism by which values are translated into action” (Locke & Henne, 1986). Abstract values, such as for example health and sustainability, need to be translated into concrete action plans, for instance by means of shopping for more local and less processed produce. Following Locke’s description, goals are the closest concept to action and explanation of behaviour (Locke & Henne, 1986) in the HPC. They are the anticipation of an end point of an action (Locke, Saari, Shaw, & Latham, 1981) and the product of a motivational process (Blanke, 2008). Specific goals regulate attention and action better then vague goals. For example, having more detailed shopping lists in a grocery shopping context is expected to be leading towards a positive action regulation (Wing & Jeffery, 2001; Metz, et al., 2000; Lowe, 2003), i.e. sticking to the original plan of buying healthy and sustainable ingredients. Dynamic support systems can extend such static shopping lists by supporting users also in unexpected situations, like the unavailability of certain ingredients, and allowing them to more easily develop new goals on the spot.

Goal-setting

The HPC is a development based on the goal-setting theory (Locke & Latham, 1990a). As such it asserts that goals are regulating behaviour. “Goal-setting research has shown repeatedly that people who try to attain specific and challenging goals perform better on tasks than people who try for specific but moderate or easy goals, vague goals such as ‘do your best’, or no goals at all” (Locke & Latham, 1990a). Goal-setting looks at goals and intentions and tries to identify “what causes these and what makes them effective” (Locke & Latham, 1990a). Specific and well-defined goals are therefore imperative if actions towards healthy and sustainable behaviour are to be achieved. Supporting the setting of specific goals enables the individual to focus their behaviour and has to be a vital aspect of every intervention measure.

Performance

Reaching a goal requires action to be taken. The HPC uses the term performance in the context of work conditions to describe the efficiency of what people are doing. Because this concept is very specific to workplace behaviour only, a broader view is taken in the following using the terms performance, behaviour and action synonymously. This opening of the scope aims at making the HPC more applicable for other relevant areas of behaviour (Blanke, 2008), such as the grocery shopping application considered in this work. In the HPC action or performance is goal oriented and motivated, while goals reflect the direction and the persistence of the action process (Locke & Latham, 1990b; Kleinbeck, 1996). However, the HPC is not explicit in explaining how exactly goals are translated into actual actions.

Motivation

Motivation plays an essential part for the acting person and the action itself. A motivated action is characterised by the three criteria direction of attention, effort and persistence and is specific to the challenges and demands facing the acting person (Latham & Locke, 2007). It is driven by goals and intentions, which are seen as the direct initiators of action by the HPC. These motivational aspects are situationally specific and conscious (Locke & Latham, 1990a), meaning that context variables influence the motivation and that motivation often includes a conscious, cognitive relevant process. Aiming at increasing and maintaining the motivation to act towards general goals, a suitable support system needs to pay attention to all of these factors. It needs to focus the attention and provide means of helping the user to overcome challenging demands in relevant contexts and situations, so that the effort can be kept up and a persistent course of action can be maintained, for instance through features such as the dynamically adapting shopping list.

Intention

Intentions in the context of the HPC are defined similar to goals except that goals are focused on a particular end state that the action aims to achieve, while intentions describe the determination of a person to carry out a specific action (Locke & Henne, 1986). Intentions are seen as directly linked to the action in the HPC, which is consistent with Ajzen’s definition of intention as the condition shortly before showing a behaviour in question (Ajzen, 2006a). In contrast to motivation, which is the general tendency to act in a particular subject area, the intention is more immediate and focused on single specific goals. Interventions, which can support translating more generic goals into actual behaviour, aim at increasing intention to act in a desired way.

Emotions

Another important aspect in this process is emotions, which are a crucial part of the motivational system and the connected cognitive processes (De Ridder & de Wit, 2006). In the context of the HPC emotions "…are both a result of action and an inducement to further action (or non-action)" (Locke & Henne, 1986). Emotions are the result of a comparison between the set goals or personal value standard with the achieved goals and occur in a sub-conscious level most of the time. Although emotions are no predictor what behaviour is chosen or even if a person acts at all, a motivational theory without considering emotions would not be justifiable. This is because emotions are the type of feedback confirming personal values are matched and that the chosen actions lead to the desired outcomes. Without this internal feedback the motivation and intention to act would be very limited (Locke & Henne, 1986). Encountering obstacles can lead to non-achievement of goals thereby triggering negative internal feedback influencing the emotional perception of the situation. For example, in a grocery shopping situation the non-availability of a particular ingredient for a pre-planned recipe can interrupt the goal striving and lead to negative emotions, de-motivation and falling back into unwanted habits. Therefore, avoiding such negative internal feedback, for example by providing instant alternatives, can help to keep up the motivation to follow the original health and sustainability goals. Because emotion is changed by action, a distinction between pre-emotion prior to execution and post-emotion after the outcome is perceived can be made. The post-emotion of an action is the pre-emotion for the follow-on action, therefore a chain of emotional states along a complex sequence of actions needs to be maintained. Dynamic personalised interventions are well suited to provide the necessary supports and feedbacks to avoid negative emotion occurring, thereby facilitating complex behaviours to be executed until conclusion minimising the risk of abortion along the way.

Moderators

While the HPC argues that motivation, intention and emotion all influence the behaviour, translation of specific demands into actual performance is mainly regulated by moderators and mediators. Starting with the moderators, these are the factors which influence the relation between goals and actions (Locke & Latham, 1990a). The HPC lists the following six points as moderators

a. Ability
b. Task Complexity
c. Expectancy and Self-Efficacy
d. Situational factors
e. Feedback
f. Commitment

These aspects reflect the origin of the theory in organisational and work psychology and some need to be adapted to make them applicable in a more general behavioural model while others might not be applicable at all.

Ability and task complexity

Ability (a) is the requirement or precondition a person needs to act or respond in an adequate way to a challenge (Locke & Latham, 1990a). Goals that are beyond the ability of a person can obviously not be achieved, therefore it is important that only such goals are set to reflect what is actually

achievable with reasonable effort. For example, it makes no sense to propose a smartphone-based intervention for people who are not accustomed to using such devices.

Ability is inherently linked with **task complexity (b)**. Complex tasks require more knowledge and ability to achieve the desired outcomes. Therefore, challenging goals need to be broken down into manageable sub-task to cope with task complexity. It has been shown that "a specific challenging goal has maximum effect when the individual has high ability, there is commitment to the goal, there is feedback showing progress in relation to the goal, the individual has high self-efficacy or expectancy of performing well, and the task is simple" (Locke & Latham, 1990a). The explanation for this phenomenon is that simple tasks can be more easily translated into performance and positive feedback, while the effort put into difficult tasks not necessarily leads to immediate satisfaction (Locke & Latham, 1990a). Personalised interventions therefore need to make sure that complex tasks are broken down into manageable pieces.

Self-efficacy

More important than the actual ability when it comes to motivation are expectancy and **self-efficacy (c)**. The expectancy approach considers the expectation that a behaviour leads to a desired result as driver of motivation, however it does not focus on circumstances or perceived ability. The goals are seen as given, and the individual's choice is limited to select the right behaviour. Self-efficacy is a broader concept that has been defined in the context of the Social Cognitive Theory (SCT) (see section 2.1.3 below), which refers to people's "capabilities to exercise control over their own level of functioning and over events that affect their lives" (Bandura, 1991a) or more simply spoken it "**…** is what I believe I can do with my skills under certain conditions" (Maddux, 2002; Snyder & Lopez, 2007). In contrast to considering only the objective ability to perform a given task, self-efficacy is therefore the individual's perception and appraisal of his/her own ability to perform the task taking current circumstances into account. It strongly influences the individual's goal choice (Latham & Locke, 2007), which means that not only a behaviour is chosen to achieve a pre-determined goal but rather goal choice itself is considered based on reflection of ability and given circumstances. This cognitive process needs to be supported in any intervention, for instance by means of carefully considering context conditions and ability before making unrealistic suggestions.

Such context conditions are crucial and have been introduced as **situational factors (d)** into the HPC. They have not been part of the original HPC but were put forward in more recent work (Latham & Locke, 2007). The consideration of situational factors is essential for goal planning as well as task performance. For example, when designing interventions to achieve more healthy and sustainable grocery shopping habits the context in which these are deployed needs to be considered, for instance by making sure that no unattainable goals are presented.

Feedback

Feedback (e) occurs two-fold in the HPC: it acts as a moderator affecting the strength of the effect between goals and action (Locke & Latham, 1990a). Information towards desired goal achievement leads to adjustments of the behaviour (Locke & Latham, 1990a) and the feedback itself can have a motivational influence on the behaviour (Kleinbeck, 1993). It has been shown that specific feedback has a stronger effect then generalised feedback: while goals without feedback are ineffective (Erez, 1977; Locke, Saari, Shaw, & Latham, 1981), feedback and goals together can improve the performance and positively influence the motivation (Locke & Latham, 1990a). This is in accordance

with the goal-setting theory being the foundation for the HPC (Locke, Saari, Shaw, & Latham, 1981; Locke & Latham, 1990a).

The HPC goes beyond that by introducing the second aspect of rewards at the end of each task, which can be considered a specific form of feedback again. In the following there will be no distinction between feedback and rewards, and both will be referred to simply as feedback. The reason for this is that in the scenario of dynamic personalised interventions feedback can be given throughout all stages. Feedback should be delivered during actions as well as at the end of a performance to support the change or maintenance of favourable behaviour. Sub-goals can be considered as feedback (Locke, Saari, Shaw, & Latham, 1981) and enable the more granular evaluation of progress and satisfaction during the behavioural process (Latham & Locke, 2007).

Both notions of feedback are inherently linked with self-efficacy, as both positive and negative feedback shape the perception of personal abilities and circumstances (Locke & Latham, 1990a) and therefore determine what kind of goals, difficult or easy, someone will set/choose depending if their self-efficacy is low or high (Latham & Locke, 2007). Self-efficacy is the "…self-confidence that the goal for a specific task is, indeed, attainable" (Latham & Locke, 2007), therefore feedback needs to be designed to take these factors into account.

Commitment

Finally, **commitment (f)** is the focus of an individual towards specific goals and protects the person against distractions from other goals. It is important to note, that commitment is a volitional process requiring a goal to be wanted. This contrasts with purely desirable or seemingly achievable goals, which on their own will not lead to any actions (Locke & Latham, 1990b). If commitment is not specific to a goal and the implicated performance, the positive effect on the behaviour is limited. Commitment is itself influenced by four factors:

- Expectancy and self-efficacy
- Rewards and incentives
- Goal acceptance (assigned goals; participative goals; self-set goals)
- Peer influence and pressure

The first two factors are moderators in their own right and have been discussed before already. However, it should be noted that they have an explicit effect on commitment and are therefore repeated in the list of influence factors on the same above. According to Locke & Latham (Locke & Latham, 1990a) "…high expectancy and self-efficacy lead to high levels of goal commitment" as well as "…to high levels when goals are self-chosen…" and "…they affect the individual's response to feedback concerning progress in relation to goals and may even affect the efficiency of their task strategies" (Locke & Latham, 1990a). The same is true for rewards and incentives, which are a prospect of the goal to be achieved and have been shown to positively impact commitment (Locke & Latham, 1990a; Locke & Latham, 1990b), especially when the set goals with the desired rewards match the motivation of the acting person.

The next factor influencing commitment is goal acceptance. It has been shown to be most powerful if a legitimate authority assigns the goals. It is important that the task is well explained and has a meaning for the performing person (Locke & Latham, 1990a). It is influenced by individual differences in demographics and personality, "…especially when goals are assigned rather than being

self-set" (Locke & Henne, 1986). However, it is not necessarily the case that participative set goals lead to a-priori higher goal commitment or better performance.

Another factor affecting commitment is peer influence and pressure. Groups can set their own standards regarding performance output. It has been shown that this can lead to a lowering of goal standards and consequently restricted output (Taylor, 1967; Locke & Latham, 1990a). In contrast to this, newer studies found that participatively set group goals combined with individually set goals can have a positive outcome (Wegge & Haslam, 2005; Latham & Locke, 2007). Again, similar to the general hypothesis of the goal-setting theory, specific and challenging rather than "do your best" goals lead to improved performance also in groups (Wegge & Haslam, 2005; Latham & Locke, 2007).

The main criticism of the concept of commitment is that goals seem to be assigned only from the outside and are not personalised. Aspects like "I do this because I like to" or "enjoying doing it" are missing. The concept is focused on achieving high performances (Locke & Latham, 1990a) and does not consider the value of good or pleasant outcomes where the goal might be the action itself and not so much a defined end-state (Blanke, 2008).

Mediators

According to the HPC performance is not only regulated by these moderators but also by mediators. They are variables, which try to explain how goals affect the performance or how these variables help to translate a goal into behaviour. Wood and Locke identified three aspects they named "universal task strategies" (Wood & Locke, 1986; Locke & Latham, 1990a):

- Direction of attention
- Effort
- Persistence

These variables correspond with the three attributes of motivated action – direction, intensity, and duration (Locke & Latham, 1990a). For example, a shopping list provides direction of attention providing intermediate sub-goals to reach the higher order goal of sticking to the shopping list to achieve a healthy and sustainable outcome. Personalised interventions need to ensure to minimise the effort required to keep up the direction of attention and enable persistent execution of the targeted behaviour for the whole duration of the grocery shopping scenario.

It is important not to assume a linear-causal relationship between these three aspects, because there are intervening variables such as for example tiredness, which despite higher effort can lead to lower performance outcome (Hacker & Richter, 1997). It is therefore not possible to predict high performance based on these. However, motivation requires all three to be present.

Further to that, mediators include task specific strategies. Wood and Locke (Wood & Locke, 1986; Locke & Latham, 1990a) distinguish two types of task-specific strategies: stored and new. Stored task specific strategies are already well learned and automatized, also referred to as habitualisation, and do not need a lot of conscious nor cognitive attention. According to Brug (2008) habitualised behaviour can be triggered through environmental aspects alone without conscious involvement. The second type are new task specific strategies, which in general will be triggered when the first type can't be used due to unforeseen circumstances and obstacles. New plans and new problem-solving strategies need to be developed and in the best case this newly executed behaviours will be

stored and used becoming stored task specific strategies over time. Goals or the anticipation of a desired outcome of an action can indirectly motivate a person to develop task-specific strategies or plans (Locke & Latham, 1990a). If a dynamic personalised intervention can facilitate this process, then better behaviour can be expected over time even without the intervention being applied. Supporting healthy and sustainable behaviour even in the presence of obstacles such as missing ingredients is therefore expected to lead to habitualising such behaviours in the long run.

While the original HPC considers task specific strategies as mediators (Locke & Latham, 1990a), they are also strongly linked to ability and can therefore also function as part of this moderator. It will be shown in section 2.1.2.3 that this re-assignment allows to consider the remaining mediators as exclusively motivational aspects helping to simplify the model without affecting its applicability or imposing any restrictions.

2.1.1.2 Graphical representation of the model

All relevant concepts of the HPC have been discussed in the previous section. The interaction of these concepts can be made explicit resulting in the graphical representation of the model depicted in Figure 6 (Locke & Latham, 1990a).

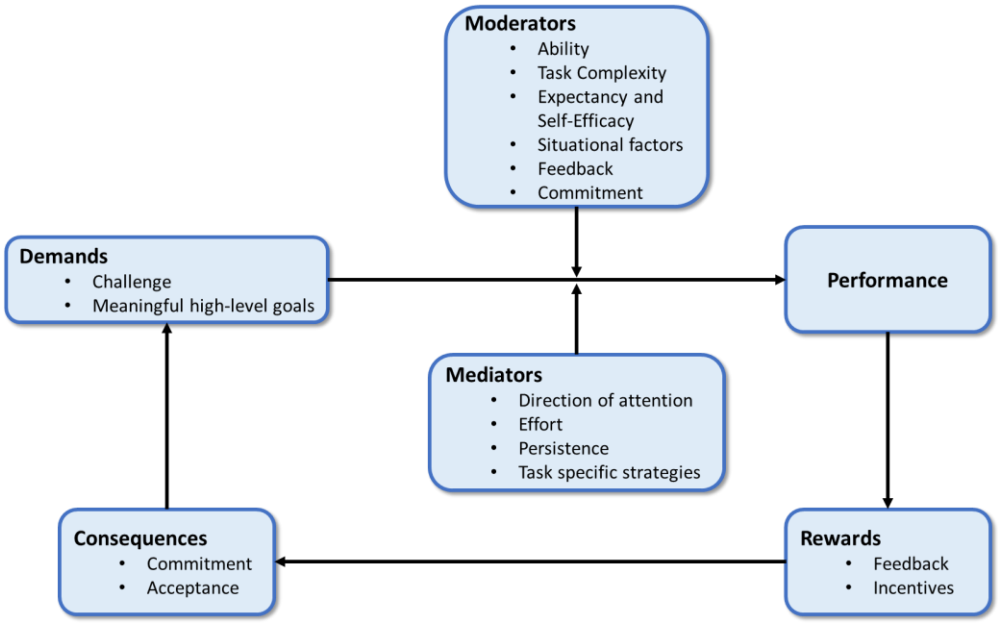


Figure 6 The High Performance Cycle (Locke & Latham, 1990a)

Due to the origin of the theory for the optimisation of work processes, all action in the HPC is triggered by demands. These demands lead to the execution of performance, which is also influenced by moderators and mediators as discussed above. Performance in the HPC leads to rewards comprising feedback and incentives and resulting in consequences such as commitment and acceptance. According to the HPC this closes the cycle influencing demands and high-level goals corresponding to potential future tasks.

The aim of the HPC was to improve motivation focusing on the employee. The circular structure reflects the fact that motivation needs to be maintained throughout many consecutive challenges and focuses on the importance of not considering individual tasks in isolation. This approach is very relevant to maintaining health and sustainability goals as well, due to the fact that these require

ongoing commitment and motivation of the individual and simple once-off actions are not sufficient in such a scenario either. Therefore, the HPC serves as the base theory in the following and it will be shown how other theories can benefit from being integrated in such a circular structured motivational model.

2.1.2 Action-Regulation Theory

Another behavioural theory developed in the context of work and organisational processes is the Action-Regulation Theory (ART). It was strongly influenced by Hacker (1986) and has been used as a foundation to measure and optimise work structures. The ART originated in Eastern Europe in the 20th century and is therefore influenced by socialist ideas of human behaviour and performance in the workplace. As a process model it is based on the Russian activity theory (Ulich, 2005) and on the TOTE-Model (Miller, Galanter, & Pribram, 1960). The aim was to overcome the partialism and Taylorism of working conditions and to build complete or holistic tasks, which is seen as a fundamental criterion for personal development in working conditions (Hacker, 1993a; Hacker, 1986) as well as achieving efficient and humanized work (Hacker, 2003). Again, the basic concept is easy to translate into a more general behavioural model applicable to other areas.

The basic idea of this theory is the regulation of action (Schelten, 2002) promising to overcome the gap between the visible part and the cognitive part of an action. The main focus of the ART can be seen in the attempt to connect the cognitive processes with the external action (Oesterreich, 1987).

Conscious behaviour and goal-driven or targeted actions are a vital characteristic regarding the human being (Oesterreich, 1987), therefore the ART does not consider unconscious behaviour and actions, which are difficult to measure and evaluate. The individual interacts with and influences the environment in a conscious, organizing and targeted way, while at the same time the surrounding is influencing back on the person (Oesterreich, 1987). This leads to a change in the environment, as well as in the individual and their personality (Hacker, 2005; Hacker, 1986). In other words, the performer is producer as well as product of his/her own actions (Hacker, 1986).

While the HPC emphasises the motivation (Locke & Latham, 1990b), the ART is focused on the execution of the actual activity or behaviour. It proposes a hierarchical-sequential model of consecutive actions and elaborates on how goals are divided into sub-goals to create feasible and actionable plans (Zacher & Frese, 2018). Both theories are considered to be process motivational approaches, because they try to describe the process of motivation and how motivation occurs and is translated into behaviour. They both draw a very rational picture of human beings emphasising the conscious and volitional regulation and control of a person's object-oriented action.

2.1.2.1 Definition of concepts

The ART uses very similar terms as the HPC. Sometimes the meaning is slightly different, though, therefore the definitions from the perspective of the ART will be provided in the following. Also, some new terms are introduced that are specific to the ART and have not been considered in the HPC.

Values and norms

In the ART values are understood as a controlling and guiding concept, which influence the extend and quality of work performance. They are mediated by norms, reputation and living standards (Hacker, 2005; Hacker, 1986). Although such a behaviouristic statement seems to imply that the

individuum is only led by outside conditions and values are not scrutinised, action and behaviour are influencing their surrounding and can thereby actively alter their circumstances.

In contrast to values, norms are not explicitly defined in the ART, even though the term is used extensively. Norms are used almost synonymously to values, with the implicit distinction that norms describe a standard or a rule (Blanke, 2008; Hacker, 2003). The natural internalisation of socially mediated norms and values and their validity can help as an orientation and cognitive ease when it comes to goal-setting positively affecting motivation (Blanke, 2008). Again, similar to values, norms seem to be a passive concept in the ART, where the individual only adapts to external social conditions (Hacker, 2005; Wiendieck, 1993) but not actively reflects on their respective content.

Compatibility with the HPC

Values are clearly defined in the HPC as actively acquisitioned through experience, whereas in the ART values seem to be a much more passive concept, where the interaction with the environment remains unconscious. It is not clear if it can be made conscious in the ART in the same way as it is described in the HPC. Locke et al. (Locke & Henne, 1986) explicitly state that values can be conscious or subconscious, while in the ART it can only be inferred from the general description that the interaction of a person with the surrounding influences the same and therefore also the values. However, it is not part of any conscious and reflective process (Blanke, 2008).

Norms can be found in both the HPC and the ART although the term is not explicitly defined in either. While in the ART the term norm is used extensively (Blanke, 2008) the HPC uses the term mainly in the context of group norms (Locke & Latham, 1990a). However, it lacks further clarification on how norms are acquired and if they can be part of a conscious, reflective process.

Redefinition of the task

An important concept of the ART not used in the HPC at all is the redefinition of the task. In the ART it refers to the phenomenon that different people perceive and interpret identical tasks in different ways (Hacker, 2003; Blanke, 2008) and that this has an impact on the resulting behaviour. The Russian psychologist Sergei Rubinstein (1914) developed the approach of redefinition, which addresses the cognitive regulation of tasks. This “mental regulation of activity is mediated by the object of that activity” (Hacker, 2003), influenced by the variety of people’s goals, motives, knowledge, experience, norms and attitudes. Therefore, external set tasks are subjectively interpreted and personalised, taking self-efficacy, available resources and the cognitive and emotional evaluation of the task (Hacker, 2003) under reconsideration. For example, two people could have an interest in eating healthier and more sustainable. While one person defines this task by eating something healthy once a day and less meat based, the other person could build daily meal plans considering nutritional values and the sustainability of each ingredient. Both, in this example, redefine and personalise the task into different goals and resulting from this a different set of actions.

Compatibility with the HPC

The HPC does not contain a concept of redefinition of the task. To see this, it is important not to confuse the redefinition with reflection, as redefinition is based on the internalised norms and values without questioning those as such (Blanke, 2008). However, whilst norms and values are not affected, the concept of redefinition goes beyond the HPC’s direct and seemingly passive translation of goals into actions by making explicit the intermediate cognitive process (Blanke, 2008).

Action and activity

Where the HPC is talking about performance, the ART uses the term action to refer to the execution of behaviour (Hacker, 1998). As discussed above both terms will be used synonymously in the following. Actions are at the core of the ART and contain a social meaning (Kalbermatten, 1987; Kaminski, 1996) regulated by acquired knowledge and experience (Hacker, 2003). They are organised in sequential phases as well as on hierarchical levels, each representing a mode of control. Three levels of conscious awareness of the process and its representation are distinguished (Hacker, 2003):

- Intellectual
- Knowledge-based
- Senso-motoric.

These simultaneously regulate the behaviour, which is an essential part of the action (Schelten, 2002). The conscious and volitional regulation guides the action, which is oriented towards an object (Blanke, 2008). “The most important characteristic of action regulation is that actions are controlled by goals, that, from a cognitive perspective, can be seen as anticipations of the results that one intends to achieve” (Hacker, 2003), otherwise the action would lose target and direction (Wiendieck, 1993). The ART combines a cognitive, behaviouristic approach with a humanistic approach and concludes that behaviour can neither be reduced to only passive reactions nor thinking alone (Mühlfelder, 2003; Oesterreich, 1987).

Actions comprise both cognitive processes as well as the visible part of an executed behaviour (Oesterreich, 1987). However, in the context of the ART only conscious and target oriented acting is addressed, which constitutes an inherent characteristic of the human being (Oesterreich, 1987). Actions can be broken down into operations, which are in general unconscious, but can be made conscious if necessary. Habitualised behaviour is mostly unconscious and as such can form an operation to a superordinate more complex action. It becomes conscious when an obstacle occurs or if the need to change the same arises. For example, the non-availability of an ingredient in a grocery shopping situation means the interruption of a sequence of actions. It is at this point where a dynamic personalised intervention can support better choices to alter unwanted habitualised behavioural patterns.

In summary, actions are goal oriented, conscious, volitional, object oriented, socially embedded and hierarchical-sequential organised (Hacker, 1986). A person’s actions influence the environment while at the same time the environment influences back on the individual. This process happens in a conscious, planned and goal-oriented way (Blanke, 2008) resulting in the individuum being the producer as well as the product of his/her actions (Hacker, 1986). To capture this ongoing process, the ART defines activity as a superordinate concept to action. The definition of this term gives a profound inside how the ART sees the human being. Rubinstein (1962) and Leontjew (1982; Wiendieck, 1993) see the activity of the human being as the process of altercation of the individuum with the world. During this interaction the acting person acquirers the world both physically as well as intellectually, changing the environment as well as themselves. Activity defines a process which realises a certain relation of human beings towards the environment, other people and tasks imposed on them (Rubinstein S. L., 1962). It is the activity that lets the individuum stay in interdependence with the social and physical world (Hacker, 1986).

Compatibility with the HPC

Actions are the key differentiator of the ART in comparison to the HPC. The latter does not elaborate on how exactly goals are translated into actual actions, instead the focus is on the motivational process and its influence on performance. The ART describes the translation from a goal into an action via a hierarchical-sequential model, emphasising the regulation of behaviour and goals guiding the action towards an object, while the HPC uses moderators to explain the influence factors affecting the relation between goals and performance. Both theories agree on the anticipation of goals as an essential aspect for focused actions, goals being the start and end point of actions as well as that actions are goal oriented. In both a very close link between actions and goals is postulated.

While the ART explicitly talks about a conscious process where cognitive aspects are connected with external actions, the HPC does not make any explicit comments on that. However, through the fact that actions are motivational oriented and one of the motivational aspects is direction of attention we can assume that performance in the HPC is also a conscious process.

Another difference between the HPC and the ART is the latter's emphasis on how the action of a person influences the environment and the environment influences back on the person. In the ART both the environment and the person are changing in the process, which means that the action also needs to be changed and adapted on an ongoing basis. The HPC on the other hand is less clear on this subject, however it also hints that people are adapting to changing circumstances and that cognitive resources are needed for goal pursuit (Latham & Locke, 2007).

Goals

All actions are preceded by goals, which the ART defines as the anticipation of a desired condition following from the execution of the action (Hacker, 1993a; Hacker, 1986). "The most important characteristic of action regulation is that actions are controlled by goals, that, from a cognitive perspective, can be seen as anticipations of the results that one intends to achieve" (Hacker, 2003). Goals constitute a desired change of environmental conditions (Oesterreich, 1987). They activate people to get involved in an action and at the same time organise and guide the action (Hacker, 1986) defining the start and end point of the behaviour. Actions and goals are forming a tree-like structure, with every superordinate goal comprising more granular sub-goals resulting in hierarchical-sequential action plans, each of which potentially comprising of even more granular sub-goals (Hacker, 2003). Without goal anticipation and visualisation of resulting action plans the action would lose its direction (Wiendieck, 1993). Achieving a (sub)-goal leads to the emergence of emotions which influence consecutive goal choices (Hacker, 2003) in the hierarchical-sequential model proposed by the ART.

According to the ART, socialisation can lead to goals being taken over without reflection or questioning them (Hacker, 1986). This can lead to a relief of cognitive strain when it comes to goal choice. Hacker distinguishes in his hierarchical-sequential model goals and sub-goals which are communicating with each other through feedback-loops. For example, the higher-order goal of a healthy and sustainable diet can be broken down into more manageable sub-goals, one of which being healthy and sustainable grocery shopping, which in turn is broken down into goals of sticking to the shopping list, buying all required ingredients, and so on. Supporting manageable sub-goals and habitualising the associated behavioural patterns reduces cognitive strain and enables better performance with regards to the overall more abstract health and sustainability goals.

Compatibility with the HPC

Both the HPC as well as the ART see goals as an organising and guiding process, which are inducing an action. While the ART provides a detailed description how goals are translated into actions via its hierarchical-sequential model with sub-goals, the HPC only focuses on the necessity of precisely set goals and accompanying feedback. Moreover, goals are influenced by social aspects by both the HPC as well as the ART. While the HPC emphasises how goals are influenced by values, the ART speaks about values as part of a guiding and controlling process driven by socialisation. Finally, the ART emphasises the importance of the anticipation of the desired change in the environment (Hacker, 2003) to achieve a goal, which is only matched by the HPC's concept of expectancy and self-efficacy (Locke & Latham, 1990a).

Goal-setting

The process of continuously choosing new sub-goals within the hierarchical-sequential model of the ART requires ongoing goal-setting at all stages of the behaviour. Goal-setting is the cognitive process of defining and choosing attainable sub-goals that can be expected to lead to achieving the desired results. It happens in the context of subject and object conditions (Oesterreich, 1987), taking into account perceived personal ability and current circumstances (Hacker, 2005; Hacker, 1986). Similar to the redefinition of the task goal-setting is also impacted by other aspects such as norms, values and motivation (Blanke, 2008), which are acquired during socialisation processes. These can help with goal selection by reducing the cognitive impact on the individual, who makes his/her goal choices according to these learned patterns.

Compatibility with the HPC

Goal-setting is an important part of both the HPC as well as the ART. It is a specific element in the process model of the ART, while the HPC, being itself considered a goal-setting theory, focuses on the conditions under which goal-setting is most successful using its concepts of moderators and mediators. The ART emphasises aspects like competence, personal meaning and appraisal as well as norms and values influencing goal choice.

Motivation and intention

Throughout the process motivation is needed to motivate actions. The ART makes a distinction between motivation and motives (Blanke, 2008). A motive is seen as a general tendency while motivation is the condition closest to a behaviour regulated by higher-order goals (Hacker, 1993b; Hacker, 2003). Motivation refers to the anticipation and consequences of an action as well as to the process of an action. It depends on the self-evaluation of personal ability, the personal expectation of the outcome of an action compared to the effort put into reaching the goal,
and self-set goals and their level of difficulty. Motivation resulting from self-set goals also depends on the adapted consensus of the individual with social norms and values (Hacker, 2005; Blanke, 2008).

The definition of motives and motivation in the ART is not consistent with other theories, in particular with the Theory of Planned Behaviour (TPB). Therefore, the term motivation will be used to describe what the ART refers to as motive in the following, while the term intention, which according to the TPB refers to the condition shortly before showing a behaviour in question (Ajzen, 2006a), is called motivation in the ART and will be used instead here.

Compatibility with the HPC

There has been little consideration of motivation in earlier work on the ART. The classical definition of motivation comprising direction of attention, effort, and persistence is included in the HPC but cannot be found in the ART as such. Only more recently the relevance of motivation and intention has been integrated into the ART (Hacker, 2003).

Despite the different naming convention mentioned in the section above, the concepts itself are very similar between the HPC and the ART. Both theories see the motivation (aka motive in the ART) as a general tendency to act and define the intention (aka motivation in the ART) as the condition closest to the action that the acting person is exhibiting shortly before showing the behaviour in question. The ART's hierarchical-sequential model makes it inherently possible for people to reconsider their action plans and intentions depending on the circumstances, whereas the HPC emphasises that motivational aspects like intentions are situationally specific and conscious (Locke & Latham, 1990a) as part of a motivational process. Hence, we can conclude that both theories are considering an active involvement of the acting person with his/her environment and that feedback is an essential part of guiding intentions and the actions following from it.

Motivation depends on the level of difficulty of a self-set goal in both theories, with challenging and demanding goals conjectured to increase the motivation. Goals have a motivating strength in both theories. While the ART emphasises the action and its consequences in conjunction with the expected effort which needs to be put into reaching the goal, the HPC focuses on anticipation and consequences of actions more indirectly through the setting and expectation to achieve high goals.

Both the ART and the HPC elaborate on the importance of knowledge when it comes to motivation. Learning and knowing the actions needed to reach a goal increases the motivation. It is discussed in the context of self-efficacy in both theories and also as a part of the HPC's moderators and mediators influencing ability and task specific strategies.

Feedback

Goal-oriented behaviour as required by the hierarchical-sequential model of the ART depends on feedback in every step. It is part of the cognitive process on all levels, which also comprises defining goals, planning actions and the actual execution of actions (Oesterreich, 1987; Hacker, 1986). The ART clearly states that without feedback, goal-oriented behaviour is not possible. As has been mentioned before, the ART is based on the Test-Operation-Test-Exit (TOTE) model (Miller, Galanter, & Pribram, 1960), therefore it also focuses on comparing the actual value with the desired value leading into a correction of behaviour if necessary (Blanke, 2008). According to the TOTE-Model an intention would be repeated as long as it takes to reach the set goal, the ART is more flexible in this regards also allowing for alternative goals to be set in the process depending on the feedback received during the execution of a behaviour and to re-adjust plans and goals, so that they do not get stuck in the execution process. Feedback is not only given at the end of an action but during the whole time of execution, therefore interruptions can be detected and the information can be fed back to the higher levels of the process, where goal and sub-goal planning for the action happens (Blanke, 2008) and adaptations of the action plan can be made. For example, unavailability of ingredients when following a grocery shopping list can trigger feedback that the original action plan is no longer valid, requiring the re-adjustment of recipe planning to adapt to new circumstances. A dynamic personalised intervention is well-placed to support this process.

Another type of feedback used in the ART is performance appraisal, which is described as having a motivational character (Hacker, 2005) depending on what type of emotions are triggered. Although emotions have been described as "…inherently associated with our actions…" by Hacker (2003), the original conception of the ART was strongly rational and did not pay much attention to emotions and motivation (Schelten, 2002). Emotions can be seen as pre- and post-cognitive evaluations of actions, i.e. before an action is selected and executed emotions are influencing this particular process and similar at the end of an action emotions play a key role as internal feedback influencing the following evaluation of goal-setting and future actions (Hacker, 1986). Therefore, also the redefinition of the task includes a cognitive as well as an emotional evaluation of the task. Both aspects are relevant when it comes to the effort or persistency someone puts into achieving a goal. For instance, if a task is perceived as boring less effort and persistency will be mobilised compared to a task which is interesting.

Compatibility with the HPC

Both the ART as well as the HPC are stating that goals without feedback or that goal-oriented behaviour without feedback are ineffective. Feedback provides information towards a goal and, if necessary, leads to adjustments of an action. While the HPC provides feedback and rewards at specific points within its cyclic structure, the ART is based around the idea of continuous feedback throughout the whole process of an action and not just at the end. The ART explicitly states that feedback is part of a cognitive process whereas such a statement is only implicit in the description of the HPC.

The second difference between the use of feedback in the two theories is that the HPC includes the concept of self-efficacy. In contrast to the ART the HPC elaborates on how the perception of personal abilities and circumstances, which is influenced by feedback, has an impact on goal choice.

Because the ART has been developed in the context of work and organisational psychology it sees salary as a strong incentive and motivator to show certain behaviours. Salary can be considered as a form of external feedback. A matching concept in the HPC is that context variables influence the motivation, with salary being understood as one of these possible context variables. The HPC understands external feedback also as a motivator, which influences the motivation of the acting person.

Emotions are the starting point and the end point of a behaviour in both the HPC and the ART. Pre- and post-emotions, which are the result of the evaluation of actions and subsequently influence the set-goal and following actions are used in both theories. The HPC achieves this by comparing set goals with achieved goals and sees this type of internal feedback as very relevant to motivate a person. A similar result is achieved in the ART by introducing the redefinition of the task, where goals are selected based on previous experience and the resulting emotions.

2.1.2.2 Hierarchical-sequential model of behaviour

The ART explicitly describes all behaviour in terms of sequential phases of actions structured in hierarchical levels of control. In each level sub-goals are being set, feedback is taken into account and action plans are constantly re-evaluated and adapted to the evolving circumstances. This model of behaviour can be graphically visualised in the tree-like structure depicted in Figure 7.

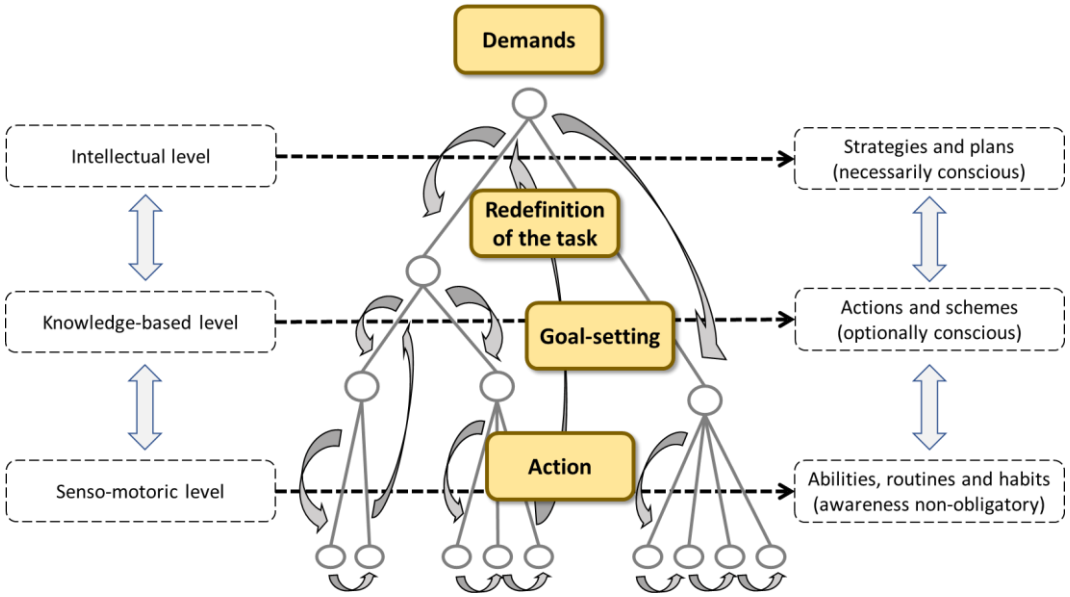


Figure 7 Hierarchical-sequential model of behaviour (Hacker, 2003)

Roughly three levels on which behaviour is regulated can be distinguished: intellectual, knowledge-based and senso-motoric (Hacker, 2003). On top, the intellectual level is where demands are translated into self-set goals. This step is called the redefinition of the task and necessarily needs to happen consciously. It is the cognitive process where externally set tasks or demands are personalised and strategies and high-level plans are developed. The reason for the redefinition of the task is that different people can perceive and understand the same task in different ways (Hacker, 2003).

The second level is where high-level plans are refined and where the context conditions and the available abilities are taken into account to develop more detailed strategies and action schemes. It is called the knowledge-based level in the ART and can be either conscious or subconscious. It is on this level that the goal-setting and –anticipation takes place and where the hierarchical-sequential concept of the ART is strongly reflected. Sub-goals are defined, and action plans are developed. Depending on which goal is chosen on the redefinition of the task level very precise and context dependent action plans have to follow, so that the individual can actively visualise how exactly to reach the goal.

The third level is concerned with routine and actual senso-motoric execution of the action. It happens mainly subconsciously and usually does not require awareness except for situations when interruptions occur. On this level of regulation, the acting person's abilities, routines and habits are used to perform actions without requiring the involvement of major cognitive capacity.

To reach the task criteria or the set goals, feedback-loops can be found on all levels of this hierarchy. The feedback-loops continuously measure and evaluate the progress of the behaviour towards the goal and send information up to higher levels to facilitate adjustments of behaviour if required. A hierarchical-sequential model of behaviour as proposed by the ART is very useful to understand how dynamic intervention applications need to interact with the user. The strength of dynamic feedback provided by such means is that they can influence the feedback loops directly as they occur during the execution of behaviour at the right time and the right place.

For example, a general demand or task to adhere to a healthy and sustainable diet is usually too abstract and therefore personalised into more manageable sub-goals. This redefinition of the task comprises the selection of preferred recipes in accordance with personal health and sustainability requirements and preferences. This cognitive process needs conscious awareness but can be supported by personalised recipe suggestions. The better the suggestions fit the individual's preferences the easier it is to select adequate goals thereby reducing cognitive strain. These superordinate goals need to be made more precise by building sub-goals and concrete action plans. In the running example adaptable and flexible shopping lists capture these action plans. They rely on the understanding of the context and require knowledge of what is possible and what to expect in a shopping situation. This can be conscious or subconscious, for example most people have a subconscious expectation what will be available in the shop they usually frequent. Finally, the execution of the action plan means to go to the shops and buy the pre-planned ingredients. Again, this can be very efficiently supported by a mobile dynamic application that enables ticking off ingredients from the shopping list. In case something is unavailable, alternatives need to be drawn up. This can trigger feedback loops all the way up the hierarchical structure, potentially requiring new recipes to be selected and ingredients to be replaced by alternatives. This process is cognitively demanding and therefore significantly benefits from a dynamic support system that helps to navigate the re-adjustment of the behaviour. The HealthStainable application implements this by supporting the process of shopping for alternative recipes by suggesting alternative action plans across all levels of the hierarchical model. This re-setting of goals and sub-goals with accompanying adapted precise action plans requires different levels of conscious involvement and carries the risk of falling back into unwanted behaviour in case of lack of alternative goal choices and action plans. Avoiding this issue helps to keep the intention to act in a desired way high and can be expected to decrease the intention-action gap.

2.1.2.3 Integration of the ART with the HPC

The High Performance Cycle and the Action-Regulation Theory both try to describe how demands are translated into behaviour and how the individual is motivated. The HPC focuses on the circular structure underlying motivation, with previous experiences influencing future behaviour. The ART on the other hand has its focus on the hierarchical-sequential structure of behaviour and the cognitive process of translating goals into actions. Both theories therefore have their own strengths, however they are also both lacking in some regard: "where the Action-Regulation Theory has a motivational gap, the motivational theory (HPC) has a regulation gap" (Ulich, 2005).

To overcome each theory's limitation and to build a comprehensive model of human behaviour building on the strengths of each theory an integration of both is proposed in the following. In the previous sections it has been shown, which concepts overlap, and which concepts are missing in each. The first major observation is that both theories elaborate on how demands are translated into actions and performance. Figure 8 shows the hierarchical-sequential model proposed by the ART flipped on its side illustrating how the translation process corresponds with the process outlined in Figure 6 for the HPC.

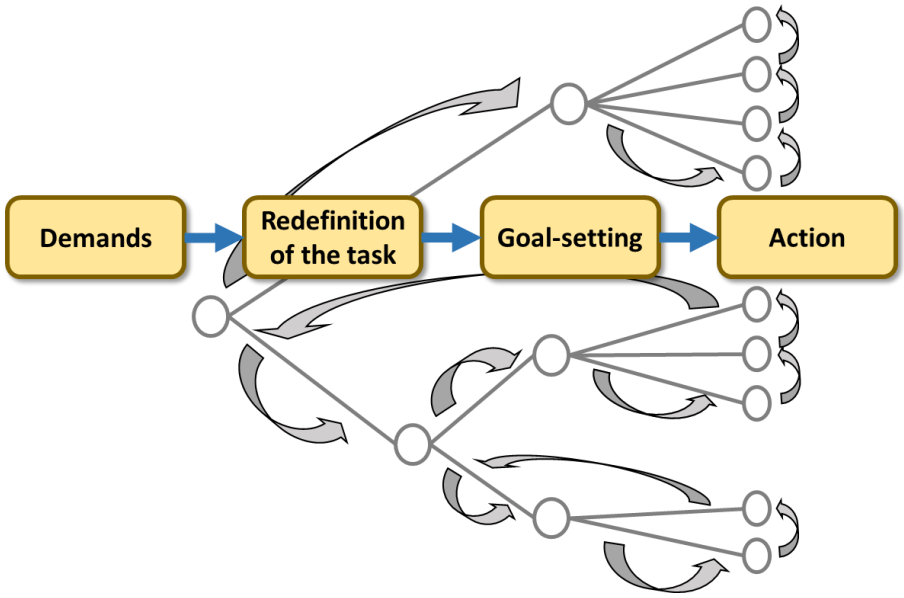


Figure 8 Translation of demands into actions in the hierarchical-sequential model of the ART.

The key difference between the ART and the HPC is that instead of going straight into action and performance from the demands, as it is done in the HPC, the redefinition of the task and an explicit description of the goal-setting process is included in the ART. Both aspects are important because they visualise the process of regulation of translation and adjustment of goals and actions. The resulting circular model is depicted in Figure 9.

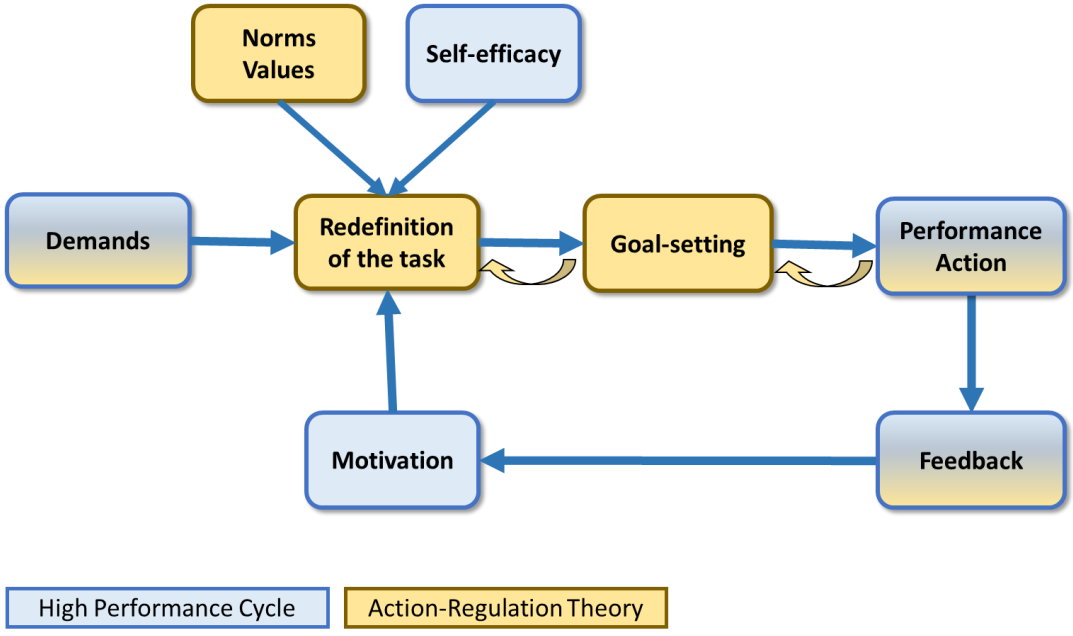


Figure 9 Motivational cycle of behaviour with explicit goal-setting, integrating HPC and ART

As already discussed above the ART's redefinition of the task is heavily influenced by norms and values (Blanke, 2008), while the HPC elaborates on moderators and mediators and how they affect the translation of demands into performance.

The main moderator is the self-efficacy, which also implicitly comprises aspects of ability, task complexity and situational factors. Other moderators discussed in the HPC are feedback, which also exists in the form of rewards in the cycle, as well as commitment, which is built through feedback and the resulting emotions and therefore also part of the cycle already. Due to this redundancy and the dominant importance of self-efficacy, the moderators are boiled down to self-efficacy only in the graphical representation of the fused model depicted in Figure 9.

The second influence factor on the translation of demands into performance according to the HPC are mediators, comprising direction, effort, persistence and task specific strategies. While task specific strategies can again be seen as contributing to self-efficacy, the other three are main characteristics of the definition of motivation. Therefore, motivation is used instead of the mediators in the graphical model shown in Figure 9 with the understanding that motivation together with self-efficacy influence translation of goals into actions consistent with the essence of the HPC.

Performance results are the actual achievement and the visible part of an action or behaviour according to the HPC. In its original layout performance has only been externally evaluated leading to rewards and consequences, while in the hierarchical-sequential model of the ART, feedback is also given throughout the whole process of an action allowing for the adjustments of the same. Therefore, we can distinguish between external as well as internal feedback. Regardless of this distinction, both types of feedback influence emotions such as the well-being and level of contentment. Such post-emotions, becoming pre-emotions for subsequent behaviour, strongly influence the motivation, which itself has a strong impact on how someone deals with new demands and tasks again, closing the cyclical model of behaviour (Locke & Latham, 1990a; Blanke, 2008).

Because the HPC is lacking a concise description of the cognitive process and demands are immediately connected to performance the circle is closed with the demands in the HPC. Having a more precise model of this translation from demands into actions borrowed from the ART, this closing of the circle can be made more accurate, with demands remaining external to the individual and motivation directly impacting only the redefinition of the task, which is the concept describing the personalisation of external tasks.

In summary, “behaviour always consists of two aspects: a cognitive, non-visible part and a performing, visible part. While the HPC is skipping the whole cognitive part, or at least remains very unspecific about it, the ART can fill this gap with a well-defined and visualised sub-model explained above” (Blanke, Beder, & Klepal, 2016). Figure 9 depicts an integrated model of behaviour, drawing from the strengths of both theories, that tries to overcome their shortcomings and provide a basis for explaining behaviour and its link to motivation.

2.1.3 The Social Cognitive Theory

The theories discussed in the previous two sections have both been developed in the context of work and organisational processes, which manifests itself in their focus on how specific external demands are translated into performance. It was argued that both are also applicable to a broader scope, however the distinction between the individual and the outside environment is not made explicit in either the HPC or the ART.

This interface between individual and the environment has been studied in the context of the Social Cognitive Theory (SCT). It was developed by Albert Bandura as an extension to his learning theory,

which found its main attention in the 1970s (Bandura, 1971). Sometimes, the term social cognitive theory is used generically to subsume a class of similar concepts and theories related to the interaction between the person and his/her environment. However, in the following the SCT refers to the specific theory proposed by Bandura (1999).

According to the SCT "people are self-organizing, proactive, self-regulating and self-reflecting. They are contributors to their life circumstances" (Bandura, 2005). The SCT emphasises that "people are producers as well as products of social systems" (Bandura, 1999), pointing out the importance of a conscious interaction with the environment and socio-structural networks. The ART describes this interdependency as dialectical (Rubinstein S. L., 1962), whereas SCT sees the interacting determinants bidirectional (Bandura, 1999). This general perspective, seeing people as proactive and not just reacting, was and still is the common approach in social science. It was the answer to the principals of behaviourism and psychoanalysis, which saw humans as mainly passive, only reacting to external stimuli (Bandura, 1978). The SCT draws a rational thinking picture of a person (Bandura, 1999), similar to the view taken in the ART, with the main focus of the SCT being its emphasis on the individual's ability to reflect on external circumstances as well as on his/her own abilities and knowledge.

2.1.3.1 Definition of concepts

Similar to the previous two theories elaborated before the concepts introduced by the SCT will be defined in the following and analysed with respect to their compatibility with the ART and HPC, again with the goal of integrating the SCT into an augmented and overall consistent and comprehensive model of behaviour that can benefit from all underlying concept's strengths.

Values and norms

Like the HPC and ART, the SCT sees all behaviour as being influenced and guided by personal and moral standards (Bandura, 1989). These personal and moral standards can be understood as values and norms, with a distinct emphasis on the reflective component that is prevalent throughout the SCT (Bandura, 1991a).

While norms are not explicitly mentioned, the SCT talks about knowledge and competencies, which are acquired by the individual through active involvement in the cultural practices (Bandura, 1999). Behaviour is guided and regulated by these norms through "negative self-sanctions for actions that violate […] personal standards" (Bandura, 1991b; Bandura, 1999) on one hand, and "positive self-sanctions for conduct faithful to […] moral standards" (Bandura, 1991b; Bandura, 1999) on the other. These moral standards are acquired through the mechanism of social referential comparison, which is when a person compares him/herself to particular others (Bandura, 1991a).

Compatibility with the HPC and ART

The focus of the SCT is on the individual's self-reflection and active interaction with the environment (Bandura, 1999), which is not the primary concern of either the HPC or the ART. The latter even sees values as passively acquired only, and therefore not reflected on as part of the behavioural process, whereas the SCT defines its goal choices through "judgement of one's behaviour in relation to personal standards" (Bandura, 1991a), which are actively acquired. Therefore, active reflection as vital part of the cognitive process is the key differentiator of the SCT (Bandura, 1999), with the individual being seen as "self-organising, proactive, self-reflective and self-regulative" (Bandura, 1986; Bandura, 1999).

The ART stresses that the individual adapts to external social conditions (Hacker, 2005; Wiendieck, 1993), which matches the SCT's observation that "social structures are created by human activity to organise, guide and regulate human affairs in given domains by authorised rules and sanctions" (Bandura, 1999). However, the key difference is that external social conditions are taken into account as is by the ART, whereas the SCT emphasises the ability to actively reflect on their respective content.

Knowledge and observational learning

Knowledge plays a vital role in the SCT to explain behaviour. It is the representation of successful structures, rules and strategies to attain a desired goal (Bandura, 1999), which is acquired by interacting with the environment through exploration or through verbal instructions. New ideas about the world and suitable behaviour how to reach goals are developed, while such thoughts and behaviour influence back on the environment and the developed ideas at the same time (Bandura, 1999).

Knowledge leads to what the SCT calls conceptions, which "serve as guides for the production of skilled action and as internal standards for making corrective adjustments in the development of proficiency" (Bandura, 1999). Conceptions therefore constitute the SCT's version of action plans and feedback loops.

Knowledge can be acquired through observational learning, which is another key concept in the SCT describing the ability of human beings to learn from the observed successes and mistakes of others without having to try the observed behaviour themselves. People learn through observation and are able to adapt the observed behaviour to new conditions, meaning that realistic goals can be set by watching other people perform similar tasks (Bandura, 1999). Self-observation is another means to setting realistic and adaptive goals and to "evaluating one's progress toward them" (Bandura, 1991a).

Observational learning emphasises the cognitive ability of people to anticipate future outcomes and adjust the own behaviour accordingly. It also leads to the adoption of standards (Bandura, 1999), which are the SCT's view of norms and values in a society.

Compatibility with the HPC and ART

Knowledge and observational learning are unique features of the SCT. The HPC makes reference to task specific strategies, which are learned and implicitly include action plans and are therefore related to the knowledge concept introduced by the SCT. The ART does not have a similar notion as part of its model of behaviour.

Behaviour

Central to the SCT is the concept of behaviour, which it defines as a process comprising both a cognitive, non-visible, and an execution, visible, part. Behaviour bi-directionally influences and is influenced by personal as well as environmental variables. The SCT postulates a reciprocal causal relationship between all these (Bandura, 1999; Bandura, 1989).

People are seen by the SCT as both the "producers as well as products of their environment" (Bandura, 1989). Conscious selection of a certain behaviour also selects the potential environment, which through this process becomes the actual experienced environment (Bandura, 1999).

“Consciousness provides the information base for thinking about events, planning, constructing courses of action, and reflecting on the adequacy of one’s thinking and actions” (Bandura, 1999). At the same time the environment determines which behaviours are feasible. Time and opportunity are important aspects when choosing a behaviour (Bandura, 1989). This conscious selection process requires cognitive capacity and participation (Bandura, 1989). The SCT also acknowledges subconscious or habitualised behaviour, which does not need cognitive attention and is regulated and executed on lower cognitive levels (Bandura, 1999).

The SCT states that behaviour can only be properly understood by considering socio-structural, physical and psychological parameters interacting with each other (Bandura, 1999; Bandura, 1989). Demographics, socioeconomic status or family structure only indirectly influence behaviour (Bandura, 1999), while knowledge, which is acquired through observation of others and the consequences through “…exploratory activities, verbal instruction, and innovative cognitive syntheses” (Bandura, 1999; Bandura, 1991a; Bandura, 1978; Bandura, 1989), affects the behaviour much more directly according to the SCT. In this sense the SCT explains behaviour using knowledge as immediate pre-cursor variable, which is acquired through the interaction of the individual with his/her social environment.

“Knowledge structures representing the models, rules and strategies of effective action serve as cognitive guides for the construction of complex patterns of behaviour” (Bandura, 1999). The creation of action plans, enabling the execution of such complex behaviours, is therefore seen as a cognitive process driven primarily by knowledge according to the SCT. Such action plans are called conceptions in the SCT and are based on a multilevel system of control (Bandura, 1999; Bandura, 1991a) very similar to the ART’s hierarchical-sequential model of behaviour.

Behaviour always contains an anticipating component, which allows predict the goals that can be achieved by it, which is called forethought in the SCT (Bandura, 1999; Bandura, 1991a; Bandura, 1989). The anticipation of an outcome or goal motivates and guides the behaviour and actions (Bandura, 1989), which lead to consequences and “affect the opinions and effects of later decisions” (Bandura, 1991a). Actions are therefore seen as a causal sequence of events that the acting person can influence thereby shaping the development of the outcome over time.

Compatibility with the HPC and ART

For obvious reasons all behavioural theories have a notion of behaviour. While the SCT is using the term behaviour, the HPC talks about performance and the ART uses the phrase actions. All these essentially mean the same thing: the predominantly conscious execution of actions to achieve a goal. Therefore, all terms will be used synonymously in this work. The only difference between the three is the focus that each theory puts on its concept of behaviour/performance/action.

The SCT focuses on behaviour as an interactive and reflective process in which the acting person influences his/her environment and vice versa. The HPC is less specific on this subject, although it also argues that people are adapting to changing circumstances (Latham & Locke, 2007). The ART on the other hand also puts some emphasis on how the action of a person influences the environment and how the environment influences back on the person, although demands are translated into action plans without immediate reflection in its model of behaviour. Therefore, all three theories essentially agree on this subject with the SCT putting special emphasis on the interactive acquisition of knowledge about the environment and reflection as part of the behavioural process.

Knowledge is the key pre-cursor variable to behaviour according to the SCT. While the ART mentions a knowledge-based cognitive level required for the setting of goals and the creation of action plans, it is far less specific in how knowledge is acquired or how it has a reflective influence on the behaviour in the process. The HPC notion of the influence of knowledge on behaviour is much stronger. It elaborates on ability and task-specific strategies, which both are knowledge-based moderators and mediators influencing the performance. However, in contrast to the SCT the HPC does not put any emphasis on the reflection of goals and behaviour. While the HPC directly links goals to performance, both the SCT and ART see a need to elaborate on the intermediate cognitive process and define behaviour as the combination of a cognitive, invisible as well as a visible part.

To describe the cognitive process the main contribution of the ART is its hierarchical-sequential model. Although the SCT does not elaborate on how this is built or executed in detail, it also talks about a multilevel system of control (Bandura, 1999; Bandura, 1991a), which means the same thing.

In summary, the SCT introduces knowledge as main pre-cursor variable to behaviour and argues that the individual is reflective towards the environment and his/her behavioural choices. Thereby a relation between the behaviour and its impact on the environment is established going beyond the previously discussed HPC and ART.

Self-efficacy

In the previous section it was argued that knowledge in relation to the environment is a main driver of behaviour according to the SCT. However, often behavioural choices are more driven by the individual's subjective perception of his/her knowledge about personal abilities in the context of the current circumstances. This perception is called self-efficacy and plays a crucial role in the SCT for the explanation of behaviour. Self-efficacy asks, if the acting person has the resources and competences to master the required task in the current situation, as otherwise there would be no incentive to act (Bandura, 1999; Bandura, 1991a). This also includes beliefs about the environment and how influenceable or controllable it appears (Bandura, 1991a). According to the SCT, self-efficacy also gives some indication how much effort someone invest and how persistent he/she will be, even if obstacles occur (Bandura, 1991a; Bandura, 1978).

Self-efficacy is the belief that people "can produce desired effects by their own actions" (Bandura, 1999). It refers to "people's beliefs about their capabilities to exercise control over their own level of functioning and over events that affect their lives" (Bandura, 1991a) or in more simple terms, self-efficacy is "what I believe I can do with my skills under certain conditions" (Maddux, 2002; Snyder & Lopez, 2007). A personalised intervention needs to address self-efficacy in two ways: first, it should ensure that messages and suggestions are reflecting personal abilities by providing goal choices that are matching circumstances and means. Second, perceived ability should be bolstered when possible by providing adequate support for complex tasks or when obstacles are encountered. For example, healthy and sustainable grocery shopping needs to be supported in the context of cooking abilities and the availability of equipment and ingredients, while also providing means for following through on more complex tasks, for instance by providing detailed shopping lists and action plans.

The SCT sees self-efficacy as a cognitive process having a strong anticipatory component (Bandura, 1999; Bandura, 1991a). Future outcomes of potential behaviour are reflected by the individual in the context of his/her personal abilities to achieve the desired results. This reflection takes personal knowledge as well as outside circumstances into account and tries to determine if one is able to

produce the result as well as how the achievable result is favourable or unfavourable with respect to personal goals (Bandura, 2004).

Compatibility with the HPC and ART

Self-efficacy has been developed as a concept by the SCT (Bandura, 1978), therefore all other theories derive the concept from the definition introduced by the SCT. The concept focuses on the consideration of abilities in the set circumstances which leads to choosing specific, valued goals. The HPC adopted the concept from the SCT and introduced it as one of its moderators. Therefore, the use of self-efficacy is almost the same in both the HPC and the SCT, with minor terminological differences: for example, the HPC talks about expectancy where the SCT uses the term anticipation. This difference indicates a slightly different focus, with the HPC originating in a more rational work and organisational context whereas the SCT tries to be broader and capture a wider range of behaviour not necessarily linked to professional qualification.

The SCT notes that the reflection of personal abilities influences how goals are determined (Bandura, 1978). In this sense self-efficacy specifies what needs to be taken into consideration to redefine a task and how demands are translated into personalised goals. Therefore, while the ART is not explicitly utilising a concept of self-efficacy itself, the redefinition of the task implicitly requires self-efficacy as defined by the SCT in this process. This observation is consistent with the merged model of HPC and ART derived in section 2.1.2.3 and depicted in Figure 9.

The SCT puts more emphasis on the reflection of personal and environmental factors than either the HPC or the ART. This also affects the use of self-efficacy in the three theories, with the HPC and ART not emphasising the self-efficacy concept as strongly as the SCT with its focus on a reflective cognitive process. Therefore, the SCT provides more insight into how the redefinition of the task is actually carried out, with demands being personalised based on perceived abilities and environmental circumstances.

Environment

The SCT puts a lot of emphasis on the interaction of the individual with his/her environment as seen in the previous section. It postulates a reciprocal causal relationship between environment, personal factors and behaviour (Bandura, 1999; Bandura, 1989). Therefore, unlike the HPC or ART it introduces and elaborates on environmental factors and their influence on the behaviour, the individual and vice versa. The SCT distinguishes three different types of environment (Bandura, 1999):

- Imposed environment
- Selected environment
- Constructed environment

The first is the environment imposed on the individual by socio-structural circumstances no matter what the individual's views or attitudes towards these structures is. It leaves very little or no room for actions (Bandura, 1999). For example, a shop offers a restricted environment where availability of products and their order within the shopping experience are not up to the customer. The customer can therefore only react to this environment but cannot control the environment itself.

The next type is the selected environment, where a personal choice can be exercised in order to select which aspects of the environment are used and which in turn then constitute the selected environment (Bandura, 1999). For example, selecting a certain milieu for instance spending time with equal minded people determines future actions. Such personal choice of the environment someone is interacting with influences behaviour and actions (Bandura, 1999). Organic supermarkets for example constitute a particular selected environment where behaviours in favour of healthy and sustainable grocery shopping are encouraged.

Finally, the constructed environment is created in a reciprocal process where individuals are building and constructing their own social environment and institutional systems (Bandura, 1999). This involves an interactive process between personal, behavioural and environmental aspects (Bandura, 1999). For example, establishing an interest group for healthier and more sustainable eating would actively contribute to creating a constructed environment where sustainability and health are valued, and this type of behaviour is supported.

Compatibility with the HPC and ART

Although the HPC also puts some emphasis on the interaction of the individual with the environment and the ART describes the interaction of a person with his/her surrounding, the SCT goes into much more detail with regards to this topic in its detailed description of the active, reciprocal relationship between the environment, the individual and his/her behaviour.

Personal factors

In its triadic reciprocal causal relationship model the SCT emphasises the relationship between environment, behaviour and personal factors (Bandura, 1999; Bandura, 1989). These personal factors include

- cognitive,
- affective and
- biological determinants.

Cognitive personal factors comprise aspects such as knowledge and abilities, which enable the individual to process available information on the environment and to choose the right behaviour to reach desired goals (Bandura, 1999). Their effect on the behaviour, in particular through self-efficacy, has been discussed in the sections above.

Affective determinants of behaviour are the emotions and attitudes a person experiences towards an object in a situation. They can have informative value and influence personal competence and self-efficacy (Bandura, 1978). Positive and negative emotions work as feedback and guide the behaviour (Bandura, 1991a). The cognitive and emotional appraisal of situations determines the level of motivational inducement of action (Bandura, 1978). It has also been shown that people with high efficacy and perceived control over their environment show less helplessness and depression, because they are more self-confident in executing a behaviour in question and at the same time controlling interfering negative thoughts (Bandura, 1999). Better coping skills are typically seen in people showing less emotional arousal (Bandura, 1978). For example, unavailability of items on a shopping list has been shown to lead to frustration and negative emotions (Aylott & Mitchell, 1999), which impedes the ability to achieve set goals of preparing healthy or sustainably sourced recipes later.

Biological factors influencing behaviour are related to the physiological state of the individual. For instance, tiredness or hunger have an impact on the perception of the environment and the chosen behaviour. For example, it has been shown that shopping behaviour changes when people are hungry and that they are more likely to spent more, which is even true for non-grocery items (Xu, Schwarz, & Wyer, 2015).

Compatibility with the HPC and ART

The SCT puts personal factors into a reciprocal causal relationship with the environment and the behaviour. It summarises cognitive, affective and biological factors within this concept, whereas the HPC and ART put more focus on the cognitive factors only and include affective and biological factors more marginally into their models of behaviour.

The impact of cognitive factors on behaviour through self-efficacy is mirrored in the HPC, which took over this concept from the SCT. Cognitive personal factors are not as explicit in the elaborate model of the cognitive process within the ART, which, while also requiring knowledge and ability acquired through the interaction with the environment, assumes these to be more passive and less influenced by reflection.

Emotions have not been a relevant aspect in the strong rational view of behaviour taken in the ART (Schelten, 2002), although it has been noted that they are inherently associated with actions (Hacker, 2003). The HPC acknowledges that emotions are a crucial part of the motivational system (De Ridder & de Wit, 2006). Both the ART and the HPC see emotions as the start and end point of every action, with feedback on the behaviour leading to an emotional state relevant for the following behaviours. This notion of feedback on emotion matches the informative value attributed to emotions by the SCT (Bandura, 1978).

The aspect of self-confidence is unique to the SCT. Although self-efficacy plays a similar role in the HPC, self-confidence goes beyond that by also considering the emotional aspects of the perception of the own abilities of an individual in a given context and social environment.

Finally, biological factors as described by the SCT only have a minor role in the work focused HPC and ART. The HPC mentions needs as drivers of behaviour, and biological determinants can be seen as a sub-category of these.

Goals and goal-setting

Very similar to the ART the SCT also sees all behaviour as goal driven and postulates a hierarchical structure of goals (Bandura, 1999; Bandura, 1991a). Within this hierarchy the SCT makes a distinction between broader goals that reflect personal values of the acting person and proximal sub-goals, which take the current context into account and guide the behaviour accordingly (Bandura, 1999; Bandura, 1991a).

The SCT emphasises the creative, proactive and self-reflective side of the individual, who is able to anticipate which actions are suitable to cause what change in the environment (Bandura, 1999; Bandura, 1991a). Goals are the result of this anticipation of future outcomes considering feasibility in the given circumstances and personal abilities. A strong aspiration or personalisation of a goal is an indication of the effort and persistence someone is willing to invest (Bandura, 1991a) and

motivation is conjectured to be substantially increased by a combination of goals and feedback (Bandura, 1991a).

Goal-setting in the SCT is therefore driven by the active anticipation of likely consequences and the creation of action plans that are perceived as "likely to produce desired outcomes and avoided detrimental ones" (Bandura, 1999; Bandura, 1978; Bandura, 1991a) in the context of knowledge of the social setting and existing rules. Behaviour and actions are motivated and directed through goal-setting, which constitutes the cognitive, non-visible part of behaviour (Bandura, 1999; Bandura, 1991a). The SCT with its strong focus on self-efficacy considers goal-setting in the context of environment and abilities and postulates that together with "evaluative reaction to one's own performances" (Bandura, 1999), i.e. feedback, it provides the "cognitive mechanism for motivation and self-directedness" (Bandura, 1999). The adoption of goals is seen as "self-investment in the activity" (Bandura, 1999) leading to increased motivation.

Compatibility with the HPC and ART

Goals as defined in the SCT are very similar to the ART. The hierarchical structure comprising superordinate goals, reflecting personal values, and proximal sub-goals, guiding the actual behaviour, has some similarity to the hierarchical-sequential model of behaviour regulation proposed by the ART. In contrast to the latter it lacks the graphical clarity of the different levels of regulation that the ART provides

The reflection of personal values postulated by the SCT can be mapped onto the ART's redefinition of the task. However, the latter does not consider the reflection of norms and values as part of the redefinition of the task as such. The individual is therefore seen as more actively participating in the process of personalising goals and goal-setting by the SCT.

The ART highlights the importance of the anticipation of the desired change in the environment to achieve a goal, which gives the behaviour its direction. This notion is found in the SCT as well and is even more emphasised by its strong focus on self-efficacy, which highlights the role context and environment play in the goal-setting process. In the SCT the anticipation or forethought is said to also include a motivational component. Anticipation of a goal determines effort, direction and persistence to achieve the same, which are the mediators of the motivational process outlined in the HPC.

The SCT indicates that goals with performance feedback work best (Bandura, 1991a), which is the main conjecture of the circular structure of motivation proposed by the HPC. The HPC emphasises the importance of specific goals for motivation, whereas the SCT only talks about valued goals although specificity of goals can be implicitly assumed from the hierarchical structure, which necessarily requires detailed action-plans and granular sub-goals. However, while the SCT mentions "construction of complex patterns of behaviour" (Bandura, 1999) this notion of precise action plans is only made explicit in the ART.

In conclusion, all three theories have essentially the same concept of goals as guiding principles for the behaviour, and the SCT is no exception (Bandura, 1999; Bandura, 1991a). Although the HPC does not have an explicit notion of goal-setting to describe the cognitive process of creating and choosing goals, it sees goals as the mechanism by which values are translated into action (Locke & Henne, 1986). The ART makes goals and goal-setting more specific through its redefinition of the task and

the resulting hierarchical-sequential model of goals and sub-goals as well as the construction of explicit action plans. The SCT adds focus on reflection and self-efficacy as essential part of the cognitive process, thereby complementing both the HPC and the ART with this aspect.

Motivation and intention

According to the SCT motivation is caused by the cognitive anticipation and forethought of future desired outcomes of action and behaviour (Bandura, 1999). Motivation is influenced by adoption of standards (Bandura, 1999), meaning that people holding strong values with regards to an object show stronger motivation to act accordingly. "Whether a given performance is regarded favourably or negatively will depend upon the personal standards against which it is evaluated" (Bandura, 1991a). Motivation is also influenced by the proximity of the goals, with those more closely related to the here and now expected to guide and motivate actions in the present (Bandura, 1999).

Self-set goals can amplify the cognitive mechanism of motivation (Bandura, 1999). Direction, effort and persistence towards such goals are expected to be stronger. External demands or set goals are more difficult to personalise, therefore a lower motivation activation can be expected. On the other hand, if a goal is self-set then motivation to execute a behaviour to reach that goal can be expected to be higher. Such self-motivation and goal aspirations are based on self-efficacy, with individuals choosing "which challenges to undertake, how much effort to invest in the pursuits and how long to persevere in the face of difficulties" (Bandura, 1991c; Bandura, 1999). Challenging goals are expected to increase the motivation and performance achievements further (Bandura, 1999) if they are consistent with the efficacy beliefs of the individual, i.e. if they are not perceived as too difficult.

The SCT does not distinguish between intention and motivation and unlike the other theories uses both terms synonymously. Motivation is both seen as the general tendency as well as shortly before a behaviour (Bandura, 1978).

Compatibility with the HPC and ART

The anticipation of desired outcomes and the translation into goals is the cause for motivation according to the SCT. Goals itself therefore have a strong motivating impact in the SCT, which is a view shared by the HPC and to a certain degree by the ART as well. Both the SCT and ART contain a hierarchical structure of goals, with the SCT stating that proximal goals, i.e. goals closer to the action, have a motivating momentum whereas the ART sees higher-order goals as predominant motivators.

The SCT states self-set goals and strong personalisation leads to more effort and persistence and hence increased motivation. This is consistent with the HPC, which also sees persistence and effort as two important mediators of the motivational process. The ART, with its focus on the redefinition of the task also includes strong personalisation of goals in its model, although the motivational implications are not elaborated there. Self-set goals and more challenging goals are conjectured to increase motivation by all three theories.

The HPC sees self-efficacy as moderator of motivation and postulates that it influences motivation. Therefore, the strong focus of the SCT on self-efficacy and the reflection of personal abilities in the context of the environment can be understood as part of the motivational process, although the SCT itself does not explicitly see the motivational impact of self-efficacy. In this sense the HPC augments the SCT by postulating that self-efficacy is a key contributor to motivation.

Feedback

According to the SCT behaviour or actions are continuously monitored by the acting person to compare progress to the desired goals (Bandura, 1999; Bandura, 1991a). Feedback accompanies actions and provides comparative information, correcting mismatches between goals and actions (Bandura, 1999; Bandura, 1978) for example when encountering obstacles. Feedback is based on self-monitoring of behaviour and the resulting effects, which enables judgement of the behaviour in relation to standards or acquired norms and environmental circumstances (Bandura, 1991a).

The SCT conjectures that goals combined with performance feedback increase the motivation (Bandura, 1978). Both external feedback, i.e. given by others, and internal feedback, i.e. by means of self-reflection and self-observation, shape what courses of action are pursued (Bandura, 1999). External incentives can motivate personal goal pursuit (Bandura, 1991a) and can range from financial compensation to acknowledgement by important reference groups or role models. For example, the external acknowledgement of others that they find it commendable how healthy someone eats and how conscious someone is about sustainability can be a big motivator for extrinsically motivated people. On the other end of the spectrum, internal feedback through self-reflection and self-observation induce motivation to behave in certain ways and to pursue certain goals (Bandura, 1991a; Bandura, 1978). Internal feedback and "self-incentives motivate and direct behaviour through cognitive anticipatory mechanisms" (Bandura, 1991a). The SCT postulates that "people who reward their own attainments usually accomplish more than those who perform the same activities under instruction but without self-incentives" (Bandura, 1978).

Feedback can be seen in the context of learning, where the results or the effects of one's action are noticed and lead to an adjustment of the action (Bandura, 1999). The SCT also describes how observational learning, i.e. seeing other people act and the consequences of their actions, can influence the knowledge about behaviour. This can be understood as a form of feedback as well (Bandura, 1999).

Feedback also impacts on emotions, for instance when encountering obstacles during the execution of a behaviour. Because affective personal factors influence behaviour according to the SCT, this is another mechanism how feedback indirectly guides goal pursuit.

Compatibility with the HPC and ART

The SCT describes feedback as the cognitive process by which actions are constantly monitored and adjusted accordingly. This is consistent with the ART, which looks at feedback loops on all regulatory levels. Within its hierarchical sequential model feedback is constantly taken into consideration and the behaviour is adapted when obstacles are detected. Also, the HPC considers feedback as the information given towards a desired goal potentially leading to adjustments of the behaviour (Locke & Latham, 1990a). The difference between the ART and HPC is the granularity, with the HPC considering feedback in its motivational cycle mainly at the end of the visible part of the performance, whereas the ART also has multiple internal feedback loops integrated on all cognitive levels. In comparison to HPC and ART, the SCT does not take such a formalised and structured view of the process. Instead, the focus of the SCT is on the individual and his/her self-reflection and self-observation. According to the SCT, this leads to internal feedback loops which are similar to the adaptive action plans of the ART.

Feedback is seen as a moderator of motivation by the HPC, which sees goal-specific feedback in particular as strong motivator of behaviour. The SCT also acknowledges the motivational impact of feedback, which together with set goals increases motivation. This is also the view taken by the ART, therefore all three theories agree on this aspect. The SCT, HPC and ART all see the impact feedback has on emotions and the influence these have on subsequent actions.

In summary, the SCT, HPC, and ART are very similar in regards to their consideration of feedback. All consider external as well as internal regulation of behaviour, with the HPC and ART taking a more technical view whereas the SCT focuses on the self-reflection of the individual.

2.1.3.2 Triadic reciprocal model of behaviour and multi-level system of control

Triadic reciprocal model of behaviour

The SCT defines behaviour in relation to the environment and personal factors, each bi-directionally influencing each other (Bandura, 1999; Bandura, 1989). This reciprocal causal relationship between behaviour, environment, and personal factors forms the triadic reciprocal model of behaviour depicted in Figure 10 (Wood & Bandura, 1989).

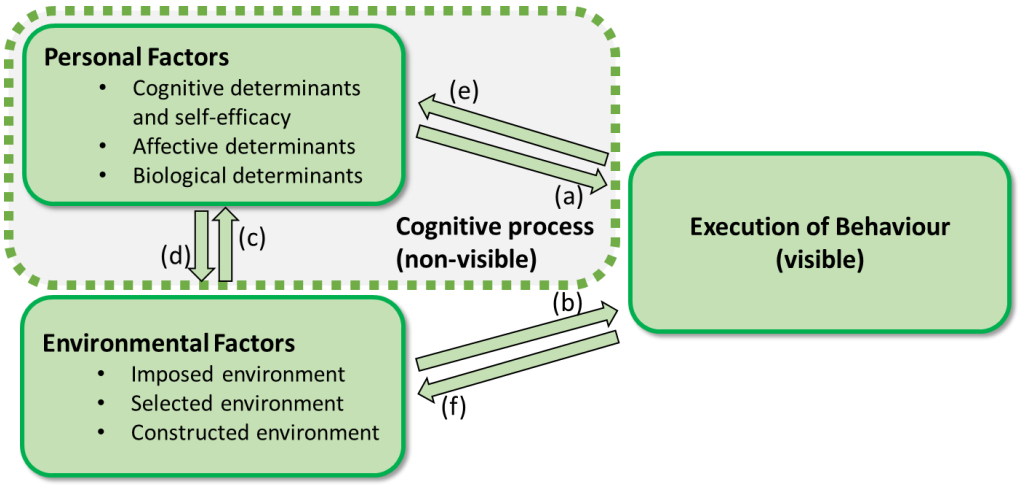


Figure 10 Triadic reciprocal model of behaviour

According to this model behaviour comprises both a cognitive, non-visible, and an execution, visible, part (Bandura, 1999). The execution of behaviour is dependent on both personal factors (a) as well as on the environment the actions are carried out in (b). It is facilitated by a cognitive process underpinning behaviour choices and execution, which is guided by personal factors comprising cognitive, affective and biological determinants. In particular, the self-efficacy, which connects cognitive determinants such as perceived knowledge and ability with the opportunities provided by the environment (c), determines what actions are selected and executed.

The cognitive process also influences the environment itself (d) according to the SCT, with the option to select or even construct circumstances that enable certain behaviours. The same reciprocity is postulated between the execution of the behaviour and personal factors (e), where for example feedback from the execution is used to learn and acquire new knowledge.

Finally, the execution of an action has an impact on the physical environment (f), which also leads to a change in the environmental factors guiding the behaviour going forward.

Multi-level system of control

The reciprocal causal relation between the cognitive factors and the execution of the behaviour is described as a multilevel system of control by the SCT (Bandura, 1999; Bandura, 1991a). This is very similar to the hierarchical-sequential model proposed by the ART and can therefore be visualised similarly as shown in Figure 11.

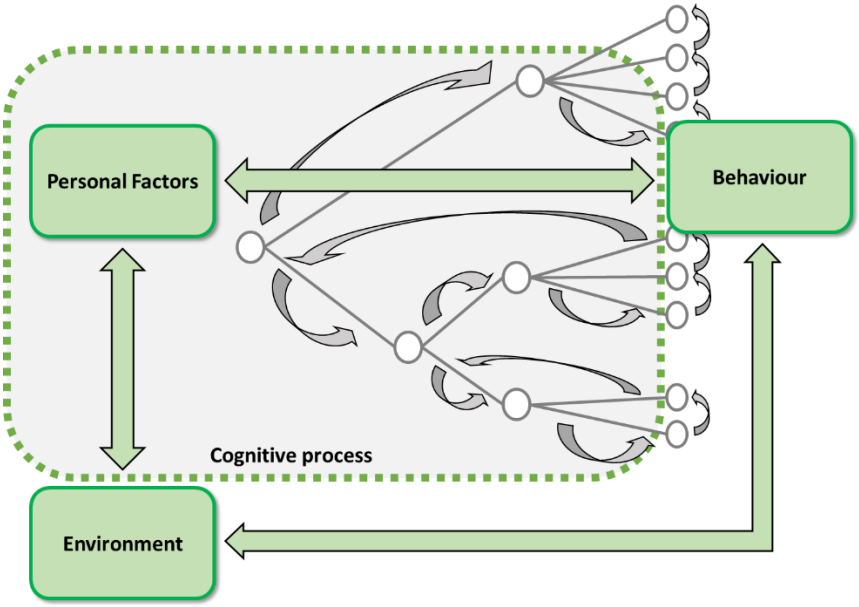


Figure 11 Multi-level system of control

The basic idea is to use knowledge and built structured hierarchical conceptions of potential action plans. These conceptions serve as guides for executing the behaviour, however they are open for corrective adjustments when required (Bandura, 1999). A conception of an action plan comprises multiple operations, which are run simultaneously and interactively, visualising how "input activates a multifaceted dynamic throughput that produces the output" (Bandura, 1999). A key aspect is the ability to create ideas and action-plans without having them tried physically and use observational learning instead. This visualisation of conceptions helps to execute the behaviour according to these action-plans and to consider and anticipate feedback loops in the process. The more precise the cognitive representation of action-plans the more likely it is that the person will be able to act successfully (Bandura, 1999).

The multi-level system of control proposed by the SCT is therefore describing a much more pro-active cognitive process than the hierarchical-sequential model proposed by the ART, which puts more emphasises on the re-action to unexpected events. The SCT states that "while performing activities, they form ideas about what leads to what, act on them or predict occurrences from them, judge from the results the adequacy of their thoughts and change them accordingly" (Bandura, 1999). In contrast to this the cognitive processing in the ART is less anticipatory and potentially requires activation on higher cognitive levels during the sequential execution of the action-plan, whereas the SCT allows for multiple operations to be pre-planned simultaneously and in advance. Both the SCT and the ART, however, describe a very similar hierarchical cognitive representation of goals and sub-goals preceding the execution of behaviour, with corrective physical and cognitive adjustments possible in case unforeseen obstacles are encountered. The key difference is the time when contingency plans are created, with the ART assuming this to be triggered by the obstacle,

whereas the SCT assumes more cognitive pre-planning including potential alternatives within its cognitive representation already.

When a behaviour is planned and executed for the first time it typically requires cognitive control on higher levels. The more routine someone has, or the more habitualised a behaviour is, the less cognitive control is needed, and the regulation of the action is supervised by lower control levels. As the main difference between SCT and ART is the timing rather than the level at which cognitive control is exerted, this effect is the same according to both theories. Higher control levels only get involved, if an obstacle occurs and a feedback loop triggers the necessity for adjustments. The difference between ART and SCT in this case is, that a conception of the SCT could potentially already contain a feasible contingency plan, whereas the ART assumes this plan to be made on the spot.

The advantage of the view taken by the SCT is that anticipation and forethought help to have an action plan ready in a situation where adjustment of behaviour is required, however this also requires more a priori cognitive capacity. Because it is not possible to anticipate every possible scenario, ad-hoc planning cannot be avoided altogether, and cognitive strain can result from the stress of not having a contingency ready. The ART is more economical with respect to initial cognitive planning; however, it relies on the ability to immediately and spontaneously come up with adequate plans, which can be time consuming in a stressful situation and therefore potentially lead to inferior results. Both over-planning and under-planning potentially lead to similar cognitive strain in unforeseen situations. Dynamic personalised alternative suggestions can support such situations and overcome inadequate action plans thereby overcoming the stress caused by either issue.

2.1.3.3 Integration of the SCT with the HPC and ART

It has been shown in section 2.1.2.3 how the HPC and ART can be integrated into a combined model of behaviour, which benefits from the strengths of each theory and overcomes some of their individual limitations. In the following it will be discussed how the SCT can be integrated as well, again with the aim of adding further aspects helping to explain behaviour. The four main aspects where the SCT goes beyond the models proposed by the HPC and ART are

- a notion of the environment and its influences on the individual and his/her behaviour,
- the reflectivity of the individual in every aspect of his/her relationship with the environment,
- an understanding of knowledge and learning influencing the self-efficacy,
- and the pro-active anticipation or forethought of multiple pathways or conceptions towards future outcomes.

The limitations of the SCT on the other hand, where the HPC or ART provide more insight and better elaborations, are

- a lack of clarity how the multi-level system of control and the triadic reciprocal model of behaviour integrate,
- no clear definition of demands, which makes the choice of goal seem arbitrary and gives the impression that people are able to choose without restriction other than those imposed by the environmental factors

- and no clear picture how motivational aspects are embedded within the triadic reciprocal model despite the theory's elaboration on motivation and feedback and their influence on affective personal factors

It has already been noted that the multi-level system of control is very similar to the hierarchical-sequential model proposed by the ART (cf. Figure 11), for which it has been shown how it visualises the translation of demands and goals into action-plans (cf. Figure 8). As this translation is primarily understood by the ART as the cognitive process involving personal factors and guiding the behaviour, it is natural to introduce the conceptions of the SCT into this part of the cognitive process as shown in Figure 11.

Therefore, the delineation of the cognitive process as opposed to the visible part of the behaviour and the environment can be integrated into the fused model between the HPC and ART (cf. Figure 9) as depicted in Figure 12.

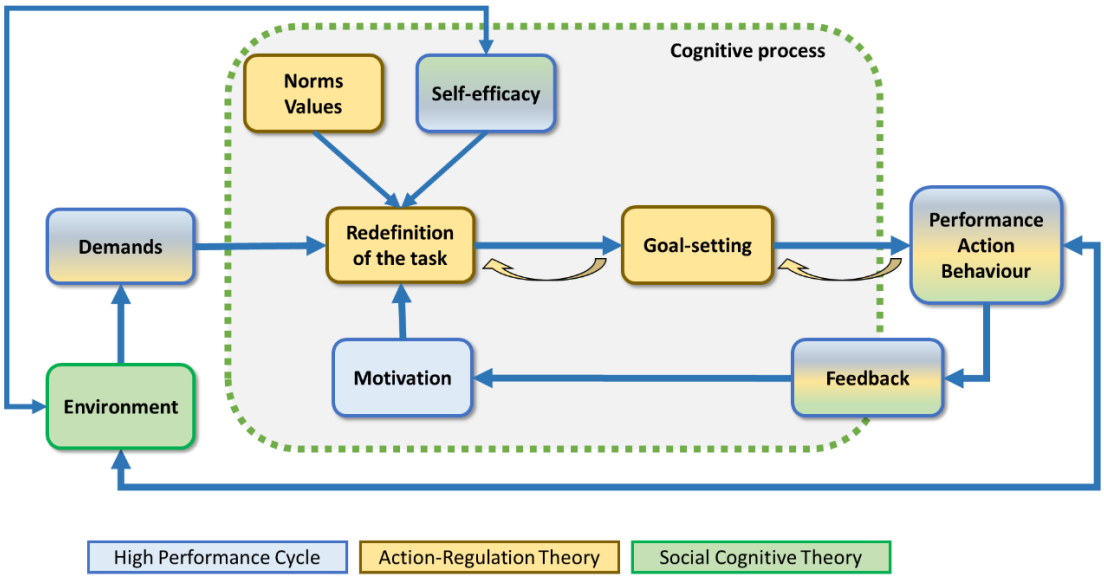


Figure 12 Nested double cycle of behaviour, integrating the SCT with HPC and ART

The main contribution of this fused model including the SCT is the addition of environmental factors outside the cognitive process, which are in a causal reciprocal relationship with the execution of the behaviour as well as with the personal factors, in particular the self-efficacy already present in the original motivational cycle. The view taken implicitly by the SCT is that demands originate as environmental constraints, which can be made explicit by connecting it accordingly to the HPC's concept of demands. The result is a nested double cyclical structure, comprising an outside and an inside cycle. The new outside cycle describes how the environment imposes demands, which are translated into adequate goals and actions, which in turn alter the environment and so on. In case the environment presents an unforeseen obstacle to the action, the reciprocity between the two introduced by the SCT together with the feedback loops of the ART allow for backwards traversal of the inner cycle from the environmental obstacle back to the redefinition of the task and the selection of a suitable alternative. The inside cycle remains unchanged and is concerned with the cognitive motivational process derived from the HPC and ART.

Self-efficacy is present in both the SCT and HPC and can therefore be merged with the understanding that it interacts with the environment, which is not as explicit in the HPC due to its lack of explicit environmental factors within the model.

The SCT includes not only cognitive personal factors such as the self-efficacy, though. Affective factors influencing the behaviour within the cognitive process need to be considered, too. The HPC introduces emotions into its motivational cycle to explain how feedback influences the mood of the acting person and therefore the motivation for future behaviour, which is very similar to the view taken by the SCT so that both concepts can be merged. This is under the reasonable assumption that affective personal factors do not influence the environment directly.

In summary, the nested double cycle of behaviour depicted in Figure 12 outlines a model of the interaction between the cognitive process of behaviour and motivation in relation to external environmental determinants. This brings together the contributions of the SCT with the model of behaviour provided by the HPC and ART and their integration.

2.2 Quantitative Behavioural Theories

2.2.1 Theory of Planned Behaviour

The integrated model developed in the previous section tries to explain how external demands are translated into personalised goals and actions, however it lacks means for quantifying and measuring the influence factors governing this process. It will be shown how the Theory of Planned Behaviour (TPB) (Ajzen, 2006a) can be applied to close this fundamental gap. The approach was developed based on the older theory of reasoned action (Fishbein & Ajzen, 1975) to integrate aspects of behavioural control. The TPB is based on three beliefs linked to behaviour and conjectured to determine the strength of behavioural intention to act: behavioural beliefs, normative beliefs and control beliefs.

Unlike the HPC, ART and SCT discussed before, the TPB does not belong to the motivational approaches but rather to the attitudes and attributional approaches (Fishbein & Ajzen, 1975). Nevertheless, it will be shown how the previously developed nested double cycle will benefit from adding a defined attitude approach and how the TPB in turn can overcome its lack of a motivational and goal-setting concept, which in the previously discussed model are essential for understanding and influencing behaviour.

The TPB emphasises that the individual is seen "…as an essentially rational organism, who uses the information at his disposal to make judgments, from evaluations, and arrive decisions" (Fishbein & Ajzen, 1975). In this sense the TPB is compatible with the HPC, ART and SCT discussed above, which all share a common rational understanding of the individual and his/her interaction with the environment.

2.2.1.1 Definition of concepts

Consistent with the approach taken above, the concepts introduced by the TPB will be defined in the following and analysed with respect to their compatibility with the HPC, ART and SCT.

Attitudes

With the TPB being considered an attitudes and attributional approach the concept of attitude is central to the theory. It is defined in the TPB as "a learned predisposition to respond in a consistently

favourable (or unfavourable) manner with respect to a given object" (Fishbein & Ajzen, 1975). This definition comprises three basic aspects:

- attitude is learned
- it predisposes action
- and such actions are either favourable or unfavourable towards an object.

It has always been the understanding in the social sciences and psychology that human behaviour must be understood in the context of past experiences, which are an important factor in shaping and influencing present behaviour. This influence is explained by attitudes, being the outcome of learning from past experiences (Campell, 1963; Fishbein & Ajzen, 1975) that are carried over into the present and guide the actions of a person. In other words, past experience determines the predisposition to respond consistently towards favourable or unfavourable circumstances.

"Attitude is typically viewed as a latent or underlying variable that is assumed to guide or influence behaviour" (Fishbein & Ajzen, 1975). This predisposition to carry out a specific action or a class of behaviours does not specifically predict behaviour, though, it rather refers to the overall favourability of a behavioural pattern (Fishbein & Ajzen, 1975). Therefore, knowing something about a person's attitudes cannot predict a specific behaviour as such, however a likelihood for a behavioural/non-behavioural response in the presence of the stimulus object (Fishbein & Ajzen, 1975) can potentially be derived from the knowledge of someone's attitudes towards that object and vice versa. In this sense, the individual can be placed on a bipolar affective dimension depending on what actions are perceived as either favourable or unfavourable towards an object with the attitude as the guiding influence where a person stands on this scale. The TPB therefore subsumes concepts like value, attraction or valence under the criteria of this bipolar dimension (Fishbein & Ajzen, 1975).

For example, the attitude of an individual towards concepts like health or sustainability are learned over time depending on the individual's experiences and interactions. In turn, these attitudes influence how a person perceives certain actions, like for instance buying locally sourced or seasonal produce, as either favourable or unfavourable and adapts his/her own grocery shopping behaviour accordingly when possible. Obviously, specific actions cannot be predicted by the understanding of someone's attitudes, however a general tendency to be more likely to show certain behaviours can be derived. Personalised interventions can make use of this knowledge by guiding people towards behaviours they perceive as positive, which makes the assessment of attitudes an important aspect of the design of such measures.

Compatibility with the HPC, ART and SCT

The concept of attitude does not play an explicit role in either the HPC, ART, or the SCT, however the TPB sees values as part of the concept of attitude (Fishbein & Ajzen, 1975), which is a concept that is important in both the HPC and the ART and used very similar to the concept of attitude as defined by the TPB.

The HPC describes the concept of values also as actively learned through experience and motivating the behaviour, which is more or less exactly how the TPB defines the role of attitudes when it comes to their acquisition and impact on the behaviour. According to the HPC, values can be either conscious or subconscious and therefore also can be subject to reflection and actively changed. This

is consistent with the TPB's view of the individual being essentially rational and using the available information to make judgments (Fishbein & Ajzen, 1975).

The ART sees values as controlling and guiding concepts, too, which influence the extend and quality of performance (Hacker, 1986). However, in the ART values are acquired through socialisation and not subject to reflection at the same level as within the HPC. In this sense it is further apart from the TPB with regards to acquiring attitude through experience, however it plays a similar role with regards to influencing the behaviour.

Finally, the SCT sees the reflection of personal and moral standards as basis for behavioural choices, which broadly matches the TPB's view of attitudes as learned predisposition towards a behaviour. Attitudes as defined by the TPB are a broader concept than values on their own (Fishbein & Ajzen, 1975), though, and therefore have the potential to augment a model of behaviour by making the influence on goal choice more operational as will be shown below.

Beliefs

According to the TPB beliefs are a precursor variable to the attitudes. They are the information and the knowledge someone holds about an object, i.e. beliefs connect an object to some attributes. The difference to a person's attitudes is that these describe the evaluation of an object, i.e. if a person perceives it as either favourable or unfavourable (Fishbein & Ajzen, 1975).

Beliefs can be attributions of a person about themselves, other people, institutions or behaviours and are used to explain and make sense out of the world. They are very likely to be used in a causal manner (Fishbein & Ajzen, 1975), for example a person is considered to be married if he/she is wearing a plain gold ring, although this causal relationship is by no means certain. Those causal attributions are essential, because they help to act appropriately in a reasonable timeframe without getting lost in complex cognitive processes. The concept belief can be applied, if subjective assertions relating an object to an attribute and the strength between them can be made. The TPB also subsumes terms like opinion, knowledge or stereotype under the concept of beliefs (Fishbein & Ajzen, 1975), as these relate more to how a belief is acquired rather than how it impacts the behaviour as such.

The sum of someone's beliefs are building the foundation of his/her attitudes, intentions and behaviour. Therefore, if it can be measured and quantified it allows to derive predictions on how a person perceives an action and ultimately how likely it is that that person acts in a certain way. This approach is one of the major contributions the TPB has made, as it enables the development and application of quantitative methods to the field of behavioural modelling.

The TPB distinguishes three types of beliefs (Ajzen, 2006a):

- behavioural beliefs
- normative beliefs
- and control beliefs.

The TPB proposes a specifically structured inventory to assess these beliefs (Ajzen, 2006b) in order to quantify the intention that someone shows towards a certain behaviour, which will be further elaborated below.

The first are **behavioural beliefs,** which are defined as "beliefs about the likely consequences of the behaviour" (Ajzen, 2006a). These beliefs are specific to the result of the actual action and reflect the expectation of the impact the chosen behaviour will have. As such they are responsible for "producing a favourable or unfavourable attitude toward the behaviour in question" (Ajzen, 2006a). For example, a questionnaire asking questions such as if it is important to maintain a healthy diet is assessing the behavioural belief regarding this subject. It assesses how positive or negative the attitude towards that specific behaviour is, which according to the TPB is one of the three influence factors of the intention to act in this regard.

Next, **normative beliefs** are defined as "beliefs about the normative expectations of others" (Ajzen, 2006a). They reflect how the individual thinks others would perceive an action and therefore how they would react to one's behaviour. This notion is sometimes also referred to as "normative feedback" (Bailey & Harper, 2015). Normative beliefs "result in perceived social pressure or subjective norms" (Ajzen, 2006a). By knowing what meaningful others are doing, it is possible to compare behaviour and to feel pressured to act in a specific way in accordance with the expectation. In a questionnaire, normative beliefs can be assessed using questions asking for example how others would feel about maintaining a sustainable diet. According to the TPB this assesses subjective norms as the second important influence factor for the behavioural intention.

Finally, **Control beliefs** are defined as "beliefs about the presence of factors that may facilitate or impede performance of the behaviour" (Ajzen, 2006a). They capture the perceived ability to show a specific behaviour under the given circumstances. In this sense they are very related to the concept of self-efficacy, which is also about the reflection of the own ability in the context of environmental conditions. "Control beliefs give rise to perceived behavioural control" (Ajzen, 2006a), which is the understanding of the individual to what extend his/her behaviour can impact future outcomes. It is the level of control someone is able to exert over his/her environment and what difference the own actions make. To assess control beliefs in a questionnaire, questions like for example if someone thinks it is easy or difficult for him/her to follow a certain specific behaviour, e.g. following a healthy diet, can be used. The TPB conjectures that this assessment of perceived behavioural control is the final third major influence factor determining the behavioural intention. This additional component is the main contribution of the TPB, which distinguishes it from the theory of reasoned action.

Compatibility with the HPC, ART and SCT

Neither of the HPC, ART, nor SCT take explicit note of beliefs as defined in the TPB. Having said that, all three beliefs that are distinguished by the TPB to drive behavioural intention also play some role in the other theories, albeit using different terminology and not giving these concepts the prominence that the TPB does.

The link between the attitudes in the TPB and the values in the HPC, ART and SCT has been discussed before. Behavioural beliefs are seen by the TPB as giving rise to favourable or unfavourable connotation of behaviours and are therefore the cause manifesting themselves in the form of attitudes towards the behaviour in question. Hence, behavioural beliefs can be considered as the measurable equivalent of the TPB with the concept of values presented in the other theories.

The TPB talks about norms as "…beliefs that certain referents think the person should or should not perform the behaviour in question" (Fishbein & Ajzen, 1975). Normative beliefs lead to normative pressure to comply with the required behaviour (Fishbein & Ajzen, 1975). These subjective norms

defined by the TPB can be considered as standards or rules someone feels obliged to observe, which is a concept that is also important in the ART. They are formed through the interaction with other people (Fishbein & Ajzen, 1975), which complies with the ideas presented in all the HPC, ART and SCT.

Similar to the HPC and the ART it is not clear in the context of the TPB either, how much reflection of norms can take place, although it can be assumed that the rational understanding of the individual shared by all three theories implies a certain similar level of reflection. To a certain extend evaluations of the situation, the social pressure and potential outcomes of a certain behaviour can be seen as a reflective approach towards beliefs (Ajzen, 1985). As a consequence, continuous assessment of beliefs can provide an evolving and dynamic picture of the individuals intentions to act, which can be facilitated within dynamic and automated questionnaires for example delivered through mobile phone applications.

Finally, control beliefs as defined in the TPB are very similar to the concept of self-efficacy, which plays a prominent role in the HPC and SCT (Ajzen, 2002). Self-efficacy is essentially "the perception of ability to perform a behaviour under given circumstances" (Ajzen, 2002), which is the same as the TPB's belief that a behaviour can be executed due to the presence of enabling or impeding factors (Ajzen, 2006a). The major difference between the TPB's control beliefs and in particular the SCT's view on self-efficacy is the reflective causal reciprocal relationship between self-efficacy and the environment. However, HPC, SCT and TPB all describe aspects of perceived ability to impact and control the environment taking available context conditions into account in their respective definitions of self-efficacy and control beliefs.

Similarly, the ART is mentioning that actions are regulated by the personal knowledge and experience (Hacker, 2003), although it does not put as much focus on the context conditions as the SCT. Perceived behavioural control also encompasses the need to make tasks as simple as possible and avoid cognitive strain, which is compatible with a tendency for cognitive economy seen as another factor influencing behaviour in the ART (Hacker, 2003).

In the integrated model of behaviour between the HPC, ART and SCT presented above, self-efficacy together with norms and values all influence the redefinition of the task. These three aspects from the HPC, ART and SCT almost correspond one-to-one to the three beliefs defined by the TPB, with the TPB defining inventories for measuring and quantifying such influence factors on the intention to act. Therefore, one of the main benefits that can be derived from the TPB is making a fused model of behaviour operational beyond the qualitative capabilities of the models provided by the HPC, ART and SCT.

Behaviour

The TPB talks about behaviour as the actions someone is carrying out with respect to a given object influencing the environment and changing the circumstances and personal beliefs (Ajzen, 1985). Time and opportunity determine behaviour (Ajzen, 1985), i.e. the actions of an individual depend on the possibility that a desired outcome can be achieved. Ability, skills and information are crucial when it comes to perform a behaviour and control over those aspects is required (Ajzen, 1985). In other words, actions need to be carried out at the right time, in the right place, using the right information.

According to the TPB behaviour is volitional, goal-directed and organised alongside well-built plans (Ajzen, 1985), although volitional behaviour can fail in the presence of strong emotions, stress or compulsions (Ajzen, 1985) in which case a lesser degree of control or goal-orientation can be expected. Behaviour can be either conscious or subconscious, with habitualised patterns not requiring cognitive attention until interrupted, at which point conscious action planning is needed again (Ajzen, 1985). Such interruptions in the intention-behaviour relation can lead to a change in information and beliefs and therefore to a change in the behaviour (Ajzen, 1985).

Behaviour constitutes the visible and externally observable endpoint of a cognitive process (Fishbein & Ajzen, 1975), which comprises attitudes towards the behaviour, subjective norms and perceived behavioural control, which in turn are ultimately guided by the three underlying parameters behavioural beliefs, normative beliefs and control beliefs (Fishbein & Ajzen, 1975). The premise of the TPB is that these beliefs acquired in the past, and that are quantifiable through adequate inventories, ultimately determine how specific potential behaviours are appraised and therefore how behavioural choices are made.

Hence, to change a behaviour the underlying beliefs need to be changed or amplified, as these are the predominant influence factors affecting the intention to act. The TPB conjectures that "other more distal factors, such as demographic characteristics or personality traits, are assumed to have no direct effects on behaviour" (Ajzen, 1985) and therefore neither need to be assessed nor addressed directly to evaluate or influence someone's behaviour.

According to the TPB, personalised interventions aiming at evaluating and influencing behaviour therefore first and foremost need to take behavioural beliefs, normative beliefs and control beliefs as predominant precursor variables into account when shaping the messages given to an individual. For instance, a person's behaviour to behave more sustainable can be reinforced by addressing the beliefs most relevant to the individual with regards to this subject. If a person holds strong normative beliefs, then a message involving the opinion of relevant role models on the subject is expected to yield a strong effect, whereas a person motivated predominantly by behavioural beliefs will adapt his/her behaviour based mainly on new information. Control beliefs can be addressed by messages that reinforce control over the environment. For example, a person with strong normative beliefs will likely respond to messages on the sustainable behaviour of groups he/she feels connected to, whereas someone with strong behavioural beliefs will react to messages on environmental impact. In summary, personalised interventions need to address the relevant aspects for the individual in order effectively address behavioural change.

Compatibility with the HPC, ART and SCT

The TPB focuses on beliefs and intentions trying to quantify the likelihood that a behaviour in question is being executed based on these precursor variables. It postulates that beliefs are ultimately driving a person's behavioural decisions, which is much less obvious in any of the other three theories, although concepts like self-efficacy, norms and values play a similar role in the HPC, ART and SCT. The fact that past behaviour influences beliefs in the TPB is very similar to the idea of acquired knowledge and experience in the SCT and ART. It also relates to the self-efficacy concept present in the SCT and HPC, which elaborates on how the appraisal of own abilities and circumstances plays a significant role in choosing behaviours.

The focus of the HPC is on the motivational process and how motivation is influencing performance and vice versa, while the TPB does not elaborate on motivation at all. In this sense the TPB is more concerned with the immediate pre-cursors to behaviour whereas the HPC looks at the medium- and long-term evolution, which is covered in the TPB through the notion that beliefs can evolve over time.

The ART looks at the action-regulation that happens during the execution of complex action plans. The TPB also finds that behaviour is volitional, goal-directed and that action-plans need to be built (Ajzen, 1985), however it is missing a concrete concept of how the translation of goals into actions is achieved, which is unique to the ART. However, while not being as explicit as in the ART, the TPB also notes that interruptions in the intention-behaviour relation result in changes in the behaviour due to change in available information and beliefs (Ajzen, 1985).

While the TPB sees beliefs as the dominant pre-cursor variable to behaviour, the SCT argues that knowledge is what mainly influences which behaviour is executed. It can be argued that beliefs constitute a form of knowledge, in particular as the TPB also states that past experiences shape these beliefs. Vice versa the SCT finds that "expectations, beliefs, self-perceptions, goals and intentions give shape and direction to behaviour" (Bandura, 1989), while behaviour exerts influence back on thought patterns and emotional reactions (Bandura, 1989). In this sense, regardless if it is called knowledge as in the SCT or beliefs as in the TPB, both state that behaviour is guided by pre-cursor variables that are learned from previous experience. Both the SCT and the TPB agree that specific experience and what is learned from it plays a dominant role in shaping the behaviour and that general variables such as demographics have no direct influence.

Therefore, all four theories take a slightly different perspective on behaviour/performance/action, although all are describing a very similar concept in the end. In conclusion, the four theories complement each other with different aspects that all influence the behaviour and its development over time.

Behavioural intention

One of the main contributions of the TPB is to provide a means to determine the likelihood that a certain behaviour towards an object is shown by an individual. This likelihood is captured in the behavioural intention, which is the "subjective probability of a person to perform the behaviour in question in respect to a given object" (Fishbein & Ajzen, 1975).

Intention is the condition shortly before showing a behaviour in question (Ajzen, 2006a) and all actions are controlled by intentions. Its strength is determined by the attitude toward the behaviour, subjective norms, and the perception of behavioural control according to the TPB. "The more favourable the attitude and subjective norm and the greater the perceived control, the stronger the person's intention to perform the behaviour should be" (Ajzen, 2006a). For example, the more important health and sustainability is to an individual personally, i.e. the more favourable his/her attitude towards the subject is, the more the person is conscious of his/her social context appreciating healthy and sustainable behaviour, i.e. the more driven by subjective norms the person is, and the more able the person feels to follow a healthy and sustainable diet, i.e. the higher his/her control beliefs are, the more likely it is that he/she follows through with healthy and sustainable behaviour. A dynamic personalised intervention can address all three of these precursor variables in order to increase its likelihood of success.

The TPB introduces the notion of a behaviour-goal unit, where "every intended behaviour is a goal". Intentions constitute the plan of actions linking the goal with the immediate execution of actions. Behavioural intentions are therefore the TPB's equivalent of action plans, which are the representation of the person's conscious and volitional decisions to execute a behaviour in question. As a consequence, intentions can only properly be assessed when the behaviour in question is volitional (Ajzen, 1985) and connected to concrete actions. Such action-plans, and therefore the behavioural intention linked to them, need to be distinguished from the more general tendency to execute a behaviour, which would be better captured by a concept of motivation, although the TPB itself does not distinguish between long-term motivations and short-term intentions (Ajzen, 1985).

Also, the context plays a crucial role for behavioural intentions. Only when the opportunity arises people will be able to follow their intentions. This means that not all intentions will be executed, intentions may be abandoned or revised to be changed depending on the circumstances (Ajzen, 1985). Abilities and knowledge play a major part in this, as the volitional control over a behaviour depends strongly on the information held about the situation and the reflection of the same. The ability and experience to handle unforeseen obstacles or "…perform different behaviours in a variety of settings" (Ajzen, 1985) allows for the dynamic adaption of action plans in reaction to the circumstances. Such interruptions in the intention-behaviour relation can lead to a change in information and beliefs and therefore to a change in behaviour and intentions (Ajzen, 1985).

The TPB also recognises that emotions can influence behaviour in a non-volitional way (Ajzen, 1985). Emotions "…can serve as background factors that influence behavioural, normative and/or control beliefs. Thus, it is well known that general moods can have systematic effects on belief strength and evaluations" (Ajzen, 2011). Emotions are both the result of behaviour as well as influencing future intentions through their effect on underlying beliefs.

A behavioural intention does not necessarily lead to the desired behaviour (Mairesse, Macharis, Lebeau, & Turcksin, 2012), though. This phenomenon is quite common and referred to as the intention-action/behaviour gap, attitude-behaviour gap, or knowing-doing gap (Ajzen, 2016; Grunert, 2011; Hoek, Pearson, James, Lawrence, & Friel, 2017; de Schutter, 2015; Bailey & Harper, 2015). For example, in the area of sustainability it is well-known that the actual behaviour shown by people does often not match their good intentions (Mairesse, Macharis, Lebeau, & Turcksin, 2012).

Compatibility with the HPC, ART and SCT

The concept of intention is central to the TPB postulating a behaviour-goal unit, which is linked by the behavioural intention. Every intended behaviour is to a certain extend also a goal and therefore all behaviour is goal-directed (Ajzen, 1985) according to the TPB. The HPC has a very similar notion of intention, describing it as the determination of a person to carry out a specific action (Locke & Henne, 1986). While the intention is seen as the immediate determinant of the behaviour, the HPC also introduces the additional concept of motivation, which describes the more general tendency to act on certain goals. The TPB does not make this distinction between motivation and intention, it rather states that a general tendency can be derived from the attitude towards a behaviour, which ultimately has the same effect because similar to the motivation in the HPC the attitude is learned and adapted over time.

In contrast to the TPB, the ART takes a very detailed look into the cognitive process that leads from goals to actual behaviour using its hierarchical-sequential model of action regulation. Although it

does not use the term intention to describe the goal-setting process, the pathways within the tree-like structure of the model representing the selection of appropriate sub-goals and actions can be seen in analogy to the behaviour-goal unit of the TPB. This is consistent with the TPB also seeing intention as a part of goal-derived action plans; however, these are far less elaborated in the TPB (Ajzen, 1985) in comparison to the ART. For this reason, the feedback loops introduced by the ART are not explicitly modelled in the TPB, however it implicitly relies on the influence of actions on a person to achieve a similar effect: performance of a particular behaviour may lead to new beliefs towards a particular object (Fishbein & Ajzen, 1975) after anticipating and evaluating the consequences of the desired behaviour (Fishbein & Ajzen, 1975; Ajzen, 1985). Such information obtained as feedback during the execution of behaviour then is expected to lead to adjustments of the intention, taking further aspects such as knowledge, ability, circumstances and social context (Ajzen, 1985) into account. “When new information becomes available after a person has stated his intention, the new information may affect his salient beliefs about the behaviour and thus lead to changes in attitudes, subjective norms, and intentions: at the end of this process the person is no longer interested in carrying out his original intention” (Ajzen, 1985).

Similar to the TPB the SCT does not distinguish between motivation and intention, either. According to the SCT motivation is caused by the anticipation of future desired outcomes, where these outcomes are evaluated against standards and values to see if they are favourable or not. This is very similar to the TPB’s notions of behavioural and normative beliefs, which also provide the means to evaluate behaviour and therefore influence intention accordingly. Motivation is affected by the proximity of goals according to the SCT (Bandura, 1999), which is matched in the TPB by stating that intention is the condition shortly before showing a behaviour in question (Ajzen, 2006a).

The SCT focuses on learning and gaining new information to influence knowledge, which is used to adjust the behaviour towards a desired goal. This is also found in the TPB, which states that information is influencing the belief system and thereby the intention to act.

All four theories consider knowledge and circumstances as influencing behavioural intentions. Behaviour is seen as conscious and volitional process, which allows to create and adjust action plans in response to anticipated and evolving circumstance. Behaviour changes the environment, which in turn reflects back on the individual and his/her intentions.

The main contribution of the TPB is its inventories for measuring and quantifying behavioural intention as result of underlying beliefs. This goes beyond the qualitative models proposed in the HPC, ART and SCT, enabling to quantify the strength of a behavioural intention towards a given object.

2.2.1.2 Operationalisation of the model

A graphical representation of the TPB has been proposed by Ajzen (Ajzen, 2006c). It is depicted in Figure 13 showing how the concepts introduced in the previous section fit together and what variables interact with each other to explain behaviour towards a given object. The figure shows a flow of information from the left to the right, starting from a beliefs layer, via an aggregated internal representation layer culminating into the behavioural intention which ultimately results in the behaviour in question.

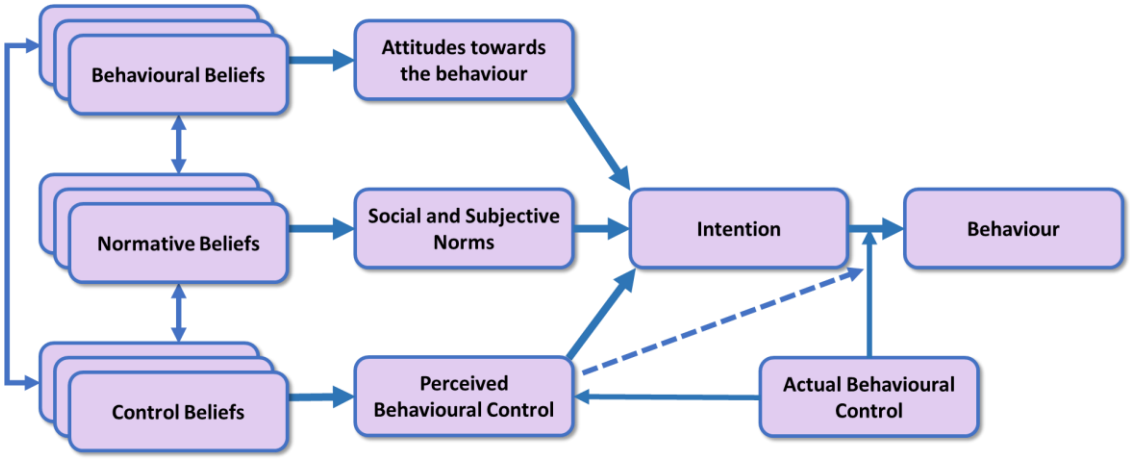


Figure 13 The Theory of Planned Behaviour (Ajzen, 2006a)

At the core of every behaviour are the three types of beliefs a person holds towards the behaviour in question according to the TPB: behavioural beliefs, normative beliefs and control beliefs. Beliefs can be accessed via specifically designed questions and constitute the input to the model.

The second layer of the model comprises internal representations of these three types of beliefs, each aggregating the questions asked for each category. "Behavioural beliefs produce a favourable or unfavourable attitude towards the behaviour" (Ajzen, 2006a); therefore, they are aggregated into an internal variable representing the same. The next category are the normative beliefs, which result in "perceived social pressure or subjective norms" (Ajzen, 2006a) and are aggregated accordingly in the corresponding internal variable within the model. Finally, control beliefs lead to perceived behavioural control and, again, are aggregated into a third internal variable.

"In combination, attitude toward the behaviour, subjective norm, and perceived of behavioural control lead to the formation of a behavioural intention" (Ajzen, 2006a). The TPB conjectures that "…the more favourable the attitude and subjective norm, and the greater the perceived control, the stronger should be the person's intention to perform the behaviour in question" (Ajzen, 2006a). Therefore, all these three internal variables are combined into the third layer, ultimately forming the behavioural intention in the model, which is an indicator for the likelihood that a behaviour in question will be shown by an individual.

This information flow, from questionnaire to the target quantity of behavioural intention, is made operational by proposing a linear relation between the quantities (Ajzen, 2006c; Ajzen, 1991). According to the TPB, the behavioural intention is therefore calculated as a weighted sum:

$$BI = w_A A + w_{SN} SN + w_{PBC} PBC$$

of the attitude toward the behaviour A, the subjective norms SN and the perceived behavioural control PBC (Ajzen, 2006a). The respective weight factors w_A, w_{SN} and w_{PBC} can either be determined from large enough datasets or set to reflect the assumption of the relative importance between the three variables. In the absence of a-priori assumptions all weight factors can be set to 1. The other constituent parts A, SN and PBC are calculated from the answers of accordingly designed questionnaires as follows (see appendix B for examples):

First, the attitude towards the behaviour is calculated as weighted sum of the numerical answers to the questions relating to behavioural beliefs:

$$A = \sum_{i=1}^{n_A} w_i^{BB} e_i^{BB}$$

using the strength of each belief as weight factor w_i^{BB} and the corresponding answer from the questionnaire e_i^{BB} (Ajzen, 2006a). The weight factors w_i^{BB} can be used to weigh the relative importance of each question within the questionnaire if required, or to include reversed questions by setting it to a negative value. In the absence of a-priori assumptions on individual questions the weight factor can be set to ± 1.The evaluations e_i^{BB} are chosen to represent the strength of a behavioural belief, using a 5-point Likert scale in the questionnaire.

The subjective norm is calculated very similar as:

$$SN = \sum_{i=1}^{n_{SN}} w_i^{NB} e_i^{NB}$$

using the strength of each normative belief as weight factor w_i^{NB} and the corresponding answer from the questionnaire e_i^{NB} (Ajzen, 2006a), again determined on a 5-point Likert scale. Reversed questions can be included using negative w_i^{NB}.

Finally, the perceived behavioural control is calculated as:

$$PBC = \sum_{i=1}^{n_{PBC}} w_i^{CB} e_i^{CB}$$

using the strength of each control belief as weight factor w_i^{CB} and the corresponding answers in the questionnaire e_i^{CB} (Ajzen, 2006a), again obtained on 5-point Likert scales. As before, the relative strength and direction of the questions can be controlled using the weight factors w_i^{CB}.

In summary, the TPB proposed an operationalisation of the model, allowing to calculate the behavioural intention BI as indicator for the likelihood of a behaviour being shown depending on the evaluation of a questionnaire comprising behavioural beliefs e_i^{BB}, normative beliefs e_i^{NB} and control beliefs e_i^{CB}. This approach will be used to conduct the studies presented in section 3.2 below.

2.2.1.3 Integration of the TPB with the HPC, ART and SCT

The TPB enables the operationalisation of the relation between measurable beliefs and the behavioural intention to act on a goal. The qualitative models of the HPC, ART and SCT lack this ability, however they provide a much more elaborate view on other factors influencing the behaviour. In particular, the TPB lacks a cognitive model for how precisely goals are chosen and translated into action-plans and behaviour. According to the nested double cycle of behaviour proposed in section 2.1.3.3 (cf. Figure 12) the redefinition of the task is influenced by self-efficacy, norms and values. In the TPB, as discussed in section 2.2.1, the pre-cursor variables of the

behavioural intention (cf. Figure 13) relate to these three concepts and can therefore be partially substituted as depicted in Figure 14.

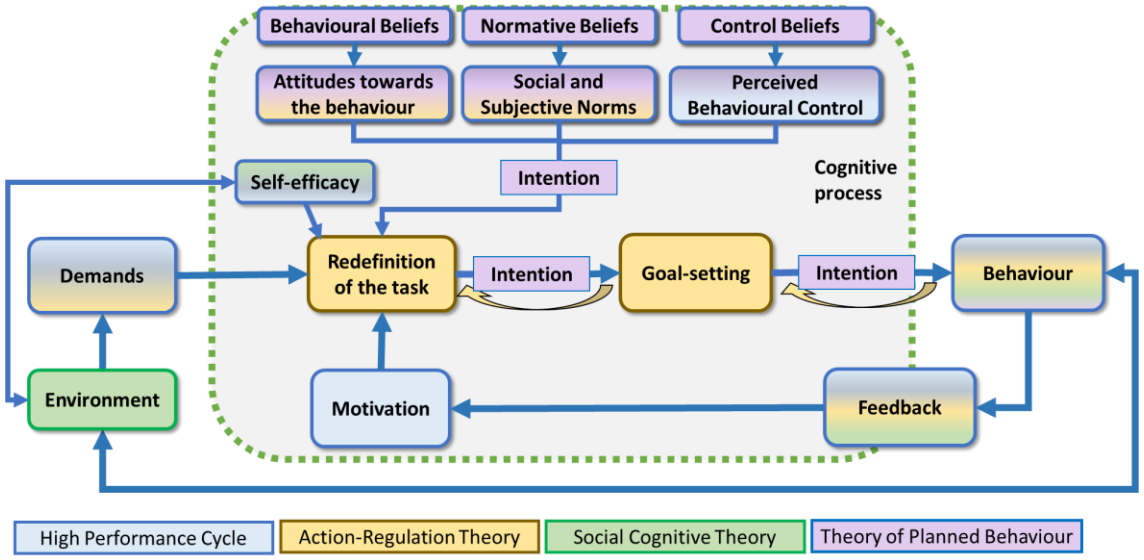


Figure 14 Nested double cycle of behaviour with quantifiable intention, integrating the TPB with HPC, ART and SCT

Values as defined by the ART are matched with the TPB's attitudes towards the behaviour. Similarly, norms influencing the redefinition of the task according to the ART are matched to the TPB's concept of subjective norms. Both can therefore be substituted by the better quantifiable variables of attitudes towards the behaviour and subjective norms provided by the TPB.

The TPB's perceived behavioural control matches the moderating influence of self-efficacy defined in the HPC. The influence of the environment on the self-efficacy outlined in the HPC as well, and the reflective aspects of self-efficacy, postulated in the reciprocal causal relationship with the environment by the SCT, are not captured by the TPB's perceived behavioural control to such an extent, though. Therefore, self-efficacy remains an explicit influence factor in its own right in the model proposed in Figure 14, with its measurable aspects being moved into the perceived behavioural control variable provided by the TPB.

The three variables attitudes towards the behaviour, subjective norms and perceived behavioural control are accumulated into the behavioural intention according to the TPB. This quantity influences the goal choice in the redefinition of task, with goals corresponding to higher behavioural intention more likely to be chosen.

In the integrated model proposed here, behavioural intention is carried through the cognitive process of redefinition of the task and goal-setting, with the hierarchical-sequential model introduced by the ART and its visualisation of concrete action plans expected to increase the final intention to act immediately before the actions are carried out.

Finally, the TPB also lists actual behavioural control as one of the factors influencing both the perceived behavioural control as well as the final behaviour. This maps onto the SCT's triadic reciprocal relationship between environment, self-efficacy and behaviour. This is already covered by the model and therefore the actual behavioural control of the TPB is omitted going forward in favour of the more elaborate model provided by the SCT.

In summary, the model proposed in Figure 14 augments the nested double cycle of behaviour depicted in Figure 12 with quantifiable behavioural intentions, being the likelihood that a behaviour in question is carried out. This brings together the qualitative models reviewed in section 2.1 with the quantitative model of behaviour proposed by the TPB and its operationalizable inventories for measuring the intention to act.

2.2.2 Self-Determination Theory[1]

In the previous section an integrated model of behaviour was developed that combines the qualitative models of behaviour HPC, ART and SCT with the TPB to quantify the behavioural intention to act based on belief centred inventories. While behavioural intention is a good indicator for the condition shortly before the behaviour, other motivational factors also have an influence on behaviour, in particular in the way feedback is processed by the individual. This is already hinted at by the HPC, however it is missing a quantifiable entity to measure this effect.

To overcome this shortcoming the Self-Determination Theory (SDT) provides an approach that describes motivation in terms of a continuum of self-determination. This variable captures the individual's autonomy towards an object, i.e. if he/she is motivated intrinsically or extrinsically to carry out tasks relating to a subject matter.

The SDT is characterised as an "empirically based theory of human motivation, development, and wellness" (Deci & Ryan, 2008a) by its authors. It distinguishes three basic psychological needs: autonomy, competence, and relatedness, which can be supported or hindered by the surrounding and social environment leading to a certain type of motivation with a certain strength. To predict the outcome of a behaviour the SDT includes aspects like autonomous motivation, controlled motivation, and amotivation as well as looking at intrinsic and extrinsic motivation in relation to goals (Blanke, Beder, & Klepal, 2017c).

The SDT is both a content as well as a process-oriented approach. Autonomy, competence and relatedness show clear contend orientation, while the self-determination continuum, which will be detailed below, shows strong similarities to process oriented approaches.

The SDT provides a broad framework to quantitively evaluate human motivation, describing itself as an "organismic dialectical approach" (Ryan & Deci, 2021), meaning that people are seen as pro-active, curious and growth oriented. Further to that, the SDT describes the constant dialectic interaction between the individual and his/her social environment, which leads to changes in the individual. This is very similar to the behavioural theories discussed previously, therefore integrability can be expected.

2.2.2.1 Definition of concepts

Before going into the details of the model proposed by the SDT, the use and definition of concepts in the theory will be outlined and compared with the HPC, ART, SCT and TPB to validate their compatibility.

[1] A shorter version of the integration of the SDT with the HPC, ART, SCT and TPB has been published in *Buildings* under the title "*An Integrated Behavioural Model towards Evaluating and Influencing Energy Behaviour—The Role of Motivation in Behaviour Demand Response*" (Blanke, Beder, & Klepal, 2017a)

Needs

Competence, autonomy and relatedness are the three key inborn needs yielding enhanced self-motivation according to the SDT (Ryan & Deci, 2000). If they are satisfied, well-being and proper functioning will occur, if thwarted, ill-being will be the consequence (Deci & Ryan, 2008a). Needs are universal and do not differ by culture, only the way how they are satisfied may differ according to the SDT (Deci & Ryan, 2008b)

The SDT states that basic needs are an energizing state (Ryan & Deci, 2000), which can lead to intrinsic motivation and behavioural self-regulation (Ryan & Deci, 2000). For example, the ability to build adequate action-plans has the potential to satisfy the need for competence. It also is expected to increase the level of autonomy, assuming that in this case tasks are not imposed unnecessarily on the individual. Finally, relatedness focuses on a supporting social environment or important reference groups, which appreciate the efforts to behave in a certain way. If all these three needs are met, an increase in intrinsic motivation can be expected according to the SDT (Ryan & Deci, 2021).

Compatibility with the HPC, ART, SCT and TPB

Needs are a fundamental concept in the SDT. Except for the HPC, none of the previously discussed theories emphasise this notion. The HPC agrees with the SDT in that it sees needs as inborn and as being the “fundamental motivational concept” (Locke & Henne, 1986), however it does not focus on the three needs of competence, autonomy and relatedness and rather sees needs in a broader scope (Locke & Henne, 1986).

The HPC asks at which individual threshold someone starts to act and how, whereas the SDT does not assume any such threshold (Deci & Ryan, 2008b). Instead it focuses on need satisfaction, whether a need can be fulfilled or is thwarted and how this impact the self-motivation (Ryan & Deci, 2000).

Values and norms

Values are built through internalisation and integration particularly during childhood socialisation according to the SDT. Internalisation is the notion that a value is acquired without reflection, whereas integration refers to the active process of transforming a general value into a personal value (Ryan & Deci, 2000). Awareness, which is how the SDT calls this reflective capability of the individual, is crucial for this transformation and integration of values (Deci & Ryan, 2008b; Deci & Ryan, 2008a; Ryan & Deci, 2000). Internalisation and integration are not just relevant during childhood socialisation, but also influence the regulation of behaviour across the life span of a person (Ryan & Deci, 2000).

Although the SDT does not contain a definition of norms, it talks about culturally endorsed values and behaviours, which lead to the potential expression of the key needs competence, autonomy and relatedness within a society. This expression of needs can differ depending on cultures holding different values (Ryan & Deci, 2000). On the other end of the spectrum, the SDT also describes controlled circumstances, which lead to a person having little autonomy and feeling pressured and controlled to act according to such norms and standards.

Compatibility with the HPC, ART, SCT and TPB

The SDT is very similar to the SCT in its focus on how values are reflected by the individual before being integrated into one's belief system. This reflection, called awareness in the SDT, is not present in the ART, while the TPB and HPC mention that values can be conscious or subconscious and are open for reflection if required. All five theories agree that values are acquired through socialisation and interaction with the environment.

Although norms are not explicitly defined by the SDT, its notion of controlled circumstances is similar to the TPB's normative beliefs, albeit only in a negative context of reducing autonomy and therefore motivation. Extrinsically motivated behaviour can be influenced by important others, who are serving as orientation for the behaviour (Ryan & Deci, 2000), which conceptually matches the TPB's normative beliefs as well. The SCT calls this mechanism social referential comparison, which is when a person compares him/herself to particular others to build standard norms (Bandura, 1991a).

Motivation

The major contribution of the SDT is the introduction of quantifiable descriptors for motivation. Like the HPC and the ART the SDT defines motivation via the three aspects of direction, effort and persistence (Ryan & Deci, 2000). Although being used synonymously in the SDT and SCT, motivation should not be confused with the behavioural intention outlined before in the context of the TPB, which is defined in there as the intention or the subjective probability of a person to perform a behaviour in respect to a given object (Fishbein & Ajzen, 1975). Motivation should be seen as a general tendency, while intention is the condition shortly before showing a behaviour in question (Ajzen, 2006a).

According to the SDT "motivation produces" (Ryan & Deci, 2000), meaning that motivation is an activating and goal-oriented process influencing the process of self-motivation and self-regulation. Beside the inborn needs, which are the basis for self-motivation (Ryan & Deci, 2000), the SDT also points out the importance of the social context, which can have a big influence to facilitate or inhibit motivation. While people show a similar desire to satisfy their basic needs, personality has an influence on how people behave towards their surrounding and reflects on their underlying motivation (Ryan & Deci, 2000). Different people may behave differently in the same social context, while the same person can act quite differently to different social contexts (Ryan & Deci, 2000).

The SDT sees the type of motivation on a scale of self-determination ranging from intrinsic motivation via extrinsic motivation to the extreme of amotivation related to the type of regulation (see Figure 15). The SDT tries to keep track of which kind of motivation is exhibited at any time considering that these forces are causing a person to act (Ryan & Deci, 2000).

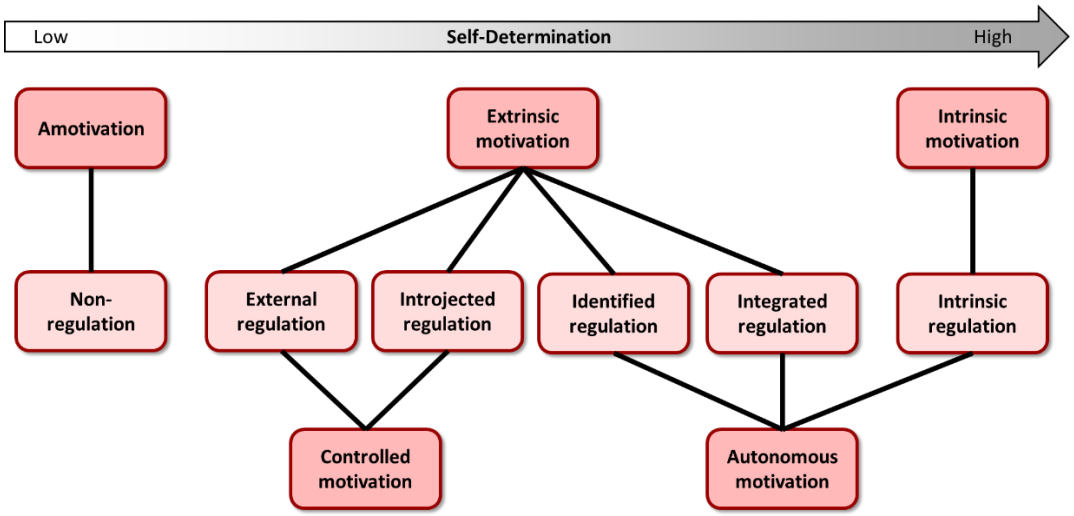


Figure 15 Self-determination scale of motivational type (Ryan & Deci, 2000)

Intrinsic motivation is seen as something naturally given and inherent to a person. It describes an open and active mind, which is always seeking for stimulations and new input. "Intrinsic motivation is motivation based on the satisfactions of behaving for its own sake" (Ryan & Deci, 2021), and is based on interest, enjoyment and inherent satisfaction. Internal motivation contrasts with being externally pressured; this observation is used to categorise the environment and reflect on other's and one's own behaviour in a social context. The SDT is not looking for the causes of intrinsic motivation, but instead examines the conditions in which it is shown and tries to find variables, which sustain and enhance intrinsic motivation versus diminishing it (Ryan & Deci, 2000).

Extrinsic motivation is organised on a continuum of internalisation of goals and activities ranging from external regulation, introjection, and identification to integration. "Extrinsic motivation is behaviour that is instrumental – that aims toward outcomes extrinsic to the behaviour itself" (Ryan & Deci, 2021). The more internalised the motivation or goal, the more autonomous a person will act. Like for the intrinsic motivation, the social context plays an essential role when it comes to supporting or hindering internalisation of values, goals or belief systems (Ryan & Deci, 2000). External regulation is driven by external rewards, avoiding punishment and the need to comply with rules. Introjected regulation shows more self-control and can also be driven by internal rewards. Identified regulation is characterised by goals having a personal importance and are valued, while for the integrated regulation goals are already adopted as being personal.

Both external and introjected regulation are based on avoiding punishment or shame or to receive an external reward (Deci & Ryan, 2008a) and are therefore sometimes considered together as **controlled motivation** in the SDT. Similarly, identified, integrated and intrinsic regulation are sometimes combined into **autonomous motivation** "in which people have identified with an activity's value and ideally will have integrated it into their sense of self. When people are autonomously motivated, they experience volitional, or a self-endorsement of their action" (Deci & Ryan, 2008a). The SDT conjectures that autonomous motivation leads to greater psychological health and well-being (Deci & Ryan, 2008a).

The absence of self-determination leads to **amotivation** according to the SDT. Amotivation is characterized by anxiety concerning competence (Ryan & Deci, 2000) and can be the result of lack of

value attributed to an activity (Ryan R. M., 1995), a lack of competence and control or a negative expectation to achieve a desired outcome (Seligman, 1975). "In contrast to motivation, amotivation reflects the lack of intention to act" (Deci & Ryan, 2008b). Therefore, in the SDT the term intention is used for all types of autonomous and controlled motivation (Deci & Ryan, 2008b). Note, that this is not consistent with the definition of the TPB and a distinction between motivation and intention based on the immediacy with regards to the action will be made in this work.

Compatibility with the HPC, ART, SCT and TPB

The HPC defines direction, effort and persistence as main constituents of motivation. All three can also be found in the SDT. The distinction of motivation into intrinsic, extrinsic, autonomous and controlled is not made explicit in either of the other theories, though. However, external rewards and incentives like salary and feedback can be considered as a form of extrinsic motivation and are described as part of the HPC and ART.

In contrast to the HPC, which also postulates an increase in motivation when negative feedback is given (Matsui, Okada, & Inoshita, 1983; Locke & Latham, 1990a), the SDT states that negative feedback does not enhance motivation but thwarts the need for competence instead (Deci & Ryan, 2008b). However, the SDT and HPC agree with regards to the influence of the social environment, which can influence motivation in either a positive or negative way (Ryan & Deci, 2000; Kleinbeck, 1996).

According to the SDT, autonomy is the main driver for motivation. Autonomy as a concept is very related to self-efficacy found in the SCT and HPC and also by proxy in the TPB's control beliefs. All these aspects autonomy, control beliefs and self-efficacy are based on the perception and evaluation of the environment by the individual if a certain behaviour is possible to execute or not. The autonomy someone has, to choose his/her own goals is also one of the motivational drivers postulated by the ART (Hacker, 2003).

The SCT's notion of imposed, selected and constructed environment (Bandura, 1999) can be seen to correspond to the continuum of self-determination proposed by the SDT, with controlled behaviour relating to the imposed environment and autonomous behaviour matching the selection and construction of environments.

Knowledge and acquiring new knowledge regarding a certain action or actions can increase motivation according to the ART (Hacker, 2005). This is matched by the SDT and its view on competence as basic need that needs to be satisfied in order to generate motivation.

As mentioned before, intention is used in the SDT for all regulated motivational types except the non-regulated amotivation. Because the behavioural intention introduced by the TPB has a different meaning, the use of the term as in the SDT will not be applied in this work. Instead, motivation is seen as the general tendency to act whereas intention is used in the way defined by the TPB as the condition shortly before showing a behaviour in question (Ajzen, 2006a).

Behaviour

The SDT uses the term behaviour almost synonymous to motivation and sees behaviour as a vehicle to satisfy needs (Ryan & Deci, 2000) influenced by the dialectic relationship between individuum the social context and environmental factors, experience and development (Ryan & Deci, 2000).

Behaviour is regulated by its direction, energy and persistence (Ryan & Deci, 2000), in particularly autonomous and intrinsically motivated behaviour is postulated to predict persistence and adherence. For example, someone who is deeply interested in healthy or sustainable groceries can be expected to put more effort into this and will try longer to reach these goals than someone who for instance got advice from a GP to eat healthier or feels pressured through the media to behave more sustainable.

The reasons to act can vary widely depending on experience and anticipated consequences and knowledge based on past behaviour influence motivation and therefor future behaviour (Ryan & Deci, 2000). Motivation plays a crucial role when it comes to behaviour, which could either be executed because the activity is valued, i.e. the motivation is intrinsic, or because of external coercion, i.e. the motivation is extrinsic (Deci & Ryan, 2008b). This division into these two categories helps people to make sense out of their own and other people's behaviour in social situations (Ryan & Deci, 2000).

The SDT states that people who are intrinsically motivated show better performance compared to those who are extrinsically motivated (Deci & Ryan, 1991; Ryan & Deci, 2000; Deci & Ryan, 2008b) and that behaviour based on intrinsic motivation has a significant influence on cognitive and social development (Ryan & Deci, 2000). Feelings of autonomy, competence and self-determination during action improve intrinsic motivation, which on the other hand improves the behaviour itself (Ryan & Deci, 2000). Intrinsically motivated behaviour is seen as autonomous and volitional (Deci & Ryan, 2008b; Deci & Ryan, 2008a), whereas extrinsically motivated behaviour is controlled, lacks autonomy and is based on the gain of external rewards or to avoid punishment (Deci & Ryan, 2008a). "When people are controlled, they experience pressure to think, feel, or behave in particular ways" (Deci & Ryan, 2008b), which reduces motivation and performance according to the SDT.

Motivation for a behaviour can range from amotivation or unwillingness, to passive compliance, to active commitment (Ryan & Deci, 2021), reflecting differing degrees to which the regulation of the behaviour has been internalised and integrated (Ryan & Deci, 2000). The stronger the internalisation and integration the stronger the commitment towards the behaviour and vice versa.

"Behaviours that are the least autonomous are referred to as externally regulated" (Ryan & Deci, 2000) followed by introjected, identified, and integrated regulation of behaviour in accordance with the definition laid out in the context of motivation (cf. Figure 15). The latter describe the increasing degree of conscious valuing of behavioural goals and the acceptance of the behaviour as personally important (Ryan & Deci, 2000; Deci & Ryan, 2008b). However, all these are still considered extrinsically motivated behaviours, unless the behaviour is executed out of pure enjoyment (Deci & Ryan, 2008b) and can therefore be considered intrinsically motivated.

Compatibility with the HPC, ART, SCT and TPB

The SDT does not distinguish between the terms motivation and behaviour. For that reason, it does not contain notions such as action-plans or any elaborate model like the hierarchical concept of behaviour outlined in the ART or SCT and focuses on the motivational drivers of behaviour instead. Behaviour itself is seen as conscious in the HPC, ART, SCT and TPB, which is not explicitly part of the SDT either, however it can be derived from the concepts of awareness and mindfulness used in the SDT (Deci & Ryan, 2008a). Similarities with the SDT can be found in the dialectic interaction between

the individuum and the environment, which also includes a social meaning of behaviour within the environment in the SDT.

The SDT's understanding of motivation and therefore behaviour is different to the HPC, ART, SCT and TPB, which all see behaviour as the execution of intentions following a cognitive process, whereas the SDT sees behaviour as a vehicle to satisfy innate needs via the different motivational types instead. The SDT conjectures that depending if needs are satisfied or thwarted, people develop different motivational behaviour (Deci & Ryan, 2008a). The HPC, ART, SCT and TPB on the other hand all lack a similar characterisation of the behaviour in terms of the motivational spectrum ranging from intrinsically to extrinsically motivated behaviour introduced by the SDT. Therefore, the SDT complements the previously discussed theories by introducing this aspect of motivated behaviour without impacting on the notion of the cognitive process preceding behaviour detailed in particular in the ART.

Goals

The SDT also has a concept of goals, although again unlike the previously discussed theories the notion is introduced in a purely motivational context again. Goals "are seen as differentially affording basic need satisfactions and are thus differentially associated with well-being" (Ryan & Deci, 2021). Therefore, the primary purpose of goals is to influence motivation by having an impact on the person's well-being. A distinction is made between life goals, reflecting an extrinsic aspiration such as financial success, becoming famous or attractiveness, and goals reflecting some intrinsic aspiration, such as "personal growth, building relationship and being generative for the community" (Deci & Ryan, 2008b). Again, this distinction is analogous to the motivational scale of determinism ranging from intrinsic to extrinsic and the impact on motivation is accordingly.

Aspiration is defined by the SDT as the adoption of an extrinsic or intrinsic goal. For instance, goals can be chosen to substitute non-fulfilled needs, which leads to extrinsically motivated behaviour and goals (Deci & Ryan, 2008a). On the other end of the spectrum, intrinsic goals lead to personal growth and well-being and therefore satisfy these basic needs according to the SDT (Ryan & Deci, 2000). Because goals guide activities (Deci & Ryan, 2008a) the behaviour is motivated accordingly.

Compatibility with the HPC, ART, SCT and TPB

All theories discussed before see goals as something that guides behaviour and the SDT is no exception to that. The main reason according to the SDT is that aspiration of goals contributes to basic need satisfaction and to gain well-being, whereas the HPC, ART, SCT and TPB take a much broader view and do not limit themselves to this aspect only. In contrast to the SDT, the HPC bases behaviour on external demands, and does not see inborn needs as the main driver, because they do not give any information about the individual tolerance threshold at what point someone starts to act and how, or what kind of behaviour the person chose to satisfy his or her needs (Locke & Henne, 1986). Instead, the HPC sees goals as "the mechanism by which values are translated into action" (Locke & Henne, 1986) but mostly in the context of externally set demands.

While the SDT and the SCT both speak of aspiration of a goal, they are not referring to exactly the same concept. The emphasis of the SCT is on personalisation in the context of the willingness to invest effort and persistence, whereas the SDT describes aspiration in the context of extrinsic and intrinsic life goals. In the SDT, where everything is focused on motivation and the self-determination scale that predicts motivation, goals are defined on the same spectrum between extrinsic and

intrinsic. While the HPC, ART and SCT also link motivation and goals by stating that motivation is an activating and goal-oriented process, they lack a similar elaborate model of types of motivation which the SDT provides.

Unlike in the ART there is no elaborate goal-setting mechanism in the SDT, although it emphasises the importance of internalising goals to increase motivation. “To integrate a regulation, people must grasp its meaning and synthesize that meaning with respect to their other goals and values” (Ryan & Deci, 2000). The redefinition of the task as defined in the ART can therefore be understood similar to the SDT’s notion of internalisation, which outlines how non-intrinsic motivation can be transformed into intrinsic motivation to improve behaviour. The stronger the internalisation of external values and tasks the higher the motivation and the better the behavioural outcome (Ryan & Deci, 2000; Deci & Ryan, 2008b) according to the SDT. However, the SDT shows a gap when it comes to precisely describe the translation of goals into actions, which is much more elaborate for instance in the ART’s visualisation of action-plans through its hierarchical-sequential model.

The internalisation and personalisation of extrinsically motivated behaviour depends on the social environment as well as on the perceived competence and autonomy of a person (Ryan & Deci, 2000), which is linked to self-efficacy as defined in the SCT and the control beliefs as defined in the TPB. The higher the perceived autonomy and personal competence the higher the possibility to attain the desired goal under the current circumstances. All three concepts are based on the perception and evaluation of the environment, if certain actions are possible to execute or not (Blanke, Beder, & Klepal, 2017a).

In summary, the SDT sees goals in the context of need satisfaction and defines them on the same autonomy scale as the motivation between extrinsic and intrinsic. It can benefit from the broader view provided by the HPC, ART, SCT and TPB while at the same time contribute with its elaborate model of motivational types.

Feedback

Feedback is not explicitly defined in the SDT; however, it distinguishes rewards and self-incentives corresponding to extrinsic and intrinsic motivation and implies that different types of feedback are required to efficiently increase motivation. According to the SDT feedback should be aimed to increase autonomy and competence, which in turn leads to increased intrinsic motivation (Ryan & Deci, 2000). This is because such feelings of competence and autonomy increase the internalisation and identification with goals towards intrinsic motivation (Deci & Ryan, 2008b). On the other end of the spectrum, the SDT also conjectures that external rewards negatively affect intrinsic motivation (Deci & Ryan, 2008b), although they have a positive impact on extrinsic motivation. As a consequence, feedback needs to be adjusted towards the individual’s motivational type, with a clear preference for such feedback aimed at improving personal autonomy, which is deemed to be more effective to increase motivation.

People are motivated differently, which gives an indication what type of feedback should be given. Someone who is intrinsically motivated does not necessarily need external incentives like monetary rewards, because the activity itself is satisfactory. Intrinsic motivation therefore can be supported by such feedback that supports autonomy and competence (Burgers, Eden, van Engelenburg, & Buningh, 2015; Osbaldiston & Sheldon, 2003). It has been shown that informational feedback or non-controlling instructions are good feedback forms for intrinsically motivated people (Burgers,

Eden, van Engelenburg, & Buningh, 2015). Extrinsically motivated people on the other hand require monetary or other types of incentives to stay motivated. The behaviour in question is normally shown only as long as incentives are given (Steg & Vlek, 2009; He, Greenberg, & Huang, 2010) and disappears as soon as the incentives are withdrawn. It is therefore important to understand what kind of motivational type a person is, keeping in mind that everybody is different, and that feedback needs to be personalised (He, Greenberg, & Huang, 2010; Vine, Buys, & Morris, 2013) and contextualised. In summary, feedback for individuals with controlled motivation needs to be different to feedback for people showing autonomous motivation with regards to an object.

Compatibility with the HPC, ART, SCT and TPB

Rewards and self-incentives as used by the SDT are very similar to the concept of feedback in the HPC, ART and SCT. The major difference between the SDT and the other three theories is that it postulates that only positive feedback increases motivation, whereas negative feedback decreases motivation. The HPC and SCT on the other hand argue that "maximum improvement following negative feedback occurs when there is high self-efficacy" (Bandura, 1988; Locke & Latham, 1990a), which implies that in this case negative feedback is also increasing the performance of a behaviour.

Because the SDT is the only theory that proposes a scale of self-determinism, the type of feedback can be distinguished, depending if a person is autonomously motivated or shows controlled motivation towards an object.

2.2.2.2 Main conjectures of the SDT

The core of the SDT deals with the explanation of motivation. It is based on three basic psychological needs: "autonomy, competence, and relatedness" (Ryan & Deci, 2021), which can be both supported as well as hindered by the social environment, influencing intrinsic or extrinsic motivation. Besides intrinsic and extrinsic motivation the theory describes autonomous motivation, controlled motivation, and amotivation, which can predict a performance outcome. The SDT is built on six "mini-theories" (Ryan & Deci, 2021) trying to predict future psychological growth and well-being and therefore motivation:

The **Cognitive Evaluation Theory** is focusing on intrinsic motivation. Intrinsic motivation describes a behaviour, which someone likes to do because it is enjoyable out of its own. For example, eating more sustainable can be the result of finding it interesting to learn where products come from and how they are produced. The social environment plays an important role when it comes to supporting competence and autonomy. The higher the feeling of competence and autonomy, the higher the intrinsic motivation. Intrinsic motivation is the most favourable motivation, because people act out of themselves and do not need any incentives to keep going (Ryan & Deci, 2000).

The **Organismic Integration Theory** is focusing on extrinsic motivation and its different expressions. Extrinsic motivation is characterised by its need for external incentives and can be distinguished into a continuum of categories ranging from external regulation on one end, via introjection, and identification to integration on the other end closest to intrinsic motivation (cf. Figure 15). A person will act more autonomous the more he/she has internalised a given extrinsic goal or behaviour. Again, the social environment is crucial when it comes to supporting or hindering the internalisation of values or goals (Ryan & Deci, 2021; Osbaldiston & Sheldon, 2003). External incentives can be monetary or non-monetary, for example gaining points or virtual rewards can count as incentive as well and can support an externally motivated person to keep going.

The **Causality Orientations Theory** describes inter-personal differences and the dialectic interaction of each person with their social context. It distinguishes three types of causality orientations (Ryan & Deci, 2021):

- "Autonomy orientation" refers to individuals who purely act based on their own interests
- "Control orientation" happens when someone acts based on wanting to achieve rewards or approval
- While an orientation is called impersonal or "amotivated" in case an action is impeded by a fear of insufficient capabilities and competences

These three types are linked to the different types of regulation (cf. Figure 15), with "autonomous motivation comprising intrinsic, identified and integrated motivation, the controlled motivation comprising external and introjected regulation and finally amotivation" (Ryan & Deci, 2000), describing a condition where no intention to act exist and behaviour can be even counterproductive (Osbaldiston & Sheldon, 2003). "Amotivation results from a person not valuing a behaviour or outcome, not believing that a valued outcome is reliably linked to specific behaviours or believing that there are behaviours instrumental to a valued outcome but not feeling competent to do those instrumental behaviours" (Ryan & Deci, 2000). While the first two can be supported with adequate feedback, the latter would not respond to any kind of incentives. Therefore, personalised interventions can only be effective with the first two types.

The **Basic Psychological Needs Theory** focuses on the three inborn psychological needs: "autonomy, competence, and relatedness" (Ryan & Deci, 2021). The environment is crucial when it comes to supporting those needs (Verstuyf, Patrick, Vansteenkiste, & Teixeira, 2012). If they are supported, appropriate behaviour, which will lead to well-being, is the consequence. On the other hand, if these basic needs cannot be satisfied motivation is expected to drop (Osbaldiston & Sheldon, 2003) and as a result ill-being can be predicted. Particularly, if a goal such as for example buying certain ingredients for a chosen recipe cannot be achieved, the acting person might get frustrated, disappointed or stressed because an alternative action-plan needs to be developed. Supporting feelings of competence and autonomy, as is achievable with dynamic personalised interventions can lead to better outcomes in this regard.

The **Goal Contents Theory** describes the impact of intrinsic and extrinsic goals on motivation. Extrinsic goals (e.g. appearance, fame or being rich) are associated with less well-being while intrinsic goals (e.g. self-care or caring for others) are associated with an increase of well-being (Ryan & Deci, 2021). If a task or goal is well personalised or internalised, it will lead to a higher likelihood that the behaviour in question will be shown. The type of motivation and the social context define which goal will be selected (Deci & Ryan, 2008a). Therefore, the environment influences through supporting or hindering goal choice and personalisation of the same. Perception of autonomy and competence in the given circumstances are all contributing to the internalisation of goals. Those three traits can be seen similar to the self-efficacy concept. The higher the perceived autonomy and personal competence, the higher the possibility to attain the desired goal under the current circumstances the more likely it is to show a certain behaviour (Blanke, Beder, & Klepal, 2017c).

The **Relationships Motivation Theory** is focusing on "development and maintenance of close personal relationships" (Ryan & Deci, 2021; Osbaldiston & Sheldon, 2003). The idea is that relationships are a key contributor to an individual's well-being. In particular, high levels of

autonomy and competence do not necessarily mean high levels of independence. On the contrary, autonomy and competence are a sign of good support from the surrounding and well-established relationships. Reference groups are important both for orientation but also for approval that the own behaviour is accepted and supported.

2.2.2.3 Operationalisation of the model

The six mini-theories of the SDT postulate that self-determination and autonomy are the main reason for motivating behaviour and that the more internalised a goal is the more motivation is shown to pursue it. A graphical visualisation of the information flow inspired by the TPB is depicted in Figure 16 showing how the different types of goal aspiration lead to different mechanisms of regulation associated with self-determination and autonomy.

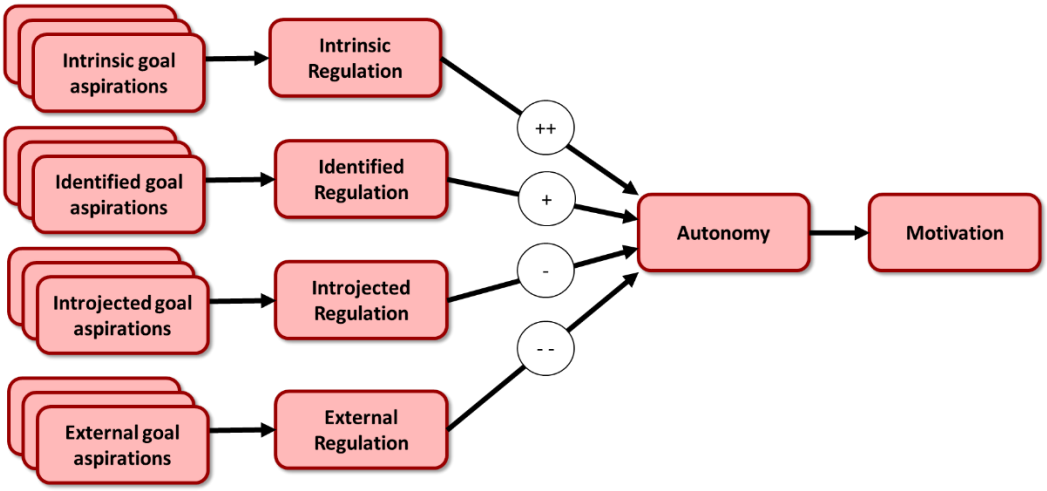


Figure 16 Visualisation of autonomy as proposed by the SDT

Four different types of goal aspiration are distinguished that can be assessed using suitable questionnaires (Ryan & Deci, 2021) (see appendix B for examples). **Intrinsic goal aspiration** is characterised by an innate interest in the topic and can therefore be determined from evaluating questions like for example if a person enjoys doing a related activity. **Identified goal aspirations** are those acknowledging the personal importance of a goal to an individual. Questions if someone values an activity and considers it to be contributing to personal well-being are used to evaluate the strength of these. Next, **introjected goal aspirations** are based on avoidance of negative consequences or punishment. They can be evaluated through questions relating to feeling of pressure to do something or being afraid of related negative consequences. Finally, **external goal aspirations** are the least internalised and are solely based on how others appreciate the person for a specific action. They are evaluated through questions about what other people think to be right or wrong.

These different types of goal aspirations lead to different types of regulation associated with each (cf. Figure 16). The SDT then defines the **Relative Autonomy Index** as a measure to determine the level of self-determination with regards to a subject matter. Higher values indicate more autonomous motivation, lower values indicate more controlled motivation (cf. Figure 15). It is the weighted sum of the different regulations

$$RAI = 2R_{Intrinsic} + R_{Identified} - R_{Introjected} - 2R_{External}$$

where the intrinsic regulation $R_{Intrinsic}$ is weighed with a positive factor of +2, the identified regulation $R_{Identified}$ is weighed with a positive factor of +1, the introjected regulation $R_{Introjected}$ is weighed with a negative factor of -1 and the external regulation $R_{External}$ is weighed with a negative factor of -2.

The intrinsic regulation is calculated as a weighted sum

$$R_{Intrinsic} = \sum_{i=1}^{n_{Intrinsic}} w_i^{Intrinsic} a_i^{Intrinsic}$$

of intrinsic goal aspirations $a_i^{Intrinsic}$ determined from a questionnaire and weighted by appropriate factors $w_i^{Intrinsic}$ to reflect the importance of each individual question. The goal aspirations $a_i^{Intrinsic}$ are determined on a 5-point Likert scale and the weight factors $w_i^{Intrinsic}$ can also be chosen negative to accommodate reverse questions. In the absence of apriori assumptions on the importance of individual questions all weight factors can be set to ± 1.

The identified regulation is calculated equivalently as

$$R_{Identified} = \sum_{i=1}^{n_{Identified}} w_i^{Identified} a_i^{Identified}$$

from the identified goal aspirations $a_i^{Identified}$ weighted by corresponding weight factors $w_i^{Identified}$. Again, identified goal aspirations are measured on a 5-point Likert scale and negative weight factors enable the use of reversed questions.

Introjected regulation is the weighted sum

$$R_{Introjected} = \sum_{i=1}^{n_{Introjected}} w_i^{Introjected} a_i^{Introjected}$$

of introjected goal aspirations $a_i^{Introjected}$ and external regulation is the weighted sum

$$R_{External} = \sum_{i=1}^{n_{External}} w_i^{External} a_i^{External}$$

of external goal aspirations $a_i^{Introjected}$, all measured on a 5-point Likert scale and weighted according to their relative importance.

In summary, the relative autonomy index RAI proposed by the SDT allows to operationalise the model and calculate a quantity that can be used to determine the motivational type of an induvial based on the evaluation of a questionnaire comprising intrinsic goal aspirations $a_i^{Intrinsic}$, identified goal aspirations $a_i^{Identified}$, introjected goal aspirations $a_i^{Introjected}$ and external goal aspirations $a_i^{Introjected}$. This approach will be used to conduct the studies presented in section 3.2 below.

2.2.2.4 Integration of the SDT with the HPC, ART, SCT and TPB

The SDT provides a quantitative model how different measurable types of goal aspiration are translated into self-determination and autonomy, which it sees as the main driver for motivation and behaviour. This is unique amongst the model discussed before. The TPB does not consider motivation at all, while the HPC, ART and SCT all have a view on motivation but do not provide any means of quantifying these motivational variables. Therefore, the integration of the SDT into the nested double cycle of behaviour including intention presented in Figure 14 can be augmented with the quantification abilities of the SDT resulting in the model depicted in Figure 17 (Blanke, Beder, & Klepal, 2017c; Blanke, Beder, & Klepal, 2017a), which now contains a quantifiable motivation component in analogy to the integration of the TPB presented before.

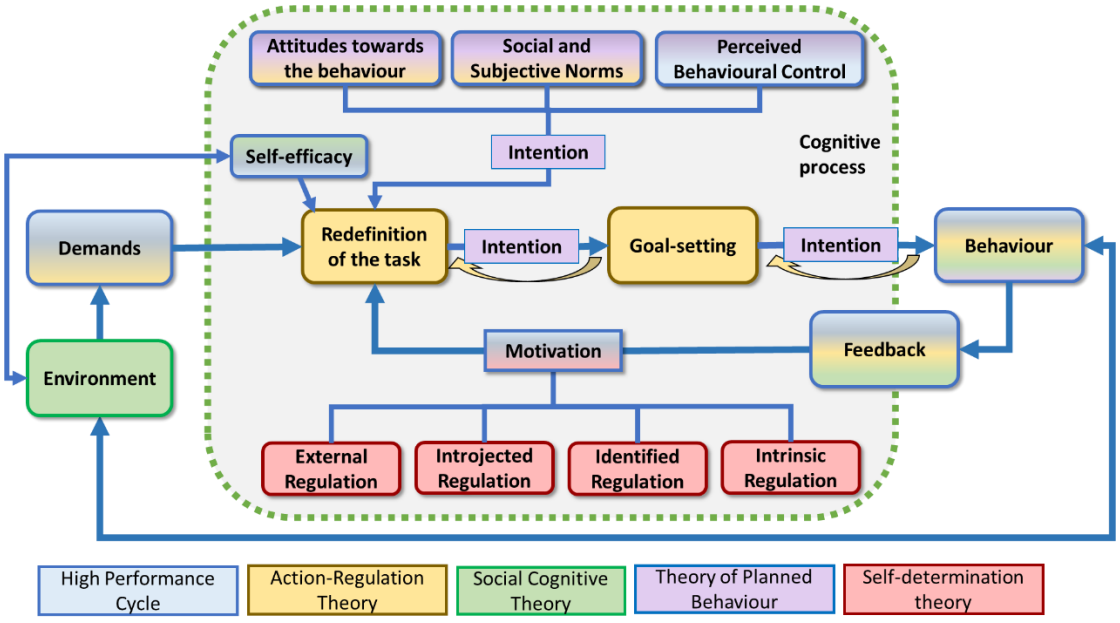


Figure 17 Nested double cycle of behaviour with quantifiable intention and motivation, integrating all behavioural theories discussed in this work

Because the SDT does not interfere with the concepts introduced by the other theories, and because the motivational aspect of autonomy can be simply added to the motivational concepts proposed by the other theories, in particular the HPC, this integration is very straightforward. The additional benefit is that the SDT provides a quantitative model based on measurable values. Together with the TPB this allows to derive two behaviour guiding quantities to describe intention and motivation.

2.3 A behavioural model to facilitate personalised interventions

The main goal of a behavioural model in the context of this work is twofold: to understand the influence factors on behaviour towards a specific object and thereby to facilitate the design of dynamic personalised interventions that lead to better behaviour with regards to that object. The basis for this is the integrated behavioural model depicted in Figure 17, which incorporates and unifies the concepts derived from the five underlying behavioural theories of the High Performance Cycle (HPC), the Action-Regulation Theory (ART), the Social Cognitive Theory (SCT), the Theory of Planned Behaviour (TPB) and the Self-Determination Theory (SDT).

The behavioural model developed in the previous sections integrates different predominant aspects from each of these theories, complementing each other and overcoming individual limitations. The

HPC provides the framework onto which all other theories are superimposed. Its lack of a clear cognitive model is overcome by the ART, which explains how demands and tasks are taken over and translated into visualisable action plans. The SCT expands the focus of the HPC and ART beyond work processes and introduces a clearer notion of the interface between the individual and his/her environment. Finally, the TPB facilitates the measurement and quantification of intentions (Dawson, Mullan, & Sainsbury, 2015), while the SDT is added to understand and quantify the types of motivation driving the behaviour. The underlying behavioural theories were chosen to have broad utility and empirical support.

Each of the building blocks of the model can be mapped onto specific features of the intervention, which should be designed so that the cognitive behavioural process captured by the model is optimally supported. For example, a phone application intervention, such as the HealthStainable application outlined in section 1.3.1, should be designed accordingly to optimally support healthy and sustainable behaviour. The building blocks and the underlying behavioural theories of the integrated model leading to a desired behaviour are (cf. Figure 17):

1. **Demands (HPC, ART)**, which are the externally set guiding challenges and policies that the intervention aims to address. Empirical support for the positive influence of such broader factors on performance has been shown for example by (Selden & Brewer, 2000).
2. **Redefinition of the task (ART)**, which is the process of personalising these vague guidelines into concrete, meaningful and useful goals. Empirical support for the correlation between personalisation and perceived usefulness has for instance been established by (Tossell, Kortum, Shepard, Rahmati, & Zhong, 2012).
3. **Self-efficacy (SCT, HPC)**, which is the reflection of personal abilities in a given context with respect to the subject in question. There is broad empirical support for the role of self-efficacy in behaviour change processes (Zhang, Zhang, Schwarzer, & Hagger, 2019; Harrison, Jr., Hochwarter, & Thompson, 1997).
4. **Goal-setting (ART)**, which is the process of breaking down superordinate goals into actionable sub-goals and action plans. Many studies (Tubbs, 1986; Locke E. A., 1996) have empirically shown the performance gain achieved by goal-setting.
5. **Feedback (HPC, ART, SCT)**, which is the evaluation of and information about the impact and consequences of the behaviour including the emotion this is causing. Meta-analysis of feedback research has shown that informative feedback can positively influence motivation and behaviour (Wisniewski, Zierer, & Hattie, 2020).
6. **Environment (SCT)**, which is the reciprocal relationship between the external world and the individual's actions within the given context conditions. The SCT has a long history of empirical validation, as for example in (Strong, Parks, Anderson, Winett, & Davy, 2008; Phipps, et al., 2013)
7. **Attitudes towards the behaviour (TPB, ART)**, which are the predispositions of a person to respond consistently to a subject matter. The TPB is widely used and there is broad empirical support for its usefulness and relevance in the context of promoting health and sustainable behaviours (Biasini, et al., 2021).
8. **Social and subjective norms (TPB, ART)**, which are the perceived social pressures from relevant others and groups influencing the behaviour. The influence of social and subjective norms on behaviour has been extensively studied and validated (e.g. (Steg & Vlek, 2009; Keizer & Schultz, 2018)).

9. **Perceived behavioural control (TPB, HPC)**, which is the perception of factors that facilitate or hinder a behaviour.
10. **Intrinsic regulation (SDT)**, is the extent to which a person is acting out of enjoyment and curiosity rather than to avoid negative consequences or receiving an incentive. Autonomous motivation has been found to be positively influencing changes in health behaviour (Ntoumanis, et al., 2021) as well as sustainability (Schösler, de Boer, & Boersema, 2014).
11. **Identified regulation (SDT)**, which is the extent to which a person has internalised an external goal as his/her own and is willing to act on it accordingly.
12. **Introjected regulation (SDT)**, which is the extent to which a person is driven by the avoidance of negative consequences of an action regarding a subject area.
13. **External regulation (SDT)**, which is the extent to which a person requires external incentives and rewards to act in regard to a subject area.

All these points provide a checklist against which an intervention design framework should be validated to ensure that all aspects of motivational influence factors are addressed. In addition to this, points 7-10 have also been operationalised to be quantifiable using suitable inventories as outlined in section 2.2 resulting in the two main measurable indicators that have been defined within the model (cf. Figure 17):

- Intention (TPB), which is the state immediately before a behaviour is shown. It can be used to gauge the likelihood that a behaviour in question is executed and depends on the factors described in points 7-9 above.
- Motivation (HPC, SDT), which is the longer-lasting general tendency to engage or not engage with a certain topic. It is characterised by the level of autonomy, which is an indicator of the motivational type of a person towards a subject area determining what is required to accept a goal in general and translate it into actual behaviour. It is derived from the factors described in points 10-13 above.

The model can therefore be operationalised in three distinct ways:

1. The qualitative aspects provide the basis for evaluating existing interventions with respect to their support of the relevant cognitive process in relation to a given subject area, e.g. healthy and sustainable grocery shopping (see section 3.1).
2. The quantitative aspects can be used to survey existing intention and motivation in relation to the given subject area (see section 3.2).
3. Based on the results of this qualitative and quantitate evaluation novel model-driven interventions can be designed to address the behaviour, intention, and motivation in the given subject area (see section 3.3).

In summary, the nested double cycle of behaviour depicted in Figure 17 provides a design framework for assessing and implementing features targeting different aspects of the behavioural process in relation to a given subject area based on established and empirically supported concepts. The model describes behaviour as a comprehensive process encompassing all the aspects that have been introduced by the different underlying behavioural theories. Because all aspects mutually influence others as indicated in the model, maximum impact is expected to be achievable if most aspects are covered by some feature of the intervention. The model also ensures that a comprehensive view is taken and that missing features can be identified and added if required.

3 Studies

Having derived a theoretical model of behaviour, in the following section three studies based on this framework will be presented. The first study reviews and analyses the most popular recipe and food shopping applications currently available on the Google Play Store with regards to the features and concepts derived from the qualitative behavioural models outlined in section 2.1. This analysis aims at giving an overview which applications are popular in this context and which features they include, linking them back to the concepts of the behavioural models to assess the level of support provided for the identified categories.

The second set of studies is based on a survey in the context of healthy and sustainable grocery shopping and the analysis of the correlation between both. It aims at giving some insights into self-reported intentions, motivation, and behaviour in this domain. The questionnaire used in this study includes sections based on the structure provided by the two quantitative models detailed in section 2.2. The Theory of Planned Behaviour (TPB) is applied to analyse the behavioural intentions (BI) in more detail, while the Self-Determination Theory (SDT) is used to assess the Relative Autonomy Index (RAI) as indictor of the type of motivation of participants. Furthermore, the study elaborates on the different persona types of participants based on the constituent concepts of the TPB: attitudes, subjective norms, and perceived behavioural control. Such a categorisation can help to analyse individual drivers, which should be taken into consideration when designing interventions for behavioural change.

Finally, a third case study will be presented based on the outcomes of studies I and II. It will be showing how the model-driven design framework outlined in section 2.3 can be operationalised and applied to implement a smartphone based dynamic intervention and ecological momentary assessment (EMA) of behavioural parameters to support healthy and sustainable grocery shopping behaviour. The outcome of this case study is the HealthStainable application already previewed above in section 1.3.1.

3.1 Study I: Categorisation of current recipe and food shopping smartphone applications[2]

Improving behaviour to achieve healthier and more sustainable food choices can be supported by recipe and food shopping smartphone applications. These applications are typically designed based on ad-hoc ideas, without involving theoretical concepts (Riley, et al., 2011) or focusing just on single components of behavioural theories (Sama, Eapen, Weinfurt, Shah, & Schulman, 2014), often unintentionally. Their commercial success is driven by popularity and underlying business models. While this makes sense for the application developer, the application of behavioural modelling techniques like those outlined above promise a more rigorous approach to application design, potentially enabling the identification and targeting of relevant concepts to optimally support and influence behaviour. In this study existing smartphone applications are analysed to see how their features map onto identified behavioural concepts with the goal of categorising their supports for different drivers of behaviour. The following survey will answer the question, if and to what degree the concepts of demands, redefinition of the task, goal-setting, self-efficacy, feedback, and

[2] A shorter version of this study has been published in *Computers in Human Behavior Reports* under the title "*Improving food shopping behaviour: a model-based review of mobile applications to assist with healthy and sustainable grocery shopping*" (Blanke, Billieux, & Vögele, 2021a).

environment as identified by the behavioural models are supported by current smartphone applications in the domain of healthy and sustainable grocery shopping?

The methodology for this study is closely related to the Heuristic Evaluation (Wilson, 2014) approach developed in the field of user experience (UX) (ISO9241, 2019), which proposes to define suitable heuristics first (Quiñones, Rusu, & Rusu, 2018) and then evaluate application features with respect to support of these. As the name suggest it is based on defining evaluation heuristics (Schön, Thomaschewski, & Bader, 2017), such as those proposed by Nielsen (Nielsen, 1994; Nielsen Norman Group, 2021). However, this step is often ad-hoc, without reference to theoretical concepts and adapted or augmented as required (e.g. (Reis, Páris, & Gomes, 2020; Suzianti, Minanga, & Fitriani, 2017)).

3.1.1 Method

The study presented here is based on the integrated qualitative model developed in section 2.1 (cf. Figure 12). The model is used to analyse existing recipe and food shopping applications with regards to their features supporting specific aspects of the behavioural process that have been identified to have an impact on healthy and sustainable behaviour. A review of the most popular food planning, recipe and shopping list applications has been carried out. Applications were selected based on the following criteria:

- Applications were listed in the "Food & Drink" category of the Google Play Store on the 21st Aug 2020 and available in an English language version in Ireland
- More than 1M installs and at least 100 ratings were reported on the Google Play Store on the 21st Aug 2020
- Applications had to provide at least recipe planning support and grocery shopping list features as part of their range of functions offered
- Applications were excluded from consideration if they were specific to a shop (e.g. 7-Eleven), delivery service (e.g. Domino's Pizza) or product (e.g. Thermomix)

A total of 27 applications matched these criteria. The following Table 2 lists all these ordered by their popularity on the Google Play store according to AndroidRank.org (2020):

Rank	Title	Installs	Total ratings	Average rating
23	Cookpad - Create your own Recipes	10.0 M	237129	4.71
50	Tasty	5.0 M	121797	4.7
56	Yummly Recipes & Shopping List	5.0 M	109866	4.53
62	Allrecipes Dinner Spinner	5.0 M	77738	4.57
71	Cookbook Recipes	5.0 M	49397	4.39
119	myTaste Recipes	1.0 M	47548	4.19
132	My CookBook Recipe Manager	1.0 M	33396	4.71
134	BigOven Recipes, Meal Planner, Grocery List & More	1.0 M	32730	4.53
139	Kitchen Stories - Recipes & Cooking	1.0 M	29595	4.7
177	Mealime - Meal Planner, Recipes & Grocery List	1.0 M	16698	4.61
188	Easy Recipes	1.0 M	14543	4.67
208	Salad Recipes FREE	1.0 M	12402	4.3
209	Recipe book: Recipes & Shopping List	1.0 M	12352	4.28
218	Food Planner	1.0 M	10931	3.74

228	All Recipes Free - Food Recipes App	1.0 M	9861	4.38
253	Quick and Easy Recipes	1.0 M	7080	3.84
255	Magic Fridge: Easy recipe idea and anti-waste	1.0 M	6782	4.12
256	All free Recipes: World Cuisines	1.0 M	6536	4.38
261	Cake Recipes FREE	1.0 M	6027	4.17
262	Recipes Home - Free Recipes and Shopping List	1.0 M	5929	3.77
263	Chicken Recipes	1.0 M	5846	4.37
268	Diet Recipes	1.0 M	5121	4.74
274	Healthy Recipes	1.0 M	4478	4.4
278	Rice Recipes: Fried rice, pilaf	1.0 M	3940	4.26
281	FitMenCook - Healthy Recipes	1.0 M	3768	4.56
289	Lunch Recipes	1.0 M	3001	4.37
298	Salad Recipes: Healthy Foods with Nutrition & Tips	1.0 M	1558	4.16

Table 2 Most popular recipe and food shopping applications

The qualitative models reviewed and integrated in section 2.1 summarise the aspects that need to be considered in a behavioural intervention aimed at improving healthy and sustainable grocery shopping. Ideally, a well-designed support application should support a subset of these with suitable features. The model depicted in Figure 12 also provides insight into the order in which these features need to be presented to the application user to facilitate a structured flow of information optimally supporting the cognitive process.

A review of the applications listed in Table 2 was carried out to identify features that support positive dietary choices, which then can be mapped onto the corresponding concepts of the behavioural model using the definitions of the underlying theories (see Table 3). Some features can be mapped to multiple concepts, therefore unique numbers for each feature are given in brackets. For each feature it is now possible to decide if it is present in an application or not. The resulting list of potential features for applications aiming to support healthy and sustainable grocery shopping behaviour linked to the corresponding aspect in the behavioural model is given in the following Table 3:

Concept in model	Summary of concept	Supporting feature
Demands	Challenges imposed on the individual, e.g. by policy on public health and sustainability, that initiate the cognitive process	Recipe database specifically to support a healthy diet (1)
		Recipe database specifically to support a sustainable diet (2)
Norms and Values	Social standards and rules, acquisitioned through experience.	Recipe database specifically to support a healthy diet (1)
		Recipe database specifically to support a sustainable diet (2)
Redefinition of the task	Personalisation of demands, e.g. to follow a healthy and sustainable diet, into meaningful personal goals, e.g. the planned recipes meeting the demanded requirements	Recipe suggestions including information on nutritional values (3)
		Recipe suggestions including information on carbon footprint (4)
		Browse recipes by category to ease defining a goal according to the demands (5)
		Browse recipes by ingredient to ease defining a goal according to the demands (6)

		Search recipes and ingredients using a search field to simplify the finding preferred options (7)
		Create a personalised list of recipes to prepare (weekly plan) to enable longer-term goal planning (8)
		Create a personalised list of recipes remembered for later (favourites) to ease finding preferred options (9)
Goal-setting	Refinement of goals into sub-goals and development of precise personalised action plans, e.g. shopping lists to follow when implementing the preparation of recipes	Create shopping list from selected recipes refining higher level goals into actionable plans (10)
		Merge ingredients consistently on shopping list even when aggregating different units to generate action plans which minimise cognitive strain (11)
		Include additional products into the shopping list to enable personalisation of action plans (12)
		Delete entire recipes from the shopping list to accommodate feedback loops during the process (13)
		Delete single ingredients from the shopping list to facilitate personalisation of the action plan (14)
		Adapt amounts for ingredients to accommodate different serving sizes to personalise the action plan (15)
Self-efficacy	Consideration of personal abilities in the given context, for instance with regards to the difficulty level of cooking	Indication of difficulty level for each recipe to accommodate personal abilities (16)
		Detailed cooking instructions to support the decision for or against a recipe (17)
Feedback	Information on the progress that the behaviour provides with regards to achieving the overall goals in order to motivate better behaviour	Recipe suggestions including information on nutritional values (3)
		Recipe suggestions including information on carbon footprint (4)
		Nutritional information for the ingredients to increase knowledge of health benefits (18)
		Carbon footprint information for the ingredients to increase knowledge of sustainability impacts (19)
Motivation	General tendency to show a certain behaviour, which can be supported by motivational cues such as simple, straightforward information like a colour coded system for nutritional values or information on carbon footprint	Recipe suggestions including information on nutritional values (3)
		Recipe suggestions including information on carbon footprint (4)
Environment	Reciprocal causal relationship between the behaviour and the encountered circumstances, for	Include additional products into the shopping list to enable accommodating individual circumstances (12)

	instance when encountering obstacles	Delete entire recipes from the shopping list to accommodate feedback loops during the process (13)
		Delete single ingredients from the shopping list to allow for adjustments based on the circumstances (14)
		Marking ingredients as unavailable to enable the application to dynamically react to unforeseen circumstances (20)
		Adapt shopping list and create list of items to put back to dynamically react to changes in the environment (21)
		Suggestions to select an alternative recipe in case an obstacle was encountered, taking into consideration unavailable ingredients (22)
		Dynamic adaption of shopping list to accommodate new recipes while shopping (23)

Table 3 Qualitative aspects of the model translated into supporting features in the smartphone applications

All applications listed in Table 2 where reviewed with regards to the features listed in Table 3 and it was determined for each if a feature was implemented or not. Sometimes partial implementation of a feature was considered, in cases where features were not fully implemented but aspects of the application were designed to achieve a similar goal. This approach results in a matrix of applications and features, which in turn can be attributed to the different concepts of the behavioural model. In particular, the level of support for each concept can be derived from this matrix either as aggregate or per application. The proposed evaluation methodology therefore follows these steps:

1. Select relevant applications to be considered (Table 2) based on topic and popularity
2. Identify features in the selected applications and map them to the concepts of the behavioural model (Table 3)
3. Determine the level of support for each application/feature pair resulting in a concept support matrix (Table 4); consider partial support where applicable
4. Aggregate the level of support per feature (Table 5) by counting (Table 4, column by column) for each feature the number of applications that have support for the same; count ½ for partial support.
5. Aggregate the level of support per concept (Table 6) by adding up the support for features from step 4 according to the concept mapping determined in step 2
6. Evaluate selected individual applications with respect to concept support (Figure 18) by counting (Table 4, row by row) the number of features the particular application supports with respect to the concept mapping determined in step 2

3.1.2 Results

Applying the methodology outlined in the previous section to the applications listed in Table 2 and counting the implemented features listed in Table 3 results in the matrix depicted in Table 4. Where features are only partially supported, and hence counted as ½ in the following, the tick box is in brackets and the reason is indicated in the footnotes. Features are aggregated by model concept, with the colour coding chosen in accordance with the model colour coding introduced in Figure 12.

The features mapped to the concepts of “norms and values” as well as “motivation” are complete subsets of the features identified for “demands” and “feedback” respectively, therefore an explicit colour coding for these two was omitted from the table.

	Demands		Redefinition of the task							Goal-setting						Self-effic.		Feedback			Environment						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	3	4	18	19	12	13	14	20	21	22	23
Cookpad - Create your own Recipes							(✓)[1]		✓								✓											
Tasty	✓	(✓)[2]	✓[3]		✓		(✓)[1]		✓								✓	✓[3]										
Yummly Recipes & Shopping List		(✓)[2]	✓[3]		✓		(✓)[1]	✓	✓	✓		✓	✓	✓	✓		(✓)[4]	✓[3]				✓	✓	✓				
Allrecipes Dinner Spinner	✓	(✓)[2]	✓[3]		✓	(✓)[5]	✓	✓	✓	✓	(✓)[6]	✓		✓	✓	(✓)[7]	✓	✓[3]				✓		✓			(✓)[8]	
Cookbook Recipes	✓	(✓)[2]			✓		(✓)[1]	✓	✓	✓			✓	✓	✓	✓	✓						✓	✓				
myTaste Recipes							(✓)[1]		✓								(✓)[4]											
My CookBook Recipe Manager			✓[3]				✓	(✓)[9]	✓	(✓)[10]			(✓)[10]	✓	✓	(✓)[7]	✓	✓[3]					(✓)[10]	✓				
BigOven Recipes, Meal Planner, Grocery List & More	✓	(✓)[2]	(✓)[3,9]		✓	✓	✓	(✓)[9]	✓	✓	(✓)[6]			✓	✓	(✓)[7]	✓	(✓)[3,9]						✓				
Kitchen Stories - Recipes & Cooking	✓	(✓)[2]	✓[3]		✓		✓		✓	✓			✓	✓	✓	✓	✓	✓[3]					✓	✓				
Mealime - Meal Planner, Recipes & Grocery List	✓	(✓)[2]	(✓)[3,9]		✓		✓	✓	✓	✓	✓			✓	(✓)[11]	(✓)[12]	✓	(✓)[3,9]						✓				
Easy Recipes					✓		✓	✓	✓	✓			✓	✓			✓			✓			✓	✓				
Salad Recipes FREE	✓[13]	(✓)[13]			✓		(✓)[1]	✓	✓	✓			✓	✓	✓	✓	✓						✓	✓				
Recipe book: Recipes & Shopping List		(✓)[2]			✓	✓	✓		✓	(✓)[10]		✓	(✓)[10]	✓		(✓)[7]	✓					✓	(✓)[10]	✓				
Food Planner							(✓)[14]	✓		✓				✓	✓		(✓)[4]							✓				
All Recipes Free - Food Recipes App					✓				✓	(✓)[10]		✓		✓			✓					✓		✓				
Quick and Easy Recipes					✓											(✓)[7]	✓											
Magic Fridge: Easy recipe idea and anti-waste		✓[15]	✓			✓	(✓)[16]		✓						✓	(✓)[12]	✓	✓							✓		✓[17]	
All free Recipes : World Cuisines			✓		✓	✓	(✓)[1]		✓	(✓)[10]		✓	(✓)[10]	✓				✓				✓	(✓)[10]	✓				
Cake Recipes FREE					✓		(✓)[1]	✓	✓	✓			✓	✓	✓	✓	✓						✓	✓				
Recipes Home - Free Recipes and Shopping List			✓		✓		✓		✓	✓		✓		✓			✓	✓				✓		✓				
Chicken Recipes							(✓)[1]		✓	(✓)[18]				✓			✓							✓				
Diet Recipes					✓		✓	✓	✓	✓			✓	✓			✓			✓			✓	✓				
Healthy Recipes	✓	(✓)[2]	✓		✓	✓	(✓)[1]		✓	(✓)[10]		✓	(✓)[10]	✓				✓				✓	(✓)[10]	✓				
Rice Recipes : Fried rice, pilaf			✓		✓	✓	(✓)[1]		✓	(✓)[10]		✓	(✓)[10]	✓				✓				✓	(✓)[10]	✓				
FitMenCook - Healthy Recipes	✓	(✓)[2]	✓		✓		✓		✓	✓[9]		✓[9]		✓	✓		✓	✓				✓[9]		✓				
Lunch Recipes			✓		✓	✓	(✓)[1]		✓	(✓)[10]		✓	(✓)[10]	✓				✓				✓	(✓)[10]	✓				
Salad Recipes: Healthy Foods with Nutrition & Tips	✓		✓		✓	✓	✓	✓		✓	✓		✓	✓			✓	✓					✓	✓	✓		(✓)[8]	

1. Only searches keyword in recipe title
2. Vegetarian and/or vegan option available
3. Estimated based on serving size
4. Forwarding to instructions on external web page
5. Browse by ingredient category
6. No unified ingredient naming
7. Preparation time
8. Exclude ingredients from search
9. Only in premium version
10. One shopping list per recipe only
11. Adapt amount only for all recipes simultaneously
12. Database only contains easy recipes
13. Salads only
14. Manually import recipes from internet
15. Dynamic adaption of recipes to minimize food waste
16. Search only for ingredients
17. Recipes are adapted to accommodate missing ingredients
18. One recipe only

Table 4 Supported features relating to the concepts of the qualitative model for each smartphone application

Counting (column by column) the number of applications that implement a specific feature (½ for partial support) the support for each feature is summarised in Table 5:

Supporting feature	**#**	**%**
Recipe database specifically to support a healthy diet (1)	9	33%
Recipe database specifically to support a sustainable diet (2)	5.5	20%
Recipe suggestions including information on nutritional values (3)	9	33%
Recipe suggestions including information on carbon footprint (4)	0	0%
Browse recipes by category to ease defining a goal according to the demands (5)	21	78%
Browse recipes by ingredient to ease defining a goal according to the demands (6)	8.5	31%
Search recipes and ingredients using a search field to simplify the finding preferred options (7)	18	67%
Create a personalised list of recipes to prepare (weekly plan) to enable longer-term goal planning (8)	11	41%
Create a personalised list of recipes remembered for later (favourites) to ease finding preferred options (9)	24	89%
Create shopping list from selected recipes refining higher level goals into actionable plans (10)	17	63%
Merge ingredients consistently on shopping list even when aggregating different units to generate action plans which minimise cognitive strain (11)	3	11%
Include additional products into the shopping list to enable personalisation of action plans (12)	9	33%

Delete entire recipes from the shopping list to accommodate feedback loops during the process (13)	11	41%
Delete single ingredients from the shopping list to facilitate personalisation of the action plan (14)	22	81%
Adapt amounts for ingredients to accommodate different serving sizes to personalise the action plan (15)	11.5	43%
Indication of difficulty level for each recipe to accommodate personal abilities (16)	7.5	28%
Detailed cooking instructions to support the decision for or against a recipe (17)	21.5	80%
Recipe suggestions including information on nutritional values (3)	9	33%
Recipe suggestions including information on carbon footprint (4)	0	0%
Nutritional information for the ingredients to increase knowledge of health benefits (18)	2	7%
Carbon footprint information for the ingredients to increase knowledge of sustainability impacts (19)	0	0%
Include additional products into the shopping list to enable accommodating individual circumstances (12)	9	33%
Delete entire recipes from the shopping list to accommodate feedback loops during the process (13)	11	41%
Delete single ingredients from the shopping list to allow for adjustments based on the circumstances (14)	22	81%
Marking ingredients as unavailable to enable the application to dynamically react to unforeseen circumstances (20)	2	7%
Adapt shopping list and create list of items to put back to dynamically react to changes in the environment (21)	0	0%
Suggestions to select an alternative recipe in case an obstacle was encountered, taking into consideration unavailable ingredients (22)	1	4%
Dynamic adaption of shopping list to accommodate new recipes while shopping (23)	0	0%

Table 5 Support of different features by the 27 most popular applications

The application features specific to a healthy diet are (1), (3), and (18). They are supported by 33%, 33%, and 7% of the 27 most popular applications. This compares to the application features specific to a sustainable diet being (2), (4), and (19), which are supported by much fewer applications at 20%, 0%, and 0% respectively.

Aggregating features by the respective concepts (by colour) within the model it can be evaluated how many of the 27 most popular applications support a specific aspect of the model as summarised in Table 6:

Concept in model	**#**	**%**
Demands	14.5	27%
Redefinition of the task	91.5	48%
Goal-setting	73.5	45%
Self-efficacy	29	54%
Feedback	11	10%
Environment	45	24%

Table 6 Support of different concepts of the behavioural model by the 27 most popular applications

The number of features supporting a particular aspect of the qualitative behavioural theories can also be determined for each application individually. A suitable visualisation for comparing application with respect to this metric is the spider graph, which shows the strengths and

weaknesses of each application with respect to the concepts of the model. The spider graphs for the five most popular applications (>5M installations) are depicted in Figure 18. They can be used as a tool to understand how well the maintenance of healthy and sustainable grocery shopping is supported by the different applications.

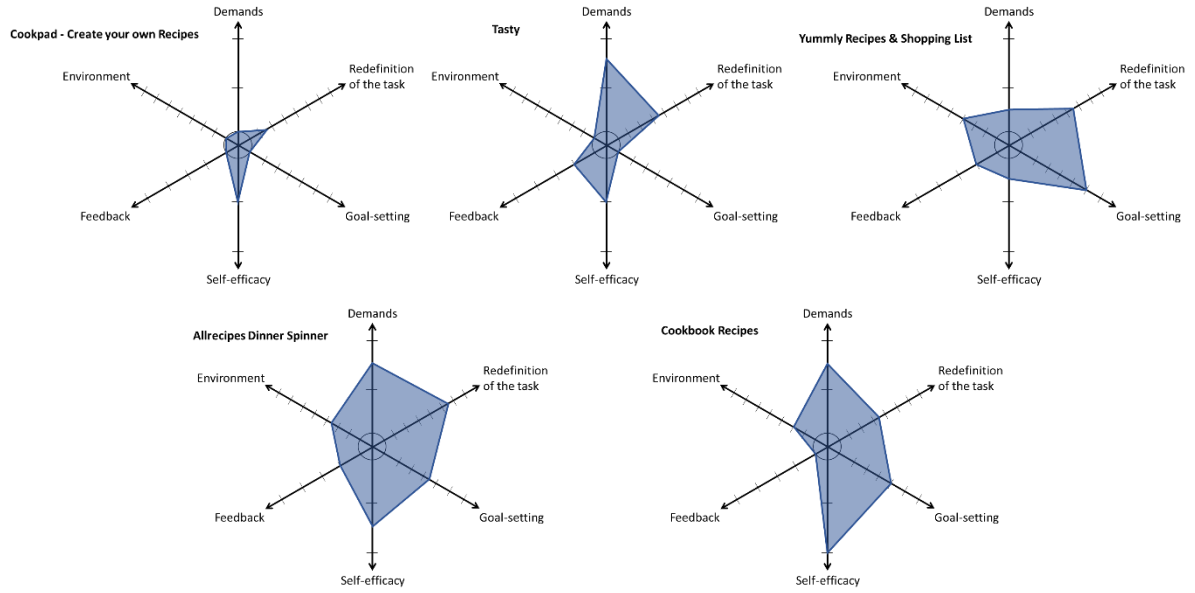


Figure 18 Spider graphs of features supporting a healthy and sustainable diet for the 5 most popular applications on the Google Play store.

3.1.3 Discussion

Although every concept of the behavioural models is supported by some of the reviewed applications there are some observable differences. The least amount of support is provided by means of feedback (10%). Likely this is because feedback for health and sustainability values requires detailed product databases on nutrition and carbon footprint, which are not cost-effective to include into a commercially viable product. Open databases (Gray, 2014) are a cost-effective way for app developers to implement this type of features, but although they exist for nutrition (U.S. Department of Agriculture, 2021) the cost of creating and curating such databases limit their availability across application domains. For instance, a similar extensive and openly available platform for sustainability information does not exist to date.

On the other end of the spectrum, most feature support is provided for self-efficacy (54%) across the reviewed applications. Again, a commercial argument can be made that this information is more readily available as most of the recipe applications included in this study are crowd-sourcing recipes, comments, and likes for free, which are usable for the purpose of supporting self-efficacy. It is not useful for providing precise feedback, though, as this type of user generated content (Krumm, Davies, & Narayanaswami, 2008) often lacks accuracy (Lukyanenko, Parsons, & Wiersma, 2014) and the translation into reliable knowledge representations is still an open research topic (Hitzler, 2021).

Features specific to a healthy diet (1,3,18) were supported much more often than the corresponding features relating to a sustainable diet (2,4,19). This indicates that health is currently considered more relevant than sustainability by the application developers and users consistent with the observations of Biasini et al. (2021), who also found that health is a more prevalent subject than sustainability when it comes to dietary behaviour.

Popularity of an application, which has been used as a selection criterion for this study, does not mean that the application broadly supports healthy or sustainable grocery shopping behaviours. There is no general observable trend, and different applications are useful for supporting different aspects of the process mainly because none of the applications have been explicitly designed for this purpose. For example, the most popular application (Cookpad) has very limited support in this regard (Figure 18, top-left) due to the fact that its main focus is on sharing recipes with others and not on supporting the individual's grocery shopping behaviour. On the other hand, the Dinner Spinner application (Figure 18, bottom-left) can be seen as supporting a much broader range of motivational concepts, which seems to be in line with the overall design goals underpinning this particular application.

The methodology used in this study is closely related to the Heuristic Evaluation approach (Wilson, 2014), which also proposes to evaluate applications using a pre-determined set of heuristics, usually focusing on usability problems (Nielsen, 1994; Nielsen Norman Group, 2021). Despite attempts being made to standardise the process of creating these heuristics (Quiñones, Rusu, & Rusu, 2018), their choice is often ad-hoc and domain specific without any reference to a theoretical approach. In contrast to this, well-established and empirically validated behavioural models (Strong, Parks, Anderson, Winett, & Davy, 2008; Phipps, et al., 2013; Selden & Brewer, 2000; Borgogni & Dello Russo, 2012; Hörisch, Wulfsberg, & Schaltegger, 2020) have the potential to put the focus on the behaviour and cognitive processes of the application users while at the same time formalising the choice of evaluation criteria with respect to behaviour relevant support aspects to supplement the usability criteria used in classical UX design processes (Nielsen, 1994; Nielsen Norman Group, 2021).

3.1.4 Limitations

The main limitation of this study is that the reviewed applications have been designed for commercial purposes and not to optimally support specific behaviour as such. The selection criteria were based on popularity rather than on a measurement of how successful the applications are to influence the behaviour in question. The proposed methodology, however, provides a useful tool for analysing how popularity, which can be seen as a voting mechanism on the perceived usefulness of these applications by the users, and support of motivational concepts match. For example, the most popular of the reviewed applications shows very little support for the behavioural concepts of the behavioural models, as its main focus is on social networking aspects and not on positively influencing the behaviour towards a healthy and sustainable diet.

A second limitation of the proposed approach to analysing applications with respect to their support of behaviour is the ambiguity of matching features to motivational concepts. While the qualitative models as outlined in section 2.1 are used to derive this mapping, the definition is specific to the application domain and has to be adapted accordingly. While this is a shortcoming of the proposed methodology, the link to established behavioural models makes this process more transparent than what is proposed for Heuristic Evaluation.

This leads into the third major limitation of the presented study, which is that as of now sustainability has had very little relevance for commercial grocery shopping smartphone applications. Very few of the most popular applications had explicit support for such features, which is why for example a vegetarian or vegan option has been considered as partial support for

maintaining a sustainable diet although the motivations behind choosing such a diet can be different.

3.1.5 Summary

A methodology for assessing the design of smartphone applications has been presented. Such a model driven approach based on the qualitative behavioural theories developed in section 2.1 not only allows to understand what aspects of the behavioural process are explicitly supported by a tool, but also enables to identify behavioural influence factors that are missing from an application to achieve certain targeted outcomes. It has been found that popularity not necessarily coincides with targeted support for improving healthy and sustainable grocery shopping behaviours and that in particular sustainability is not the key focus of the most commonly used smartphone applications in this domain. However, the presented approach can be used to lead the way towards novel application design and developments of behavioural intervention tools. Behavioural improvement can be achieved by either helping to select the most suitable applications targeting specific aspects of behaviour or by identifying features that are currently missing in existing applications and should be implemented in the future.

3.2 Study II: Survey of intentions and motivations for healthy and sustainable grocery shopping behaviour[3]

The models discussed in section 2 and in particular in subsection 2.2 identified two main quantifiable variables that need to be improved to create a lasting impact on healthy and sustainable grocery shopping behaviour: intention and motivation. The Theory of Planned Behaviour (TPB) (Ajzen, 2006a) proposed the Behavioural Intention (BI) as indicator of intention, while the Self-Determination Theory (SDT) (Ryan & Deci, 2021) proposed the Relative Autonomy Index (RAI) as indicator of motivation (see section 2.2). In the following studies indicators for both healthy and sustainable grocery shopping behaviour are assessed, and their mutual relationships are analysed. This evaluation is structured into three sub-studies, each using different questions, models, and indicators:

1. Study II-a will evaluate self-reported intention and behaviour in relation to both healthy and sustainable grocery shopping (I_H, I_S, B_H, B_S) to answer the following questions:
    a. Are the intentions to act healthily and sustainable at similar levels, and if not, in what way do they differ?
    b. Is behaving healthily considered more likely than behaving sustainably or vice versa, and how does this compare to the intention?
    c. Are there intention-action gaps for healthy and sustainable grocery shopping behaviour, and if so, are there differences in their respective size?
2. Study II-b will evaluate the Behavioural Intention score for healthy and sustainable grocery shopping (BI_H, BI_S) to answer the following questions:
    a. Do the BI scores predict self-reported intention and behaviour in relation to healthy and sustainable grocery shopping?

[3] A shorter version of this study has been accepted to be published by *Frontiers in Nutrition* under the title "*Healthy and sustainable food shopping – A Survey of Intentions and Motivations*" (Blanke, Billieux, & Vögele, 2022).

b. Does a higher immediate intention to shop healthily also imply a higher intention to shop sustainably and vice versa?
c. Are demographic factors, such as gender, age, and education, a predictor for the behavioural intention to buy healthy or sustainable groceries?
d. Are there characteristic segments of individuals determining their intention to act healthy or sustainably, and is there a difference between the two subject areas?

3. Study II-c will evaluate the Relative Autonomy Index for healthy and sustainable grocery shopping (RAI_H, RAI_S) to answer the following questions:
    a. Are the longer-term motivations to act healthily and sustainable at similar levels, and if not, in what way do they differ?
    b. Does a higher general motivation to shop healthily also imply a higher motivation to shop sustainably and vice versa?
    c. Does longer-term motivation translate into short-term intentions in the same way for healthy and for sustainable grocery shopping?
    d. Are demographic factors, such as gender, age, and education, a predictor for the longer-term motivation to buy healthy or sustainable groceries?

3.2.1 Method

The studies presented in this section are based on the integrated quantitative model developed in section 2.2 (cf. Figure 17). An online survey has been developed, which was advertised via email amongst staff (1425 in total) at the Cork Institute of Technology (CIT), a third level education institution in Ireland. 176 participants answered at least one question and out of these a total of N=144 provided replies to all questions. To achieve consistency between the studies, the analysis is based on the latter group only.

The data collection occurred in April/May 2019 including everyone who was a member of staff and had a valid staff email address at that time. The survey included detailed information about the study, the use of the collected data and a consent form (see Appendix B). Participation was voluntary and participants could stop the questionnaire at any time without any disadvantages for them. Anonymity was guaranteed by ensuring that no meta-data was collected (e.g. IP address), which could be used to identify participants. No incentives were involved or given. The study received ethical approval from both the Ethics Review Panel of the University of Luxembourg and the Ethics Review Board of the Cork Institute of Technology.

The questionnaire (see Appendix B) contained 8 sections, which successively included

- a short demographic questionnaire (section one)
- questions asking about the importance of a healthy diet and how healthy participants would classify their personal diet (section two); all answers were measured on 5-point Likert scales.
- a section (three) using the questionnaire structure of the Theory of Planned Behaviour (TPB) (Ajzen, 2006a) looking at attitude (A), subjective norms (SN), and perceived behavioural control (PBC) with respect to healthy grocery shopping behaviour; the strengths of the underlying relevant beliefs were measured on 5-point Likert scales and aggregated into A,SN, and PBC using equal weight averages (cf. section 2.2.1.2).
- a section (four) using the inventory structure of the Self-Determination Theory (SDT) (Ryan & Deci, 2021) to measure intrinsic, identified, introjected, and extrinsic motivation with

respect to healthy grocery shopping behaviour; the strengths of the underlying regulations were measured on 5-point Likert scales and aggregated using equal weight averages (cf. section 2.2.2.3)
- Sections 5, 6 and 7 repeating the structure of sections 2, 3 and 4 assessing sustainable grocery shopping behaviour
- A final question to ask about the importance of additional drivers relevant for grocery shopping (e.g. taste, price, etc.).

The following Table 7 summarises the main quantities that have been assessed in the survey:

Quantity	Abbreviation	Section in questionnaire	m	SD
Self-reported intention to act healthily	I_H	2	1.38	0.69
Self-reported healthy behaviour	B_H	2	0.4	0.86
Self-reported intention to act sustainable	I_S	5	0.77	0.93
Self-reported sustainable behaviour	B_S	5	-0.37	1.03
Behavioural Intention to act healthily (TPB)	BI_H	3	2.33	1.45
Behavioural Intention to act sustainable (TPB)	BI_S	6	0.92	1.28
Relative Autonomy Index with regards to health (SDT)	RAI_H	4	2.12	2.48
Relative Autonomy Index with regards to sustainability (SDT)	RAI_S	7	2.04	2.02

Table 7 Quantities that have been assessed, their abbreviations and reference to the sections in the questionnaire; means and standard deviations obtained in the survey are also presented.

The calculation of Behavioural Intention (BI) and Relative Autonomy Index (RAI) followed the methodology described in sections 2.2.1.2 and 2.2.2.3 was performed using the implementation in the Behavioural Modelling toolbox developed by the People Behaviour and Technology Integration Group (PBTI) at CIT (Nimbus Research Centre, 2019); statistical analysis was conducted using the scipy.stats module (SciPy.org, 2021).

The following respective data analytics approaches have been applied for the three studies (cf. Figure 19):

1. Study II-a: Self-reported intentions and behaviours
   I_H, B_H, I_S, and B_S were measured on a 5-point Likert scale. A t-test between I_H and I_S was used to determine if there is a difference between the two, and the Cohen's d was calculated to quantify the difference (question 1.a). Similarly, a t-test between B_H and B_S was used to determine if there is a significant difference, and again the Cohen's d was calculated to quantify the difference (question 1.b). Finally, a t-test between I_H and B_H was used to determine if there is a significant intention-action gap for healthy grocery shopping, and a t-test between I_S and B_S was used to determine if there is a significant intention-action gap for sustainable grocery shopping. The Cohen's d was calculated to quantify the gap and compare it for healthy and sustainable behaviour (question 1.c).

2. Study II-b: The Behavioural Intention
   The weights w_A^H, w_{SN}^H, and w_{PBC}^H were determined to maximise the Pearson correlation between BI_H and I_H to enable the calculation of the Behavioural Intention score BI_H for health

(cf. section 2.2.1.2). The same calculation was performed to determine the weights w_A^S, w_{SN}^S, and w_{PBC}^S for sustainability, maximising the Pearson correlation between BI_S and I_S. Furthermore, the Pearson correlation between BI_H and B_H and between BI_S and B_S were calculated to verify if the Behavioural Intentions as defined by the TPB predict self-reported intention and behaviour as assessed for study II-a (question 2.a). Then the Pearson correlation between BI_H and BI_S was evaluated to determine if the immediate intention to buy healthy groceries predicts the intention to buy sustainably and vice versa (question 2.b). The influence of demographic factors was evaluated using a t-test between male and female participants, between older and younger participants, and between higher and lower educated participants for both BI_H and BI_S (question 2.c). Finally, the attitudes towards the behaviour A^H and A^S, the subjective norms SN^H and SN^S, and the perceived behavioural control PBC^H and PBC^S were determined for both healthy and sustainable grocery shopping (cf. section 2.2.1.2) and participants were categorised into 8 categories depending on these characteristics being positive or negative to determine if there is a difference between health and sustainability (question 2.d).

3. Study II-c: The Relative Autonomy Index
   RAI_H and RAI_S were calculated for healthy and sustainable grocery shopping respectively. A t-test between the two was used to determine if long-term motivation to act healthily and to act sustainably is different (question 3.a). The Pearson correlation between the two was used to determine if the motivation to buy healthily predicts the motivation to buy sustainably and vice versa (question 3.b). Then, the Pearson correlation between RAI_H and BI_H as well as the Pearson correlation between RAI_S and BI_S was used to evaluate and compare how long-term motivation predicts short term intention to buy healthily and sustainably (question 3.c). Finally, the influence of demographic factors was evaluated using a t-test between male and female participants, between older and younger participants, and between higher and lower educated participants for both RAI_H and RAI_S (question 3.d).

The mutual tests between the variables are visualised in Figure 19.

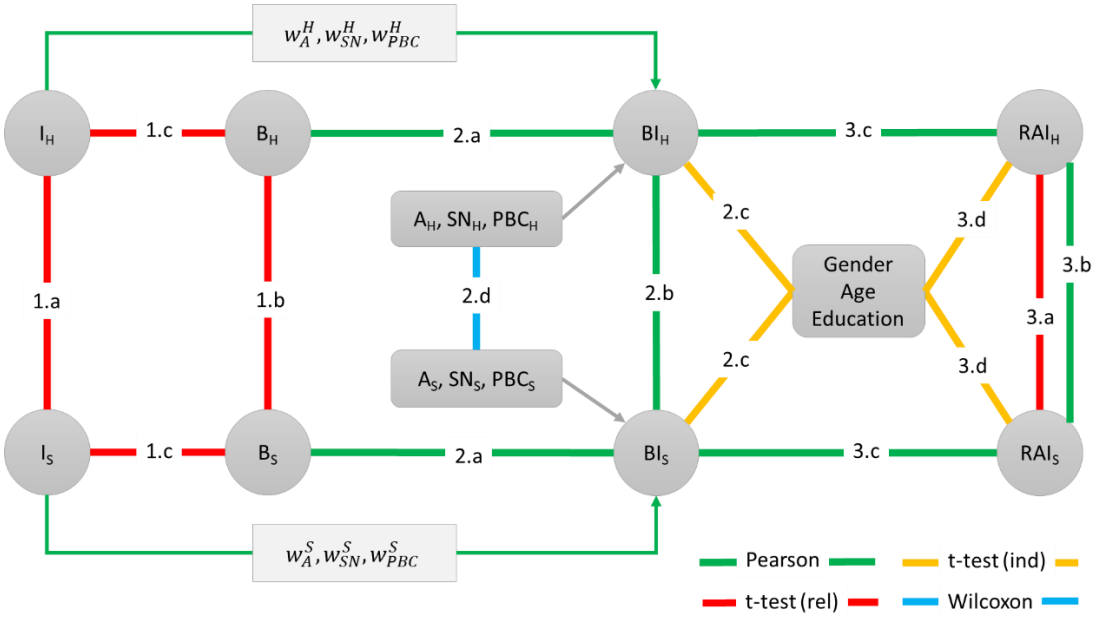


Figure 19 Mutual tests between the variables

Altogether these are 26 tests based on a dataset collected at the same time. To compensate for multiple comparisons a Benjamini-Hochberg correction procedure (Benjamini & Hochberg, 1995) has been applied.

3.2.2 Results

The survey was conducted at the Cork Institute of Technology, Ireland, with N=144 participants in total providing answers for the relevant sections of the questionnaire relating to the TPB and the SDT. Of these 53% were female, 31% male and 16% did not answer this question. One third of participants (33%) were between 45-54 years old, 27% were between 35-44, 17% were between 55-64, and 11% were between 25-34 years old. The age groups with the smallest participant rates were the 18-24 year-olds and the 65+ cohort, with a percentage of 2% and 3% respectively. 6% of participants chose not to disclose their age. The distribution of education level shows that the largest group (48%) was represented by people with a level 9 (Master's) degree followed by 21% holding a level 8 (Bachelor's) degree and 15% with a PhD. Only 16% of participants had a level 7 degree or lower, as would be expected amongst staff of a third level education institution (cf. Figure 20).

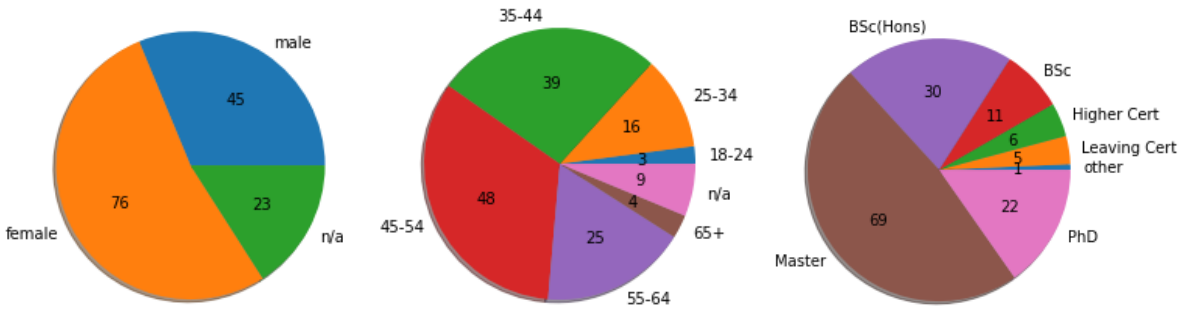


Figure 20 Distribution of participants split according to gender, age, and education level

Three distinct evaluations of the dataset are presented: in subsection 3.2.2.1 the relation between self-reported intentions and behaviour with regards to the two dimensions of health and sustainability is analysed based on sections 2 and 5 of the questionnaire. In subsection 3.2.2.2 the Behavioural Intention (BI) and derived indicators are evaluated for both healthy and sustainable grocery shopping behaviour based on sections 3 and 6 of the questionnaire. A third study is presented in subsection 3.2.2.3 detailing the Relative Autonomy Index (RAI) for both dimensions based on section 4 and 7 of the questionnaire.

3.2.2.1 Study II-a: Self-reported intentions and behaviours

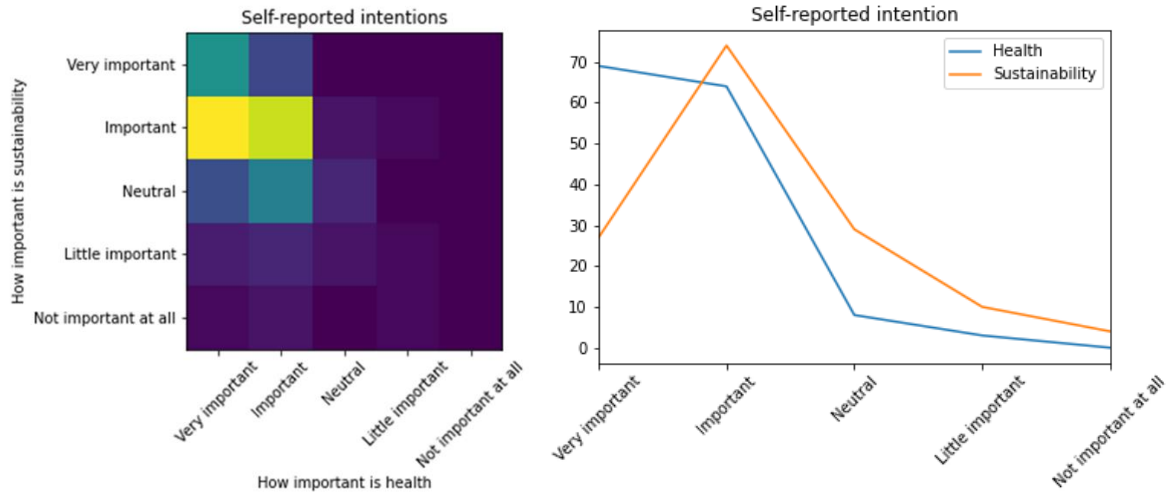
In this section the relationship between self-reported intentions and behaviour in the context of both a healthy diet and sustainable grocery shopping will be analysed. Because achieving a healthy diet in general requires healthy grocery shopping the two are not distinguished explicitly in the following to facilitate comparison with sustainable grocery shopping.

The four dimensions assessed in sections 2 and 5 of the questionnaire (self-reported intention to adhere to a healthy diet I_H, self-reported intention to adhere to a sustainable diet I_S, self-reported healthy diet behaviour B_H, self-reported sustainable diet behaviour B_S) are evaluated with respect to their four pairwise relationships. This study II-a evaluates the self-reported intention, which is distinct to the Behavioural Intention (BI) as it does not refer to any specific theory. The BI and its relation to the self-reported intention will be evaluated later in study II-b presented in section 3.2.2.2 further below.

Self-reported intentions

Self-reported intentions were assessed by asking how personally important health and sustainability was for the participant. A definition for a healthy diet was given to the participants, defined as balanced and based on plenty of vegetables and fruit, less fat - particularly the wrong kinds of fat -, limit intake of sugars and reduced salt intake based on the recommendation of the WHO (World Health Organisation, 2020). The definition for a sustainable diet, also provided to the study participants, encompassed a “reduction of the ecological footprint related to carbon emission, water and energy use as well as less animal-based and more plant-based diets and seasonal products” (Verain M. , Sijtsema, Dagevos, & Antonides, 2017; Hoek, Pearson, James, Lawrence, & Friel, 2017).

Applying a 5-point Likert scale from -2 to 2 to the answer categories the Pearson correlation between the two is $r(142)=0.35$, $p<0.001$. For the question “How important is a healthy diet for you personally?” a mean of $m=1.38$ and a standard deviation of $SD=0.69$ was observed. For the question “How important is sustainability for you when you go grocery shopping?” a mean of $m=0.77$ and a standard deviation of $SD=0.93$ was obtained. There is a significant difference between the self-reported importance of health and sustainability, $t(143)=7.84$, $p=<0.001$, with health being considered more important than sustainability by participants, Cohen's $d = 0.56$ (question 1.a). This result reflects the main focus of interest in the last decades, which was heavily laying on supporting healthy diets, while sustainability, in particular with regards to food, is a more recent topic of interest (see chapter 1.2). The obtained data is visualised in the following Figure 21 showing the observed relationship between the self-reported intention regarding a healthy diet and sustainable grocery shopping.



How important is sustainability						
	Very important	13.2% (19)	5.6% (8)	0	0	0
	Important	25.7% (37)	23.6% (34)	1.4% (2)	0.7% (1)	0
	Neutral	6.2% (9)	11.1% (16)	2.8% (4)	0	0
	Little important	2.1% (3)	2.8% (4)	1.4% (2)	0.7% (1)	0
	Not important at all	0.7% (1)	1.4% (2)	0	0.7% (1)	0
		Very important	**Important**	**Neutral**	**Little important**	**Not important at all**
	How important is health					

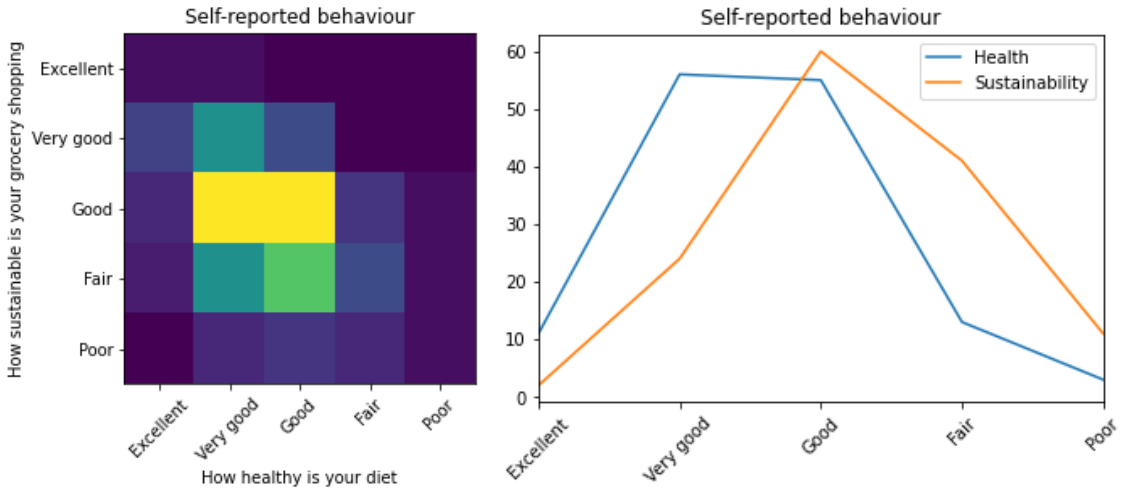
Figure 21 Self-reported intentions with respect to health and sustainability: contingency table (bottom), 2d histogram (top left), and marginal histogram (top right)

It can be observed in Figure 21 that the range in health responses is smaller compared to the sustainability dimension, where the whole spectrum of response categories is covered, which is also reflected in the standard deviations of the two. A quarter of participants find health very important and also show a tendency to find sustainability important as well (25.7%).

Self-reported behaviour

Similar to the self-reported intentions presented in the subsection before, participants were asked to self-report on their actual behaviour with regards to healthy and sustainable grocery shopping. Again applying a 5-point Likert scale from -2 to 2 to the answer categories the Pearson correlation between the two was $r(136)=0.4$, $p<0.001$. For the question “In general, how healthy is your overall diet?” a mean of $m=0.4$ with a standard deviation of $SD=0.86$ was shown. For the question “In general, how sustainable is your overall grocery shopping behaviour?” a mean of $m=-0.37$ and a standard deviation of $SD=1.03$ was obtained.

As for the self-reported intentions, the self-reported behaviour also shows a significant difference between health and sustainability, t(137)=8.22, p=<0.001, with healthy behaviour being considered to be executed more than sustainable grocery shopping behaviour by participants, Cohen's d = 1.95. Hence, the self-reported difference between health and sustainability is much larger when it comes to the perception of the own actual behaviour compared to the perception of the own intentions, where we observed a Cohen's d = 0.56 (question 1.b). The following Figure 22 visualises the data for this observed relationship between these self-reported behaviours regarding a healthy diet and sustainable grocery shopping.



How sustainable is your grocery shopping						
	Excellent	0.7% (1)	0.7% (1)	0	0	0
	Very good	3.6% (5)	9.4% (13)	4.3% (6)	0	0
	Good	2.2% (3)	18.8% (26)	18.8% (26)	2.9% (4)	0.7% (1)
	Fair	1.4% (2)	9.4% (13)	13.8% (19)	4.3% (6)	0.7% (1)
	Poor	0	2.2% (3)	2.9% (4)	2.2% (3)	0.7% (1)
		Excellent	**Very good**	**Good**	**Fair**	**Poor**
	How healthy is your diet					

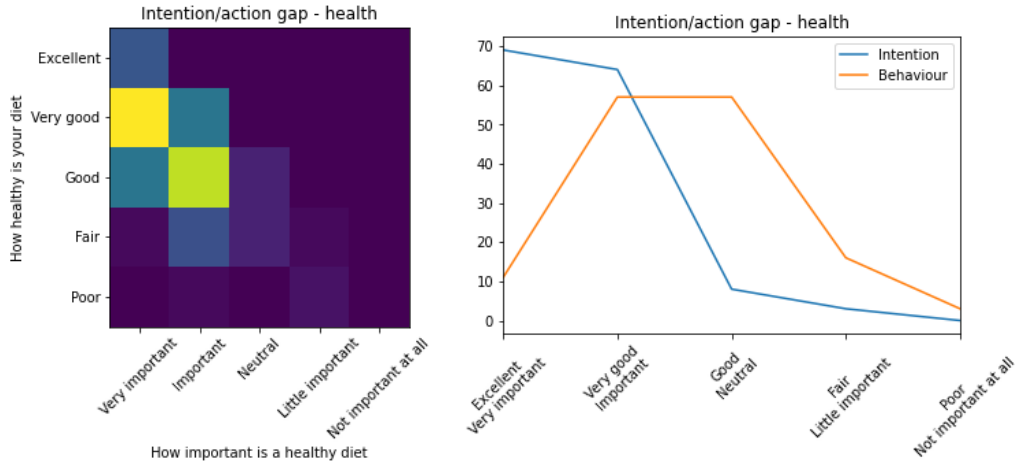
Figure 22 Self-reported behaviour with respect to health and sustainability: contingency table (bottom), 2d histogram (top left), and marginal histogram (top right)

Comparing Figure 22 with Figure 21 shows a more symmetric relationship between self-reported behaviour compared to the self-reported intention when it comes to the spread over response categories.

Self-reported intention-action gap

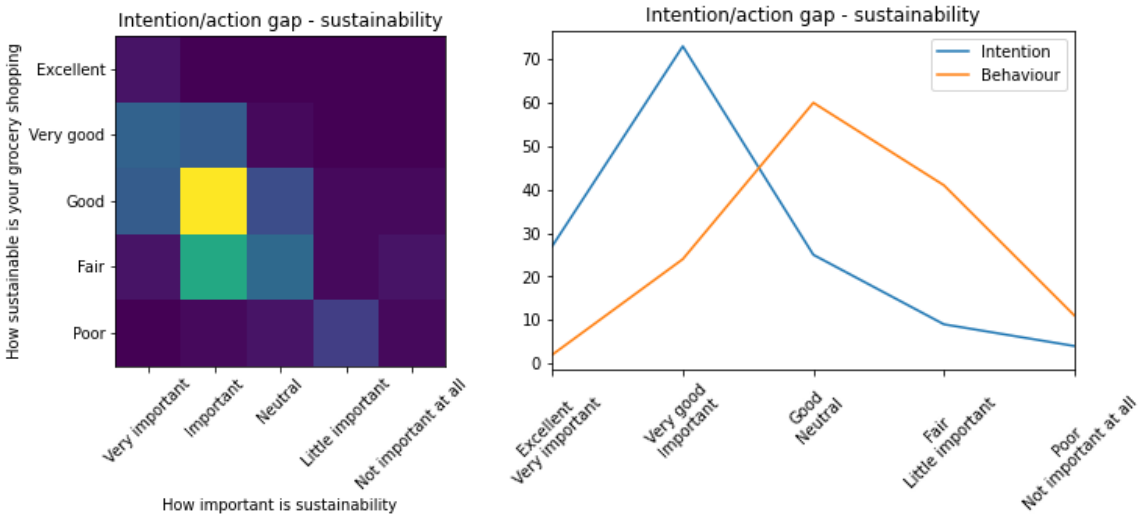
It remains to see how this self-reported intention and self-reported behaviour relate within the two dimensions of health and sustainability. The Pearson correlation between the two for health is r(142)=0.64, p<0.001, and it is r(136)=0.57, p<0.001, for sustainability. The difference between intention and behaviour is also significant in both cases, with t(143)=17.42, p<0.001, for health and t(137)=14.7, p<0.001, for sustainability. The difference can be quantified with a Cohen's d=0.97 for health and a Cohen's d=1.78 for sustainability, showing that the expected intention-action/behaviour gap, attitude-behaviour gap, or the knowing-doing gap (Ajzen, 2016; Grunert, 2011; Hoek, Pearson, James, Lawrence, & Friel, 2017; de Schutter, 2015; Bailey & Harper, 2015) exists and is larger for sustainability (question 1.c). Figure 23 and Figure 24 depict the data for these

relationships between the self-reported intention and self-reported behaviour for healthy and sustainable dieting.



How healthy is your diet						
	Excellent	7.6% (11)	0	0	0	0
	Very good	28.5% (41)	11.1% (16)	0	0	0
	Good	11.1% (16)	25.7% (37)	2.8% (4)	0	0
	Fair	0.7% (1)	6.9% (10)	2.8% (4)	0.7% (1)	0
	Poor	0	0.7% (1)	0	1.4% (2)	0
		Very important	**Important**	**Neutral**	**Less important**	**Not important at all**
	How important is a healthy diet					

Figure 23 Self-reported intention and behaviour with respect to health: contingency table (bottom), 2d histogram (top left), and marginal histogram (top right)



How sustainable is your grocery shopping	**Excellent**	1.4% (2)	0	0	0	0
	Very good	8.7% (12)	8% (11)	0.7% (1)	0	0
	Good	8% (11)	27.5% (38)	6.5% (9)	0.7% (1)	0.7% (1)
	Fair	1.4% (2)	16.7% (23)	9.4% (13)	0.7% (1)	1.4% (2)
	Poor	0	0.7% (1)	1.4% (2)	5.1% (7)	0.7% (1)
		Very important	**Important**	**Neutral**	**Little important**	**Not important at all**
	How important is sustainability					

Figure 24 Self-reported intention and behaviour with respect to sustainability: contingency table (bottom), 2d histogram (top left), and marginal histogram (top right)

Summary and discussion

The key indicators for study-II-a results are summarised in Table 8 as follows:

	1st variable	2nd variable	d	p	α_{BH}	reject H_0
1.a	I_H	I_S	0.56	<0.001	0.008	yes
1.b	B_H	B_S	1.95	<0.001	0.006	yes
1.c	I_H	B_H	0.97	<0.001	0.002	yes
	I_S	B_S	1.78	<0.001	0.004	yes

Table 8 Main study II-a results

There are three main outcomes of study II-a: first, the intention to buy more healthily is higher than the intention to buy sustainably, which also translates into the perception of the likelihood of the corresponding behaviour being carried out. This is consistent with the findings of de Shutter (2015) and Hoek et al. (2017), who also conclude that health is a more important driver compared to sustainability for dietary behaviour.

Second, the difference between health and sustainability is larger for the actual behaviours in comparison to the intentions, which indicates that participants find it easier to act on their

intentions to buy healthy groceries and that therefore translation into actual behaviour is less likely for sustainable grocery shopping.

Finally, an intention-action gap can be observed for both health and sustainability, with the gap being smaller for health than for sustainability. While an intention-action-gap is to be expected for many behaviours (Steg & Vlek, 2009), it is interesting to observe that, again, sustainability is perceived to be more difficult to act on.

3.2.2.2 Study II-b: The Behavioural Intention

In this section the Behavioural Intention (BI) as derived in section 2.2.1 will be analysed in the context of the two application domains of health and sustainability. It has been designed to measure the intention or the subjective probability of a person to perform a behaviour in respect to a given object (Fishbein & Ajzen, 1975) and therefore is an indicator of the condition shortly before showing a behaviour in question (Ajzen, 2006a). The evaluation is based on sections 3 and 6 of the questionnaire, which have been structured according to the Theory of Planned Behaviour (TPB) (Ajzen, 2006b) looking at attitude, subjective norms, and perceived behavioural control with respect to healthy and sustainable grocery shopping behaviour.

The answers from the questionnaire are aggregated as outlined in section 2.2.1 and the weights are determined to maximise the correlation between the Behavioural Intention and the self-reported intentions already used in the previous subsection. The optimal weights determined are summarised in Table 9:

	Health (BI_H)	**Sustainability (BI_S)**
Attitudes	$w_A^H = 1.4$	$w_A^S = 1.6$
Subjective norms	$w_{SN}^H = 1.0$	$w_{SN}^S = 0.5$
Perceived behavioural control	$w_{PBC}^H = 0.5$	$w_{PBC}^S = 0.5$

Table 9 Weights for calculating the Behavioural Intention, which maximise the correlation between self-reported intention and BI score for both health and sustainability.

The resulting maximal Pearson correlation between the Behavioural Intention BI_H and the self-reported intention I_H is $r(142)=0.41$, $p<0.001$, for health, while the resulting maximal correlation between BI_S and I_S is $r(142)=0.55$, $p<0.001$, for sustainability showing that the Behavioural Intention score can be used to predict self-reported intention (question 2.a, intention). In both cases, the weight for the attitude component is largest, indicating that behavioural beliefs are the strongest of the three predictors of intention. Using these weights, the Pearson correlation between the Behavioural Intention BI_H and the self-reported behaviour B_H can be calculated to be $r(142)=0.44$, $p<0.001$, showing that the BI score predicts healthy grocery shopping behaviour as postulated by the TPB. The same is true for sustainable grocery shopping behaviour, where a significant Pearson correlation of $r(142)=0.46$, $p<0.001$, between BI_S and B_S has been observed (question 2.a, behaviour). Figure 25 visualises these four joint distributions:

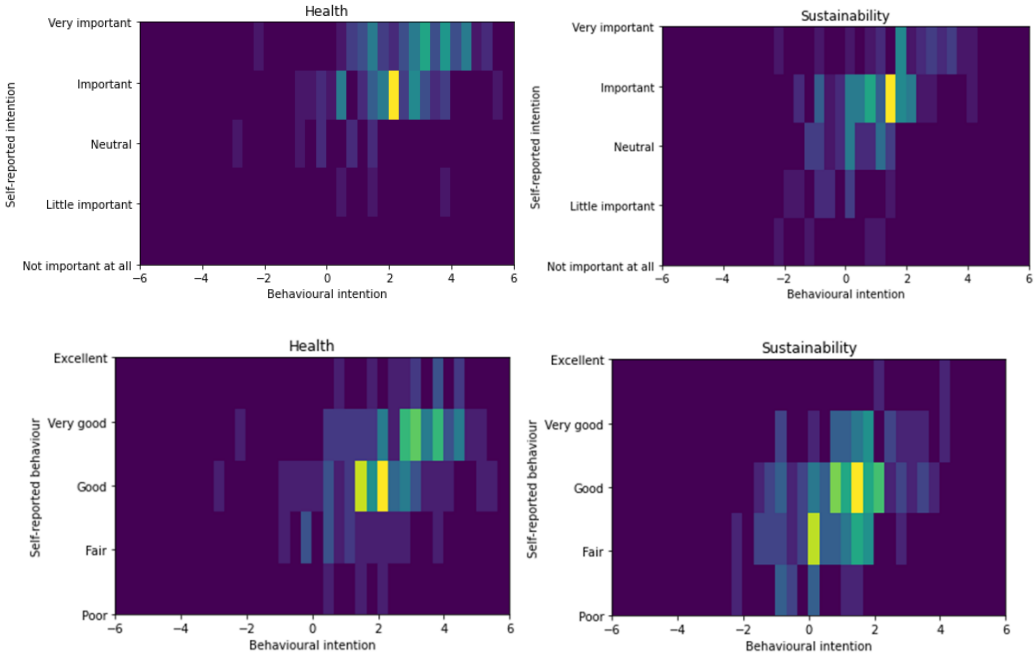


Figure 25 Distribution of Behavioural Intention and self-reported intention and behaviour: BI_H vs. I_H (top left), BI_S vs. I_S (top right), BI_H vs. B_H (bottom left), BI_S vs. B_S (bottom right)

The mean Behavioural Intention score for maintaining a healthy diet BI_H has been m=2.33 with a standard deviation of SD=1.45, while the mean Behavioural Intention score for sustainable grocery shopping behaviour BI_S is m=0.92 with a standard deviation of SD=1.28. As in the case of self-reported intentions (question 1.a) a significant difference, t(143)=9.29, p<0.001, between the two can be observed, with the intention to act healthily being higher than the intention to act sustainably (Cohen's d=1.04). However, the Behavioural Intention to buy healthy groceries BI_H and the Behavioural Intention to buy sustainable groceries BI_S has been found to be only very weakly correlated, r(142)=0.12, p=0.16 (question 2.b). The joint distribution of BI_H and BI_S is visualised in the following Figure 26:

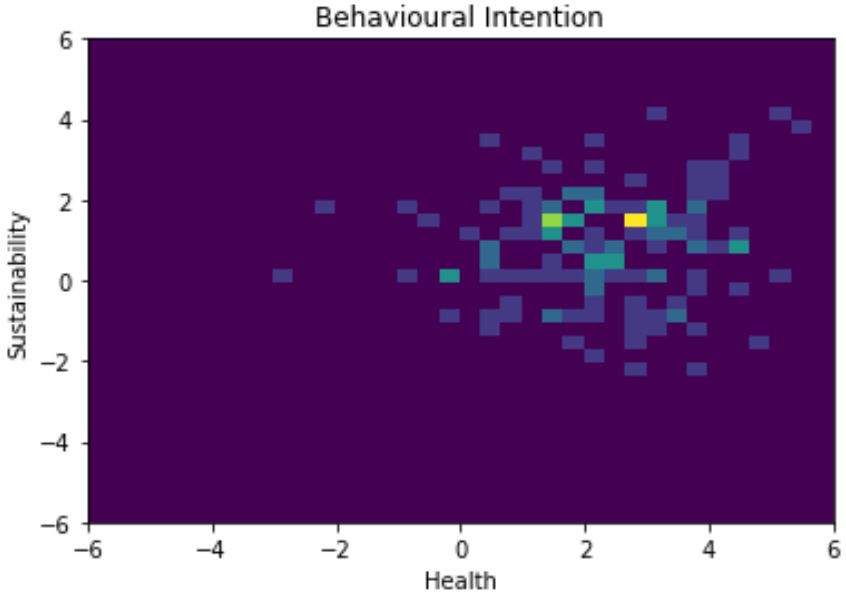


Figure 26 Joint distribution of Behavioural Intentions with respect to health (BI_H) and sustainability (BI_S).

Consideration of demographics

The BI scores have also been analysed with respect to demographic factors gender, age, and level of education. However, none of these demographic indicators exhibits a significant relationship with the measured behavioural intention (question 2.c): the difference of BI_H score between male and female participants is t(119)=-0.1, p=0.92, the difference of BI_H score between younger (<35 years) and older participants is t(133)=-1.57, p=0.12, and the difference of BI_H score between participants with postgraduate education and non-postgraduate education is t(142)=-0.4, p=0.69. While these results are all within the margin of statistical error, the strongest prediction of behavioural intention with regards to health is by age, with older participants showing slightly higher intentions to follow a healthy diet.

The same analysis with respect to sustainable grocery shopping behaviour also shows no significant relationship between the demographic indicators and the BI score: the difference of BI_S score between male and female participants is t(119)=-0.77, p=0.44, the difference of BI_S score between younger (<35 years) and older participants is t(133)= 0.19, p=0.85, and the difference of BI_S score between participants with postgraduate education and non-postgraduate education is t(142)=-0.25, p=0.8.

Figure 27 shows the distribution of BI_H with respect to healthy grocery shopping behaviour split according to demographics:

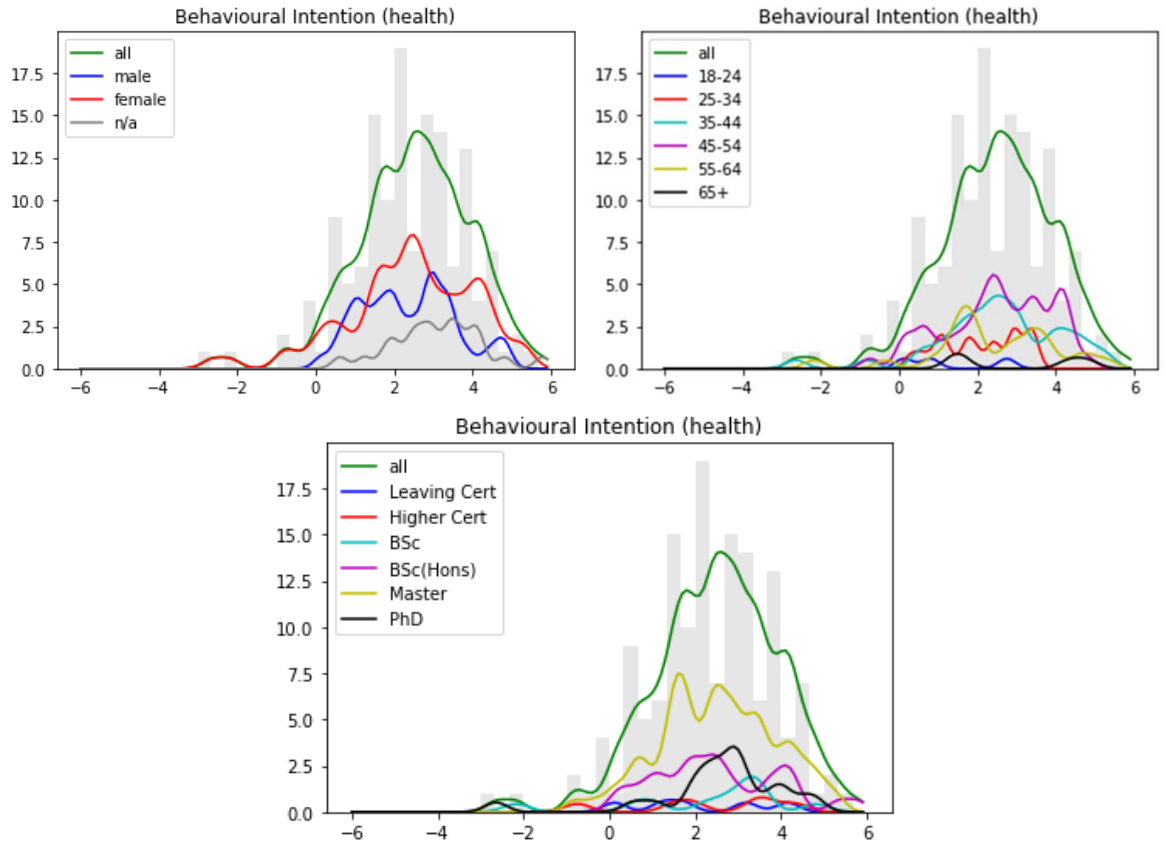


Figure 27 Distribution of Behavioural Intention with regards to healthy diet (BI_H) split into gender categories (top,left), age (top,right), and education level (bottom)

Figure 28 shows the distribution of BI_S score split into gender, age, and education level:

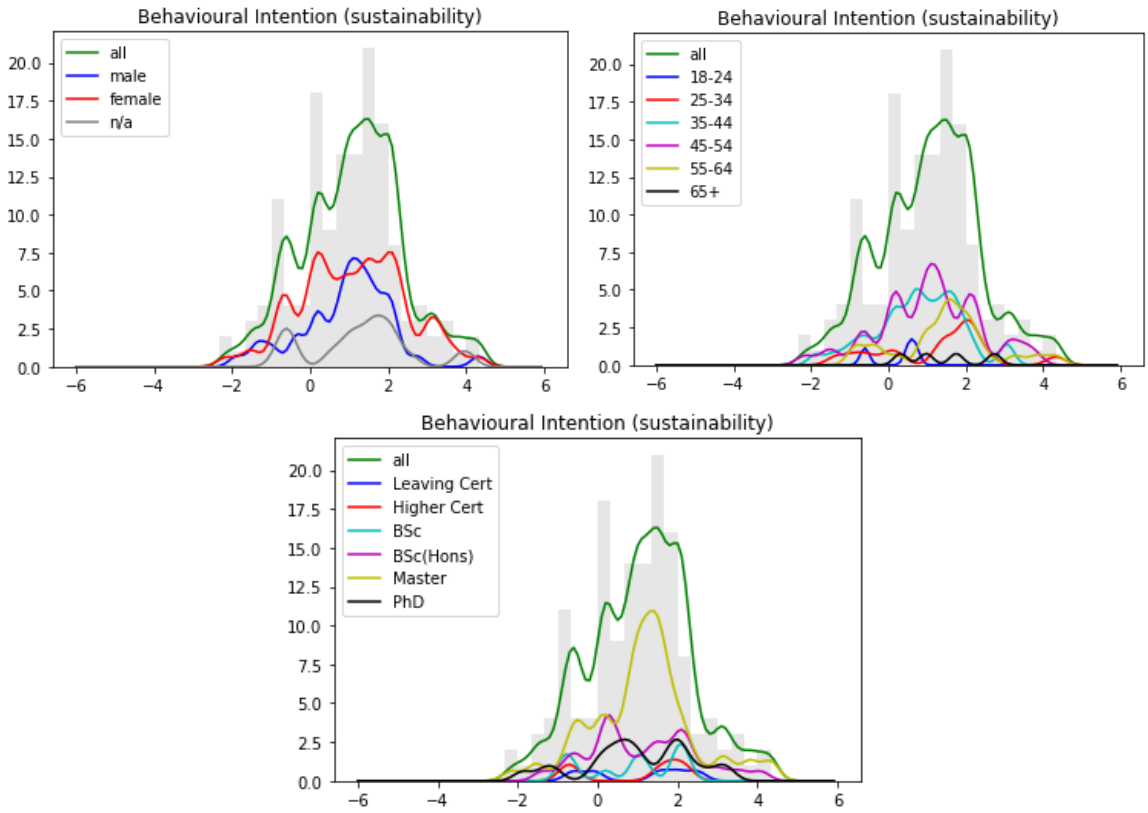


Figure 28 Distribution of Behavioural Intention with regards to sustainable grocery shopping (BI_S) split into gender categories (top,left), age (top,right), and education level (bottom)

Despite the zeitgeist postulating environmental issues to become more and more relevant for younger people and some studies suggesting a higher awareness of sustainability amongst younger and higher educated people (Rippl, 2004), this did not manifest itself in the presented study with respect to concrete behavioural intentions in relation to sustainable grocery shopping behaviour, yet.

Persona segments

The Behavioural Intention score is calculated as a combination of three underlying influence factors (cf. section 2.2.1.2): attitude, social pressure awareness, and perceived behavioural control. Instead of only considering the aggregated BI score, those three can be analysed individually, allowing to characterise each participant depending on the combination of strength of the individual factors. These can then for instance be used to further refine the design of the communication towards intervention participants in the way personas are created in the context of UX design frameworks (Matthews, Judge, & Whittaker, 2012). For example, a person showing a positive attitude towards sustainable grocery shopping but low social pressure awareness and limit perceived behavioural control over the environment will react positively to information, will show a limited reaction towards role model behaviour and requires good action plans to stick to a sustainable behaviour. By identifying to which group someone belongs it is possible to use this approach to personalise

information and interventions accordingly. Partitioning each of these three dimensions into either high (>0) or low (<0) eight different personas can be distinguished as listed in Table 10:

	Attitude	*Social pressure awareness*	*Perceived behavioural control*
A	positive	high	high
B	Positive	low	High
C	Positive	High	Low
D	positive	Low	Low
E	Negative	High	High
F	Negative	Low	High
G	Negative	High	Low
H	Negative	Low	Low

Table 10 List of the eight different personas depending on the combination of the three influence factors attitude, social pressure awareness, and perceived behavioural control

The following Figure 29 visualises the number of occurrences of these different personas of participants with respect to both aspects, health and sustainability:

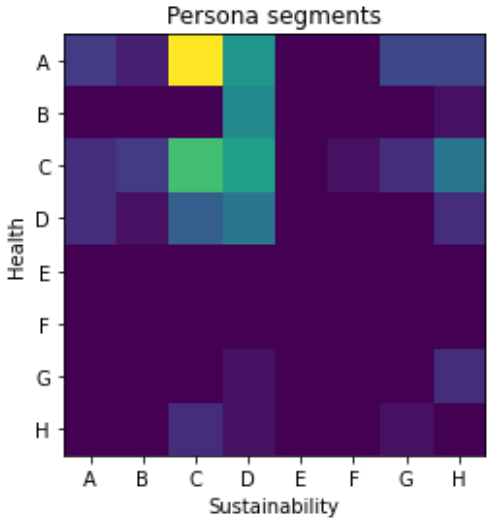


Figure 29 2D histogram of the segmentation of participants into different personas with regards to health and sustainability.

		Sustainability								
		A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	
Health	**A**	2.8% (4)	1.4% (2)	16% (23)	8.3% (12)	0	0	3.5% (5)	3.5% (5)	35.4% (51)
	B	0	0	0	7.6% (11)	0	0	0	0.7% (1)	8.3% (12)
	C	2.1% (3)	2.8% (4)	11.1% (16)	9% (13)	0	0.7% (1)	2.1% (3)	6.3% (9)	34% (49)
	D	2.1% (3)	0.7% (1)	4.9% (7)	6.3% (9)	0	0	0	2.1% (3)	16% (23)
	E	0	0	0	0	0	0	0	0	0
	F	0	0	0	0	0	0	0	0	0
	G	0	0	0	0.7% (1)	0	0	0	2.1% (3)	2.8% (4)
	H	0	0	2.1% (3)	0.7% (1)	0	0	0.7% (1)	0	3.5% (5)
		6.9% (10)	4.9% (7)	34% (49)	32.6% (47)	0	0.7% (1)	6.3% (9)	14.6% (21)	100% (144)

Table 11 The corresponding contingency table for Figure 29

The group that stands out is the "AC" persona (16%), i.e. participants that are characterised by positive attitude, high social pressure awareness and high perceived behavioural control towards health while showing a positive attitude, high social pressure awareness and low perceived behavioural control with regards to sustainability. People in this group can be described as generally positive in the context of healthy eating behaviour and sustainable grocery shopping. Furthermore, they are strongly influenced by social pressure from their environment and meaningful others to act according to social norms and expectations with respect to both dimensions. While this group feels that they have a high level of behavioural control towards healthy eating and grocery shopping behaviour, the perceived level of control to act accordingly is lower in the context of sustainability.

The second strongest group is "CC" (11.1%), who show positive attitude, high social pressure awareness, and low perceived behavioural control in regard to both health and sustainability. This group can be characterised with a positive attitude towards both aspects, while at the same time being socially aware of their environment and what other people say, think and expect. The "CC" persona therefore distinguishes from the "AC" group in that the perceived behavioural control is lower in the health dimension, too.

Overall, more than 87% of participants feel a low perceived behavioural control with regards to sustainability as opposed to 56% of participants who feel the same with regards to healthy eating behaviour (question 2.d). The difference is significant as indicated by a Wilcoxon signed rank test resulting in $W=1070$, $p<0.001$, indicating that people find it more difficult to act sustainable than they find it to act healthily.

Summary and discussion

The main outcomes of study II-b are summarised in Table 12:

	1st variable	2nd variable	r	p	α_{BH}	reject H_0
	BI_H	I_H	0.41	<0.001	0.019	yes
	BI_S	I_S	0.55	<0.001	0.01	yes
2.a	BI_H	B_H	0.44	<0.001	0.017	yes
	BI_S	B_S	0.46	<0.001	0.013	yes
2.b	BI_H	BI_S	0.12	0.16	0.029	no
2.c	BI_H	gender		0.92	0.048	no
	BI_H	age		0.12	0.025	no
	BI_H	education		0.69	0.04	no
	BI_S	gender		0.44	0.037	no
	BI_S	age		0.85	0.046	no
	BI_S	education		0.8	0.044	no
2.d	PBC_H	PBC_S		<0.001	0.021	yes

Table 12 Main results of study II-b. The first two lines are the validation of the correlation between BI score and self-reported intention after the optimisation of the weights.

There are four main outcomes of study II-b: first, the behavioural intention score as defined by the TPB indeed predicts intention and behaviour, which has been one of the main assumptions throughout this work. This is in line with the many studies based on the TPB (Biasini, et al., 2021), which also were able to empirically validated its applicability to various different scenarios (Ajzen, 2016).

Second, only a very weak correlation between the behavioural intentions to act healthily and to act sustainably has been observed. This suggests that the two topics need to be addressed independently, which is not always the case, in particular when health is seen as a part of a sustainable diet or vice versa (e.g. (de Gavelle, et al., 2019; Biasini, et al., 2021)).

Third, no statistically significant dependence of the behavioural intention towards any of the demographic factors was observed when it comes to healthy or sustainable food shopping behaviour in this survey. This is in contrast to the findings of Ripple (2004), who postulates higher awareness of sustainability amongst younger and higher educated people, and points to a potential bias in the survey population towards higher educated participants, which is a limitation of the presented study.

Finally, perceived behavioural control has been found to be much lower for sustainability in comparison to healthy dietary behaviour. This suggests that there is a lot of potential for improving sustainable behaviour by information campaigns to consumers and by providing more detailed guidance, such as for example through product labelling with respect to environmental impacts similar to the nutrition labelling schemes already commonly applied in the health domain (National Health Service, 2021).

3.2.2.3 Study II-c: The Relative Autonomy Index

In this section the Relative Autonomy Index (RAI) as derived in section 2.2.2 will be evaluated in the context of the two application domains of health and sustainability, analogous to the study presented in the previous section 3.2.2.2. The RAI was designed to measure the type of motivation

on a spectrum from extrinsic to intrinsic regulation (Ryan & Deci, 2021) and can be used to shape intervention design in addition to the intentions and personas discussed before.

In contrast to the intention considered in the previous section, which is the condition shortly before showing a behaviour in question (Ajzen, 2006a), motivation is seen as a more general tendency towards a specific subject area. The evaluation in this section is based on sections 4 and 7 of the questionnaire, which have been structured according to the Self-Determination Theory (SDT) (Ryan & Deci, 2021) looking at intrinsic, identified, introjected, and extrinsic motivation with respect to healthy and sustainable grocery shopping behaviour. The SDT assumes that the higher the RAI the more intrinsic the motivation, i.e. that the behaviour is self-driven and out of curiosity or joy. On the other end of the spectrum, a low RAI corresponds to a more extrinsic motivational type, i.e. the behaviour is driven by external incentives or to avoid punishment. Unlike the Behavioural Intention (BI) discussed above, the motivational type as measured by the RAI indicates a similarity with respect to general interest in both topics.

Overall, the mean RAI_H for maintaining a healthy diet has been m=2.12 with a standard deviation of SD=2.48, while the mean RAI_S for sustainable grocery shopping behaviour is m=2.04 with a standard deviation of SD=2.02.

The Relative Autonomy Index with respect to healthy eating behaviour RAI_H is very similar to the Relative Autonomy Index with regard to sustainably RAI_S, $t(143)=0.39$, $p=0.7$, Cohen's $d=0.03$ (question 3.a). This compares with a significant difference for the Behavioural Intention, indicating that the general motivational type with regards to the two topics is similar but does not translate into immediate intention in the same way. Also unlike in the case of the BI, a significant Pearson correlation of $r(142)=0.49$, $p<0.001$, between the two dimensions of healthy and sustainable grocery shopping can be observed (question 3.b). Hence, the motivational type of a person with regards to one subject area of healthy or sustainable grocery shopping predicts the other. In other words, the data shows that an intrinsically motivated person with respect to healthy food choices is also intrinsically motivated to follow a more sustainable diet and that consequently similar incentives and positive supports should be applicable in both domains.

The following Figure 30 shows the joint distribution of the Relative Autonomy Index RAI_H and RAI_S in the two dimensions of health and sustainability:

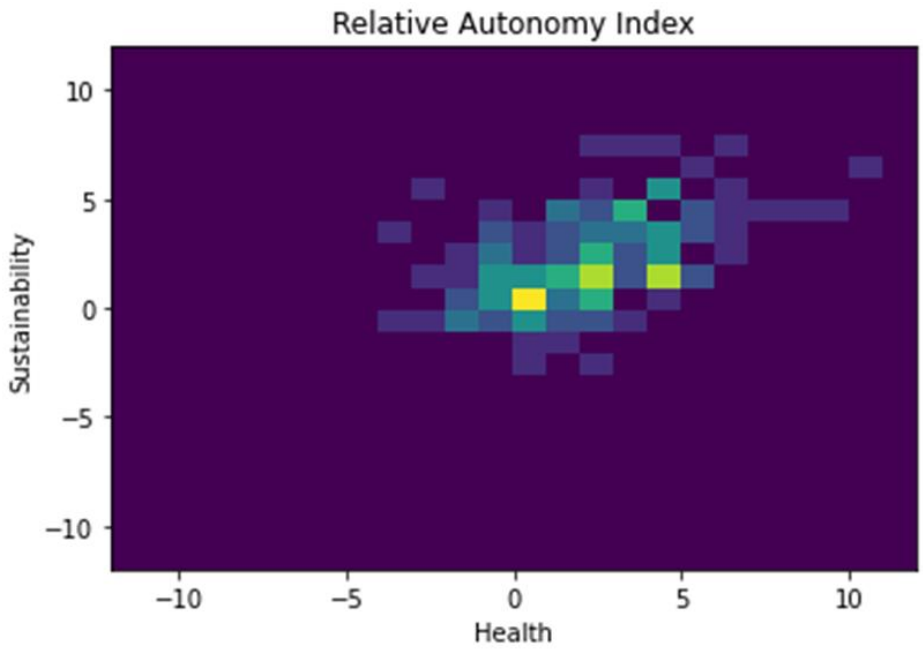


Figure 30 Joint distribution of the Relative Autonomy Index with regards to health (RAI_H) and sustainability (RAI_S).

Next, the relationship between Relative Autonomy Index (RAI) and Behavioural Intention (BI) is analysed. A significant Pearson correlation of $r(142)=0.44$, $p<0.001$, between RAI_H and BI_H can be observed indicating that intrinsic motivation translates into positive behavioural intention for healthy diet choices. This is also the case for translating the general motivation to act sustainably into intention, with a significant correlation between RAI_S and BI_S observed, $r(142)=0.23$, $p<0.01$ (question 3.c). However, the correlation is much smaller for the latter, indicating that general motivation towards sustainable grocery shopping does not translate into more immediate behavioural intention as strongly as for health. This finding is consistent with the analysis of dominant persona segments above, where the perceived behavioural control was found to be lacking for a significant proportion of participants when it comes to sustainable grocery shopping behaviour. The joint distributions are depicted in Figure 31:

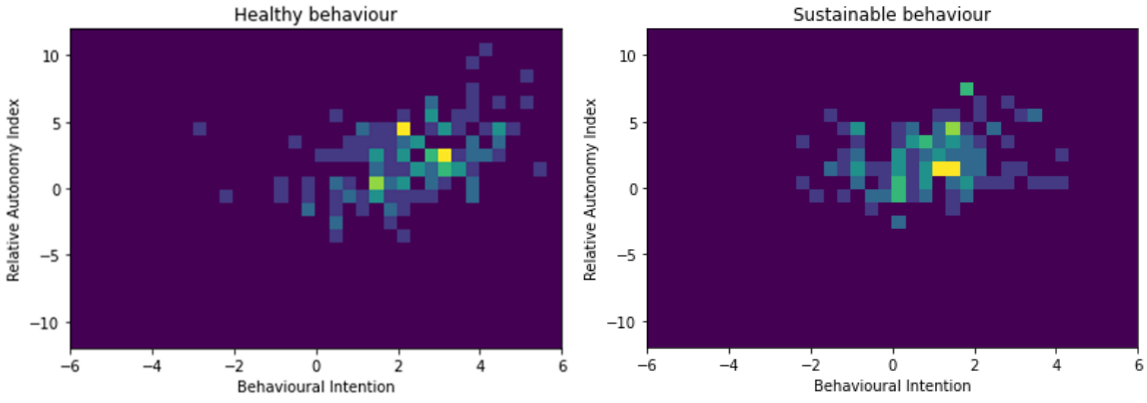


Figure 31 Joint distribution between Behavioural Intention (BI) and Relative Autonomy Index (RAI) with regards to health (left) and sustainability (right).

Consideration of demographics

The measured RAI has also been analysed with respect to demographic factors gender, age, and level of education. None of these demographic indicators shows a significant relationship with the measured motivational types (question 3.d): the difference of RAI between male and female participants is t(119)=0.45, p=0.66, the difference of RAI between younger (<35 years) and older participants is t(133)=-0.08, p=0.94, and the difference of RAI between participants with postgraduate education and non-postgraduate education is t(142)=-1.25, p=0.21.

The same is the case for the motivational type in relation to sustainable grocery shopping behaviour, with no significant relationship between the demographic indicators and the RAI observable: the difference of RAI between male and female participants is t(119)=-1.26, p=0.21, the difference of RAI between younger (<35 years) and older participants is t(133)=1.42, p=0.16, and the difference of RAI between participants with postgraduate education and non-postgraduate education is t(142)=0.85, p=0.4. Overall, demographics has been seen to not have a significant influence on the motivational type, both with regards to healthy as well as with regards to sustainable grocery shopping behaviour.

Figure 32 shows the distribution of RAI_H with respect to healthy grocery shopping behaviour split into the demographic groups:

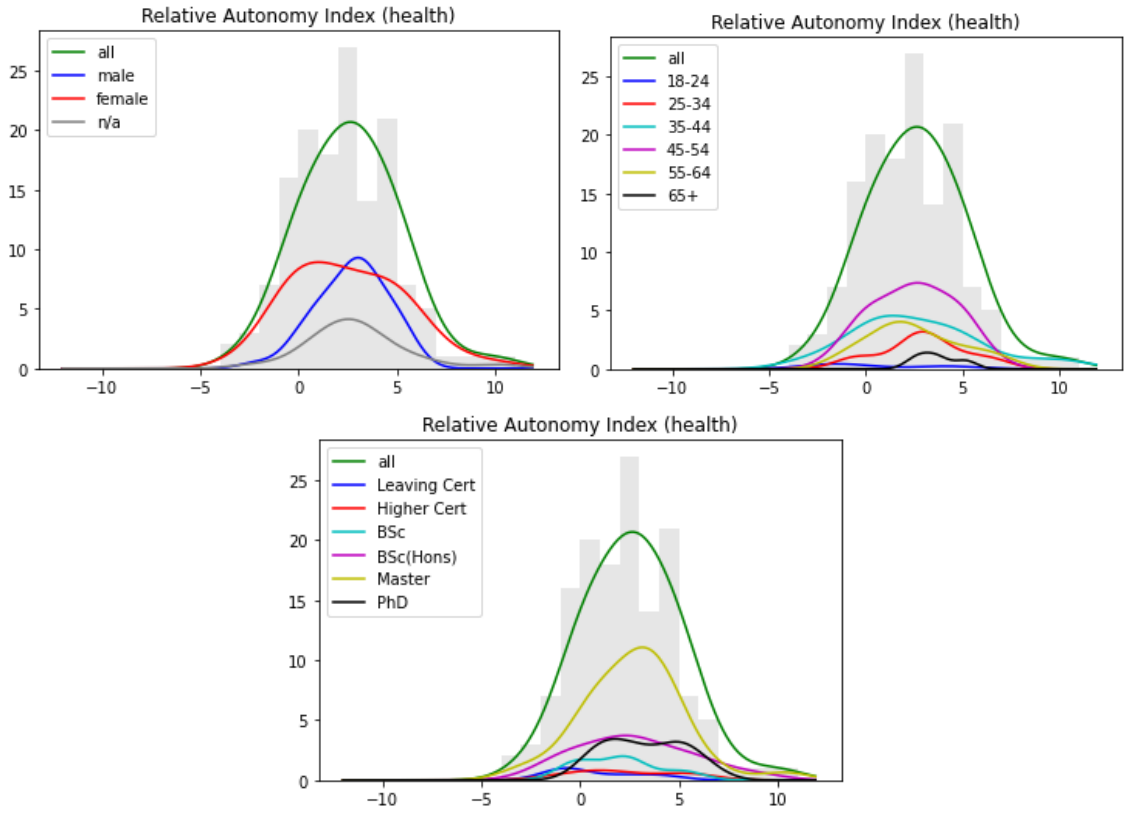


Figure 32 Distribution of Relative Autonomy Index (RAI) with regards to healthy diet split into gender categories (top,left), age (top,right), and education level (bottom)

Figure 33 depicts the distribution of RAI_S with respect to sustainability split into gender, age, and education level:

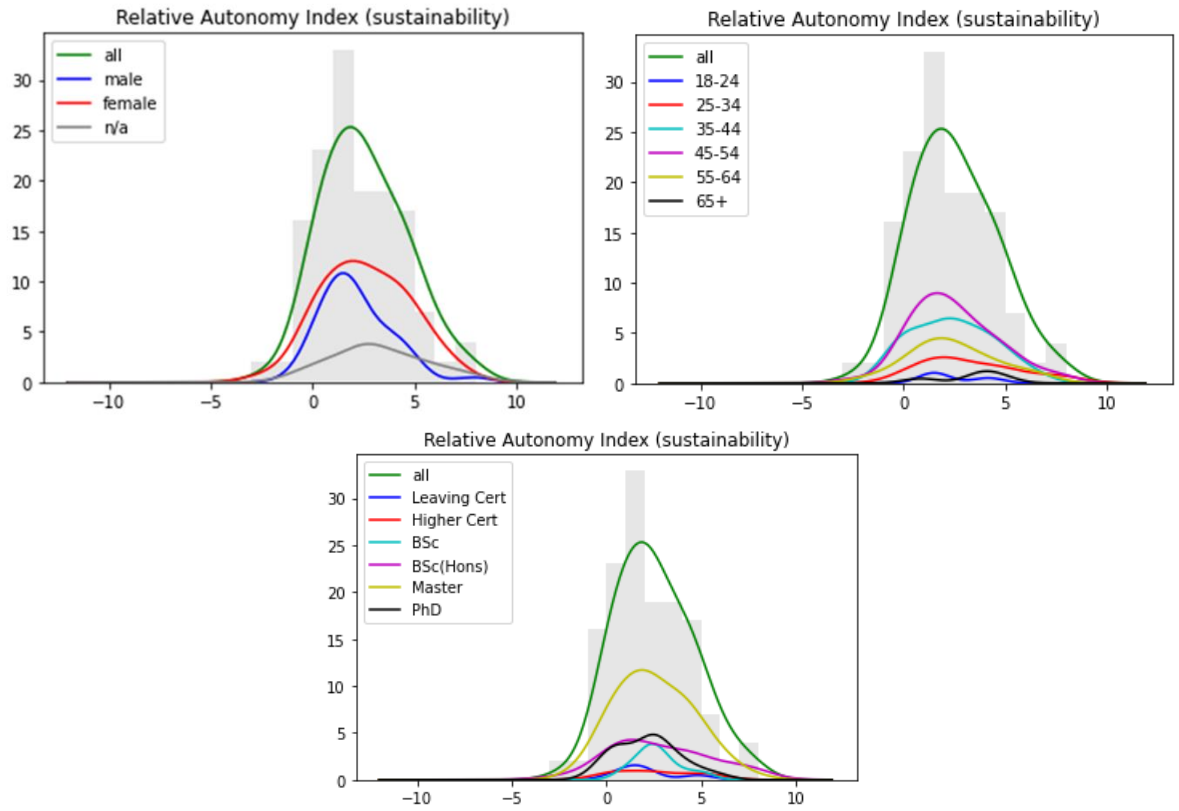


Figure 33 Distribution of Relative Autonomy Index (RAI) with regards to sustainable diet split into gender categories (top,left), age (top,right), and education level (bottom)

Summary and discussion

The key outcomes of study II-c are summarised in the following Table 13:

	1st variable	2nd variable	r	d	p	α_{BH}	reject H_0
3.a	RAI_H	RAI_S		0.03	0.7	0.042	no
3.b	RAI_H	RAI_S	0.49		<0.001	0.012	yes
3.c	RAI_H	BI_H	0.44		<0.001	0.015	yes
	RAI_S	BI_S	0.23		<0.01	0.023	yes
3.d	RAI_H	gender			0.66	0.038	no
	RAI_H	age			0.94	0.05	no
	RAI_H	education			0.21	0.033	no
	RAI_S	gender			0.21	0.031	no
	RAI_S	age			0.16	0.027	no
	RAI_S	education			0.4	0.035	no

Table 13 Key outcomes of study II-c

There are four main outcomes of study II-c: first, the level of general motivation towards a healthy and towards a sustainable diet has been found to be very similar. This is surprising given that study II-a and study II-b have both shown that short-term intention to act healthily is higher than for sustainability, which is also supported by the findings of de Shutter (2015) and Hoek et al. (2017). There seems to be a decline in similarity between the two topics the more concrete the actual action becomes, with general motivation starting out very similar and the gap widening for short-term intention becoming even wider for the actual behaviour.

Second, the two topics of health and sustainability are correlated when it comes to general long-term motivation. This indicates that participants who show an interest in health also show an interest in sustainability and vice versa, however that is not reflected in the same level of translation into actual behaviour.

Third, long-term motivation translates into short-term intention both for health and sustainability, although the translation is weaker for sustainable grocery shopping behaviour. This is consistent with the other findings discussed above.

Lastly, no significant correlation between long-term motivation and demographic factors was observed in this survey. Again, as in the case of the behavioural intentions discussed above, this could be the result of a selection bias, which is a limitation of this study, where participants originated from a higher educated cohort than the population average.

3.2.2.4 Additional drivers

Grocery shopping is influenced by other aspects, not just healthy or sustainability. A final question was included into the questionnaire to gauge the importance given to such additional drivers, such as convenience of a product, price, quality, and taste. Figure 34 shows the results what importance the participants put to the different factors.

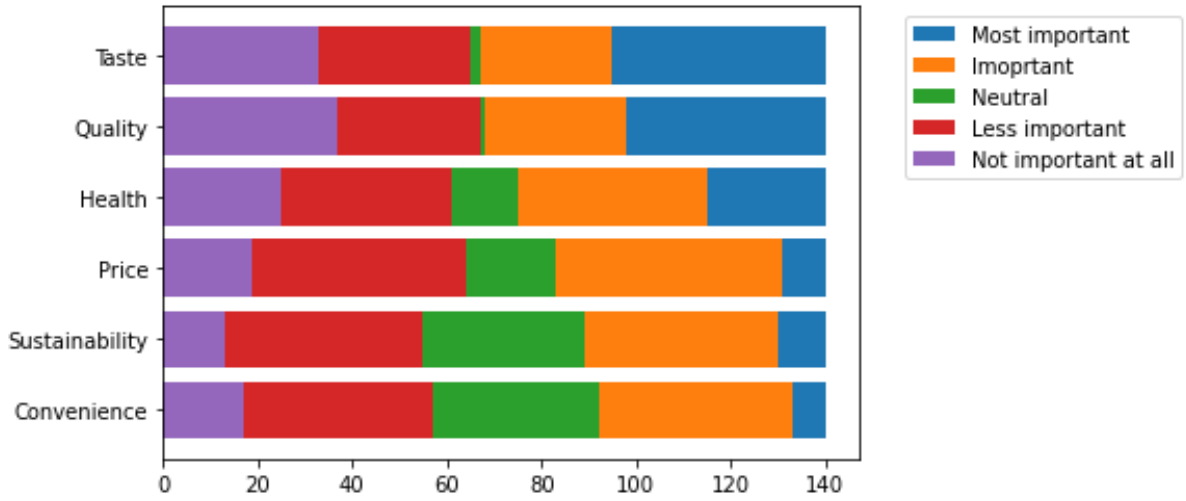


Figure 34 The relevance of the aspects: taste, quality, healthiness, price, sustainability, and convenience with regards to grocery shopping.

It can be seen that the order of importance when it comes to the decision to buy a specific product is as follows: taste, quality, health, price, sustainability, and convenience. With respect to healthy and sustainable grocery shopping it can be noted that these are 3rd and 5th in comparison to other drivers. Taste and quality rank more important than both and more focus on health than on sustainability can be observed again.

3.2.3 Limitations

As with all voluntary questionnaire-based studies some bias in the number and type of people participating can be expected (Stedman, Connelly, Heberlein, Decker, & Allred, 2019). Out of the potential 1425 people to whom the study was advertised, 176 (12.4%) responded by clicking on the survey link provided and answering at least some questions. Throughout the survey, attrition was

such that at the end 144 (81.8%) useable samples were obtained. No incentives to participate were given, therefore it can be assumed that a level of interest in the topic was present for some participants.

The main limitation of the presented study is that it was conducted only amongst staff at the Cork Institute of Technology in Ireland. This resulted in a shift towards higher educational levels (63% with a post-graduate degree) compared to the population average (13% with a post-graduate degree (Central Statistics Office, 2016)) as well as in an overrepresentation of middle-aged adults (78% of 35-64 year olds compared to a population average of 40% (Central Statistics Office, 2016)). A noticeable gender imbalance was observed, with 53% female participants, 31% male participants and 16% who chose not to disclose their gender. However, analysis of these demographic factors showed no significant influence on the results (see consideration of demographics in sections 3.2.2.2 and 3.2.2.3).

The survey assumed that participants understand the concepts of healthy and sustainable diets based on the definitions provided. Although it cannot be ruled out that this assumption had an impact on the results, the higher-than-average education level of participants is a mitigating factor reducing this risk.

The study focused only on health and sustainability factors that influence grocery shopping behaviour. Other important influence factors in the context of grocery shopping, such as for instance hunger or emotions (Nederkoorn, Guerrieri, Havermans, Roefs, & Jansen, 2009), were not considered.

3.2.4 Summary

The three studies presented in this section were based on the integrated quantitative model developed in section 2.2 (cf. Figure 17). Study II-a (cf. section 3.2.2.1) evaluated self-reported intentions and behaviour, both regarding healthy and sustainable grocery shopping. Study II-b (cf. section 3.2.2.2) used the tools proposed by the Theory of Planned Behaviour (TPB) to quantify and analyse behavioural intentions and persona segments with respect to health and sustainability. Finally, Study II-c (cf. section 3.2.2.3) used the tools proposed by the Self-Determination Theory (SDT) to quantify and analyse motivational factors with respect to healthy and sustainable grocery shopping.

The first main outcome of study II-a has been that the difference between health and sustainability is smaller when it comes to the intention (questions 1.a) than it is with regards to the perception of the own behaviour (question 1.b). While health is more important than sustainability for both self-reported intention and self-reported behaviour, the difference between the two is much closer regarding the intentions to act. Participants therefore are translating their intentions into actions more effectively for healthy than for sustainable grocery shopping behaviour. While high intentions to act healthily are likely to translate into better behaviour, a high intention to act sustainably does not translate into better sustainable actions in the same way.

The second main outcome of study II-a was that an intention-action gap can be observed for both healthy and sustainable grocery shopping, but that the health-related intention-action gap is smaller compared to the sustainability-related intention-action gap (question 1.c). This is explainable by the fact that up until recently the focus was mainly on supporting consumers to eat healthy diets, with

sustainability and environmentally friendly approaches to food becoming more and more important only very recently.

The first main outcome of study II-b has been that BI scores predict self-reported intention and behaviour (question 2.a) and that again health is of higher priority than sustainability for a significant subset of participants when it comes to grocery shopping behaviour. This is consistent with the findings of study II-a.

The second main outcome of study II-b was that the behavioural intentions for healthy and for sustainable grocery shopping are only weakly correlated (question 2.b). However, a significant persona segment of participants was identified, who found it more difficult to act sustainable than they find it to act healthily due to a lack of perceived behavioural control (question 2.d). The weak correlation of the behavioural intentions indicates that the two dimensions health and sustainability need to be addressed independently in any intervention to achieve better behavioural outcomes.

No statistical significant dependence of behavioural intention on demographic factors like gender, age, or education level for both healthy and sustainable grocery shopping has been observed (question 2.c). While the results were all within the margin of statistical error, the strongest prediction of behavioural intention with regards to health is by age, with older participants showing slightly higher intentions to follow a healthy diet. Although higher awareness of sustainability amongst younger and higher educated people has been postulated (Rippl, 2004), this did not manifest itself here when it comes to the behavioural intentions in relation to sustainable grocery shopping behaviour.

The first main outcome of study II-c has been that while intrinsic motivation translates into positive behavioural intention for both healthy diet choices as well as for sustainable grocery shopping (question 3.c), the latter correlation was observed to be weaker. This finding is consistent with study II-b, which showed that perceived behavioural control is lacking for acting sustainably while this could not be observed that strongly for acting healthily. People find it easier and see more opportunities to act healthily than they find it to act sustainably.

The second main outcome of study II-c was that the motivational type of a person as measured by the RAI does not differ between the subject area of healthy or sustainable grocery shopping (question 3.a) although unlike the Behavioural Intention both are correlated (question 3.b). This indicates that a person who is more intrinsically motivated towards healthy dieting behaviour is also more intrinsically motivated towards sustainable grocery shopping behaviour and vice versa.

Overall, demographics has been seen to not have a significant influence on behavioural intention nor motivational type (question 3.d), both with regards to healthy as well as with regards to sustainable grocery shopping behaviour. When asked directly which aspects are most important for grocery shopping decisions, taste and quality outrank both health and sustainability. Again, health is given more importance than sustainability consistent with the findings of all three studies.

In conclusion, all three studies have shown using different indicators that while there exists an intention-action gap for both healthy and sustainable grocery shopping behaviour, translating a general motivation to act more sustainable is perceived as more difficult than to achieve a more healthy diet. Therefore, designing an intervention to promote both healthy and sustainable grocery

shopping behaviour requires addressing sustainability in particular. The higher interest in healthy diets can be utilised to promote sustainability goals in parallel, which is helped by the correlation between the two topics observed here. Measures, such as for example a food labelling scheme common for supporting healthy grocery shopping behaviour could be extended towards sustainability aspects, providing a good vehicle to promote perceived behavioural control, which has been seen to be lacking, in this domain as well.

3.3 Case study III: A combined approach for a smartphone-based intervention design with ecological momentary assessment[4]

Smartphone applications are ubiquitous and embedded into the natural daily activity and environment of their users. In particular, recipe and grocery shopping smartphone applications have become increasingly popular (AndroidRank.org, 2020) and therefore could be suitable vehicles to raise awareness on topics such as healthy diets and sustainable grocery shopping (Clear, Friday, Rouncefield, & Chamberlain, 2015). At the same time, the integrated behavioural model developed in section 2 has been developed with the aim of being useful to design personalised interventions and assessment tools to improve awareness and positively influence behaviours. In the following, a case study will be presented showing how a model-driven approach can be adopted to design a smartphone-based intervention together with ecological momentary assessment (EMA) (Shiffman, Stone, & Hufford, 2008) to address healthy and sustainable grocery shopping behaviour. The presented case study will answer the question, how the concepts identified in the behavioural models can be operationalised to design and create a smartphone-based dynamic intervention architecture for supporting healthy and sustainable grocery shopping?

3.3.1 Method

The design framework presented in this case study is based on the integrated behavioural model as outlined in section 2.3 (see Figure 17). The contribution of the integrated model is two-fold: it provides the qualitative design goals that translate into necessary features of the application as has already been used in study I (cf. Table 3) and it also provides quantitative variables and applicable inventories such as those already used in study II (see section 3.2.1) as well as the interaction between all these contributing concepts.

The qualitative aspects to be considered in the application design according to the model presented in section 2.3 (see Figure 17) are summarised in the following Table 14:

Design Requirement	Explanation
Demands	A guiding principle of the application design needs to be defined, for example that it should support health and sustainability.
Redefinition of the task	Abstract demands should be translated into meaningful and achievable specific goals by the application design. These goals have to be specific to a behaviour such as healthy and sustainable grocery shopping.
Goal-setting	Goals need to be refined down to an actionable granularity of sub-goals so that the resulting application features explicitly

[4] A shorter version of this study has been published in *Human Behaviour and Emerging Technologies* under the title "*A Theory-Driven Design Framework for Smartphone Applications to Support Healthy and Sustainable Grocery Shopping*" (Blanke, Billieux, & Vögele, 2021).

	support the stepwise execution of action plans and simplify the achievement of goals, such as health and sustainability, even further.
Self-efficacy	Application design needs to take the abilities of its users into consideration. All information provided needs to be such that it is easily understood by the recipient and can be translated into behaviour accordingly.
Feedback	Regular and informative feedback has a positive effect on motivation and therefore needs to be provided throughout the intervention in order to keep application users engaged.
Environment	The application should be embedded into a wider setting of outside activity, such as grocery shopping or meal planning activities. Application features should focus on supporting the reciprocal causal relationship between the behaviour and the encountered circumstances, and allow to deal with eventually occurring environmental input, for instance when encountering obstacles.

Table 14 Application design goals derived from the qualitative drivers of the integrated behavioural model (cf. Figure 17)

The quantifiable aspects to be considered in the application design process according to the model presented in section 2.3 (see Figure 17) are summarised in the following Table 15:

Design Requirement	**Explanation**
Attitudes towards the behaviour	Supporting predispositions of the application user entails aspects such as raising awareness of the topic in general and generating a positive experience through simple and descriptive information, all of which need to be part of the application design process.
	Attitudes towards the behaviour can be assessed using the inventory tools proposed by the TPB and provide an insight into the level to which raising awareness and support through providing detailed information is important to consider in the application design (see sections 3 and 6 of appendix C for an example inventory for health and sustainability).
Social and subjective norms	The perceived social pressure can be used to recruit participants in relevant communities and therefore should be considered when designing the dissemination strategy. Furthermore, application design can use regular reminders to re-enforce engagement with the intervention and EMA by utilising socially meaningful messaging.
	Subjective norms are assessable using the inventory tools of the TPB and provide an insight into the level to which normative messaging is important to consider in the application and intervention design (see sections 3 and 6 of appendix C for an example inventory for health and sustainability).
Perceived behavioural control	Control over the behaviour within the environment needs to be enhanced by a successful intervention application. Designing for the support of a specific behaviour therefore should ensure that the perception of practical achievability is increased.

	Perceived behavioural control can be assessed using the inventory tools proposed by the TPB and provides an insight into the level to which supporting control is important to consider in the application design (see sections 3 and 6 of appendix C for an example inventory for health and sustainability).
External regulation	Some individuals require external incentives and rewards to carry out desired behaviours in the space addressed by the intervention. Therefore, the necessity for such external factors to motivate participation needs to be considered by the intervention design.
	External regulation can be assessed using the inventory tools proposed by the SDT and provides an insight into the level to which external incentives are important to be considered (see sections 4 and 7 of appendix C for an example inventory for health and sustainability).
Introjected regulation	Avoidance of negative consequences can also drive behaviour and therefore is worth considering when designing the messaging and information provided.
	Introjected regulation can be assessed using the inventory tools proposed by the SDT and provides an insight into the level to which information on the potential consequences of behaviour is important to be considered during application design (see sections 4 and 7 of appendix C for an example inventory for health and sustainability).
Identified regulation	Acknowledgement of the importance to act according to superordinate goals can influence if and how a behaviour is carried out by an individual. Application design can utilise this aspect by enabling the precise personalisation of goals accompanied by relevant information to elicit the desired behaviour.
	Identified regulation can be assessed using the inventory tools proposed by the SDT and provides an insight into the level to which supporting pre-existing goals is important to be considered during application design (see sections 4 and 7 of appendix C for an example inventory for health and sustainability).
Intrinsic regulation	Some people show a high a-priori level of motivation towards a subject area already. Addressing this group should be easiest, however application design needs to make sure that the high level of intrinsic motivation is kept up.
	Intrinsic regulation can be assessed using the inventory tools proposed by the SDT and provides an insight into the level to which participants already internalised goals as their own (see sections 4 and 7 of appendix C for an example inventory for health and sustainability).

Table 15 Application design goals derived from the quantifiable aspects of the integrated behavioural model (cf. Figure 17)

The implementation of features to meet these design requirements as specified in Table 14 and Table 15 is based on the outcomes of study I (see section 3.1), while the relative importance given to each feature in the context of the intervention is based on the outcome of study II-b (see section 3.2.2.2) and study II-c (see section 3.2.2.3).

In addition to these model-derived features, further technical design goals need to be taken into consideration to operationalise a personalised intervention and ecological momentary assessment (EMA) and make it acceptable to the users. These are summarised in the following Table 16:

Design Requirement	Explanation
Usefulness	The application needs to be perceived as useful, i.e. there needs to be a reason why someone is willing to install it on his/her phone.
Low-barrier access	The application needs to be easily accessible; no excessive steps should be required to download or install the application.
Trust	The application needs to be trustworthy, i.e. the source and installation process needs to be in line with the expectation of the user.
Data sparsity	No unnecessary data should be shared or uploaded; all processing should be performed as local as possible.
Ubiquity	The application should run everywhere; in particular no additional services or devices should be required.
Usability	The application needs to focus on being easy to understand and easy to use.
Cost-efficiency	The cost of running the application should be kept at a minimum; this includes back-end services in particular.
Scalability	The application needs to be scalable; this applies in particular to the back-end services which need to be able to cope with all required demand even if many people are using the application simultaneously.

Table 16 Technical application design goals

In the following a case study of a combined approach for a smartphone-based intervention with simultaneous ecological momentary assessment based on this design framework and requirements is presented. The resulting mobile application design process combines the qualitative and quantitative approaches (see sections 2.1 and 2.2) and aims to simultaneously influence and capture the variables underlying the cognitive process guiding healthy and sustainable grocery shopping behaviour. Because the application is based on these models, it can be compared and benchmarked against the results of study I (cf. section 3.1) and study II (cf. section 3.2) using the same approaches as outlined in these before.

3.3.2 Outcome

The methodology has been shown to be feasible by building an Android application (HealthStainable, (Blanke & Beder, 2020a)) for supporting healthy and sustainable grocery shopping combined with ecological momentary assessment of behaviour and intention according to the proposed model-driven design process outlined in section 3.3.1. Independent of the categorisation given by the models, the components of the design can also be categorised into back-end features, which provide functionality that is not visible to the end-user of the application, and front-end features, which represent the visible part of the intervention. Both back-end and front-end features are affected by all design requirements as listed before.

3.3.2.1 Back-end design

The back-end design comprises all relevant services and databases that are not immediately visible to the participants of the intervention. These are running locally on the participants device,

continuously in the cloud, as well as on the computer used by the intervention designer during evaluation and update cycles. The resulting system architecture, based on the design requirements outlined in section 3.3.1, is depicted in Figure 35.

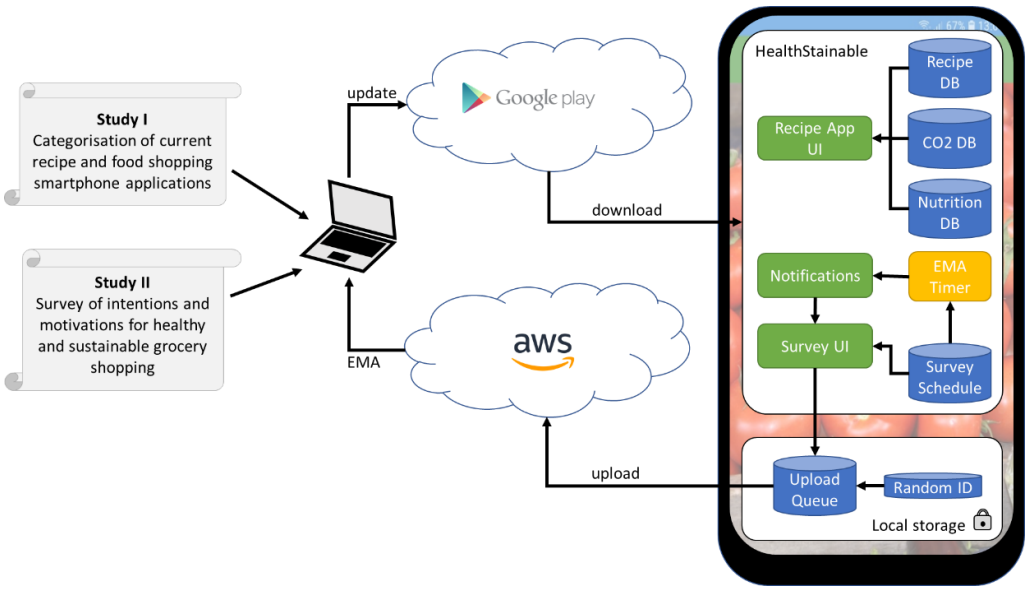


Figure 35 The HealthStainble application system architecture (front-end components shown in green, local databases shown in blue).

Table 14 lists the application design goals derived from the qualitative drivers of the integrated behavioural model. While the more visible features are part of the front-end and will therefore be discussed below in section 3.3.2.1, the supporting design on the back-end needs to facilitate these functions. The intervention itself is driven by the **demands** to achieve more awareness of health and sustainability in the context of food and grocery shopping and to positively influence the behaviour accordingly. Thus, the application design is focused on this area and embedded in the activities suitable to achieve a better outcome. The design process comprises the two precursory studies to understand both the landscape of currently available grocery shopping and recipe planning smartphone applications as well as the intentions and motivations with regards to healthy and sustainable grocery shopping behaviour (cf. Figure 35).

While the recipe database (DB) has been created to contain a wide variety of different options, the overall focus is on healthy and sustainable meals. Out of the 609 recipes, 283 have a carbon footprint of less than 50 gCO2e/100kcal (green label), 279 have a carbon footprint of between 50 and 200 gCO2e/100kcal (orange label), while 47 recipes are above 200 gCO2e/100kcal (red label). The distribution of nutrition labels in accordance with the European food labelling directive (Council of the European Union, 1990) and the food labelling guidelines of the UK National Health Service (NHS) (National Health Service, 2021) is broken down in Table 17:

	orange threshold	red threshold	green	orange	red
CO2	50 gCO2e/100kcal	200 gCO2e/100kcal	283	279	47
Fat	3 g/100g	17.5 g/100g	122	412	75
Saturates	1.5 g/100g	5 g/100g	258	228	123
Sugar	5 g/100g	22.5 g/100g	399	150	60
Salt	0.3 g/100g	1.5 g/100g	278	320	11

Table 17 Distribution of recipes in the recipe DB broken down into carbon footprint and nutrition labels.

Integrating the carbon footprint into a recipe application and making it readily accessible through a label schema similar to health-related food labelling concepts is unique and has not been found in any of the reviewed applications.

The **redefinition of the task**, i.e. the translation of abstract demands into personal meaningful goals, is based on the awareness of and availability of suitable information. To provide this information a database of carbon footprint and nutritional information has been created and linked with the recipe database. This allows the calculation of all health and sustainability indicators, i.e. energy, fat, saturates, carbohydrates, sugar, protein, salt, and CO2 footprint, for all recipes and ingredients to be presented to the participant. It also facilitates the calculation of colour coded food labels both for the health as well as for the sustainability indicators, which accompany this information for easier comprehension.

These nutrition and carbon footprint databases are limited to the products also occurring in the recipe database and contains 648 items, which are exactly matched to each recipe and also contain the correct conversions between units necessary to create a consistently combined shopping list. All this functionality supports the **goal-setting**, by enabling the creation of personalised shopping lists. Goal-setting is further supported by the recipe database, which also allows to dynamically adapt serving sizes affecting all other functional units of the shopping list application, thereby integrating into the personal circumstances of the participants.

The architecture facilitates regular **feedback** through a timed ecological momentary assessment (EMA) approach, which fosters self-reflection on the topics of health and sustainability on a regular basis. An EMA timer is implemented that triggers push notifications based on a pre-defined schedule (cf. Figure 35) to remind participants to engage with the intervention. A notification is sent every evening at 6pm during the intervention period. In case the notification is ignored another reminder is sent 1h later and reminders remain on the participants home screen until an action is taken. When a reminder for feedback is acted on, the application will present itself through the survey user interface, which in this case replaces the regular recipe application. The survey UI will present a dynamic set of multiple-choice questions and communications as defined in the survey schedule database. The survey schedule database allows to define at what time intervals which questions or communications are to be presented to the participant. This feature can be used for the ecological momentary assessments of intention, motivation and behaviour as well as to elicit daily self-reflection and self-feedback with respect to healthy and sustainable grocery shopping behaviour (see appendix C, section 8).

Table 15 lists the quantifiable model aspects, which are assessed by the EMA. The factors underlying the behavioural intention (BI), attitudes towards the behaviour, social and subjective norms, and perceived behavioural control, are assessed in two week intervals through the survey schedule presented in section 3 and 6 of appendix C for healthy and sustainable grocery shopping respectively. Similar, the factors underlying the relative autonomy index (RAI), i.e. external, introjected, identified, and intrinsic regulation, are assessed in a two week interval through the survey schedule presented in section 4 and 7 of appendix C. This allows to regularly assess the change of BI and RAI for the participants in the intervention.

All these quantifiable aspects of the model also impose design requirements in their own right beyond their function within the EMA (cf. Table 15). Supporting the **attitudes towards the**

behaviour with respect to health and sustainability can be achieved by providing relevant information, which is drawn from the nutrition and carbon footprint databases as outlined above. The same is true for the **social and subjective norms**, which are addressed by the data-driven traffic-light style labelling approach, and the **perceived behavioural control**, which can be improved by providing guidance based on rigorous data from the databases during meal planning and grocery shopping. Easily accessible and accurate information on the subject area also helps with **identified and intrinsic regulation** and can therefore be expected to increase motivation.

The technical requirements summarised in Table 16 are compulsory for deploying any application to participants. A major concern of most people when they are asked to install any new or unknown application onto their own mobile device is **trust**. It is therefore imperative to deploy the application through the official app store (Google Play), which mandates that the application is reviewed by the relevant entity and follows all rules and regulations accordingly. In case of HealthStainable the application targeted the Food & Drinks category and a content rating of PEGI3. Furthermore, the only two permissions required are “full network access” for uploading the EMA data and “run at startup” to trigger ongoing EMA reminders even when the phone is re-started during the period of time of the intervention. Crucially, unlike other similar applications both of these permissions to not trigger a warning during the installation of the app, which could deter participants unnecessarily. Full ethics approval of the University of Luxembourg was sought and communicated to all participants.

Linked with the aspect of trust is the requirement for **data sparsity**. The application architecture achieves this by separating out the communication of EMA data with the back-end server from the rest of the application, only communicating approved survey data together with a completely anonymised random ID. This data is kept strictly local on the device and is separated from all other apps as well as the update and identity mechanisms of Google Play. This mechanism achieves complete anonymisation of the data uploaded to the AWS S3 servers.

To be able to use the intervention in any setting, such as the supermarket when shopping where internet connectivity might not be available. This **ubiquity** is achieved by maintaining a local copy of the recipe database as well as nutrition and carbon footprint data on the mobile device itself. Also, the EMA data uploads cannot depend on uninterrupted connectivity, therefore all uploads are collected in an upload queue stored locally on the device and the upload is deferred until a network connection becomes available again. Downloading new data into the application is managed through the Google Play Service update mechanism only, which is also completely independent of continuous connectivity (see Figure 35).

When deploying any application to the general public, **scalability** of all back-end services, in particular those running on centralised servers in the cloud, needs to be ensured in case that many people are using the application simultaneously. The HealthStainable application achieves this by utilising elastic services such as AWS Lambda and AWS S3 to manage EMA reply processing and storage. This elasticity also allows for **cost-efficiency** with no upfront costs being incurred for running the application. Also, the recipe database, nutrition database, and carbon footprint database need to be licensed at no cost. While the nutrition database (USDA Food Composition Databases) is licensed Public Domain, the recipe database, product database, and carbon footprint database had to be compiled based on publicly available information.

3.3.2.2 Front-end design

The front-end design concerns the aspects of the intervention which are immediately visible to the participants. These are running locally on the participants device but also comprise aspects such as dissemination and recruitment. The front-end directly interacts with the back-end databases on the device (see Figure 35, *blue components*), therefore the distinction is fluid sometimes. While the intervention presents itself to the end-user solely through the user interfaces (see Figure 35, *green components*), it simultaneously serves as a vehicle to deliver the ecological momentary assessment (EMA) and the features derived from the integrated behavioural model.

The qualitative aspects of the model (Table 14) indicate which features need to be implemented to achieve improvements in behaviour relating to healthy and sustainable grocery shopping. The **redefinition of the task**, that is the translation of abstract goals into meaningful personalised goals, is supported by the *recipe app user interface (UI)* through the following features:

1. All recipe suggestions include information on nutritional values and carbon footprint (see Figure 36, left).
2. Recipes can be either searched or browsed by category or ingredient using categorised lists and text search (see Figure 2, middle and right).
3. Personalised plans for grocery shopping as well as for longer-term planning (favourite list) can be created (see Figure 36, middle).

These meaningful high-level goals need to be broken down into actionable sub-goals and plans. This process is called **goal-setting** and is supported in the *recipe app UI* by the following features:

4. A consistent shopping list can be created and managed from selected recipes and additional items can be added (see Figure 37, right).
5. It is possible to delete and adapt shopping list items according to pantry and personal preferences (see Figure 37, middle).
6. Serving sizes can be adapted at any time to cater for personal circumstances (see Figure 36, left).

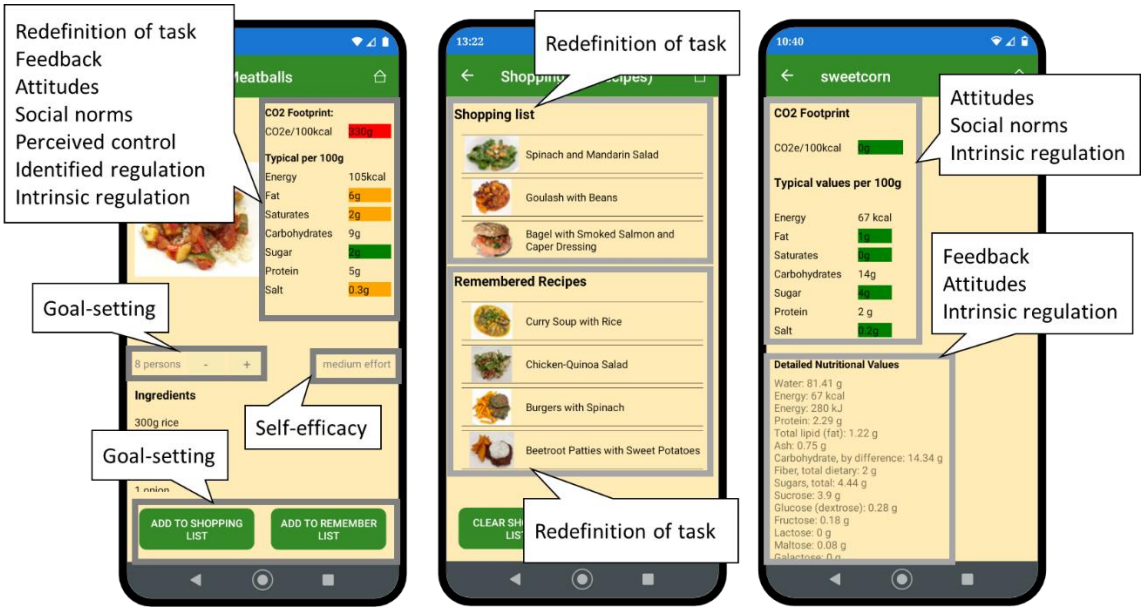


Figure 36 The HealthStainable front-end and how it implements the concepts from the behavioural model

According to the model **self-efficacy** needs to be considered during goal setting and therefore needs to be translated into application features that support the same. The *recipe app UI* component aims to achieve this by

7. indicating the difficulty level for each recipe (see Figure 36, left) and
8. providing detailed cooking instructions to support the decision for or against a recipe.

Ongoing **feedback** on the progress is required to keep up the motivation for healthy and sustainable grocery shopping throughout the intervention. It is provided on demand through the *recipe app UI* as well as regularly through the *notifications* and *survey UI* implementing the following set of features:

9. Recipe suggestions are provided including information on nutritional values and carbon footprint (see Figure 36, left).
10. Nutritional and carbon footprint information is always available for all ingredients individually to increase knowledge of health benefits and sustainability impacts (see Figure 36, right).
11. The progress on the grocery shopping is tracked by allowing to tick off or placing new items and recipes on the shopping list (see Figure 36, middle)
12. Daily reminders are sent to facilitate considering the own grocery shopping behaviour in relation to health and sustainability and giving self-feedback (see Figure 38, left and right)

The reciprocal relationship between the participant and the **environment** is captured and facilitated through the *recipe app UI* and the *survey UI*. The relevant features are:

13. To allow to include additional products into the shopping list (see Figure 37, middle)
14. To delete products or entire recipes from the shopping list in order to adjust to current circumstances (see Figure 37, left)
15. Marking ingredients as unavailable and dynamically adapt the shopping list, create a list of items to put back, and suggest alternative recipe options (see Figure 37, middle)

16. Dynamically adapt the shopping list to accommodate new recipes while shopping (see Figure 37, left)
17. Facilitate regular reflection on the grocery shopping behaviour with respect to health and sustainability through regular reminder notifications (see Figure 38, left and right)

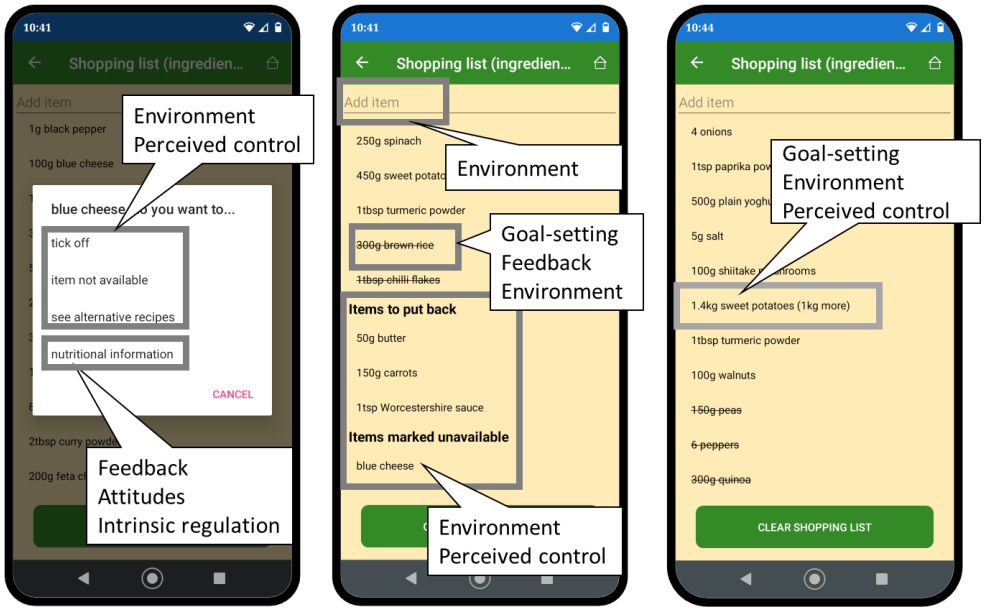


Figure 37 The HealthStainable front-end and how it implements the concepts from the behavioural model

The quantifiable aspects of the model (Table 15) indicate features that can be implemented to achieve improvements in behaviour relating to healthy and sustainable grocery shopping, and that are also available to be measured through the ecological momentary assessment (EMA) as already outlined in the back-end section. The front-end aspects of the EMA are implemented in the *notification* and *survey UI*, which utilise the smartphone's notification capabilities:

18. To push regular notifications and remind the participant to open the application (see Figure 38, left).
19. To regularly gather feedback from the application user by presenting multiple choice style questions at defined time intervals throughout the intervention (see Figure 38, middle).

The model aspects listed in Table 15 are not only to gather EMA feedback, but also indicate further features that should be implemented in order to achieve maximum impact in the intervention. The **attitudes towards the behaviour** are supported by all features designed to raise awareness and provide meaningful information on the topics of healthy and sustainable diets. These are presented to the end user through the *recipe app UI* and the *survey UI* and include:

20. Nutritional and carbon footprint information for all recipes and ingredients (see Figure 36, left and right)
21. Continuously raising awareness of health and sustainability through regular reflection and self-feedback (see Figure 38, right)

Social and subjective norms in the first instance should be utilised to recruit participants, because people are more likely to engage with a topic if they are exposed to it in the context of their

community and they feel social pressure from relevant others. Further to that the application features implemented in the *recipe app UI* and the *survey UI* targeting this aspect are:

22. Traffic-light style presentation of food labelling and carbon footprint information for each recipe and ingredient, allowing to compare the information against the common best practice (see Figure 36, left and right)
23. Regular reminders to self-reflect on the own grocery shopping behaviour in relation to health and sustainability supports awareness of these social norms (see Figure 38, left and right)

Participants need to have positive **perceived behavioural control** to behave in a desired way, particularly in areas with less actionable knowledge. To support this the *recipe app UI*

24. helps to identify healthy and sustainable recipes by presenting all relevant information during the recipe planning and grocery shopping process through food and CO2 labelling (see Figure 36, left).
25. The shopping list dynamically and consistently adapts to the requirements as they emerge throughout the meal planning and grocery shopping activity thereby increasing the capacity to maintain control of the situation (see Figure 37).

The four types of **regulation, i.e. external, introjected, identified, and intrinsic,** determine how motivated a participant is to engage with the subject area. While externally motivated and introjected participants require direct incentives in an intervention, identified and intrinsic regulation can be directly addressed by application features. The *recipe app UI* and the *survey UI* achieve this by

26. providing all relevant information on health and sustainability implications at a glance through the colour coded labelling scheme (see Figure 36, left).
27. Daily self-reflection triggered by regular notifications also help to address identified and intrinsic regulation, thereby increasing motivation to keep engaged (Figure 38, right).

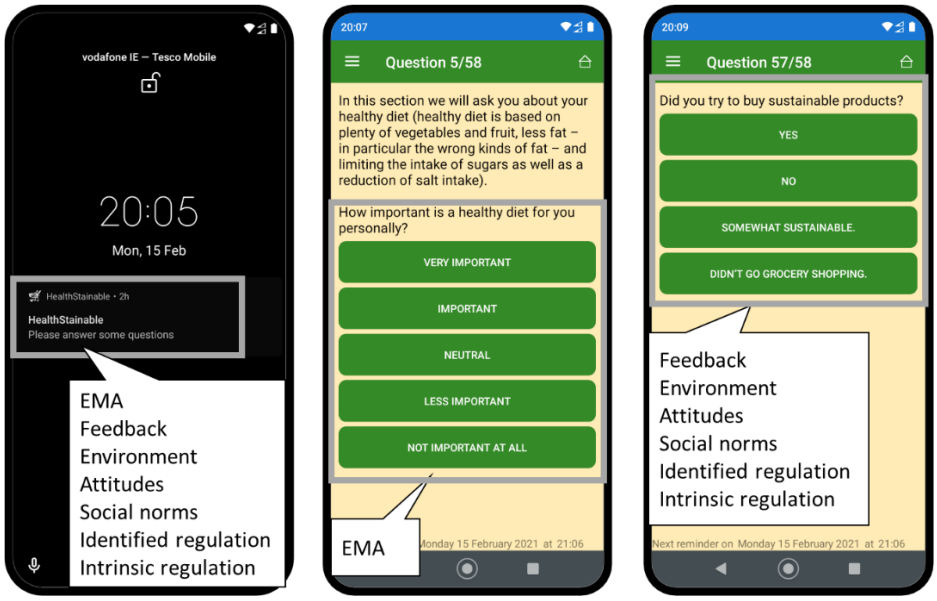


Figure 38 The HealthStainable front-end and how it implements the concepts from the behavioural model

Finally, of the technical requirements summarised in Table 16 some are affecting the front-end design directly. The application has to be **useful**, so that a participant installs it on his/her device in the first place. For this reason, it is not sufficient to limit the design to the EMA and *survey UI* aspects only, but a fully functional application has to be provided that is addressing a real need, such as the recipe application for assisting with the daily task of grocery shopping, which serves as a vehicle to deliver the additional functionality in the process. In particular, by wrapping everything into a recipe and grocery shopping app the **demands** of healthy and sustainable behaviour that this intervention aims to address are embedded into a front-end that is not solely focusing on these aspects alone, but provides useful and meaningful additional functionality that make it possible to effortlessly integrate into everyday activities.

Very much linked to this aspect is the requirement for **low-barrier access**. It needs to be straightforward to download and install anything that is required onto the smartphone and the participant needs to be able to achieve this with little or no help. The application has been accepted to be deployed to the Google Play Store (see Figure 39, (Blanke & Beder, HealthStainable, 2020a)) and is available for download to the general public. This enables sending a simple link to participants or asking them to search for the keyword (“HealthSatinable”) themselves, making it very easy to access.

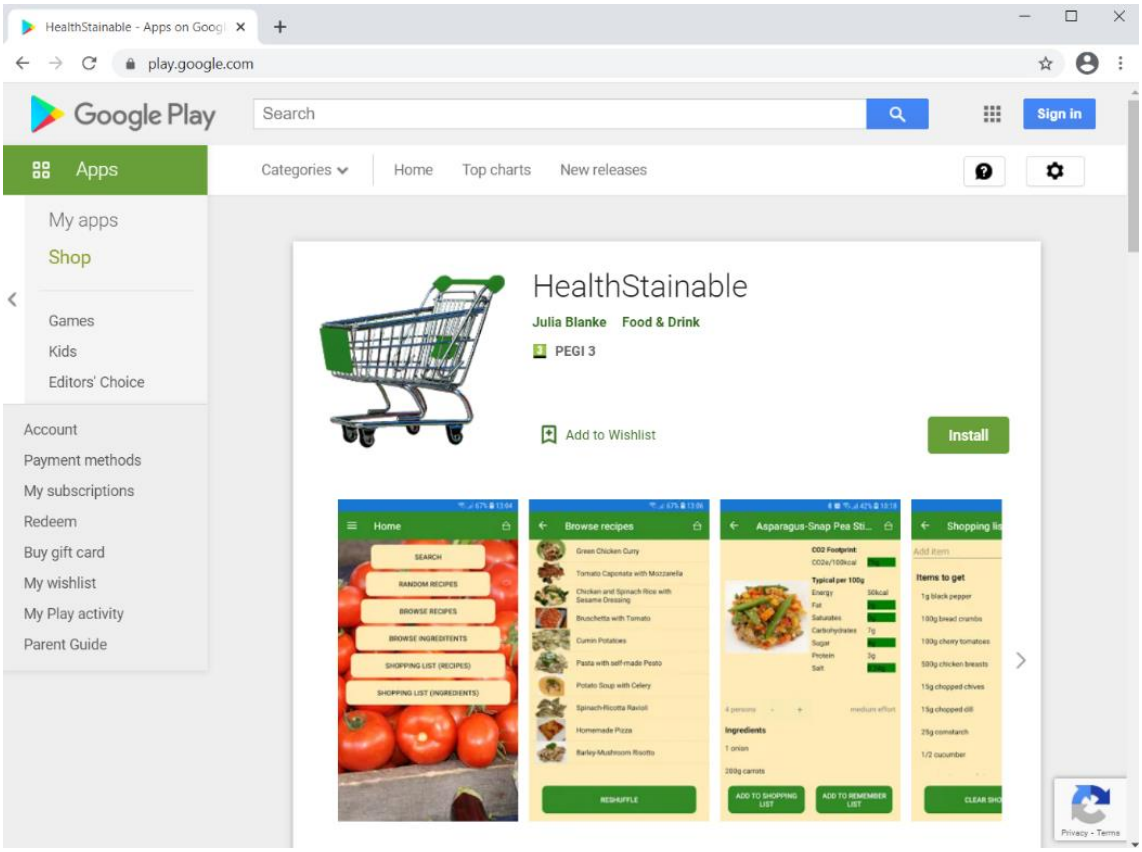


Figure 39 Google Play Store listing of the HealthStainable application

Finally, **usability** is a design goal linked to the usefulness discussed before. The application aims to achieve this by following proven UI patterns for smartphone applications (Neil, 2014). The application starts off with a springboard pattern (see Figure 2, left) to enable quick access to all important functionality. Throughout a hierarchical stack-based navigation pattern is followed to provide intuitive navigation and a navigation drawer pattern is applied to simplify this further.

3.3.2.3 Application design in the context of study I

The goal of study I (see section 3.1) has been to categorise existing popular recipe and food shopping applications with respect to the behavioural model used to derive the design goals in this section. If the same methodology was to be applied to the HealthStainable application, the resulting feature mapping in accordance with Table 3 is shown in the following Figure 40:

	Demands		Redefinition of the task							Goal-setting						Self-effic.		Feedback				Environment						
HealthStainable	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

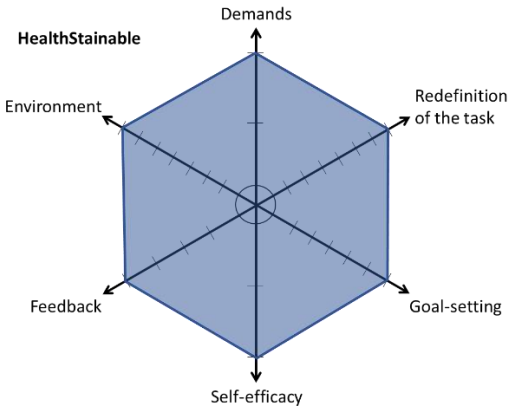


Figure 40 Feature mapping and corresponding spider graph of features supporting a healthy and sustainable diet for the HealthStainable application.

As expected, because the HealthStainable application was built based on the model itself and because study I has been serving as input to the application design process, all relevant features as derived from the model are present.

The presented design process and its applicability to a dynamic intervention for supporting healthy and sustainable grocery shopping behaviour in ongoing everyday settings shows how behavioural theories and modelling can be applied. This addresses the criticism of traditional behavioural modelling tools to be static snapshots of behaviour only and not applicable to the digital world (Spruijt-Metz & Nilsen, 2014) and leads the way towards novel design methodologies based on rigorous and well-established theoretical concepts.

3.3.2.4 Application design in the context of study II

The goal of study II (see section 3.2) has been to assess intentions and motivations for healthy and sustainable grocery shopping using the traditional approach of deploying a once off static questionnaire. The ecological momentary assessment (EMA) capabilities of the HealthStainable application can be used to continue this assessment and integrate the same questionnaires into a dynamic setting. This allows to understand the intentions and motivations of participants and their evolution in relation to the results presented in the section 3.2. The goal of this case study is not to replicate the findings of study II again, but to show that ecological momentary assessment of these indicators is technically feasible while being integrated into an embedding vehicle application and that the individual in-subject results can be compared against the findings of study II.

The HealthStainable application has been deployed to the Google Play store on 13/10/2020 and is available for download to everyone since. Installing and opening the application results in the questionnaires being presented with the data being dynamically collected in the time-intervals for each question as detailed in appendix C. Participation in the EMA was completely anonymous and voluntary and no incentives were provided resulting in 33 people using the application at some stage out of which 6 final participants fully filled the questionnaire relating to the behavioural intention and relative autonomy index at least once until 9/2/2020. Table 18 shows the data collected from

these participants, including the evolution of Behavioural Intention (BI) scores, persona segment (cf. Table 10), and Relative Autonomy Index (RAI) with respect to health and sustainability.

	#1	#2	#3	#4	#5	#6
Age	18-24	45-54	18-24	35-44	18-24	18-24
Gender	F	F	M	M	F	F
BI_H – 1ST assessment	2.8	3.3	0.43	1.4	3.08	2.4
BI_H – 2ND assessment		3.8		2.87	2.87	
RAI_H – 1ST assessment	1.0	2.33	0.0	1.0	6.33	3.67
RAI_H – 2ND assessment		1.67		0.67	5.67	
BI_S – 1ST assessment	1.92	1.35	2.17	-1.78	2.42	1.85
BI_S – 2nd assessment		1.88		0.32	1.63	
RAI_S – 1st assessment	4.67	1.67	-1.0	-2.67	2.33	0.67
RAI_S – 2nd assessment		2.33		-0.33	3.0	
Persona (health) – 1st assessment	D	C	D	B	A	C
Persona (health) – 2nd assessment		A		A	A	
Persona (sust.) – 1st assessment	D	D	D	H	C	C
Persona (sust.) – 2nd assessment		D		D	C	

Table 18 Assessment results for the six case study participants (BIH: Behavioural Intention, health; BIS: Behavioural Intention, sustainability; RAIH: Relative Autonomy Index, health; RAIS: Relative Autonomy Index, sustainability)

Table 19 shows the comparison of each individual case against the data from study II revealing that all participants are in line with the distribution of behavioural intention scores and relative autonomy indexes found:

Participant	1st assessment	2nd assessment
#1	z(df=4)=3.96,p=0.41	
#2	z(df=4)=0.64,p=0.96	z(df=4)=2.02,p=0.73
#3	z(df=4)=5.86,p=0.21	
#4	z(df=4)=8.83,p=0.07	z(df=4)=1.79,p=0.77
#5	z(df=4)=5.21,p=0.27	z(df=4)=2.5,p=0.64
#6	z(df=4)=2.78,p=0.59	

Table 19 z-test results to evaluate if case study participants are drawn from the distribution of participants of study II with respect to BI score and RAI.

While none of the test shows any statistical significant outlier, participant #4 is on the fringe of the distribution of the larger sample size of study II during his first assessment, z(4)=8.83,p=0.07, but moved closer within the expected range, z(4)=1.79,p=0.77, in his second assessment.

Participants #2, #4, and #5 replied to the questionnaire twice, therefore it was possible in this case to also determine the change of the behavioural intentions and relative autonomy indexes between the two measurements. The change can be evaluated in the context of the distribution of the wider population as assessed in study II. The resulting changes are shown in Table 20:

Participant	ΔBI_H	ΔBI_S	ΔRAI_H	ΔRAI_S	$\frac{\Delta BI_H}{SD_{BI_H}}$	$\frac{\Delta BI_S}{SD_{BI_S}}$	$\frac{\Delta RAI_H}{SD_{RAI_H}}$	$\frac{\Delta RAI_S}{SD_{RAI_S}}$
#2	0.5	0.53	-0.67	0.67	0.34	0.41	-0.27	0.33
#4	1.47	2.1	-0.33	2.33	1.0	1.63	-0.13	1.15
#5	-0.22	-0.78	-0.67	0.67	-0.15	-0.61	-0.27	-0.33

Table 20 Change of Behavioural Intention and Relative Autonomy Index relative to the population's standard deviations (BIH: Behavioural Intention, health; BIS: Behavioural Intention, sustainability; RAIH: Relative Autonomy Index, health; RAIS: Relative Autonomy Index, sustainability)

Again participant #4 stands out by showing the most significant change. His behavioural intention to buy healthy groceries increased by 1.0x the standard deviation, the behavioural intention to buy sustainable groceries increased by 1.63x the standard deviation, and the relative autonomy index to buy sustainable groceries increased by 1.15x the standard deviation seen in the reference population. Only the relative autonomy index with respect to health did not change much.

Figure 41 visualises these results, showing the participants of the case study in relation to the distribution of participants of study II (cf. Figure 26 and Figure 30). Participant #4 is clearly visible, being at the fringe of the BI score distributions with respect to sustainability. It can be observed that he started out with very negative motivation and intention towards sustainability and developed a more positive intention with regards to both health and sustainability towards the second assessment, while the motivational type changed only for sustainability but remained similar for health.

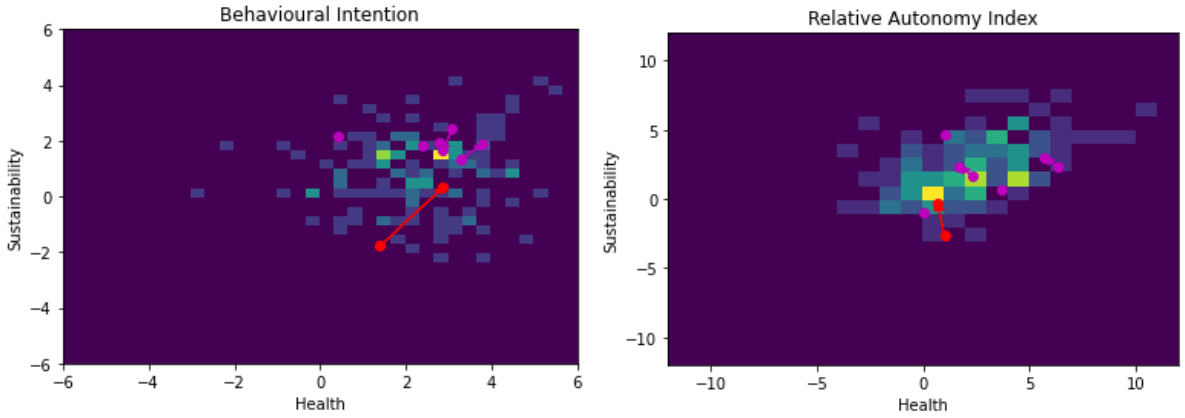


Figure 41 Case study participants in relation to the BI score and RAI distribution determined in study II. Participant #4 is shown in red.

This is also reflected in the persona segment (cf. Table 10) of participant #4, which changed from H to D with respect to sustainability and from B to A with respect to health, indicating that the attitude towards sustainability became positive and the perception of social norms with respect to health became important.

Figure 42 visualises the persona segment changes of the case study participants in relation to the distribution of persona segments observed in study II (cf. Figure 29):

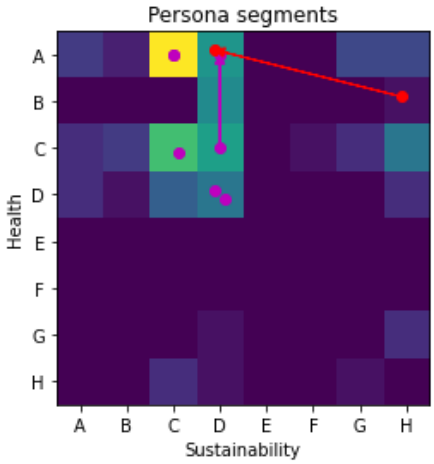


Figure 42 Case study participants in relation to the persona segment distribution determined in study II. Participant #4 is shown in red.

It has been demonstrated how by putting the dynamic EMA results of individual participants into the context of the static study II individual changes in intention and motivation can be interpreted and how changes of individual's responses can be tracked through consecutive assessments. This leads the way to dynamically adapting and personalising intervention design to the needs of individual participants. The data is collected for each individual of a single-subject case study, hence the intention has not been to evaluate the efficacy of the intervention but rather to demonstrate the applicability of the methodology, which enables a cost-effective evaluation of application design based on a small number of relevant test subjects.

3.3.3 Limitations

The main limitation has been that the presented case study has been deployed during COVID-19 lockdowns. This resulted in a limited ability to recruit participants, because planned recruitment channels, like the engagement of community groups with face to face presentations to motivate interested parties to participate in the intervention, were not available. Online recruitment via Facebook, WhatsApp, FitnessBlender.com, the Google Play Store, and via the faculty of humanities and social sciences homepage at the University of Luxembourg (Blanke & Vögele, 2020b) have been the only available dissemination channels, resulting in 33 application users out of which only 6 followed through with at least one EMA within the experiment. While more participants would have allowed for a broader evaluation in the context of study II, the scope of the presented case study has not been to replicate the findings presented in section 3.2, but to demonstrate how a personalised intervention can be developed and how individuals can be assessed during the execution.

An important secondary factor of the COVID-19 lockdowns was that everyone had to adapt to the new circumstances, and it has been conjectured that this explicitly affected grocery shopping behaviour (Morgan, 2020) shifting not only towards more online grocery shopping but also spending less time in the shops trying to speed up the process. Constantly changing rules around local mobility and grocery shopping likely also led to a situation, where potential participants did not want to engage with the topic as much as expected from previous studies.

There has been no external funding available for this case study, therefore no incentives could be given to participants. While it can be assumed that the type of people who voluntarily participated show a bias towards being interested in the topic of the intervention, however without an adequate

compensation for the time spent on the intervention, most participants did not seem to feel obliged to continue throughout the two weeks of the experiment resulting in a very high attrition rate. Out of the 33 participants, only six filled at least one questionnaire and only 3 followed through with the intervention experiment to the second assessment. It can be concluded that lack of compensation is a major impediment to EMA studies, in particular if participation is completely anonymous and no direct engagement with participants is possible during the experiment.

Finally, the application case study has only been developed for the Android operation system. This excluded all users of iOS devices from participating, accounting for 18% of the European smartphone market in 2020 (O'Dea, 2020).

3.3.4 Summary

An application design methodology case study based on the behavioural model developed in section 2.3 has been presented. It has been shown that the approach is feasible, and that the theories can be operationalised in a combined dynamic intervention and ecological momentary assessment. The approach aims at addressing the criticism that behavioural theories are too static to be applicable to the digital world (Spruijt-Metz & Nilsen, 2014) and do not support the development of just-in-time interventions (Riley, et al., 2011; Spruijt-Metz & Nilsen, 2014; Klasnja, et al., 2015).

Utilising the concepts from the behavioural models, it was demonstrated how these can be translated into specific design goals and ultimately features of a smartphone supported dynamic intervention. The presented methodology therefore has been shown to be applicable "to guide the design of decision rules for the delivery of intervention components" (Riley, et al., 2011; Spruijt-Metz & Nilsen, 2014; Klasnja, et al., 2015), thereby progressing the state of the art of behavioural modelling tools.

Behavioural modelling and User Experience (UX) research show significant overlap and can learn and benefit from each other. The models developed and validated in psychology and the social sciences are well-suited to inform application design by providing guidance how to identify relevant aspects of human behaviour to help maximise the behavioural impact. The theories also can be used to inform how to measure and assess an individual's psychological characteristics, which offers a rigorous approach to application design compared to more ad-hoc techniques commonly applied, such as personas based on stereotypical assumptions.

The case study has been evaluated in the context of studies I and II presented in section 3.1 and 3.2 respectively. The case study application HealthStainable was shown to cover all model aspects by design, therefore the proposed methodology is an evolution of the Heuristics Evaluation approach (Wilson, 2014) towards informing and improving application development. It has also been demonstrated how ecological momentary assessment enables the continuous evaluation of test subject's intention and motivation and observe their in-subject evolution individually over time. This approach enables the identification of subjects deviating from the expected norm as well as provides continuous input into developing and improving the intervention over time to best support every participant. This methodology therefore also offers a cost-effective single-subject evaluation methodology, that can be used to analyse the behavioural impact created by the application.

4 Conclusion

4.1 Summary

This work aims to address three consecutive research questions:

> *The main research question this work aims to address is, if existing behavioural models and theories can be combined to be suitable for the design and development of dynamic smartphone-based applications?*

Smartphone-based interventions are designed to assist people in their day-to-day activities. To that end they provide reminders and information that allow to carry out certain tasks better and that ideally improve the behaviour with regards to some overarching goals. To design these applications, it is necessary to understand how to explain, predict and influence human behaviour. Behavioural models and theories have been developed to achieve these goals; however, many smartphone applications are not explicitly developed according to a design process, which also takes behavioural aspects thoroughly into consideration.

Existing behavioural models and theories are often focused on specific areas, contexts or limited aspects of behaviour and therefore do not lend themselves well to a system design process that needs to cover a broad spectrum of features and requirements. However, each of these theories provides terminology and inventories to assess and describe the processes associated with certain behaviours and therefore can potentially contribute to a systematic and rigorous approach for supporting and positively influencing behavioural patterns and habits.

To be applicable to the task of designing smartphone-based interventions, the unifying factor between the motivational and behavioural theories reviewed in this work is that they all focus on self-regulation, which is the conscious process of interaction between the individual and his/her environment. The reason is that it is this interaction that can be supported by reminders and information provided through a smartphone application. The behavioural theories that have been identified to contribute to this approach are the High Performance Cycle (HPC) (Locke & Latham, 1990a), the Action-Regulation Theory (ART) (Hacker, 1986), and the Social Cognitive Theory (SCT) (Bandura, 1999), the Theory of Planed Behaviour (TPB) (Ajzen, 1985), the Self-Determination Theory (SDT) (Ryan & Deci, 2000). Each of these adds its own perspective to assessing and influencing behaviour, however on their own none of the existing behavioural theories have been found to be sufficient to be applicable to the digital world (Spruijt-Metz & Nilsen, 2014).

Table 1 lists the concepts and terminology each of the individual theories contributes to the field. To be able to compare the different concepts, it was necessary to unify the terminology and identify similarities and differences. The main contribution of this work is the resulting integrated behavioural model (cf. Figure 17), which aims at bringing together the benefits and strengths of the individual underlying theories and models. The HPC provides the basis for the integration, with its motivational cycle (cf. Figure 6) providing a skeleton structure that shows how specific goals are linked with specific feedback. The main shortcoming of the HPC is that it immediately connects external demands to actions and lacks a clear explanation of how this cognitive process is executed. Because a supporting intervention application needs to address this process in particular, the concepts of the HPC on their own are not sufficient to fully cover every aspect of the process. To overcome this limitation, it has been shown how the ART can be used to fill this gap with its explicit

hierarchical model of goal-setting and action regulation (cf. Figure 9). The ART adds an explicit redefinition of the task to the process, which has to be supported in a dynamic intervention. The major shortcoming of the ART on the other hand is its lack of recognising how motivation reflects back on behaviour, which in turn is addressed by the HPC. While both theories merged together address these issues, they are still lacking a clear notion of the interaction between the individual and his/her environment. A dynamic intervention wants to integrate itself into exactly this reciprocal relationship, therefore a model for filling this gap is required to design an application accordingly. The SCT outlines the triadic reciprocal relationship between the individual, the environment, and the behaviour, hence it provides the concepts necessary to overcome this limitation. On its own the SCT has no clear notion of the cognitive process how goals are translated into actual behaviour, therefore the integration of HPC, ART, and SCT (cf. Figure 12) delivers all the building blocks required to sufficiently describe the behavioural and motivational process that a dynamic intervention needs to address.

> *The second research question this work aims to address is, if the motivational drivers and their translation into actual behaviour are different for healthy and for sustainable grocery shopping, and if there is a relationship between the two that can be exploited to improve smartphone-based design?*

To answer this question in the context of a rigorous behavioural modelling approach proposed in this work it is necessary to augment the qualitative integrated model of behaviour based on the HPC, ART, and SCT with a model suitable for quantifying indicators that measure how external demands are translated into actual behaviour. To achieve this goal the TPB defines the behavioural intention (BI), which has been shown how it can be seamlessly integrated into the HPC, ART, and SCT (cf. Figure 14). While the TPB focuses on short-term disposition, longer-term motivation is not covered by the behavioural intention. To overcome this limitation the SDT has been identified to provide the relative autonomy index (RAI) as an indicator of general long-term motivation. Similar to the TPB it has been shown how the SDT can be integrated with the other theories, resulting in the main outcome of this work: the nested double cycle of behaviour with quantifiable intention and motivation (cf. Figure 17). This integrated model of behaviour aims at comprehensively covering all relevant aspects of the cognitive process that is governing behaviour with regards to a given subject area, which can be supported by a dynamic intervention, and at the same time provides the means for assessing and quantifying the underlying behavioural parameters.

Based on this theoretical foundation, the behavioural intention and longer-term motivation as measured by the relative autonomy index both in relation to healthy as well as sustainable grocery shopping have been assessed (see section 3.2). The main finding was that health is a more important driver for deciding on grocery shopping than sustainability. However, the difference between the two topics is smaller in regard to longer-term motivation, indicating that a general willingness for sustainable grocery shopping is present that does not translate into actual behaviour as strongly as the motivation to buy healthily. A significant intention-action gap exists for both topics, but it is larger for sustainability. This is mainly due to the lack of perceived behavioural control, which is a bigger issue for sustainability than it is for healthy grocery shopping behaviour. Intervention design therefore needs to address improving perceived behavioural control in particular for sustainability, to allow for a better translation of positive intention into actual behaviour.

The immediate behavioural intention to buy healthy and to buy sustainably has been found to be only very weakly correlated. This means that someone who buys healthy products not necessarily also shows an intention to buy sustainably and vice versa. On the other hand, the longer-term relative autonomy index showed a correlation between the two subject areas, indicating that intrinsic self-regulation with respect to healthy behaviour predicts intrinsic self-regulation with respect to sustainability and vice versa. For the design of an intervention with the goal of increasing both the intention to act healthily and the intention to act sustainably this means, that the two subject areas need to be both addressed explicitly and independently.

Looking at the relationship between relative autonomy index and behavioural intention for healthy grocery shopping behaviour, a correlation between the two has been found. This means that a general tendency to act healthily translates into short term intention and behaviour. This is not the case for sustainability, where no such correlation has been observed meaning that long-term motivational type does not predict intention and behaviour in the same way as for healthy shopping behaviour. Even if someone is in general intrinsically motivated to act sustainably, the intention to buy sustainably sourced grocery products is not necessarily reflected in the behaviour. For designing a suitable intervention achieving better sustainability outcomes in particular, a clear structure of goal setting and action planning is therefore required, enabling the translation of more abstract tendency into concrete behaviour.

> *The third research question this work aims to address is, if and how the motivational concepts derived from behavioural models and theories can be addressed by smartphone-based interventions and applications to support healthy and sustainable grocery shopping behaviour?*

To address this question the most popular smartphone applications for helping with grocery shopping and recipe planning have been reviewed and analysed with respect to the behavioural model developed in this work (see section 3.1). The behavioural models and theories have been shown to provide a foundation to categorise the features of the application with respect to their contribution to support a specific aspect of the cognitive and behavioural process. It has been found that most motivational concepts are addressed by a subset of the reviewed applications, at least to a degree, although commercial considerations lead to a skew in support in favour of features that are more cost-effective to implement. In particular, crowd-sourcing of data is creating limitations for the effective communication of feedback with respect to health or sustainability, which would require thorough nutritional and carbon footprint databases being integrated with the overall functionality. While applications are more likely to support a healthy diet, not many are available, yet, which would explicitly support sustainable grocery shopping in the same way.

A design case study was conducted to evaluate how the concepts derived from the behavioural model cannot only be used to categorise functionality, but also how the model can be operationalised and translated into a viable and comprehensive dynamic intervention (see section 3.3). As a result, another major contribution of this work is the development of a model-based design methodology for developing dynamic smartphone-based interventions. The methodology is based on identifying relevant qualitative as well as quantifiable aspects of the motivational process and guiding the design of the intervention accordingly. This is to ensure that all factors influencing

motivation and behaviour are addressed by the application, and that the empirical findings derived using the behavioural model can also be considered.

Applying the proposed design methodology to the task of creating a smartphone application addressing healthy and sustainable grocery shopping resulted in the development of the HealthStainable application. The development of this proof-of-concept application exemplar shows, how each of the motivational concepts derived from the underlying behavioural models and theories could be addressed by a smartphone-based intervention to support healthy and sustainable grocery shopping behaviour.

4.2 Limitations

This work has been motivated by the fragmentation of existing behavioural theories and models, which each on their own have been conjectured to be not up to the task of being applicable to the digital world (Spruijt-Metz & Nilsen, 2014). The proposed integration of different theories and models aims at overcoming this issue by creating a more comprehensive model of motivation and behaviour that encompasses all aspects of the underlying approaches, unifies their terminology, and fills the gaps of the individual constituents. While this solves the non-trivial task of selecting the appropriate concepts from the most suitable model, the aim of creating a unified comprehensive framework runs the danger creating its own complexity and thereby becoming unmanageable in itself.

The operationalisation of the integrated model requires the translation of the theoretical concepts into actual features of the intervention. This translation depends on the interpretation of the concepts from the underlying theories and can therefore be subject to discussion. This limitation is mitigated by unifying concepts' definitions across the underlying theories and models and elaborating on their mutual relationships and delineations.

The behavioural models and theories used in this work are all focused on the individual. Social interactions are encapsulated in concepts such as norms and values and the interaction with the environment. The task of meal planning and grocery shopping often happens in a family context; therefore, it is embedded into the interaction between different people whose goals and actions overlap and need to be aligned. The model is therefore limited to applications where the goals of the decision makers are shared and therefore the resulting action plans do not negatively interfere with each other.

4.3 Concluding remarks

Many people are interested in changing their habits and behaviour to improve the impact they make on the environment. This trend also affects what people chose to eat and therefore has implications on their grocery shopping behaviour. Health is a major concern when changing one's diet, but it is suspected that sustainability is gaining importance. However, lack of information and perceived behavioural control makes it difficult to translate such intentions into actual shopping behaviour, in particular when it comes to sustainability goals.

Smartphone applications are used to obtain information anytime and anywhere; however, it is unclear how these applications need to be designed to direct a desired behaviour. This work proposes a comprehensive behavioural model based on the High Performance Cycle by Locke and Latham (1990a), the Action-Regulation Theory by Hacker (1986), the Social Cognitive Theory

(Bandura, 1999), the Theory of Planed Behaviour (Ajzen, 1985) and the Self-Determination Theory (SDT) by Ryan and Deci (2000) to derive an assessment and design framework for such applications to overcome the often ad-hoc and commercially driven approaches to application development. The proposed design framework is not only restricted to the area of healthy and sustainable grocery shopping but has been successfully applied to other areas of interest including civic participation (Pham & Blanke, 2017), property management (Blanke, 2019), waste water reuse (Byrne, Fitzgibbon, Minescu, & Blanke, 2019), and energy efficiency (Blanke, Beder, Twomey, Ozdemir, & Klepal, 2017b; Vázquez, et al., 2018; Beder, Blanke, & Klepal, 2018; Beder, Blanke, & Klepal, 2019).

The presented work has shown that it is feasible to integrate similar related theories and concepts into each other, and to operationalise them in the context of intervention design. This does not preclude other models and theories being integrated, and future work might require further elaboration of aspects of the model based on such additional inputs. For instance, the focus on the individual's cognitive process, only indirectly involving the social context by assuming shared goals and non-conflicting action plans, is a limitation that could be addressed in future work to better explain and address social interactions.

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Appendices

A. Abbreviations

FBDG: food-based dietary guidelines
ART: Action-Regulation Theory
HPC: High Performance Cycle
SCT: Social Cognitive Theory
SDT: Self-Determination Theory
TPB: Theory of Planned Behaviour
BI: Behavioural Intention
RAI: Relative Autonomy Index
EMA: Ecological Momentary Assessment
UI: User Interface
UX: User Experience
DB: database

B. Survey: Intentions and motivations of healthy and sustainable food shopping

What is this questionnaire about?
This questionnaire is about evaluating and accessing your healthy and sustainable food shopping behaviour. Furthermore, will we ask you about your motivation and intention to keep a healthy diet and buy sustainable food products.

Who can participate and how long will it take?
Everybody who is over 18 can participate. The questionnaire takes about 10-15min.

What happens with the collected data?
The questionnaire is anonymous, and the collected data are only used for research purposes. This research project was approved by the Research Ethics Committee at the Cork Institute of Technology and the ethical commission of the University of Luxembourg (ERP 18-078) (IMpreSS).

What happens if I want to stop in the middle of the questionnaire?
Your participation is on a voluntary base. You can stop at any time by closing the browser window without any personal disadvantages.

If you have any questions or concerns, please contact: Julia.Blanke@cit.ie

Section 1 - Demographics

1. What is your age:
    - 18-24
    - 25-34
    - 35-44
    - 45-54
    - 55-64
    - Over 65

2. What is your gender:
    - Male
    - Female
    - Other

3. What is your highest education level achieved?
    - Junior Certificate
    - Leaving Certificate
    - Higher Certificate
    - Ordinary Bachelor's degree
    - Honours Bachelor's degree or Higher diploma
    - Master's degree
    - PhD degree
    - Other

Section 2 – Self-reported intention and behaviour (health)

In this section we will ask you about your healthy diet (healthy diet is understood as balanced and based on plenty of vegetables and fruit, reduced fat (particularly the wrong type), and limited intake of sugars and salt) [for further information you can look at: http://www.who.int/news-room/fact-sheets/detail/healthy-diet].

4. How important is a healthy diet for you personally?
    - Very important
    - Important
    - Neutral
    - Less important
    - Not important at all

5. In general, how healthy is your overall diet? Would you say . . .
    - Excellent
    - Very good
    - Good
    - Fair
    - Poor
    - Don't know

Section 3 – Behavioural Intention (health)

In this section we will ask you about your intentions regarding a healthy diet.

6. Sticking to a healthy diet is reasonable *(Attitude)*
    - Strongly disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly agree

7. People who are important to me think that a healthy diet is overrated *(Subjective Norms, reversed question)*
    - Strongly disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly agree

8. It is easy to stick to a healthy diet *(Perceived Behavioural Control)*
    - Strongly disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly agree

9. Adhering to a healthy diet is a waste of time *(Attitude, reversed question)*
    - Strongly disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly agree

10. Most of my friends are sticking to a healthy diet *(Subjective Norms)*
    - Strongly disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly agree

11. To adhere to a healthy diet is difficult *(Perceived Behavioural Control, reversed question)*
    - Strongly disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly agree

12. It is important to me that food I usually eat is healthy *(Attitude)*
    - Strongly disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly agree

Section 4 – Relative Autonomy Index (health)

In this section we will ask you about your motivation staying on a healthy diet.

There are a variety of reasons why people trying to stay on a healthy diet. Please indicate how much you agree with the following statements:

13. Because I simply enjoy sticking to a healthy diet. *(Intrinsic Motivation)*
    - Strongly disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly agree

14. Because a healthy diet is important and beneficial for my health and lifestyle*. (Identified Regulation)*
    - Strongly disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly agree

15. Because I would feel bad about myself if I didn't adhere to a healthy diet. *(Introjected Regulation)*
    - Strongly disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly agree

16. Because it is fun and interesting to keep a healthy diet. *(Intrinsic Motivation)*
    - Strongly disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly agree

17. Because others like me better when I am on a healthy diet. *(External Regulation)*
    - Strongly disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly agree

18. Because I'd be afraid of the consequences if I'm not sticking to a healthy diet. *(Introjected Regulation)*
    - Strongly disagree
    - Disagree
    - Neutral

- Agree
- Strongly agree

19. Because it helps my image keeping up with a healthy diet. *(External Regulation)*
    - Strongly disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly agree

20. Because it is personally important to me to have a healthy diet. *(Identified Regulation)*
    - Strongly disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly agree

21. Because I feel pressured to adhere to a healthy diet. *(Introjected Regulation)*
    - Strongly disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly agree

22. Because I have a strong value for being healthy. *(Identified Regulation)*
    - Strongly disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly agree

23. For the pleasure of discovering and mastering new things I try to stay on a healthy diet. *(Intrinsic Motivation)*
    - Strongly disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly agree

24. Because I want others to see me as someone, who takes care of him-/herself. *(External Regulation)*
    - Strongly disagree
    - Disagree
    - Neutral
    - Agree

- Strongly agree

Section 5 – Self-reported intention and behaviour (sustainability)

In this section we will ask you about your sustainable shopping behaviour (sustainability is understood as reduction of the ecological footprint related to carbon emission, water and energy use as well as less animal-based and more plant-based diets and seasonal products).

25. How important is sustainability for you when you go grocery shopping?
    - Very important
    - Important
    - Neutral
    - little important
    - Not important at all

26. In general, how sustainable is your overall grocery shopping behaviour? Would you say . . .
    - Excellent
    - Very good
    - Good
    - Fair
    - Poor
    - Don't know

Section 6 – Behavioural Intention (sustainability)

In this section we will ask you about your intentions to buy sustainable food products.

27. Buying sustainable food items is reasonable *(Attitude)*
    - Strongly disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly agree

28. People who are important to me think that sustainability is overrated *(Subjective Norms, reversed question)*
    - Strongly disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly agree

29. It is easy to buy sustainable food products *(Perceived Behavioural Control)*
    - Strongly disagree
    - Disagree
    - Neutral

- Agree
- Strongly agree

30. Figuring out which products are sustainable is a waste of time *(Attitude, reversed question)*
    - Strongly disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly agree

31. Most of my friends are buying sustainable food products *(Subjective Norms)*
    - Strongly disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly agree

32. To buy sustainable food products is not always easy *(Perceived Behavioural Control, reversed question)*
    - Strongly disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly agree

33. It is important to me that food I usually buy is sustainable *(Attitude)*
    - Strongly disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly agree

Section 7 – Relative Autonomy Index (sustainability)

In this section we will ask you about your motivation buying sustainable food.

There are a variety of reasons why people buy sustainable food. Please indicate how much you agree with the following statements:

34. Because I simply enjoy sustainable food. *(Intrinsic Motivation)*
    - Strongly disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly agree

35. Because a sustainable food is important and beneficial for my health and the environment. *(Identified Regulation)*
    - Strongly disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly agree

36. Because I would feel bad about myself if I didn't buy sustainable food. *(Introjected Regulation)*
    - Strongly disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly agree

37. Because it is fun and interesting to find sustainable food products in the shop. *(Intrinsic Motivation)*
    - Strongly disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly agree

38. Because others like me better when I am sustainable aware. *(External Regulation)*
    - Strongly disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly agree

39. Because I'd be afraid of the consequences if I'm not buying sustainable food products. *(Introjected Regulation)*
    - Strongly disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly agree

40. Because it helps my image buying sustainable food. *(External Regulation)*
    - Strongly disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly agree

41. Because it is personally important to me to buy sustainable food. *(Identified Regulation)*

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

42. Because I feel pressured to adhere to sustainable food products. *(Introjected Regulation)*
    - Strongly disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly agree

43. Because I have a strong value for sustainability. *(Identified Regulation)*
    - Strongly disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly agree

44. For the pleasure of discovering and mastering new things I try to buy sustainable food. *(Intrinsic Motivation)*
    - Strongly disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly agree

45. Because I want others to see me as someone, who takes care of him-/herself. *(External Regulation)*
    - Strongly disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly agree

Section 8 – Additional drivers

How important are the following aspects for you when buying a grocery item?

46. The taste of the product?
    - Most important
    - Important
    - Neutral
    - Less important
    - Not important at all

47. The price of the product?
    - Most important
    - Important
    - Neutral
    - Less important
    - Not important at all

48. The quality of the product?
    - Most important
    - Important
    - Neutral
    - Less important
    - Not important at all

49. The convenience of the product?
    - Most important
    - Important
    - Neutral
    - Less important
    - Not important at all

50. The healthiness of the product?
    - Most important
    - Important
    - Neutral
    - Less important
    - Not important at all

51. The sustainability of the product?
    - Most important
    - Important
    - Neutral
    - Less important
    - Not important at all

Thank you for your time!

C. Healthy and Sustainable Grocery Shopping (HealthStainable)

HealthStainable is a recipe and grocery shopping app, which is part of a research study with the University of Luxembourg. The focus of this app is to support healthy and sustainable grocery shopping and to help you make better decisions.

Information about nutritional values and the carbon footprint is given in a colour coded labelling system to easily see if a recipe you choose is healthy and sustainable. You can easily add these recipes to your shopping list and take the app to the supermarket to get what you need. The app supports situations where items are unavailable in the shop and will let you choose alternative recipes without the missing ingredients. It will also help you to re-organise your shopping list on the spot by showing you what items to put back into the shelves again and make your grocery shopping a success.

HealthStainable contains extensive nutritional value and carbon footprint information for each product. All recipes can be saved for later and a random recipe feature will propose recipe ideas to try out. You can also search for recipes by ingredient, so that you can find recipes to cook from what you have already at home or what you want to eat.

Features include:

28. Over 450 recipes with detailed instructions
29. Adjustable number of servings
30. Health and carbon footprint labels for all recipes and ingredients
31. Create shopping lists from recipes
32. Consistent aggregation of ingredients on the shopping list
33. Add custom items onto the shopping list
34. Alternative recipe suggestions in case of missing ingredients
35. Search recipes by ingredients to avoid food waste
36. Indication of difficulty level for each recipe
37. Maintain a list of favourite recipes
38. Random recipe suggestions

HealthStainable is part of a research project on healthy and sustainable grocery shopping with the University of Luxembourg. By downloading the app you are anonymously taking part in the research study. Your participation is on a voluntary basis and you can stop at any time by deleting the application on your phone. At no time any information from your device is accessed or tracked, except for the interactions with the app itself. All data is completely anonymised.

For this research you will be presented with a questionnaire on the first day of using the app. This questionnaire will take about 10-15min and will assess your intention and motivation in the context of healthy and sustainable grocery shopping behaviour. For the next 14 days you will also receive daily reminders to answer some brief daily questions about your grocery shopping behaviour. At the end of the study after 14 days a final longer questionnaire similar to the one at the beginning will be presented to you, which will again take 10-15 min.

It would be a great help if you could answer these questions. After 14 days no more questions will be asked, and you are welcome to continue using the app completely free of ads or other charges.

This study has ethical approval from the University of Luxembourg. It is completely anonymous, and the collected data is only used for research purposes in the context of the HealthStainable research project. If you are interested in the results or have any other questions, please send an e-mail to

julia.blanke.001@student.uni.lu and I will send you an overview of results as soon as the analysis is finished.

HealthStainable is a research project, therefore it does not contain any ads or in app purchases and your support is highly appreciated.

Section 1 - Demographics

(The following questions are only asked once at the beginning of the assessment period)

1. What is your age:
    - 18-24
    - 25-34
    - 35-44
    - 45-54
    - 55-64
    - Over 65

2. What is your gender:
    - Male
    - Female
    - Other

3. For how many people you usually cook?
    - 1
    - 2
    - 3
    - 4
    - 5
    - 6
    - 7 or more

4. Are you, or anyone you cook for on a special diet?
    - No
    - Yes, vegetarian
    - Yes, vegan
    - Gluten-free
    - Lactose-free
    - Low fat
    - Low carb
    - Yes, health related (as for diabetes, heart conditions, etc.)
    - Other

Section 2 – Self-reported intention and behaviour (health)

(The following questions are asked at the beginning and the end of the assessment period)

In this section we will ask you about your healthy diet (a healthy diet is based on plenty of vegetables and fruit, less fat – in particular the wrong kinds of fat – and limiting the intake of sugars as well as a reduction of salt intake).

5. How important is a healthy diet for you personally?
    - Very important
    - Important
    - Neutral
    - Less important
    - Not important at all

6. In general, how healthy is your overall diet? Would you say . . .
    - Very good
    - Good
    - Fair
    - Poor
    - Don't know

Section 3 – Behavioural Intention (health)

(The following questions are asked at the beginning and the end of the assessment period)

In this section we will ask you about your intentions regarding a healthy diet.

7. Sticking to a healthy diet is reasonable *(Attitude)*
    - Strongly agree
    - Agree
    - Neutral
    - Disagree
    - Strongly disagree

8. People who are important to me think that a healthy diet is overrated *(Subjective Norms, reversed question)*
    - Strongly agree
    - Agree
    - Neutral
    - Disagree
    - Strongly disagree

9. It is easy to stick to a healthy diet *(Perceived Behavioural Control)*
    - Strongly agree
    - Agree
    - Neutral
    - Disagree
    - Strongly disagree

10. Adhering to a healthy diet is a waste of time *(Attitude, reversed question)*
    - Strongly agree
    - Agree
    - Neutral
    - Disagree
    - Strongly disagree

11. Most of my friends are sticking to a healthy diet *(Subjective Norms)*
    - Strongly agree
    - Agree
    - Neutral
    - Disagree
    - Strongly disagree

12. To adhere to a healthy diet is difficult *(Perceived Behavioural Control, reversed question)*
    - Strongly agree
    - Agree
    - Neutral
    - Disagree
    - Strongly disagree

13. It is important to me that food I usually eat is healthy *(Attitude)*
    - Strongly agree
    - Agree
    - Neutral
    - Disagree
    - Strongly disagree

Section 4 – Relative Autonomy Index (health)

(The following questions are asked at the beginning and the end of the assessment period)

In this section we will ask you about your motivation staying on a healthy diet.

There are a variety of reasons why people trying to stay on a healthy diet. Please indicate how much you agree with the following statements:

14. Because I simply enjoy sticking to a healthy diet. *(Intrinsic Motivation)*
    - Strongly agree
    - Agree
    - Neutral
    - Disagree
    - Strongly disagree

15. Because a healthy diet is important and beneficial for my health and lifestyle. *(Identified Regulation)*
    - Strongly agree

- Agree
- Neutral
- Disagree
- Strongly disagree

16. Because I would feel bad about myself if I didn't adhere to a healthy diet. *(Introjected Regulation)*
    - Strongly agree
    - Agree
    - Neutral
    - Disagree
    - Strongly disagree

17. Because it is fun and interesting to keep a healthy diet. *(Intrinsic Motivation)*
    - Strongly agree
    - Agree
    - Neutral
    - Disagree
    - Strongly disagree

18. Because others like me better when I am on a healthy diet. *(External Regulation)*
    - Strongly agree
    - Agree
    - Neutral
    - Disagree
    - Strongly disagree

19. Because I'd be afraid of the consequences if I'm not sticking to a healthy diet. *(Introjected Regulation)*
    - Strongly agree
    - Agree
    - Neutral
    - Disagree
    - Strongly disagree

20. Because it helps my image keeping up with a healthy diet. *(External Regulation)*
    - Strongly agree
    - Agree
    - Neutral
    - Disagree
    - Strongly disagree

21. Because it is personally important to me to have a healthy diet. *(Identified Regulation)*
    - Strongly agree
    - Agree

- Neutral
- Disagree
- Strongly disagree

22. Because I feel pressured to adhere to a healthy diet. *(Introjected Regulation)*
    - Strongly agree
    - Agree
    - Neutral
    - Disagree
    - Strongly disagree

23. Because I have a strong value for being healthy. *(Identified Regulation)*
    - Strongly agree
    - Agree
    - Neutral
    - Disagree
    - Strongly disagree

24. For the pleasure of discovering and mastering new things I try to stay on a healthy diet. *(Intrinsic Motivation)*
    - Strongly agree
    - Agree
    - Neutral
    - Disagree
    - Strongly disagree

25. Because I want others to see me as someone, who takes care of him-/herself. *(External Regulation)*
    - Strongly agree
    - Agree
    - Neutral
    - Disagree
    - Strongly disagree

Section 5 – Self-reported intention and behaviour (sustainability)

(The following questions are asked at the beginning and the end of the assessment period)

In this section we will ask you about your sustainable food shopping behaviour (sustainability is understood as reduction of the ecological footprint related to carbon emission, energy use as well as less animal-based and more plant-based diets and seasonal products).

26. How important is sustainability for you when you go grocery shopping?
    - Very important
    - Important

- Neutral
- little important
- Not important at all

27. In general, how sustainable is your overall grocery shopping behaviour? Would you say . . .
    - Very good
    - Good
    - Fair
    - Poor
    - Don't know

Section 6 – Behavioural Intention (sustainability)

(The following questions are asked at the beginning and the end of the assessment period)

In this section we will ask you about your intentions to buy sustainable food products.

28. Buying sustainable food items is reasonable *(Attitude)*
    - Strongly agree
    - Agree
    - Neutral
    - Disagree
    - Strongly disagree

29. People who are important to me think that sustainability is overrated *(Subjective Norms, reversed question)*
    - Strongly agree
    - Agree
    - Neutral
    - Disagree
    - Strongly disagree

30. It is easy to buy sustainable food products *(Perceived Behavioural Control)*
    - Strongly agree
    - Agree
    - Neutral
    - Disagree
    - Strongly disagree

31. Figuring out which products are sustainable is a waste of time *(Attitude, reversed question)*
    - Strongly agree
    - Agree
    - Neutral
    - Disagree

- Strongly disagree

32. Most of my friends are buying sustainable food products *(Subjective Norms)*
    - Strongly agree
    - Agree
    - Neutral
    - Disagree
    - Strongly disagree

33. To buy sustainable food products is not always easy *(Perceived Behavioural Control, reversed question)*
    - Strongly agree
    - Agree
    - Neutral
    - Disagree
    - Strongly disagree

34. It is important to me that food I usually buy is sustainable *(Attitude)*
    - Strongly agree
    - Agree
    - Neutral
    - Disagree
    - Strongly disagree

Section 7 – Relative Autonomy Index (sustainability)

(The following questions are asked at the beginning and the end of the assessment period)

In this section we will ask you about your motivation buying sustainable food.

There are a variety of reasons why people buy sustainable food. Please indicate how much you agree with the following statements:

35. Because I simply enjoy sustainable food. *(Intrinsic Motivation)*
    - Strongly agree
    - Agree
    - Neutral
    - Disagree
    - Strongly disagree

36. Because a sustainable food is important and beneficial for my health and the environment. *(Identified Regulation)*
    - Strongly agree
    - Agree
    - Neutral

- Disagree
- Strongly disagree

37. Because I would feel bad about myself if I didn't buy sustainable food. *(Introjected Regulation)*
- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

38. Because it is fun and interesting to find sustainable food products in the shop. *(Intrinsic Motivation)*
- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

39. Because others like me better when I am sustainable aware. *(External Regulation)*
- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

40. Because I'd be afraid of the consequences if I'm not buying sustainable food products. *(Introjected Regulation)*
- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

41. Because it helps my image buying sustainable food. *(External Regulation)*
- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

42. Because it is personally important to me to buy sustainable food. *(Identified Regulation)*
- Strongly agree
- Agree
- Neutral
- Disagree

- Strongly disagree

43. Because I feel pressured to adhere to sustainable food products. *(Introjected Regulation)*
    - Strongly agree
    - Agree
    - Neutral
    - Disagree
    - Strongly disagree

44. Because I have a strong value for sustainability. *(Identified Regulation)*
    - Strongly agree
    - Agree
    - Neutral
    - Disagree
    - Strongly disagree

45. For the pleasure of discovering and mastering new things I try to buy sustainable food. *(Intrinsic Motivation)*
    - Strongly agree
    - Agree
    - Neutral
    - Disagree
    - Strongly disagree

46. Because I want others to see me as someone, who takes care of him-/herself. *(External Regulation)*
    - Strongly agree
    - Agree
    - Neutral
    - Disagree
    - Strongly disagree

Section 8 – Daily questions

(The following questions are asked on a daily basis throughout the whole assessment period)

47. Did you eat a main meal today?
    - No
    - Yes, cooked according to recipe.
    - Yes, cooked but not according to a recipe.
    - Yes, cooked a ready meal.
    - Yes, mixed self-made with ready made products.
    - Yes, eat left-overs.
    - Yes, eat out.

48. Would you say the meal was healthy? A balanced diet is based on: plenty of vegetables and fruit; less fat - particularly the wrong kinds of fat; limit intake of sugars; reduce salt intake.
    - Strongly agree
    - Agree
    - Neutral
    - Disagree
    - Strongly disagree

49. Would you say the meal was sustainable? Sustainability is understood as reduction of the ecological footprint related to carbon emission, water and energy use as well as less animal-based and more plant-based diets and seasonal products.
    - Strongly agree
    - Agree
    - Neutral
    - Disagree
    - Strongly disagree

50. Was the meal planned?
    - Yes
    - No
    - Didn’t have a main meal.

51. Did something unusual happened? A positive/negative event, which affected your decision to go grocery shopping?
    - Yes
    - No

52. Did you buy groceries today?
    - Yes
    - No

53. For how many days did you buy groceries?
    - 1
    - 2
    - 3
    - 4
    - 5
    - 6
    - 7
    - 7+
    - Didn't buy groceries today.

54. Did you have a shopping list for particular recipes?
    - Yes
    - No
    - Didn’t go grocery shopping.

55. Did you stick to your shopping list?
    - Yes
    - No
    - Couldn't get everything.
    - Didn't have a shopping list.
    - Didn't go grocery shopping.

56. Did you buy more than you originally wanted?
    - Yes
    - No
    - Didn't go grocery shopping.

57. Did you try to buy healthy products?
    - Yes
    - No
    - Somewhat healthy
    - Didn't go grocery shopping.

58. Did you try to buy sustainable products?
    - Yes
    - No
    - Somewhat healthy
    - Didn't go grocery shopping.

59. How satisfied are you with your grocery shopping today?
    - Very satisfied
    - Somewhat satisfied
    - Neutral
    - Somewhat unsatisfied
    - Very unsatisfied
    - Didn't go grocery shopping.