A Theory-Driven Design Framework For Smartphone Applications to Support Healthy and Sustainable Grocery Shopping

ABSTRACT

Modelling behaviour has been a core topic of Psychology and the Social Sciences since their respective inception as academic disciplines. This has resulted in a fractured landscape of different theories, all addressing different aspects of behaviour. At the same time the need to formalise the design of computer and smartphone applications has spawned the field of User Experience (UX). With the convergence of everyday behaviour and the use of mobile devices the overlap between these two fields becomes ever more important. In this paper we present a comprehensive model of behaviour, integrating five well-established theories, with the aim of creating a design framework for smartphone applications that foster motivation and promote the execution of a target behaviour. The operationalisation of the approach is demonstrated by showing how to design and implement a prototypical application to support healthy and sustainable grocery shopping behaviour. While the framework proposed is not limited to this application, it is used to exemplify the relation with previous design approaches, and the concrete implications of the model-derived framework on its implementation. Our view is that both areas of research can benefit from each other: findings from behavioural theory can inform application design, while at the same time the ubiquitous integration of mobile applications allows to dynamically apply, operationalise, and implement behavioural models into everyday life.

Keywords: behavioural models; behavioural theory; apps; smartphone; mobile application design; user experience; healthy and sustainable grocery shopping

INTRODUCTION

By definition human behaviour is at the core of the behavioural and social sciences, and related disciplines. Of central importance for these disciplines are behaviour models, which should not only adequately describe but also successfully predict behaviour, and provide the basis for interventions to change behaviour (Locke & Latham, 1990; Hacker W. , 1986; Bandura A. , 1999; Ajzen, 1985; Ryan & Deci, 2000). A closer inspection of the literature reveals a large range of models, which tend to focus on a variety of aspects. This diversity of choice means that there is no shortage of options in terms of theoretical rationales and tools for conceptualizing ICT-mediated health interventions. This diversity, however, can also make it difficult to decide which model to rely on for a given problem at hand (Michie, et al., 2005). This often leads to solution designs based on ad-hoc considerations using none or very limited theoretical foundations (Davis, Campbell, Hildon, Hobbs, & Michie, 2015; Sama, Eapen, Weinfurt, Shah, & Schulman, 2014). To address the practical problem of designing applications the field of User Experience (UX) has emerged, which specializes in investigating the interaction of people with products, systems, and services (ISO9241, 2019). Nevertheless, it has been pointed out that this discipline is driven by heuristics (Quiñones, Rusu, & Rusu, 2018) and shows a lack of theoretical background and links to existing psychological theories (Maia & Furtado, 2016). Many findings are replicating what has been known previously in the area of behavioural modelling, mainly due to the fact that most behavioural theories do not easily translate into operationalizable concepts that can be readily applied by an application designer. In this context the present paper aims to provide a comprehensive theoretical model which overcomes the respective limitations of these single models, and to guide solution design accordingly. We also elaborate on how theoretical concepts can be translated into concrete design considerations and present a prototypical application that has been designed according to the proposed theoretical model.

While the original scope of most behavioural theories is not in the realm of smartphone application design, nowadays ways of life and, therefore, our behaviour is interlinked with the use of such devices, which are ubiquitous and shape the way how we approach many daily tasks. This makes these models especially relevant for the design and integration of applications into a wider context of behavioural and behaviour change modelling. Most people have a variety of different applications on their smartphones to support them in their daily activities, for example a weather forecast, a fitness tracker, calendar or grocery shopping and recipe applications, to name a few. Our aim is here to capitalize on the latter as a prototypical exemplar to illustrate the model-based design framework developed in this paper.

While many applications are available in the domain of recipes and grocery shopping (Blanke, Billieux, & Vögele, 2021), we hypothesize that effective behavioural change directed towards more healthy and sustainable grocery shopping might be optimized if the design of applications is fuelled by the scientific knowledge derived from psychology and social science models. In this paper our aim is to demonstrate how a comprehensive behavioural model can help in guiding the design process of smartphone applications to support the behaviour in question, and to address the criticism that up until now behavioural theories “are not up to the task” in the digital world because many theories only deliver a snapshot of behaviour (Spruijt-Metz & Nilsen, 2014). Our view is that the proposed conceptual model can serve as a theoretical background for user experience (UX) design, linking this area of great practical importance and interest back to the large body of previous research on behavioural models and theories.

A COMPREHENSIVE AND CONSISTENT INTEGRATED BEHAVIOURAL MODEL

While all behavioural theories have human behaviour at their core, they take different perspectives and focus on different areas of interest. For instance, the High Performance Cycle (HPC) (Locke &

Latham, 1990) and the Action-Regulation Theory (ART) (Hacker W. , 1986) were developed in the context of work and organisational processes and are, therefore, both centred around improving work motivation and efficiency. In contrast to these, the Social Cognitive Theory (SCT) (Bandura A. , 1999), the Theory of Planed Behaviour (TPB) (Ajzen, 1985), and the Self-Determination Theory (SDT) (Ryan & Deci, 2000) were developed for a broader spectrum of potential applications. Nevertheless, each of these models focus on specific aspects underlying the behaviour, with the focus of the SCT being on the interaction of the individual with the environment, the TPB looking at behavioural intentions, while the SDT is concerned with motivational regulation. All of these theories and models can make a significant contribution to designing a solution for assessing and improving a behaviour in question, however the field remains fragmented and difficult to operationalise.

To overcome these limitations, we evaluated the definitions of concepts in each of the respective theories for communalities and overlap, while at the same time identifying gaps and limitations of the individual models. We also looked at the mutual relationships between terms and concepts, and identified mutual links and inter-dependencies. The result of this in-depth analysis is the nested double cycle of behaviour depicted in Figure 1. It shows which concepts are drawn from which underlying theory and how they are connected to each other, thus providing a comprehensive and consistent integrated behavioural model.

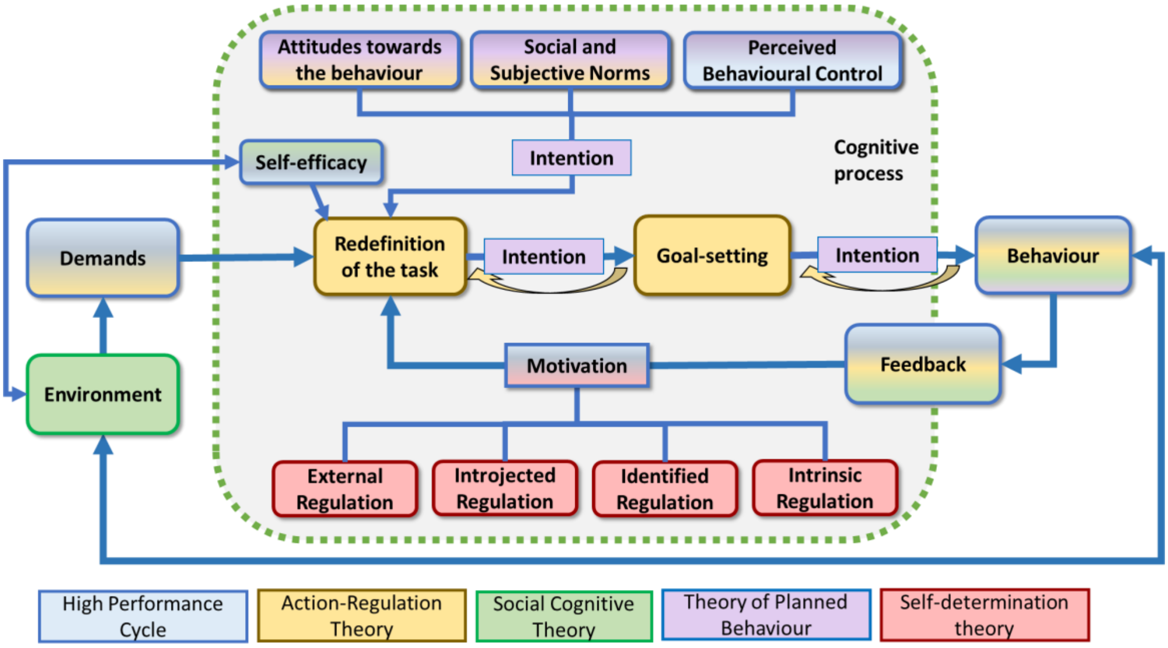

Figure 1 Nested double cycle of behaviour combining the five underlying base theories into a comprehensive and consistent integrated model of behaviour (colours correspond to the underlying theories for each concept: HPC (blue), ART (yellow), SCT (green), TPB (violet), SDT (red)).

Each of the underlying theories is more or less useful depending on the area they focus on. By integrating different behavioural models, it is possible to identify overlapping concepts, which are referred to as different terms, yet they also consider unique aspects that justify their integration to develop an integrative conceptual model. Furthermore, it is possible to identify the specific limitations of an individual theory and overcome these by connecting them to another theory which shows particular strength in the missing area and vice versa. Figure 1 shows how the different concepts from the selected theories integrate into each other resulting in a nested double cycle of links and dependencies. Where similar concepts are used but under different terms, the developed behavioural model sums those concepts up and uses the name from the most dominant theory in this area. For instance, the concept of self-efficacy is used implicitly in all models mentioned above; however, only the HPC and SCT make use of the term explicitly, and the concept itself originated from the SCT. Thus, the SCT is considered the dominant theory for the concept in this case. Similar arguments can be made for all concepts contained in the integrated model above.

The integrated theories can also be divided into qualitative and quantitative theories, depending on whether they are purely descriptive or whether they also provide means to operationalize and conceptualize a subset of variables they specify. Using this categorisation the HPC, ART and SCT can be considered qualitative, while the TPB and SDT are quantitative and provide means of assessment through psychometrically-validated questionnaires (Ajzen, 2006; Ryan & Deci, 2021).

The HPC provided the foundation of the inner behavioural cycle to which all other theories are connected. It has been originally developed in the context of work and organisational psychology and shown to be successful in improving employee performance and motivation (Selden & Brewer, 2000; Borgogni & Dello Russo, 2012). However, it also lends itself as a qualitative framework that connects important behavioural influence factors in a cyclical structure of continuously improving performance outcomes. We capitalize on its basic structure and broaden its scope to integrate other behavioural theories, making the HPC applicable to a wider area of interest. One of the main identified limitations of the HPC has been its lack of a clear description and visualisation how goals are translated into actual behaviour (Locke & Latham, 1990), which can be overcome by the ART's very precise picture of how demands or tasks are taken over and personalised by the individual, translated into precise action plans and finally into actual behaviour (Hacker W. , 2003). While the HPC and ART were both developed in organisational and work psychology and are primarily applied to optimisation of organisational process design (Hörisch, Wulfsberg, & Schaltegger, 2020; Selden & Brewer, 2000), the introduction of the SCT can help to overcome this narrow perspective on work performance. The integration of the SCT into the cyclical structure provided by the HPC widens the scope of the behavioural model by introducing a well-defined connection between the interaction of the individual with his/her environment. The SCT has been applied to assess behaviour in various domains including health (Strong, Parks, Anderson, Winett, & Davy, 2008) and sustainability (Phipps, et al., 2013). While these three theories together already provide a good picture of relevant variables concerning human behaviour, they are qualitative in nature and lack quantitative components to measure relevant behavioural parameters. While this shortcoming can be overcome by adapting existing inventories and mapping them to the concepts defined by the models (e.g. (Swindle, Ward, Bokony, & Whiteside-Mansell, 2016; Selden & Brewer, 2000; Hörisch, Wulfsberg, & Schaltegger, 2020)), it is possible to formalise inventory design by introducing explicitly quantitative theories such as the TPB (Ajzen, 2006) and the SDT (Ryan & Deci, 2000). The TPB focuses on the quantification of intention, which is understood as the condition shortly before showing the behaviour in question (Ajzen, 2006), while the SDT evaluates the motivation, which can be defined as the general tendency to show a certain behaviour in a particular area of interest. Figure 1 shows how these quantifiable parameters can also be integrated into the proposed conceptual model resulting in a consistent view of the factors (qualitative and quantitative) affecting a particular behaviour.

MODEL-DRIVEN DESIGN FRAMEWORK

The behavioural model outlined in the previous section indicates the relevant concepts and their mutual dependencies, which are identified by the underlying behavioural theories as relevant and should be addressed to achieve maximum impact. Designing an application with the goal of supporting or influencing a behaviour, therefore, needs to ensure that all these different aspects are considered comprehensively and in an integrated way. The proposed conceptual model provides a list of concepts that can be used in a design framework to identify and evaluate necessary features to support the behavioural cycle accordingly. We conjecture that following a model-driven approach that focuses on the application user's cognitive process to execute a desired behaviour has the potential to promote more optimal application design than following an ad-hoc approach essentially based on the ease of implementation of certain features, as is too often the case for many smartphone applications. In this paper we will use a smartphone application to support healthy and sustainable grocery shopping as an exemplar to demonstrate how the proposed design patterns can be translated into a real-world application (cf. HealthStainable (Blanke & Beder, 2020)), although the design framework is broader and not limited to a specific application domain. It can be applied to a variety of behavioural processes, which are volitional and conscious, focusing on the social-cognitive interaction of the individual with his/her surrounding, neither driven by inner forces nor automatically shaped and controlled by the environment alone (Bandura A. , 1989).

It should be noted that designing for supporting behavioural aspects impacts both the front-end and the back-end of a smartphone application architecture. In particular it is not limited to UI/UX design only, and can affect all components of the application ecosystem, which can include requirements on back-end databases, formation and presentation of information delivered to the user, or mechanisms for ecological momentary assessments (EMA) (Shiffman, Stone, & Hufford, 2008), to name a few. In the following we describe the concepts identified by the model individually, briefly define how they are assumed to impact behaviour, and how design patterns can be derived to affect or support these concepts as part of a theory-based design framework.

According to the HPC and ART behavioural processes are triggered by **demands** (Locke & Latham, 1990), which can be both internal (e.g. hunger) or external. The latter can be understood as external guidelines and policies, which originate from the outside and are communicated to the individual through the application. Demands are the translations of broader challenges into individual challenges, which has been shown to be a significant contributor to performance (Selden & Brewer, 2000). In the context of the design framework this can be understood as the overarching design goals of the application. It is important that such demands can be operationalised. For instance, a desired outcome of application design could be to improve healthy and sustainable diets, which then imposes constraints on the design process to ensure that these goals can be integrated into the application. More specifically, demands usually have very specific implications on how the back-end of the application is created to ensure that general guidelines and policies can be operationalised into tangible application features. For example, the design of underlying databases needs to be informed by the required information relevant to the demands, such as accurate nutritional and carbon footprint data in the case of an application targeting improving healthy and sustainable diet behaviour.

The ART describes the **redefinition of the task** (Hacker W. , 2003; Blanke, 2008) as the process how abstract and general demands are translated into personalised and meaningful goals by the individual. The same demands can be interpreted very differently by different people and it has been shown that personalisation of smartphone applications correlates with perceived usefulness (Tossell, Kortum, Shepard, Rahmati, & Zhong, 2012). In the context of an application design framework, this process should be facilitated and supported by suitable features, ideally by providing individualised information relevant for the application user in his/her respective context, that help to translate externally set demands into individualised goals. Designing features for supporting the redefinition of the task therefore should focus at the different expected types of application users and define which information from the underlying databases is relevant for which group of users, and how the information needs to be transformed to be presented adequately. This relates to the creation of personas, which have been proposed in the context of UX design frameworks (Matthews, Judge, & Whittaker, 2012).

The next step of the cognitive process leading to a behaviour according to the ART is **goal-setting** (Hacker W. , 2005; Hacker W. , 1986), which corresponds to the way superordinate goals are broken down into sub-goals and ultimately into precise and visualisable action plans. The performance gain achieved by goal-setting has been found to be empirically supported by many studies (Tubbs, 1986; Locke E. A., 1996). An application designed to be embedded into an everyday activity needs to ensure that it precisely meets the expectation of the application user in accordance with these individualized action plans. The better the flow of the application matches the actual execution of the behaviour, and the more precise the presented data and information matches the requirements during this execution the more useful the application becomes in supporting the target behaviour. For example, a grocery shopping application should ensure that the consecutive behavioural process of meal planning, shopping list creation, and grocery shopping is supported through application features such as recipe selection, consistent recipe aggregation, and flexible shopping list management. For instance, by ensuring consistency of units of ingredients or combining recipes into one unified shopping list (both not common features in many grocery shopping applications), an improvement of the perception of utility of the application potentially leading to more positive behavioural outcomes can be expected. The ART also stresses the importance of dynamic feedback loops as part of the goal-setting, which help to ensure that action-plans stay current and are updated with suitable alternatives as required. Dynamic adaption to emerging requirements is a key strength of smartphone applications; however, it is important to enable such features to optimally support goal-setting and execution.

The SCT introduces the concept of **self-efficacy** (Bandura A. , 1999; Bandura A. , 1991), which focuses on the self-perceived ability of (in this context) the application user that needs to be considered in the design process. 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). As a consequence, all provided information should be evaluated by the application designer if it is easily perceived and can be translated into appropriate behaviour by the expected target audience. Self-efficacy is conceptualized as the person's own perception of what he/she believes he/she can do under the current circumstances. It is, therefore, important in this step of the design process to identify potential external circumstances that may arise while using the application and analyse how the different targeted application users will perceive the difficulty to adjust their behaviour accordingly.

Feedback is defined in the HPC and SCT as the reflection of how far progressed a behaviour is with respect to the goal that needs to be achieved (Locke & Latham, 1990; Bandura A. , 1999). It can be either externally sourced, i.e. as a result of some form of behaviour evaluation, or originate internally, i.e. as the result of a comparison between what is perceived as achieved so far and what is the desired outcome of a behaviour. Both can lead to the potential adjustment of the behaviour during execution. Feedback also has an influence on motivation and intention to stay engaged with a plan and to show a desired behaviour accordingly. Therefore, feedback needs to occur throughout the entire activity. Meta-analysis of feedback research shows that informative feedback can positively influence motivation and behaviour (Wisniewski, Zierer, & Hattie, 2020). Application design can facilitate this by appraising behaviour directly, or also by encouraging self-reflection and self-feedback. The SDT defines the motivational type through a continuum of self-determination (Ryan & Deci, 2000), which determines the type of feedback a particular application user needs to receive to stay motivated. This can range from encouragement for intrinsically motivated individuals to monetary incentives for extrinsically motivated people and could also cover aspects such as reward schemes and gamification.

The SCT focuses on the reciprocal causal relationship between the individual and the **environment** (Bandura A. , 1999)**.** It is therefore well-suited to serve as the theoretical underpinning for all forms of ubiquitous computing, which aims at integrating the interaction of the user with the application with outside activities and circumstances. Application design can address this idea by anticipating the different contexts in which the application is used, which barriers are likely to occur and which alternatives are available to be chosen by the user. To optimally support a behaviour the application designer needs to very clearly identify, which aspects of the user's environment are immutable, which aspects can be chosen amongst a limited number of alternatives, and which aspects can be adapted to define relevant application features accordingly. For example, in a grocery shopping situation pre-planned recipes can be met with unavailability of certain products, which can be mitigated by application features to change or alter these plans accordingly while the behaviour is executed.

Although the primary goal of quantitative behavioural theories is to assess drivers of behaviour and their impact on motivation and intention, they can also be applied to inform application design aiming at improving these indicators. Applications that target these drivers are more likely to increase the motivation and create a positive impact on the behaviour in question. The TPB outlines how attitudes towards the behaviour, social and subjective norms, and perceived behavioural control all affect the immediate intention to act (Ajzen, 1985; Ajzen, 2016). 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). Application design can target these aspects separately and implement features specifically to address the beliefs of individuals accordingly. In scenarios where application users show a positive **attitude towards the behaviour**, the intention to act accordingly can be improved by presenting information first and foremost, while this approach is deemed less effective for people showing more negative attitudes. The effect on individuals who show high awareness of **social and subjective norms** can be improved by providing comparative messages and creating peer-pressure (Steg & Vlek, 2009; Keizer & Schultz, 2018), for instance by implementing aspects of gamification into the application (Berger, 2019). When **perceived behavioural control** is a predominant issue impeding a behaviour in question, this can be supported by an application design aimed at overcoming this perception and providing guidance and explanation accordingly. The TPB provides the means of assessing all three aspects independently, enabling application designers to identify the relevant personas to target their features.

A similar argument can be made for improving long-term motivation to use the application. This topic can be addressed by the SDT (Ryan & Deci, 2000), which defines **relative autonomy** as the key indicator describing general motivation. 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). According to SDT, individuals can be categorised on a spectrum from external to intrinsic motivation, which can be used as a gauge to decide if and what type of incentives need to be provided to entice a target behaviour. Hence, understanding the relative autonomy of individual application users can help to design appropriate incentive schemes and targeted feedback in a way to maximise long-term behaviour change. The SDT measures four types of regulation, all of which can be targeted by application design. The two factors negatively influencing relative autonomy are **external regulation,** which explains that some individuals need strong support or external incentives to show a desired behaviour, and **introjected regulation**, which is concerned with the avoidance of negative consequences. The presence of either requires application designers to provide external incentives, or at least to implement other schemes such as gamification and regular positive feedback, to get and keep people engaged. On the other hand, the two factors positively influencing autonomy are **identified regulation**, which describes the internalisation of superordinate goals and the need to act accordingly, and **intrinsic regulation**, which applies to individuals who do something because they like to and enjoy it. Both are addressable by providing sufficient information as well as simple ways to translate demands into goals and further into subgoals and action plans. The SDT allows to assess all these four aspects individually and identify the target audience to design application features accordingly.

All of the above concepts are derived from established behavioural theories, which were not developed with smartphone application design in mind. Instead, their focus is on providing defined (mostly social-cognitive) concepts and testable associations amongst them with the aim to predict and change behaviour. For their use in smartphone applications they need to be supplemented by design guidelines specific for the implementation of modern-day cloud-based applications. For example, issues like trust, data sparsity, ubiquity, cost-efficiency, scalability, usefulness, low-barrier access, or usability all have an impact on application design, but are not covered by these behavioural models directly.

EXAMPLE: HEALTHY AND SUSTAINABLE GROCERY SHOPPING

Model-driven application design

To demonstrate the applicability of the proposed model-based design framework we describe in the following the design of an application to support healthy and sustainable grocery shopping. The resulting Android application can be downloaded freely from the Google Play Store here: https://play.google.com/store/apps/details?id=com.HealthStainable.

The **demands** for this application are to promote a healthy and sustainable diet, in which grocery shopping plays a major role to achieve this goal. While health has been the priority up until now with regards to creating dietary guidelines, sustainability is receiving more and more attention (de Schutter, 2015; Hoek, Pearson, James, Lawrence, & Friel, 2017). The first step in designing an application targeting these demands is to focus on a clear definition of the two concepts. A healthy diet is defined by the WHO as the consumption of plenty of vegetables and fruit, less fat, in particular animal-based fat, a reduction in the intake of sugars and salt (World Health Organisation, 2020). These guidelines can be operationalised by implementing specific nutritional values. An example of such an approach is the food labelling scheme of the UK National Health Service (NHS) (National Health Service, 2021), which is based on the European food labelling directive (Council of the European Union, 1990), and provides standardised values for energy in kcal/100g, as well as fats, saturates, carbohydrates, sugar, protein and salt content in g/100g. There have also been attempts to operationalise sustainability in the context of food consumption and food production (Food and Agriculture Organisation of the United Nations, 2010; Dötsch-Klerk, Mela, & Kearney, 2015); however these guidelines are very broad, encompassing environmental impact, biodiversity, social and ethical factors all of which are difficult to quantify and implement. To implement these broad demands into a mobile application, therefore, a narrower and more focused definition is required. It has been suggested to focus on environmentally friendly diets (Verain, Sijtsema, Dagevos, & Antonides, 2017; Hoek, Pearson, James, Lawrence, & Friel, 2017), which require the reduction of the ecological footprint related to carbon emission and energy use as well as the transition from an animal-based to a more plant-based regime. To operationalise this demand in a mobile application we propose to use a metric similar to the nutritional food labelling based on the carbon emission per energy provided, which can be measured in gCO2e/100kcal. Although healthy and sustainable diets overlap to some extent, this does not hold across all product categories. For instance, reducing the intake of sugary drinks or cakes and cookies has only a moderate effect on sustainability but a significant effect on health (de Schutter, 2015). Vice versa, eating fish is a healthy source for many nutrients but has a negative impact on fish stocks and, therefore, on sustainability (Dötsch-Klerk, Mela, & Kearney, 2015).

In conclusion, operationalizable indicators for health and sustainability can be defined, with the aim to drive the development of features which support behaviour change in the desired direction. The main significance of this explicit definition of demands on application design is that it provides requirements for the databases to include consistent information on key nutritional values and carbon footprint, for each recipe and ingredient. While the USDA provides a standard reference database for nutritional values (U.S. Department of Agriculture, 2021), there is currently no similar widely accepted standard database for carbon footprint. Even with a standardised reference database available, most popular grocery shopping applications do not link to such data sources (Blanke, Billieux, & Vögele, 2021) and rely on unstructured and crowd-sourced recipe and ingredient lists instead, which makes rigorously targeting specific demands such as health and sustainability difficult to implement. To our knowledge most existing applications in this domain do not create a clear translation of input data into demands on the behaviour of the individual, resulting in sub-optimal behavioural support with respect to the two targeted dimensions of health and sustainability discussed in this example. Overcoming this issue is costly, as it requires creating relevant databases, which seems to be beyond the commercial scope of most currently existing developments.

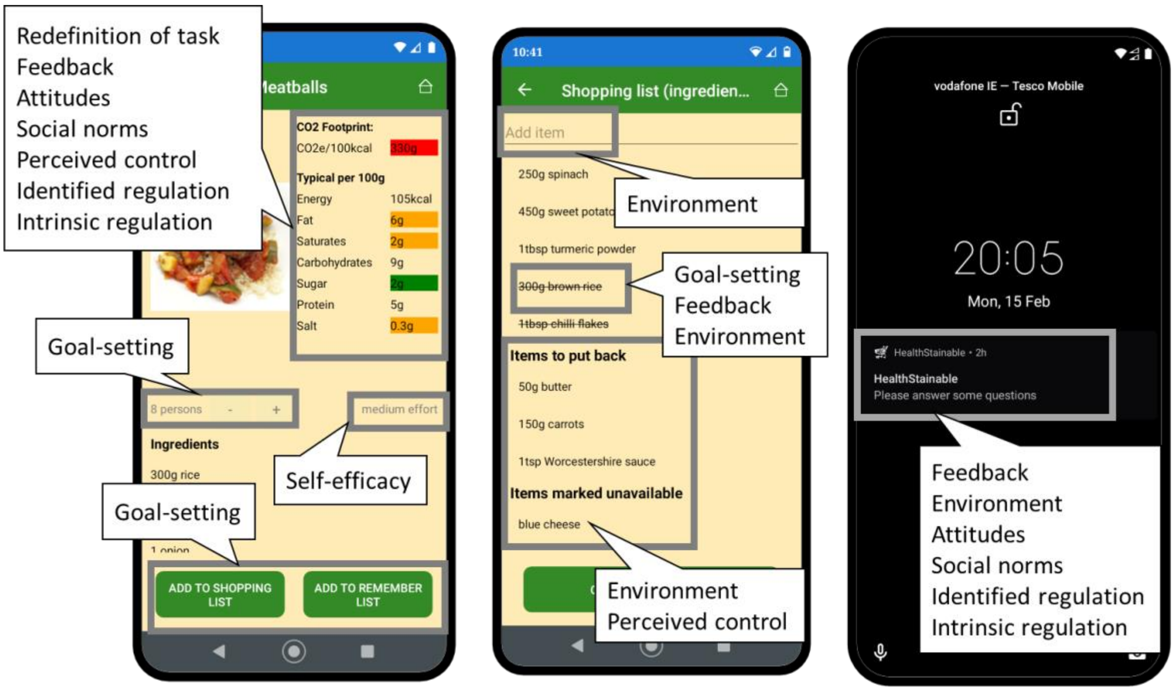

Figure 2 Screenshots of the HealthStainable (Blanke & Beder, 2020) application and relevant concepts of the model relating to functionality and User Interface (UI) elements

While the demands mostly affect the back-end design, other aspects of the behavioural model can be used to influence the front-end design (cf. Figure 2). The **redefinition of the task** needs to be implemented to allow personalisation of external demands taking individual user characteristics, such as attitudes towards the behaviour, subjective norms, and perceived behavioural control, as well as the user's self-efficacy into consideration. Based on the relevant information from the demand derived databases, this information needs to be presented in a suitable format by the application through features embedded into the user's context. For example, to optimally support individual's **attitudes towards the behaviour** the nutritional values and carbon footprint information are presented for each recipe and each ingredient, raising awareness towards health and sustainability. **Social and subjective norms** are supported by embedding this information into a traffic-light style presentation for both food labelling and carbon footprint information, providing a basis to compare this information with general expectations. **Perceived behavioural control** and **self-efficacy**, i.e. the personal anticipation if a certain behaviour can be executed under the current circumstances in concordance with one's abilities, is supported by presenting all information so that it is easy to understand and matches common expectations by adapting to existing food labelling guidelines and augmenting these towards sustainability indicators. These are all examples illustrating how the redefinition of the task can be facilitated for the different categories of end users, but of course every front-end feature should be designed to support this process in some shape or form.

User experience approaches propose to utilise personas to achieve a very similar goal of personalising the design towards different anticipated user groups; however, there is evidence that their use in the application design process is limited (Matthews, Judge, & Whittaker, 2012). Instead, we propose to specifically design application features towards the concepts introduced in the behavioural theories as outlined above. A limited, yet comprehensive, list of variables that can be addressed to guide the decision process and thereby improve the intention to carry out a behaviour in question, may provide a means for deciding on application features that enable easy translation of high level goals into concrete action plans for the majority of application users. Another benefit of utilising established behavioural theories is that the indicators for the different variables can be assessed by suitable inventories (Ajzen, 1985), which allows to determine the distribution of potential end users and to focus on the design and implementation of the application towards the most likely target audience.

A second important step of the cognitive process as identified by the behavioural model is **goal-setting**, which describes the translation of general goals into a hierarchical system of sub-goals and precise action plans to elicit the behaviour accordingly. This concept is matched in UX design by creating appropriate application flows to match the user journey to what is presented in the application. This is to map the interactions of the individual with the application with the activities and cognitive tasks that are to be supported by the application. In a grocery shopping application this amounts to a flow of activities starting from selecting recipes and summarising them into individual shopping lists, followed by functions to dynamically manage and adapt these shopping lists, and then finally help with the actual execution of the behaviour.

Throughout this user journey the reciprocal relationship between the individual with his/her **environment** impacts behaviour. Application design needs to take this into account and allow for adaptions of the flow of the application to external circumstances and triggers. Foreseeing potential obstacles and enabling continuous mitigation, both within the interaction with the application and externally, can improve application design and make it useful for the behaviour in a wider range of circumstances. In particular, allowing for situations where external obstacles are encountered and where backtracking within the action plan is necessary will greatly improve the effectiveness of an application according to the behavioural models. For instance, shopping situations can change if unanticipated events, for example the non-availability of an ingredient, derails the prepared meal plans and shopping lists. This can be mitigated by the application through allowing for an option to mark ingredients on the shopping list as unavailable, followed by the automatic creation of a list of items to put back, and suggestions of alternative recipes which do not include the unavailable ingredient. Automatically adjusting recipe and shopping lists throughout the application and providing suitable and actionable plans how to proceed will likely improve the overall experience and make the application usable in situations where obstacles in the real world are encountered.

Because the use of smartphone applications is embedded into real-world activity it is important during the application design to consider the application flow within this external context. Goal-setting and the reciprocal relationship with a dynamically changing environment are the relevant concepts from behavioural theory describing this process. Stressing the importance of anticipation of circumstances and events and creating precise and operationalizable interactions to support the adaption of hierarchical action plans should be at the core of application feature development. It is important to put the focus on the user’s daily activities and outside context as opposed to the inward-looking analysis of interactions with the application, for example through website and app usage tracking, to optimally support the target behaviour.

Regular and suitable **feedback** is essential to keep users motivated and engaged with the application and the topics concerned. To be effective and to increase motivation, feedback needs to be tailored towards the individual, very similar to how the redefinition of the task is personalised towards the target end user group. The behavioural models suggest that in the case of motivational feedback the motivational type falls onto a spectrum between extrinsic and intrinsic, which can be measured by assessing the different types of **regulation**: **external, introjected, identified,** and **intrinsic.** While extrinsically motivated people require a lot of support and incentives, intrinsically motivated people are already interested in the topic and their motivation can be maintained by providing information and regular reminders. Nevertheless, sending regular reminders and push notifications to non-intrinsically motivated application users often has the opposite effect and is susceptible to discourage the continuation and even giving-up the target behaviour. It is important, therefore, to understand application users and tailor the messaging accordingly. The benefit of applying behavioural theories to application design is again, that there are established inventories and methodologies (Locke & Latham, 1990; Hacker W. , 1986; Bandura A. , 1999; Ajzen, 1985; Ryan & Deci, 2000) that allow to assess the application user and understand his/her motivational type before sending potentially counterproductive feedback messages and notifications.

Different types of motivational mechanisms for the different types of users could be implemented. External and introjected regulation can only be targeted with external incentives. This type of user can, therefore, only be reached in a wider context usually outside the scope of mobile application development. Identified and intrinsic regulation are both addressable by providing meaningful information, hence accurate nutritional and carbon footprint information will appeal to this target audience. Nevertheless, it is important that the information provided is accurate and meaningful, imposing the same constraints on application design as already discussed above in the context of demands. Finally, intrinsic regulation can be addressed by regular push notifications, reminding the application user to check back and to interact and engage with the application. It is only this group of people, however, who will positively respond to this type of interaction, and application designers should make sure to avoid any negative impact on the long-term motivation to engage with the application.

Model-driven design evaluation

The behavioural model is not only useful for devising a targeted design methodology, it can also be used to evaluate the resulting application with respect to improving behavioural outcomes. The inventories provided by the quantitative approaches of the TPB and the SDT allow to assess changes in motivation and intention of individual application users with respect to the given topic. An example questionnaire designed accordingly for assessing intentions and motivations with respect to healthy and sustainable grocery shopping is available for download on the Open Science Framework (OSF) here: https://osf.io/usp6f/.

We propose to apply a two-step design evaluation approach: first, a survey without reference to the application should be conducted to establish a baseline of intentions and motivations with respect to the topic in question. Then, individual application users are asked to answer the same questions and their responses are tracked in relation to the baseline over a period of time while using the application to be evaluated. This can be operationalised by sending regular push-notifications to application users and requesting them to answer a set of questions from these inventories.

To demonstrate the applicability of this approach the proof-of-concept application HealthStainable (Blanke & Beder, 2020) also implements such a single-subject case study methodology to assess the potential change of individual user's intention and motivation with respect to healthy and sustainable grocery shopping behaviour. It assesses the Behavioural Intention defined by the TPB (Ajzen, 2006) as the weighted sum

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

of the attitude towards the behaviour A, the subjective norms SN, and the perceived behavioural control PBC. Depending on whether the respective attribute is positive or negative, we can also define eight distinct personas P as shown in Table 1.

Table 1 All possible persona segments depending on personal beliefs

P	*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

Similarly, we also assess the Relative Autonomy Index as defined by the SDT (Ryan & Deci, 2021; Sheldon, Osin, Gordeeva, Suchkov, & Sychev, 2017) as a measure of motivation to be the weighted sum

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

of the intrinsic regulation $R_{Intrinsic}$, the identified regulation $R_{Identified}$, the introjected regulation $R_{Introjected}$ and the external regulation $R_{External}$, all of which assessed through suitable questionnaires. The TPB and SDT therefore provide six quantifiable indicators, three for healthy grocery shopping (BI_H, RAI_H, P_H) and three for sustainable grocery shopping (BI_S, RAI_S, P_S).

Following the proposed evaluation methodology, a baseline study with $n = 144$ participants was conducted (available for download on the OSF here: https://osf.io/usp6f/). From this the distribution of Behavioural Intention values with respect to health ($m_{BI_H} = 2.33, SD_{BI_H} = 1.45$ and sustainability ($m_{BI_S} = 0.92, SD_{BI_S} = 1.28$), as well as the distribution of Relative Autonomy Index scores with respect to health ($m_{RAI_H} = 2.12, SD_{RAI_H} = 2.48$) and sustainability ($m_{RAI_S} = 2.04, SD_{RAI_S} = 2.02$) were calculated. We also determined the persona segments in the assessed population sample with respect to healthy and sustainable grocery shopping behaviour. The distribution histograms are visualised in Figure 3.

These results are now used to put the single-subject case studies into context, allowing to understand individual application users and the relative change each individual undergoes with respect to the empirical standard deviations within the wider population determined by the baseline study. The application has been published on the Google Play Store (Blanke & Beder, 2020) and between October 2020 and January 2021 six anonymous subjects submitted at least one set of answers; three of those submitted two sets of answers spaced two weeks apart while using the application. The results are summarised in Table 2.

Table 2 Assessment results for the six participants (BI_H: Behavioural Intention, health; BI_S: Behavioural Intention, sustainability; RAI_H: Relative Autonomy Index, health; RAI_S: Relative Autonomy Index, sustainability)

PARTICIPANT	#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	

For the three participants who replied to the questionnaire twice, it was possible to determine the change of the behavioural intentions and relative autonomy indexes and evaluate this change in the context of the distribution within the wider population as assessed by the pre-study. The resulting changes are shown in Table 3.

Table 3 Change of Behavioural Intention and Relative Autonomy Index relative to the popupulation's standard deviations (BI_H: Behavioural Intention, health; BI_S: Behavioural Intention, sustainability; RAI_H: Relative Autonomy Index, health; RAI_S: Relative Autonomy Index, sustainability)

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

From these data it can be seen that participant #4 showed the most significant change, with the behavioural intention to buy healthy groceries increasing 1.0 times the standard deviation, the behavioural intention to buy sustainable groceries increasing 1.63 times the standard deviation, and the relative autonomy index to buy sustainable groceries increasing 1.15 times the standard deviation seen in the reference population assessed through the pre-study. The persona of participant 4 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.

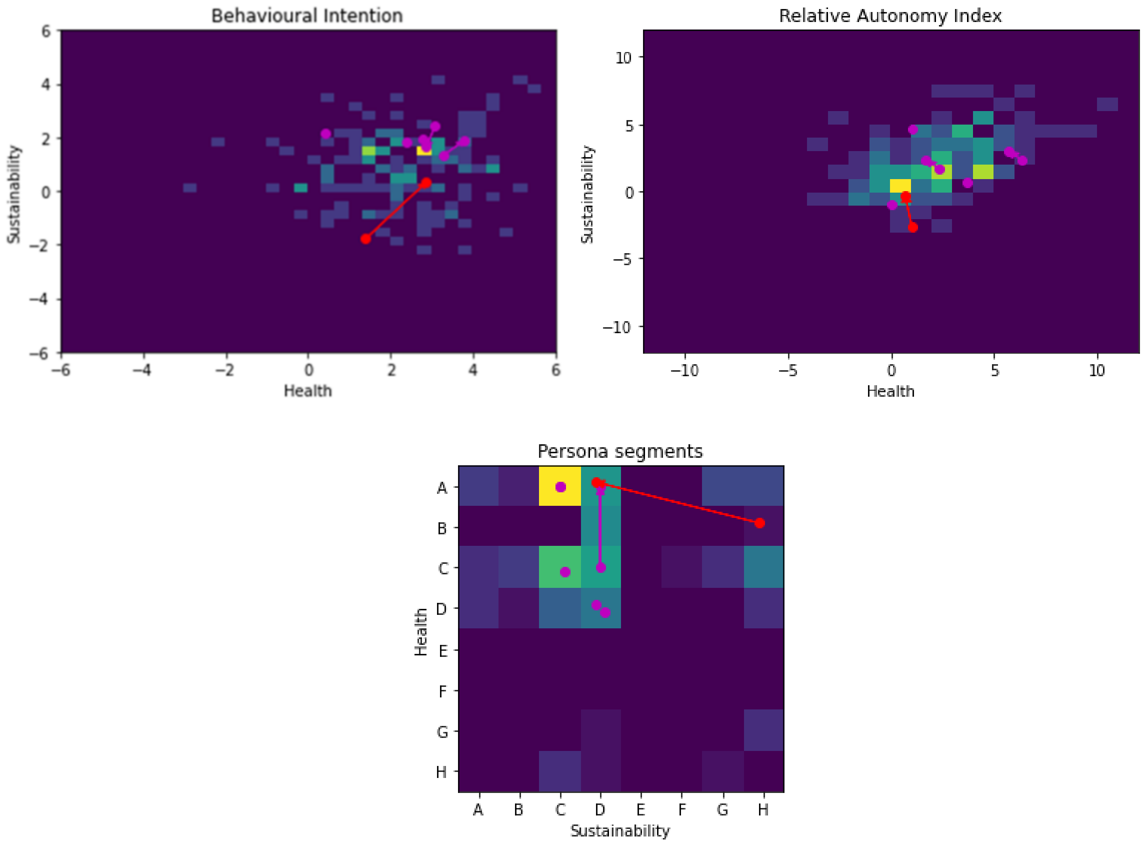

Figure 3 Change of participants' Behavioural Intention (top-left), Relative Autonomy Index (top-right), and Persona (bottom) in the context of the distribution in the wider population; participant 4 (red) showed the biggest change in all three indicators

The presented results are for each individual of a single-subject case study, therefore it has not been the intention to derive the efficacy of a particular intervention. Instead, the applicability of a rigorous behavioural modelling approach to design evaluation based on single-subject data has been demonstrated. The benefit of such an approach is that it allows for cost-effective evaluation of designs based on a few relevant test subjects.

LIMITATIONS

To follow the proposed design methodology application developers have to translate model concepts into actual application features. While the definitions and the mutual relationships identified and discussed in this paper can guide this process, the translation is not sufficiently defined and, therefore, presents a practical limitation that needs to be overcome in the future to achieve good application design.

The presented methodology has been derived from some of the most cited behavioural theories and models (Davis, Campbell, Hildon, Hobbs, & Michie, 2015). Nevertheless, the proposed model is not final and should allow for the integration of further aspects where required and appropriate. This theory development should be guided by the requirements arising from the practical application of behavioural modelling tools, which has the potential to improve the communication between the two disciplines of UX design and behavioural sciences, thereby contributing to synergies in both directions.

CONCLUSION

We presented a comprehensive behavioural model based on five established behavioural theories including the High-Performance Cycle (Locke & Latham, 1990), the Action-Regulation Theory (Hacker W. , 1986), the Social Cognitive Theory (Bandura A. , 1999), the Theory of Planned Behaviour (Ajzen, 1985), and the Self-Determination Theory (Ryan & Deci, 2000). We demonstrated their integration with the aim to fully account for the social-cognitive decision process with regards to healthy and sustainable food shopping behaviour. We translated the findings into application design patterns that can be operationalised to guide the application design and evaluation process, demonstrating how the model can be applied practically by implementing relevant features within the application. We discussed the relationship of feature design based on behavioural modelling with more commonly used application design approaches and identify communalities and differences.

While there is a significant overlap between UX approaches and the findings of behavioural modelling, both areas can learn and benefit from each other. Behavioural models developed in Psychology and the Social Sciences can inform application design by identifying relevant aspects of human behaviour that help maximise behavioural impact and long-term motivation. Furthermore, these theories also provide a means of measuring and assessing the individual's psychological characteristics, promising a more rigorous approach than using more ad-hoc techniques, e.g. personas based on stereotypical assumption rather than theory-derived surveys, as is often the case in present day application design.

While application design and development should be informed by behavioural models, behavioural research can learn from UX and other application design patterns, in that their use will show how their models and theories can be operationalised and applied in a practically relevant context. Integration into mobile applications will enable a more dynamic view of behavioural modelling, showing a direction of future research in this domain.

REFERENCES

Ajzen, I. (1985). From Intentions to Actions: A Theory of Planned Behavior. In J. Kuhl, & J. Beckmann (Eds.), *Action Control: From Cognition to Behavior* (pp. 11–39). Berlin, Heidelberg: Springer Berlin Heidelberg. doi:10.1007/978-3-642-69746-3_2

Ajzen, I. (2006). Behavioral Interventions Based on the Theory of Planned Behavior. *Behavioral Interventions Based on the Theory of Planned Behavior*. Retrieved from https://people.umass.edu/aizen/pdf/tpb.intervention.pdf

Ajzen, I. (2016). Consumer attitudes and behavior: the theory of planned behavior applied to food consumption decisions. *Italian Review of Agricultural Economics, 70*, 121-138. doi:10.13128/REA-18003

Bandura, A. (1989). Social cognitive theory. In R. Vasta (Ed.), *Annals of child development* (Vol. 6, pp. 1–60). Greenwich, CT: JAI Press.

Bandura, A. (1991). Social cognitive theory of self-regulation. *Organizational Behavior and Human Decision Processes, 50*, 248-287. doi:10.1016/0749-5978(91)90022-L

Bandura, A. (1999). Social Cognitive Theory: An Agentic Perspective. *Asian Journal of Social Psychology, 2*, 21-41. doi:10.1111/1467-839X.00024

Berger, V. (2019). Social norm-based gamification to promote eco-friendly food choice. *Journal of Consumer Marketing, 36*(5), 666-676. doi:10.1108/JCM-01-2018-2547

Biasini, B., Rosi, A., Giopp, F., Turgut, R., Scazzina, F., & Menozzi, D. (2021). Understanding, promoting and predicting sustainable diets: A systematic review. *Trends in Food Science & Technology, 111*, 191-207. doi:https://doi.org/10.1016/j.tifs.2021.02.062

Blanke, J. (2008). *Die Handlungsregulationstheorie von Hacker und der motivationstheoretische Ansatz von Locke&Latham.* Saarbrucken: VDM.

Blanke, J., & Beder, C. (2020). HealthStainable. *HealthStainable*. Google Play Store. Retrieved from https://play.google.com/store/apps/details?id=com.HealthStainable

Blanke, J., Billieux, J., & Vögele, C. (2021). Improving food shopping patterns: A review of mobile applications to assist with healthy and sustainable grocery shopping. *to appear*.

Borgogni, L., & Dello Russo, S. (2012, 1). A quantitative analysis of the High Performance Cycle in Italy. In E. A. Locke, & G. P. Latham (Eds.), *New Developments in Goal Setting and Task Performance* (pp. 270-283). New York: Routledge.

Council of the European Union. (1990). Council Directive 90/496/EEC of 24 September 1990 on nutrition labelling for foodstuffs. *Official Journal, 276*, 40 – 44.

Davis, R., Campbell, R., Hildon, Z., Hobbs, L., & Michie, S. (2015). Theories of behaviour and behaviour change across the social and behavioural sciences: a scoping review. *Health Psychology Review, 9*, 323-344. doi:10.1080/17437199.2014.941722

de Schutter, O. (2015). On our plate today: healthy, sustainable food choices. *LiveWell for LIFE - Final report.* Retrieved from https://wwfint.awsassets.panda.org/downloads/livewell_for_life_rec_report_english_final.pdf

Dötsch-Klerk, M., Mela, D. J., & Kearney, M. (2015). Sustainable diets. *Int J Food Sci Tech, 29*, 2-6.

Food and Agriculture Organisation of the United Nations. (2010). Biodiversity and sustainable diets – united against hunger. *World Food Week Symposium 2010.* Rome.

Hacker, W. (1986). *Arbeitspsychologie.* Stuttgart: Huber.

Hacker, W. (2003). Action Regulation Theory: A practical tool for the design of modern work processes? *European Journal of Work and Organizational Psychology, 12*, 105-130. doi:10.1080/13594320344000075

Hacker, W. (2005). *Allgemeine Arbeitspsychologie: Psychische Regulation von Wissens-, Denk- und körperlicher Arbeit.* Bern: Huber.

Harrison, A. W., Jr., R. K., Hochwarter, W. A., & Thompson, K. R. (1997). Testing the Self-Efficacy—Performance Linkage of Social—Cognitive Theory. *The Journal of Social Psychology, 137*, 79-87. doi:10.1080/00224549709595415

Hoek, A. C., Pearson, D., James, S. W., Lawrence, M. A., & Friel, S. (2017). Shrinking the food-print: A qualitative study into consumer perceptions, experiences and attitudes towards healthy and environmentally friendly food behaviours. *Appetite, 108*, 117—131. doi:10.1016/j.appet.2016.09.030

Hörisch, J., Wulfsberg, I., & Schaltegger, S. (2020). The influence of feedback and awareness of consequences on the development of corporate sustainability action over time. *Business Strategy and the Environment, 29*, 638-650. doi:https://doi.org/10.1002/bse.2394

ISO9241. (2019). *Ergonomics of human-system interaction — Part 210: Human-centred design for interactive systems.* Standard, International Organization for Standardization, Geneva.

Keizer, K., & Schultz, P. W. (2018). Social Norms and Pro-Environmental Behaviour. In *Environmental Psychology* (pp. 179-188). John Wiley & Sons, Ltd. doi:https://doi.org/10.1002/9781119241072.ch18

Locke, E. A. (1996). Motivation through conscious goal setting. *Applied and Preventive Psychology, 5*, 117-124. doi:https://doi.org/10.1016/S0962-1849(96)80005-9

Locke, E., & Latham, G. (1990). Work Motivation. The High Performance Cycle. In U. Kleinbeck (Ed.), *Work Motivation* (pp. 3–25). Hillsdale, London.

Maia, C. L., & Furtado, E. S. (2016). A Systematic Review About User Experience Evaluation. In A. Marcus (Ed.), *Design, User Experience, and Usability: Design Thinking and Methods* (pp. 445–455). Cham: Springer International Publishing.

Matthews, T., Judge, T., & Whittaker, S. (2012). How Do Designers and User Experience Professionals Actually Perceive and Use Personas? *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 1219–1228). New York, NY, USA: Association for Computing Machinery. doi:10.1145/2207676.2208573

Michie, S., Johnston, M., Abraham, C., Lawton, R., Parker, D., & Walker, A. (2005). Making psychological theory useful for implementing evidence based practice: a consensus approach. *BMJ Quality & Safety, 14*, 26–33. doi:10.1136/qshc.2004.011155

National Health Service. (2021). Food Labels. *Food Labels*. Retrieved from https://www.nhs.uk/live-well/eat-well/how-to-read-food-labels/

Ntoumanis, N., Ng, J. Y., Prestwich, A., Quested, E., Hancox, J. E., Thøgersen-Ntoumani, C., . . . Williams, G. C. (2021). A meta-analysis of self-determination theory-informed intervention studies in the health domain: effects on motivation, health behavior, physical, and psychological health. *Health Psychology Review, 15*, 214-244. doi:10.1080/17437199.2020.1718529

Phipps, M., Ozanne, L. K., Luchs, M. G., Subrahmanyan, S., Kapitan, S., Catlin, J. R., . . . others. (2013). Understanding the inherent complexity of sustainable consumption: A social cognitive framework. *Journal of Business Research, 66*, 1227–1234.

Quiñones, D., Rusu, C., & Rusu, V. (2018). A methodology to develop usability/user experience heuristics. *Computer Standards & Interfaces, 59*, 109-129. doi:https://doi.org/10.1016/j.csi.2018.03.002

Ryan, R. M., & Deci, E. L. (2000). Self-Determination Theory and the Facilitation of Intrinsic Motivation, Social Development, and Well-Being. *American Psychologist, 55*, 68–78.

Ryan, R. M., & Deci, E. L. (2021). Self-Determination Theory. *Self-Determination Theory*. Retrieved from http://selfdeterminationtheory.org/theory/

Sama, P. R., Eapen, Z. J., Weinfurt, K. P., Shah, B. R., & Schulman, K. A. (2014). An Evaluation of Mobile Health Application Tools. *JMIR mHealth and uHealth, 2*.

Schösler, H., de Boer, J., & Boersema, J. J. (2014). Fostering more sustainable food choices: Can Self-Determination Theory help? *Food Quality and Preference, 35*, 59-69. doi:https://doi.org/10.1016/j.foodqual.2014.01.008

Selden, S., & Brewer, G. A. (2000, 7). Work Motivation in the Senior Executive Service: Testing the High Performance Cycle Theory. *Journal of Public Administration Research and Theory, 10*. doi:10.1093/oxfordjournals.jpart.a024280

Sheldon, K. M., Osin, E. N., Gordeeva, T. O., Suchkov, D. D., & Sychev, O. A. (2017). Evaluating the Dimensionality of Self-Determination Theory's Relative Autonomy Continuum. *Personality and Social Psychology Bulletin, 43*, 1215-1238. doi:10.1177/0146167217711915

Shiffman, S., Stone, A. A., & Hufford, M. R. (2008). Ecological Momentary Assessment. *Annual Review of Clinical Psychology, 4*, 1-32. doi:10.1146/annurev.clinpsy.3.022806.091415

Spruijt-Metz, D., & Nilsen, W. (2014). Dynamic Models of Behavior for Just-in-Time Adaptive Interventions. *Pervasive Computing, IEEE, 13*, 13-17. doi:10.1109/MPRV.2014.46

Steg, L., & Vlek, C. (2009). Encouraging pro-environmental behaviour: An integrative review and research agenda. *Journal of Environmental Psychology, 29*, 309-317. doi:10.1016/j.jenvp.2008.10.004

Strong, K. A., Parks, S. L., Anderson, E., Winett, R., & Davy, B. M. (2008). Weight gain prevention: identifying theory-based targets for health behavior change in young adults. *Journal of the American Dietetic Association*. doi:10.1016/j.jada.2008.07.007

Swindle, T., Ward, W., Bokony, P., & Whiteside-Mansell, L. (2016, 11). A Cross-Sectional Study of Early Childhood Educators' Childhood and Current Food Insecurity and Dietary Intake. *Journal of Hunger & Environmental Nutrition, 13*, 1-15. doi:10.1080/19320248.2016.1227752

Tossell, C. C., Kortum, P., Shepard, C., Rahmati, A., & Zhong, L. (2012). An empirical analysis of smartphone personalisation: measurement and user variability. *Behaviour & Information Technology, 31*, 995–1010.

Tubbs, M. E. (1986). Goal setting: A meta-analytic examination of the empirical evidence. *Journal of Applied Psychology, 71*(3), 474-483.

U.S. Department of Agriculture. (2021). Nutrition Database Standard Reference. *Nutrition Database Standard Reference*. Retrieved from https://fdc.nal.usda.gov/

Verain, M., Sijtsema, S., Dagevos, H., & Antonides, G. (2017). Attribute Segmentation and Communication Effects on Healthy and Sustainable Consumer Diet Intentions. *Sustainability, 9*. doi:10.3390/su9050743

Wisniewski, B., Zierer, K., & Hattie, J. (2020). The Power of Feedback Revisited: A Meta-Analysis of Educational Feedback Research. *Frontiers in Psychology, 10*, 3087. doi:10.3389/fpsyg.2019.03087

World Health Organisation. (2020). Healthy diet. *Healthy diet*. Retrieved from https://www.who.int/news-room/fact-sheets/detail/healthy-diet

Zhang, C.-Q., Zhang, R., Schwarzer, R., & Hagger, M. (2019). A Meta-Analysis of the Health Action Process Approach. *Health Psychology*. doi:10.1037/hea0000728