Piiastiina Tikka

PERSUASIVE USER EXPERIENCES IN BEHAVIOUR CHANGE SUPPORT SYSTEMS

AVOIDING BOTTLENECKS ALONG THE WAY TO FULL POTENTIAL OF PERSUASIVE TECHNOLOGY
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Academic dissertation to be presented with the assent of the Doctoral Training Committee of Information Technology and Electrical Engineering of the University of Oulu for public defence in Martti Ahtisaari -sali (L2), Linnanmaa, on 13 November 2020, at 12 noon
Abstract

Behaviour Change Support Systems, an area of persuasive technology, aim at creating behaviour change in a broad range of domains in everyday life from better health to more eco-friendly lifestyles without using coercion or a hidden agenda. Research and development in this field has learned to use knowledge of human behaviour, user experience and interaction design methods to better systems designed for behaviour change – yet attrition rates can be high, and the effectiveness of these systems could be better.

The present dissertation comprises five studies into identifying and understanding potential pitfalls and bottlenecks where persuasive systems may fall short of their full potential. The perspectives discussed consider social factors (study II), person specific factors (studies I, II, IV and V) and system factors (interaction design) (studies III and V), and how they contribute to user experiences that support behaviour change. These studies employ both quantitative and qualitative methods, aiming at revealing perspectives on design necessities that would help advance the effectiveness and user experience of persuasive systems.

The findings add to the general scientific knowledge base in the field of persuasive technology through new insights. Key findings involve a) the effect of context and social roles on individuals’ information processing (study II), b) the role of self-image in how persuasive messages are received and how persuasive systems are involved in the construction and maintenance of an individual’s self-concept (studies IV and V), c) how information processing styles manifest in persuasive message handling (study II) and how persuasive message delivery strategy can affect the fluency of message intake (study I), and d) how system and user experience design play an important role in ensuring effective and unobstructed message delivery (studies III and V).

Overall, the dissertation forms an empirically studied picture of how distractions, interruptions and user experience design/implementation can create bottlenecks in the fluency of delivering persuasive messages to a system user. The studies also illustrate the potential of utilising knowledge regarding self-image and supporting self-image construction as means of adding fluidity to persuasive message acceptance and adding to understanding the importance of personal relevance.

Keywords: behaviour change, behaviour change support systems, persuasive systems design, user experience
Tikka, Piaa, Persuasiiviset käyttökokemukset käyttäytymisen muutosta tukevissa järjestelmissä. Pullonkaulojen välttely vaikuttavan teknologian toteuttamisessa

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**Tiivistelmä**


Löydökset lisäävät sekä vaikuttavan teknologian tutkimuksen ja suunnittelun erikoisosaamista että laajemman yleisön ymmärrystä aiheesta. Keskeiset löydökset liittyvät a) kontekstin ja sosiaalisten roolien vaikutukseen yksilöiden tiekohteen prosessoinnissa (tutkimus II), b) minäkuvaan rooliin vaikuttavien viestien käyttelyssä ja siihen, miten vaikuttavat järjestelmät ovat mukana yksilön minäkuvan rakentumisessa ja ylläpoddossa (tutkimukset IV ja V), c) miten yksilön tiedon prosessoinnin tyylin näkyvät vaikuttavien viestien vastaanottamisessa (tutkimus II) ja miten vaikeuttava viestin välistä vaihtovälinoplastologia voi vaikuttaa viestin vastaanottaman sujuvuuteen (tutkimus I), sekä d) millaisessa asemassa tietojärjestelmät ja käyttäjäkokemusmenetelmiä suunnittelut ovat silloin kun pyritään mahdollisimman sujuvasti viestinvälinkäytön (tutkimukset III ja V).

Kokonaisuutena väitöskirja tarjoaa empirisesti tutkittua kuvan siitä, millaisia pullonkauloja harrastekijät ja käyttökokemuksesta puuteellinen suunniteltu ja toteutus voivat saada aikaan vaikeuttavan viestin välijärjestelmässä. Tutkimukset osoittavat myös yksilön minäkuvan hyödyntämisen ja minäkuvan rakentumisen tukena potentiaalina silloin kun pyritään henkilökohtaisen relevanssin parempaan hyödyntämiseen ja etsitään keinoja sujuvoittaa vaikuttavan viestin vastaanottamista.

**Asiakasaratie:** käyttäjäkokemus, käyttäytymisen muutos, vaikuttavien järjestelmiä, käyttäytymisen muutos, vaikuttavien järjestelmien suunnittelu
Annikki-mummolle
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October 2020

Piiastiina Tikka
Abbreviations

BCSS  Behaviour Change Support Systems
HCI  Human-computer interaction
IS  Information System
NfC  Need for Cognition
PLS  Partial Least Squares
PSD  Persuasive Systems Design
PT  Persuasive Technology
SEM  Structural Equation Modelling
UX  User Experience
Original publications

This thesis is based on the following publications, which are referred throughout the text by their Roman numerals:


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1 Introduction

The goal for any persuasive system designer should be effective Behaviour Change Support Systems (BCSS) (Oinas-Kukkonen, 2013) that are personally relevant to their users. Existing research has produced support for such design work by means of offering design frameworks and principles and advancing our understanding of key factors in successful persuasion with technology (e.g. Fogg, 2003; Oinas-Kukkonen & Harjumaa, 2009). Overall, the success of persuasive systems relies on their users carrying on using them, and thus carrying on with the target behaviour. However, research shows that attrition rates with persuasive systems tend to be quite high: nearly 50% (Krebs & Duncan 2015; Kelders, Kok, Ossebaard & van Gemert-Pijnen, 2012). Systems that do not appeal to their users as personally relevant enough, demand too much attention and effort from their users (Krebs and Duncan 2015) or are not perceived usable and useful enough (Oinas-Kukkonen & Harjumaa, 2009) will not foster that adherence.

What, then, is personal relevance and how can we understand its build-up better? In the Elaboration Likelihood Model (Petty & Cacioppo, 1986b) the importance of personal relevance is highlighted as a part of not just message elaboration but also persuasion. Effectively, personal relevance affects elaboration motivation, that is, how strongly a message comes under scrutiny (Petty and Cacioppo, 1986). Issues that have importance and consequences in an individual’s life affect how that individual attends to persuasive information (Apsler & Sears, 1968). The Persuasive Systems Model (PSD) (Oinas-Kukkonen & Harjumaa, 2009) offers a number of design postulates that point to understanding the user needs as well as possible. The model also includes an analysis step specifically for learning what the user’s specific context is. Fogg’s Behaviour Model (FBM) (Fogg, 2009) builds on three key elements of motivation, ability and triggers. As often is the case in human-computer interaction (HCI), it is perhaps harder to identify what works than what does not work. After all, things that work do not draw much attention. It is therefore of some interest to explore areas where problems may occur. Both the PSD and the FBM models point to two main areas where communication and interaction between a persuasive system and its user may go astray: the person (user), and the system itself. The PSD model also considers context of use, which opens one more box to look into: social interaction.

Distractions can come as a part of system design itself, demanding attentional resources at an inconvenient time, perhaps causing cognitive load (Bailey & Konstan, 2006; Bailey & Iqbal 2008; Miyata and Norman 1986; Paas, Renkl &
It is also possible, that a system does not offer relevant input at the right time (Fogg, 2003; Räisänen, Oinas-Kukkonen & Pahnila, 2008) or offers it in the wrong proportions (Krebs & Duncan 2015). It is also entirely possible that the cognitive styles employed by the users are not an ideal match for how a message is delivered, such as requiring high elaboration when user is not prone to it (Cacioppo & Petty 1982; Petty & Cacioppo 1986b), or when a system user has a more profound sense of mismatch towards the intended behaviour and therefore might need a more tailored approach (e.g. Markus, 1977a; Banting, Dimmock & Lay, 2009; Cacioppo, Petty & Sidera, 1982).

As social creatures, we are subject to a number of social mechanisms of influence (Bandura, 1977), and we can also be influenced by social roles (Kang & Sundar, 2016; Mullen, Shami, Millen & Feinberg, 2010; Nonnecke & Preece, 2000). When, for example, on social media, we assume the role of someone who provides content or provides support to others, does our information processing differ from someone who has assumed a more quiet role? Interaction is influence, and on social media that influence is distributed and multidirectional and our roles may change from situation to situation – we may well handle persuasive messages differently depending on the social role and the context of each communication.

A design that offers relevance, usefulness and appropriate engagement should, by all accounts, be something a user would be happy to carry on using, but hindrances in any of these can reduce motivation and/or ability, or even hide suitable triggers. These hindrances are elements that have an effect on perceived unobtrusiveness of a system, on the ability of a persuasive information system to deliver its messages, and on how well a user processes the persuasive and behaviour change content coming from such a system. In other words, there are various factors that appear to disrupt an on-going behaviour change undertaking. While there are, no doubt, many details that warrant research attention, the present work focuses on selected factors that can disrupt, interrupt, or hinder a behaviour change process. These factors can reside with the user, the user’s social context, or with the system design itself.

The present dissertation discusses persuasion in the context of Behaviour Change Support Systems (BCSS) (Oinas-Kukkonen, 2013), which by definition refer to information systems that are “designed to form, alter or reinforce attitudes, behaviours or an act of complying without using coercion or deception.” (p.1225). This perspective rules out a number of other contexts where persuasive technology can be applied, such as advertising or politics. A more generic definition for such broader approach comes from Fogg (2003) to state that persuasive technology is...
technology for changing attitudes or behaviours with means of social influence and technology (but not coercion). Such distinction in the selected perspective means that the present dissertation and its independent studies are interested in information systems that were designed to be openly persuasive and were chosen by their users or the content provided through a system was openly aiming at supporting behaviour change.

1.1 Research questions

Effectively, three main avenues of enquiry have then been included in the present research. Figure 1 presents a flow from the three main research avenues of Person specific factors, Social factors and System factors (HCI) to the main research question of the presented research, and on to summarised sub-questions (Table 1).

The main research question in this dissertation is:

*How and to what extent do disruptive elements cause obtrusions with BCSSs?*

Table 1. Sub-questions to main Research Question aligned with the research factor they contribute to.

<table>
<thead>
<tr>
<th>Research factor</th>
<th>Research question</th>
<th>In studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social factors</td>
<td><em>How do different interaction styles in social contexts influence behaviour change?</em></td>
<td>II</td>
</tr>
<tr>
<td>Person specific factors</td>
<td><em>How does an individual’s self-image affect the success of persuasive messages?</em></td>
<td>IV, V</td>
</tr>
<tr>
<td></td>
<td><em>How do different information processing styles affect the effectiveness of a persuasive message?</em></td>
<td>I, II</td>
</tr>
<tr>
<td>System factors (HCI)</td>
<td><em>How does a system demanding users’ time and attention affect behaviour change and perceived unobtrusiveness?</em></td>
<td>III, V</td>
</tr>
</tbody>
</table>
Fig. 1. Identified research factors (on top) contributing to the main research question (middle) which in turn contains four sub-questions.

Person specific factors: Self-image, persuasion route, and reflection

The system user’s self-image (Markus, 1977a; Cacioppo, Petty & Sidera, 1982) is a factor in how persuasive messages are received and processed. The interest in self-image stems from the afore-mentioned concept of personal relevance: what constructs can we look at in order to gauge issues that a system user would deem important in their own lives, for their own endeavours, and how they deem a system they have opted to use to match their perceived need or goals? An expectation, then, is that a mis-match in message format or delivery and a recipient’s concept of what he or she is like can disrupt the persuasion process. Personality and behaviour change constitute an avenue of research, but perhaps a less trodden one is to look at self-image and its role in behaviour change. The immediate questions that arise from considering self-image are 1) what, exactly, is the effect of matching messages to self-image, and 2) can a person’s concept of self and of how a person relates to the world be accessed and altered somehow? A literature review was carried out in order to identify if self-image has been used in persuasive technology research so far, and how.

Another person specific factor relates to cognitive styles, that is, styles or tendencies of thinking styles. One distinctive identified style linked particularly to
persuasion is the need for cognition (Cacioppo & Petty, 1982), which describes an individual’s tendency towards higher or lower level of elaboration of message content (Cacioppo & Petty, 1982). Persons prone to high need for cognition are likely to form their views on the basis of reasoned, high quality arguments and to present high elaboration of available information. At the opposite end of the scale, those with a low need for cognition are more reliant on peripheral input in their decision-making, such as heuristics or who is providing the information. (Cacioppo, Petty, Fenstein, Jarvis, & Blair, 1996). The division between what is being said and who says it makes need for cognition an interesting concept in the context of social media. For example, would someone prone to more peripheral approach be more accepting of more “easy going” message repetition through a game? Need for cognition offers a construct that enables us to evaluate how information processing works in set persuasive situations, and it also provides design basis for a persuasive system delivery strategy.

**Social factors: Social roles**

Expanding from system users’ self-image theme, it is necessary to consider social interaction between individuals in an online environment. Such need arises from acknowledging a) principles of social influence in general b) the prevalence of social networking systems in everyday life, and thus c) direct interaction online forms a favourable climate for social influence. While the principles of social influence have been studied a great deal already, what is interesting in the present online context is the effect of different roles that people assume when online. Understanding the effect of assumed roles will add to the knowledge base of social influence in persuasion context. How social influence operates with persuasive systems has been discussed for example by Fogg (2003), Oinas-Kukkonen and Harjumaa (2009) and Stibe and Oinas-Kukkonen (2014). Earlier literature describes the roles of trailblazers and tracers (the latter also known as lurkers) (Oinas-Kukkonen & Oinas-Kukkonen, 2013; Nonnecke & Preece, 2000). Acknowledging this phenomenon that when online people may assume different roles that direct their conduct leads to questions of how do different roles, tasks and dynamics in group contexts affect the success of persuasion? Further questions with social roles can involve the significance of role models and even social media influencers.
System factors (HCI): Interactions and user experience

Human-computer interaction is a key element in our decision to use a system or not, and whether a system is successful at what it tries to achieve. This is no different with persuasive systems. Apart from fundamental usability research (that is, ensuring a system satisfies a minimum level user experience hygiene) one area where system design can interrupt and hinder its user’s information processing and behaviour change process is the way the system taxes the user’s attentional resources and whether the system causes perceived obtrusiveness in how it communicates with its user. Being interrupted by a system when in the middle of other tasks is known to add to cognitive load and as such can be seen a potential irritant. Would user control over when and how a system is allowed to alert the user for required activities help form positive user experiences?

That persuasive systems need to be unobtrusive is one of the key postulates presented in the Persuasive Systems Design model (Oinas-Kukkonen & Harjumaa, 2009). This postulate resonates with both building a fluid (persuasive) user experience through minimising (cognitive) bottlenecks that perceived experiences of obtrusion can cause and with the entire user experience of a persuasive system being implemented in a manner that allows the user to focus on his or her main task. Along with unobtrusiveness, the present dissertation takes interest in exploring what other user experience issues may hinder the reception and acceptance of a persuasive message.

1.2 Research approach

The research undertaken in the studies presented in this dissertation was not conducted in any one project or context. The studies were conducted with a variety of systems from purpose-built mobile apps to employing a globally used microblogging platform Twitter, and the problem domains involve healthy eating, diet awareness and punctuality. The conceptual studies were not focused on any specific problem domain as such. While nutrition and eating are topics that easily involve all humans and therefore are available as topics for any sample of participants, the thesis is not intending to be a search for solutions for the dietary problem domain. The analyses and methods employed and thus the results as well should allow for development of further research to gauge for the generalisability of the core findings regarding cognitive and user experience factors.
### 1.3 Summary of study characteristics

Table 2 (below) presents a summary of key characteristics of the original contributions in the present dissertation. The theoretical background, research methods, and research contributions are presented in greater detail in chapters 2, 3 and 4.

**Table 2. Summary of key study characteristics.**

<table>
<thead>
<tr>
<th>Study</th>
<th>Research question</th>
<th>Method</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>I: Gamifying a BCSS: rehearsal and reflection in reinforcing a health message response</td>
<td>Does a gamified process of drawing attention to implicit attitudes evoke self-reflection? Does gamification of response rehearsal contribute positively to behaviour change?</td>
<td>Explorative quasi-experiment, PLS-SEM</td>
<td>58</td>
</tr>
<tr>
<td>II: Contributing or receiving - The role of social interaction styles in persuasion over a social networking platform</td>
<td>What is the relevance of different interaction styles on information processing for those who are active contributors and those who are viewing and taking in the content without active participation? Is the learning or persuasion result different depending upon whether a system user is a silent observer or an active contributor?</td>
<td>Experiment; PLS-SEM, ANOVA, t-test</td>
<td>30</td>
</tr>
<tr>
<td>III: RightOnTime: The Role of Timing and Unobtrusiveness in Behavior Change Support Systems</td>
<td>How do [system communication] timing strategies affect behaviour change and perceived unobtrusiveness when using BCSSs?</td>
<td>Experiment (mixed design); ANOVA</td>
<td>13</td>
</tr>
<tr>
<td>IV: Tailoring persuasive technology: A systematic review of literature of self-schema theory and transformative learning theory in persuasive technology context</td>
<td>How have the theories of self-schema and transformative learning been used in persuasive technology research to date?</td>
<td>Systematic literature review</td>
<td>N/A</td>
</tr>
</tbody>
</table>
### Study Research question Method N

<table>
<thead>
<tr>
<th>Study</th>
<th>Research question</th>
<th>Method</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>V: Relevance of persuasive technology: a critical incident study of experiences with Behavior Change Support Systems</td>
<td>How do system users’ experiences show elements of relevance and reveal user experiences that affect use continuance?</td>
<td>Critical incident study; thematic analysis</td>
<td>239 (399 incidents reported)</td>
</tr>
</tbody>
</table>

### 1.4 Dissertation structure

The dissertation describes, next, the theoretical background of the independent studies (Section 2), then moving on to presenting the research methods used in the studies (Section 3). Section 4 summarises the research contributions of the independent studies, followed by general discussion (Section 5) and conclusions (Section 6).
2 Theoretical background in studies

2.1 Study I: Gamification, implicit association, and reflection

In study I, the BCSS was built on the principles of implicit attitudes (Greenwald, McGhee & Schwartz, 1998) as a mechanism for a game that would expose the player’s existing attitudes and biases regarding the problem domain (healthy eating). The expectation was that exposure to one’s own implicit thinking would work as feedback that can evoke reflection. Awareness of automatic responses is required if any motivation to change such responses is to be expected (Bargh, Chen, & Burrows, 1996). The Implicit Attitude Test (Greenwald, McGhee & Schwartz, 1998) tests implicit attitudes by revealing automatic associations to attitude items by asking a person to respond to the said items as quickly as possible. The founding principle there is that the faster the response, the less time the subject has to spend deciding how to respond: the more automatic the response the more revealing it is of the subject’s implicit thinking on the item (Greenwald, McGhee & Schwartz, 1998). Likewise, in the game built for Study I, the objective of the game is to categorise items on the mobile device screen as quickly as possible, and the faster the player achieves correct responses, the higher the scores. In this fashion, the score functioned as feedback, revealing to the user how much they had to think in order to achieve the correct responses. The IAT was deemed appropriate as a mechanism for the study and its problem domain as it has been used in healthy eating and diet-related studies before (Maison, Greenwald and Bruin, 2001; Roefs & Jansen, 2002). The development of the system has been described more closely in Manninen and Tikka (2018).

The format of the BCSS in Study I is a game, which in the study itself has been described as a highly gamified BCSS. One definition of gamification is to use characteristics of gaming with utilitarian goals (Hamari & Koivisto, 2013). This definition includes the definitions that a game has self-purpose and hedonistic use, and a gamified system’s intention is towards utilitarian goals, such as learning (ibid.). The system in Study I was built first and foremost as a BCSS, with the intention that its goal is behaviour change – and it is for this reason it is not a game that is played purely for its entertainment value. The intrinsic motivation involved in game play is reigned and repurposed to work towards the utilitarian goals (Huotari & Hamari 2012; Hamari & Koivisto, 2013) through using elements normally used in games, such as badges, points, and progression through levels.
Game elements in Study I BCSS include points and other feedback that in PSD terms constitute self-monitoring – or feedback. The player is exposed to his or her own performance in terms of a score, and also as instant feedback on correct/incorrect responses. The role of feedback in reflection is well-established in the area of personal informatics (Li, Dey & Forlizzi, 2011). Exposing a system user to feedback on their own behaviour and thinking facilitates self-reflection, which in turn allows interpretative sense-making (Ploderer, Reitberger, Oinas-Kukkonen, & van Gemert-Pijnen, 2014). Another avenue for exploring the effect of increased self-knowledge on self-reflection is through Cognitive dissonance theory (Festinger & Carlsmith, 1959). Exposing an individual to factual information about his or her own behaviour should evoke an evaluation process of either accepting or rejecting that information in order to diffuse any possible cognitive dissonance that the information may bring forth (ibid.). The ways to diffuse the dissonance can involve changing behaviour, or to outright reject the factual information. In Study I playing the game is a behavioural manifestation of the target behaviour in itself, in a form of rehearsing the target behaviour of making healthier food choices.

2.2 Study II: Social roles, cognitive styles and tweeting

The theoretical background in Study II comprises three directions that all approach a different aspect of the phenomenon under investigation in the study: Social influence (Bandura, 1977), Protection Motivation Theory (Rogers, 1975), and Elaboration Likelihood Model (Petty & Cacioppo, 1986b). The three theoretical directions all expose a different angle to what we can expect to see in the study context and how we can expect the information system at the core of the experiment to influence people.

The experiment used a microblogging platform, Twitter, as the environment for the study. A system for creating and sharing messages to a (at times) wide audience Twitter is a platform for social influence. In such a setting, system users can not only send out messages of their own or see messages from others, but they will also see how others forward and share these messages or like them. Seeing other people’s behaviour within the system allows others to learn how to conduct themselves, and knowing others see what is contributed will affect what and how these contributions are (Bandura, 1977, 1986, 1997; Zajonc, 1965). For example, social facilitation only requires knowledge of the possibility that other people can witness an activity (Markus, 1977b).
Protection motivation theory (PMT) explains the process of accepting or rejecting a behavioural recommendation (Rogers, 1975). Individuals with high protection motivation engage in behaviours that will reduce a presented risk (Cacioppo & Petty, 1981). The theory posits that a message that contains a threat, such as the negative consequences of poor lifestyle choices, will result in an individual responding to the threat by assessing the source, the severity, and the cost of the threat, as well as what is the behaviour required to avoid the threat (Floyd, Prentice-Dunn & Rogers, 2000). This assessment will lead to a state of high or low protection motivation (ibid.). If the motivation is low, an individual is likely to reject the message, and when the motivation is high, an individual is more likely to accept the threat and then potentially move towards behaviour change (ibid.). To assess the likelihood of behaviour change, the variables of response efficacy and self-efficacy can be used. These variables, essentially, indicate if the recommended behaviour is likely (in the individual’s view) to reduce the risk significantly enough, and how capable does the individual see himself or herself at producing that required behaviour (ibid.)?

Elaboration Likelihood Model presents two basic routes of human information processing: central and peripheral (Petty & Cacioppo, 1986a). When an individual involves careful consideration of a message or relevant information, elaborating upon these items in a way that leads to positive or negative thoughts regarding the message, he or she is using central processing (Petty, Briñol, & Tormala, 2002); Petty and Cacioppo, 1986b). However, when an individual relies more on heuristics and less on effortful thinking and high elaboration of a message, he or she is using the peripheral route (ibid.). To use central processing both motivation and ability are required (Petty, Barden, & Wheeler, 2002). Distractions, number of message repetitions, and personal relevance of the message all also affect the process (Petty, Barden and Wheeler, 2002; Petty and Cacioppo, 1986a). Another factor can also be an individual’s confidence in his or her own thoughts (Petty, Briñol, & Tormala, 2002). Need for Cognition (NFC) refers to an individual’s tendency to enjoy engaging in analytical thinking (Petty & Cacioppo, 1986a). Individuals with high NFC (that is, they do find enjoyment in analytical thinking) tend to use the central route (ibid.) In contrast, with individuals who are high on NFC, those with low NFC are not so likely to take pleasure in effortful and analytical thinking (Petty & Cacioppo, 1986a). Whether for reasons of lack of motivation and/or ability, such individuals lean on heuristics, cues and even affective states, such as state of mind arising from the message in how they assess a message (Petty & Cacioppo, 1986b). Behaviour change can be achieved through either processing style, but on the whole
the change through central route has been considered more sustained (Petty & Cacioppo, 1986a). Behaviour change through peripheral route can perhaps work in short-term and when mere one-off compliance is required (Petty, Barden & Wheeler, 2002).

2.3 Study III: System messages and perceived unobtrusiveness

To study factors in perceived unobtrusiveness of BCSSs, Study III approached the topic largely from the direction of timing strategies, using the concept of opportune moment (Kinneavy, 1986; Fogg, 2003; Räisänen, Oinas-Kukkonen & Pahnila, 2008) and cognitive load theory (Paas, Renkl & Sweller, 2004; Sweller, 1988). Cognitive load theory proposes that high working memory effort reduces other cognitive processes, such as problem solving (Paas, Renkl & Sweller, 2004; Sweller, 1988). Attention is a limited cognitive capacity and having to switch attention from one task to another will hinder performance on either task (Kahneman, 1973).

When a device or a system demands its user’s attention at random moments, it may result in increased cognitive load (Bailey & Iqbal, 2008; Bailey & Konstan, 2006; Miyata & Norman, 1986). Also, if the messages from the system do not come at an opportune moment, the impact of the said message may not be optimal (Fogg, 2003; Räisänen, Oinas-Kukkonen, & Pahnila, 2008), and task switching comes with a cost to working memory (Liefooghe, Barrouillet, Vandierendonck & Camos, 2008). Research into the effects of task switching and increased working memory load have shown how randomly timed interruptions have a negative effect on the performance of a main task (Bailey & Iqbal, 2008; Bailey & Konstan, 2006; Czrewinski, Cutrell & Horvitz, 2000), and can cause negative affect towards a system producing these interruptions (Bailey & Iqbal, 2008; Bailey & Konstan, 2006).

Messages or notifications from a system can come with a lower interruption cost depending on their timing (Miyata and Norman, 1986). A concept for describing the ideal timing of messages and interruptions is ‘opportune moment’ (or ‘kairos’ from the Greek), which in persuasive technology involves the problem of when to best communicate a message to the user and achieve the maximum effect (Fogg, 2003; Räisänen, Oinas-Kukkonen, & Pahnila, 2008). The issue of the opportune moment in persuasive technology can involve simply trying to minimise interruption cost (Bailey & Iqbal, 2008; Bailey % Konstan, 2006; Czrewinski, Cutrell & Horvitz, 2000) but also aim at identifying moments of communication
that could increase the impact of a persuasive message (Fogg, 2003; Räisänen, Oinas-Kukkonen & Pahnila, 2008). Kinneavy’s definition of kairos (Kinneavy, 1986) expands from timing to further related factors of how often and how much is the correct amount.

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2.4 Study IV: Self-schemas, transformative learning

A systematic literature review, Study IV, charted out the use of two seldom-seen theories in persuasive information systems. Starting from the premise that more personalized and tailored approach to offering behaviour change systems, the review searched for existing literature on the use of Self-schema theory and use of Transformative learning theory in the area of Information Systems.

Self-schema theory (Markus, 1977a) regards an individual’s perception of what he or she is like in relation to his or her environment. Such a perception can be described as “cognitive generalizations of the self, defined from part experience, that organize and guide the processing of self-related information contained in the person’s social environment” (p.64) (ibid.). A positive schema towards a specific activity can act as a moderator in the process of forming intention into behaviour (Sheeran & Orbell, 2000). An established self-schema provides, in effect, a filter or a selective function for what information is attended to and how such information is structured, or how important is valued (Markus, 1977a). Encountering more of the same type of experiences that helped form the schema will also reinforce it, the schema gaining strength in the process and becoming more resistive to schema-inconsistent information (Markus, 1977a). This concept of the self not only
describes behaviour: it also mediates and regulates it (Markus and Wurf, 1987). Self-schema has been studied in the context of message elaboration and attitude change (Wheeler, Petty & Bizer, 2005) and also behaviour change Sheeran and Orbell, 2000). These studies indicate a direct link between a person’s self-schema and behaviour and behaviour change.

Study IV also aims at expanding into learning theories to complement the social psychology already in use in building researching persuasive technology. As a theory particularly focusing on behaviour change, Transformative learning theory (Mezirow, 1995) can well work as a component in building persuasive information systems. The theory approaches change from the direction of re-evaluating one’s position when facing new information or changes in circumstances (Mezirow, 1991). Transformative learning in itself is a structured programme for an individual to change his or her understanding of the surrounding world with the view to achieve deep learning (change). Critical self-reflection of one’s experiences will lead to a change in how a person views himself or herself in relation to the surrounding world (Mezirow, 1995, 1991, 1996). A stage-based learning model, transformative learning has the explicit goal of leading the learner through the stages to a changed perspective to the world, making it an interesting approach particularly as regards self-schema theory.

2.5 Study V: Personal relevance of persuasive technology

The main research interest in Study V was the (personal) relevance of persuasive technology in view of how users continue or discontinue system use. In particular, the focus was in seeing how and what type of user experiences can be the “make it or break it” factors in continuance. As theoretical frameworks for discussing relevance the article selected an information systems-oriented model of system success factors and inhibitors (DeLone & McLean, 1992, 2003). For the more latent aspects of personal relevance in terms of what a user may want to use these systems for apart from the explicit surface reason, the theoretical lens was that of self-evaluation and its four core motives.

The information system success factor model (DeLone & McLean, 1992, 2003) and the complementing work by Cenfetelli and Schwarz (2011) present system and information enablers and inhibitors. The Cenfetelli and Schwarz framework takes six enablers (three system, three information) from DeLone and McLean, and adds six inhibitors (again, three system and three information). Cenfetelli and Schwarz (2011) identified the need for inhibitors in the framework as they recognized that
not all problems stemmed from what would be the opposite of the success factors. In Study V these ‘opposites’, which are essentially enabler fails, are explicitly put forth in the analysis as system and information “disablers”. The presence of errors, mistakes, omissions or otherwise problems with system quality was very much at the centre of many of the participant accounts in the critical incident study.

The initial open coding of the critical incident data in Study V drew attention to a number of themes regarding the deeper reasons for why people may want to use many persuasive systems, particularly ones that provide personal feedback. These aspects were studied more closely through the construction and maintenance of an individual’s self-concept and the four motivations for the self-evaluation process (Sedikides & Strube, 1995). Self-evaluation is at the heart of self-regulation, as without self-evaluation of the feedback we receive on our performance and behaviour self-regulation would not be possible (Taylor, Neter & Wayment, 1995).

There are four motives for self-evaluation: self-assessment, self-enhancement, self-verification (Sedikides, 1993; Taylor et al., 1995) and self-improvement (Taylor et al., 1995). The latter differs from self-enhancement in its purpose and time orientation.

The information sources for satisfying these motivations vary according to the motive, life domain, and individual differences (Taylor et al., 1995). For example, in self-enhancement downward social comparison and past-self information are preferred, whereas for self-improvement the preferred information sources are social upward comparison and future possible selves (Taylor et al., 1995).

One highly interesting and relevant aspect regarding what information is used for self-evaluation arises from the Taylor et al. (1995) study where the researchers observed an additional information source in direct feedback: study participants regularly referred to asking or seeking direct responses from other people. Such an aspect is interesting in the scope of Study V largely for two reasons: a) in behaviour change one strategy for eliciting reflection involves feedback, and b) many of the most used devices, namely trackers, are built on the concept of feedback. The single most used device or system type listed by the participants in Study V was some type of an activity tracker. These devices do often offer other behaviour supporting, changing, or guiding features, but the barebones information content is to show the measurable results of a user’s behaviour. At the point of today’s reasonably advanced technology, we no longer need to ask anyone else how we look, or whether a day’s activity has been enough to satisfy the recommendations: the systems are there at our disposal to provide this feedback.
2.6 Persuasive Systems Design (PSD) model

A framework for the analysis and design of persuasive systems, The Persuasive Systems Design (PSD) model (Oinas-Kukkonen & Harjumaa, 2009) builds on a number of core behaviour change theories and earlier work on operationalising behaviour change principles by means of ICT (Fogg, 2003). The model presents founding postulates that should guide all persuasive system development and collects design principles for such systems for designers and developers to use in their systems. The core of the PSD model includes elaboration likelihood model (Petty & Cacioppo, 1986), theory of planned behaviour (Ajzen, 1985, 1991), social learning theory (Bandura, 1977), and goal-setting theory (Locke & Latham, 2002).

A closely connected framework is the Outcome/Change (O/C) matrix (Oinas-Kukkonen 2010a, 2010b, 2013). The matrix is a tool for defining and tracking change direction and strength on two axis: change type, and the outcome of the change (ibid.). In the matrix, the main types of behaviour change are compliance (C-change), behaviour change (B-change) and attitude change (A-change), and the strength of the change is described as formation (F-outcome), alteration (A-outcome), and reinforcement (R-outcome). One-time compliance to a request is sometimes easy to achieve, but is not a sustained behaviour change, which is characterised more by independently taking on a new or changed behaviour and maintaining it. The ultimate change would involve accepting and embracing the change at attitude level – as an integrated element of a person’s self-concept. The stages of these changes described in the matrix identify formation as the initial stage of engaging in a new behaviour. Alteration takes place when an existing behaviour changes into a new one, and when a new or changed behaviour is encouraged and strengthened, behaviour is reinforced.

The PSD model (and O/C Matrix as its affiliate) have high relevance in the presented studies, as the PSD model was used in the construction of the research artefacts in studies I and III, and the model and the O/C Matrix provide the analytical framework for the literature review in Study IV.
3 Research methods

The studies in the present dissertation employ a selection of quantitative and qualitative methods. The experimental studies I, II and III are of a quantitative design. Studies I, II and III employ ANOVA and/or t-test in order to compare score means between participant groupings. Studies I and II use PLS-SEM as the primary technique.

Studies IV and V employ the qualitative paradigm. Study IV is a systematic literature review which gathers, analyses and then reports the outcomes of a systematic search of literature through defined databases by means of defined search terms. Study V is a critical incident technique (Flanagan, 1954) study in a survey form.

3.1 Data analysis methods

3.1.1 Partial least squares structural equation modelling (PLS-SEM)

Partial least squares structural equation modelling (PLS-SEM) was used in Studies I and II to explore the relationships between latent variables. Such a multivariate method allows researchers to build models with latent (observable) variables that arise through indirectly measuring indicator variables. As a primarily explorative method, PLS-SEM is an appropriate tool when the purpose of a model is to predict; confirmatory methods such as CB-SEM (covariance-based SEM) or confirmatory factor analysis are more appropriate for testing established theories (Hair, Hult, Ringle & Sarstedt, 2014). The PLS-SEM analysis, in the fashion of linear regression, demonstrates the explained variance in latent variables ($R^2$) and also indicates the strength ($\beta$-value) and statistical significance ($p$-value) of the relationships between the variables in the model (Gefen et al., 2011; Hair, Ringle & Sartedt, 2011, Hair et al., 2014). Even though the PLS-SEM is an explorative method, a priori knowledge and hypotheses regarding relationships between latent variables (or constructs, as they are often called) is still used and even necessary (Hair et al. 2014).

In all PLS-SEM analyses the in the studies in this dissertation SmartPLS software (www.smartpls.com) was used with relevant guidelines as published by the developers (Hair et al., 2014). Such guidelines instructed on appropriate levels for internal consistency, the reliability of the indicators and the convergent validity.
of the indicators as well as the discriminant validity of the measurement model as an assessment of the measurement model (Hair, Hult, Ringle & Sarstedt, 2014). Establishing the validity and reliability of the measurement model first will then be followed by assessment of the structural model; this assessment allows for drawing conclusions as regards the relationships between the constructs in the model.

### 3.1.2 Analysis of variance (ANOVA), t-test, and correlation

Studies II and III used analysis of variance (ANOVA) as a data analysis method. ANOVA compares groups over multiple conditions to reveal if they differ from each other (Field, 2009). In study II, ANOVA was conducted with relevant and irrelevant thoughts and perceived health behaviour change, comparing the two activity styles in the experiment (a group who contributed content and a group who simply received those contributions). Study III employed ANOVA in comparing task success and task satisfaction between the groups. IBM Statistical Package for Social Sciences (SPSS).

With the t-test it is possible to examine the significance between two groups on a single factor (Field, 2009)). Study II employed a dependent means t-test to compare the effect of timing (before and after participation in the experiment) on fruit and vegetable consumption between the two experiment conditions. Using IBM Statistical Package for Social Sciences (SPSS), Shapiro-Wilks test was employed to check that the data sets were normally distributed before the t-test.

Studies I and III employed a simple correlation analysis. Correlation shows a statistical association between data arrays (Field, 2009). Again, using SPSS software, Pearson’s correlation coefficient was used in examining the relationship between reaction times and correct/incorrect responses in the game in Study I, and in Study III correlation was checked for experiment scores (task success, task satisfaction) and perceived unobtrusiveness.

### 3.1.3 Qualitative methods

The systematic literature review in Study IV followed guidelines presented in Webster and Watson (2002). The literature search findings were analysed against the frameworks of the PSD model and the O/C Matrix, and they were analysed for the key elements in the theories of Self-schema theory and Transformative learning theory, which were the key target theories in the study and search.
Critical incident technique (Flanagan, 1954) employed in study V aims to find meaningful individual events and incidents in respondents’ experiences with a system. Developed originally for the United States Air Force, the technique was employed in the study context knowingly anticipating that reports of incidents that would satisfy the original “critical incident” criteria set by Flanagan (1954) may not be rife. Such anticipation stemmed from the nature of the devices in use: longer term use with few opportunities for major incidents but more chance of accumulated experience that over time tips the scales for the system user to make an observation that sticks out in his or her mind as meaningful. A survey questionnaire collected N responses, which were then analysed thematically. The open coded analysis allowed for an overview of factors that were identifiable from the data. In order to analyse for and discuss the study topic of relevance, an overlay of system success factors (DeLone & McLean, 1992, 2003; Cenfetelli & Schwarz, 2011) and self-evaluation motives were used to identify how participants’ experiences reflected on these existing perspectives on relevance. The thematic analysis followed guidelines by Braun and Clarke (2006) in the open coding phase and in collecting the codes under themes. These themes were then used together with the, effectively, superimposed themes of success factors and self-evaluation in order to discuss the specified research topic of the paper.

3.2 Measurement instruments: theoretical foundations

The studies in the present dissertation employed mostly previously existing measurement instruments, instruments that were developed or adapted based on existing instruments or used direct measures. For the PHBC (perceived health behaviour change) construct a new instrument was developed. Table 3 summarises the theoretical foundations of the instruments used in the independent studies.

<table>
<thead>
<tr>
<th>Construct / measurement</th>
<th>Description</th>
<th>References</th>
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<tr>
<td>Engagement in reflection (REFL)</td>
<td>The scale used in the experiment is one component from a previously developed and validated reflection scale comprising need for reflection, engagement in reflection, and insight. Relevant questions from the scale on engagement in reflection were included in the post-test questionnaire in Study I.</td>
<td>Grant, Franklin, and Langford (2002). Roberts and Stark (2008).</td>
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<td>Construct / measurement</td>
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<td>Perceived persuasiveness</td>
<td>The scale, developed specifically for assessing BCSSs, is a self-assessment scale for assessing the impact of a persuasive system. In practice it describes how favourably an individual perceives a persuasive system. Used in Study I.</td>
<td>Lehto, Oinas-Kukkonen, and Drozd (2012); Petty and Cacioppo (1986); Crano and Prilin (2006); Wood (2000)</td>
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<td>PHBC</td>
<td>A self-developed scale based on open-ended responses regarding perceived behavioural effect of a system or intervention. Essentially forming a Likert-type scale, participant responses are coded onto a scale by researchers. The purpose of the approach is to allow the participants describe their experience freely and without trying to match it to any direction or strength indicator on a ready-given scale. It is then the researchers’ task to evaluate each response and place it on the scale from a weakest possible effect to the strongest. Effectively, the instrument takes on many of the tasks in scale development by using the open-ended responses from the respondents to formulate the scale items. Used in Studies I and II.</td>
<td>Used in Studies I and II.</td>
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<tr>
<td>Number of games played</td>
<td>Direct system log item showing how many individual games a participant played during the test period.</td>
<td>Used in Study I</td>
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<td>Efficacy (EFF or EFFI)</td>
<td>In accordance with Protection motivation theory (PMT) both self-efficacy and response-efficacy must be assessed to be at an adequately high level in order for a person to reduce a perceived threat by means of accepting the behavioural recommendations. Used in Study II.</td>
<td>Rogers (1983)</td>
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<td>Relevant thoughts (thought listing activity, RELT)</td>
<td>Elaboration Likelihood Model proposes that individuals have different tendencies in how they engage in thinking and analytic activity. Thought listing is a method for assessing in individual’s elaboration activity and style regarding a given topic. The method assumes that high elaboration activity will produce a high number of thoughts and high Need for Cognition individuals will produce a higher proportion of relevant thoughts to irrelevant thoughts. Used in Study II.</td>
<td>Petty, Briñol, Tormala (1986) Cacioppo, von Hippel, Ernst (1997) Heppner, Wampold, Kivlighan (2007)</td>
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<td>Social influence (SOCI)</td>
<td>Based on previously identified features of socially influencing systems, the instrument included statements on social comparison, social facilitation, and recognition. Used in Study II.</td>
<td>Oinas-Kukkonen and Harjumaa (2009) Stibe, Oinas-Kukkonen and Lehto (2013) Stibe and Oinas-Kukkonen (2014)</td>
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<td>Petty, Briñol, and Tormala (1986) Cacioppo, von Hippel and Ernst (1997) Heppner, Wampold and Kivlighan (2007)</td>
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<td>Perceived unobtrusiveness</td>
<td>A questionnaire on perceived unobtrusiveness of a system was developed for Study III on the basis of established user experience questionnaires (NASA TLX and System Usability Scale) as well as parts of perceived persuasiveness questionnaires, and the PSD model. Guiding theory base stemmed from cognitive psychology, and there from concepts of task switching and working memory.</td>
<td>NASA TLX (task load index). System Usability Scale (SUS) Lehto, Oinas-Kukkonen, and Drozd (2013) Lehto and Oinas-Kukkonen (2015) Baddeley (1992) Rubinstein, Mayer, and Evans (2001)</td>
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<td>Construct / measurement</td>
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<td>Schematicism</td>
<td>According to self-schema theory, an individual’s response to a behaviour change message can vary depending on how strongly the individual perceives the topic or action to be part of their self-image. A questionnaire was developed for Study III to gauge the direction of participants’ schematics towards the problem domain (punctuality) with the purpose of ensuring similar number of schematics and non-schematics in each of the test conditions. Questionnaire development followed established models.</td>
<td>Oinas-Kukkonen and Harjumaa (2009) Markus (1977a) Kendzierski (1988)</td>
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### 3.3 Research ethics

All studies presented in this dissertation were conducted with human subjects. As such, ethical guidelines by the Finnish Advisory Board on Research Integrity were consulted and followed. In all studies the participants were given pre- and post-experiment information so that to begin with, they were able to give informed consent to take part and for the researchers to use any information they provided. Post-experiment information confirmed the study’s purpose and what was collected, and also repeated contact information in case any participant had questions or wanted to remove their data from the study after all. None of the studies involved experimentation or tasks that placed the participants in any harm (physical or psychological). Privacy and anonymity were carefully managed by always keeping participants identification details separate from the study data and controlling the identity information so that only the main researcher had access to it. Identity details were not collected unless necessary, for example for incentives.
4 Research contribution

This section of the dissertation presents the key findings from studies I – V. The order of studies is not chronological but rather they have been organised thematically. Study I explores the potential of using gamified rehearsal and feedback provision as means of reinforcing a health message. Study II describes an experiment into cognitive factors in peer-to-peer persuasion over a social networking platform. In study III the topic in focus is perceived unobtrusiveness through exploration of timing strategies in a coaching-type system. Study IV is a systematic literature review into the present status of self-schema theory and transformative learning theory in IS literature and, finally, study V presents a critical incident study charting experiences of relevance with BCSSs.

4.1 Study I: Reinforcing a health message through gamified rehearsal

Fascinated by the rehearsal and feedback provision potential of electronic games, Study I was constructed to explore the possibility of reinforcing health message response by simply playing a purpose-built game. Game mechanism was borrowed from the Implicit Association Test (IAT) (Project Implicit) to build a game where the task was to categorize food items under positive and negative associations as quickly as possible. The game would give the player a score based on the speed and correctness of categorization (Manninen & Tikka, 2018). The hypothesis in the experiment was that exposure to one’s own responses would reveal a potential bias in the player’s thinking, prompting reflection on behaviours and decision-making. In addition, the study hypothesized that playing the game repeatedly is a form of rehearsing target responses, and as such will help players in decision-making when it comes to food items also in real life.

Participants to the study (n=58) played the game daily over a five-day period. The system collected the number of games played as well as performance data for each participant and each instance of play. The development of the game is described in Manninen and Tikka (2018). The performance data included in the analysis was number of games played (REH as well as correct vs. incorrect categorizations and reaction times to healthy and unhealthy foods. In addition to performance data, participants provided self-assessment data on perceived persuasiveness (PEPE), perceived health behaviour change (PHBC) and engagement in reflection (REFL). The participants also provided a self-
administered fruit and vegetable portion estimation form (Cox, Anderson, Reynolds, McKellar, Lean & Mela, 1998). The analyses for the data included a PLS-SEM analysis of REH, REFL, PEPE and PHBC constructs (Figure 2), a dependent means t-test for comparing the effect of timing of self-reported fruit and vegetable consumption (comparing before and after the game play period), and simple correlations between correct and incorrect categorizations against the reaction times to healthy and unhealthy foods.

In the study the main hypotheses were that rehearsal, that is, repeated exposure for aiming for target response and receiving feedback on that effort, would induce reflection, affect the relationship between reflection and perceived persuasiveness, affect perceived persuasiveness and also produce a behavioural change that the participants would be able to notice and report themselves. Table 2 lists the hypotheses depicted in Figure 2.

**Table 4. Research hypotheses (Tikka, Laitinen, Manninen, and Oinas-Kukkonen, 2019).**

<table>
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Hypothesis

H7  Perceived Persuasiveness of a system has a positive effect on the readiness of an individual to immediately evaluate the direct impact of the system on his or her behaviour and supports system users in engaging in target behaviour.

H8  The gameplay and the increased reflection triggered by gameplay will result in an increase in actual fruit and vegetable intake after the study period.

PLS-SEM analysis of the model is shown in Figure 3, the structural model.

Fig. 2. Structural model in Study I. ***p<.01; **p<.02; *p<.05, n.s. for non-significant paths (Tikka et al. 2019).

The results supported H2, H4, H5 and H7, but H1, H3 and H6 were not supported. In short, the results then indicate that reflection and perceived persuasiveness supported health behaviour change, and rehearsal supported perceived persuasiveness. Rehearsal was also a significant moderator in the reflection – perceived persuasiveness relationship. A comparison of fruit and vegetable consumption before and after the experiment showed that overall, more fruit and vegetables were consumed after the experiment period (supporting H8). Overall the results can be taken to indirectly support the use of perceived persuasiveness construct and the perceived health behaviour change construct as indication of system use effect on behaviour as the self-reported behaviour observations were in line with the food diaries.

It was also of interest to check the correlations between correct and incorrect categorizations against the players’ reaction times to healthy and unhealthy foods. The results showed how incorrect responses went hand in hand with faster reaction times (that is, faster reaction times produced more incorrect responses). The core of implicit measures is that implicit attitudes show in reaction times, and here the
moderate correlations are a clear indication that the game revealed a slight bias towards the less-healthy foods. Categorizing healthier food items correctly took more time, and if they performed the task faster, there were more incorrect categorizations. From the correlations, then, we interpreted that with a little bit of thinking (that is, higher reaction time), it was possible for the participants to provide the correct response most of the time.

The measurement instrument for the perceived health behaviour change was a self-devised instrument with which participants are asked an open-ended question regarding how they saw any change taking place as a result of taking part in the study and using the presented system. The responses from the participants were coded onto a scale from “no effect” to “perceived behaviour change”. In this manner the participants are not asked to score their own actions, but they are asked to reflect on their behaviour as it was. In addition, the instruments produce qualitative data that can help shed light onto the experiences and thoughts of the participants, allowing them to express their reactions and thoughts in their own terms instead of trying to calibrate their experiences with a pre-set scale. In the present study the participants expressed how the game nudged them into better awareness as regards their eating, the differences between foods, and even selecting foods differently when shopping. Interestingly, even though playing the game did not seem to have a positive effect on engagement in reflection, in the open answers the participants stated that while the game had no effect, it had made them think about foods or their diet at least in some degree.

The game developed for the study provided participants with an opportunity to rehearse a given target behaviour through play, and to also reflect upon their activity through the immediate feedback (such as game scores). From the results we concluded that the moderating role of rehearsal on the relationship between reflection and perceived persuasiveness could be used more in persuasive systems facilitating behaviour change through reflection. While the study did not establish a significant relationship between amount of rehearsal and engagement in reflection, reflection was still seen affecting perceived health behaviour change construct in the model. Was the key factor here the conspicuous lack of goal-setting, which would give self-awareness a clear function of observing one’s own actions in order to establish self-regulation (Grant, Franklin & Langford, 2002)? In order to cater for a path from self-monitoring (feedback on actions in the system in the present experiment) to reflection, whether on-action or in-action (Ploderer et al. 2014), it seems necessary to understand what other parameters besides dose are necessary in order for feedback to turn into self-reflection. The volume of gameplay in the
The results also suggest that rehearsal can amplify the effect of reflection as regards a user’s perception of the persuasiveness of the system. However, rehearsal alone may not be enough to result in positive behavioural outcomes, as in the results we could see how the volume of game play did not affect the immediate health behaviour directly in the same way that it affected perceived persuasiveness. This relationship suggests that to promote change, reflection is needed, and the system user should perceive the system to be persuasive. Rehearsal could be a means to make these factors more effective. The before and after study period self-estimates of fruit and vegetable consumption showed participants consuming more fruit and vegetables after the test period, a result which supports the perceived outcomes (perceived persuasiveness, perceived health behaviour change).

In the study the exposure to one’s own performance (scores in the game) was expected to be a vehicle for reflection and the perceived health behaviour change was the self-reported outcome of the period of playing. The results in the study are inconclusive as to this relationship: why would exposure to one’s own performance not evoke reflection? If a system relies on simple feedback as the means to generate such reflection in support of behaviour change, how well founded are such expectations?

4.2 Study II: The role of social interaction styles in persuasion over a social networking platform

Study II stems from the acknowledged observation that people have different participation styles when online (Oinas-Kukkonen & Oinas-Kukkonen, 2013), and the focus was particularly on the degree of participation when on social media. Some people prefer to observe from the sidelines while others are happy (and look forward to) sharing and contributing. Interaction includes, necessarily, an element of influencing others, for example, through social learning (Bandura, 1986). While various studies were identified where the process of such social influence had been explored, the role of the recipient – the person being influenced – was perhaps not so prominent. Namely, Study II asked if there were some contexts of use that are better suited than others for accepting persuasive information? The study observes
the difference between interactions styles of active (tweeting) and passive recipient (non-tweeting) through the lens of information processing style, Need for Cognition (NfC) (Petty & Cacioppo, 1986a).

Twitter, a social networking platform, incorporates a number of social influence system features (Oinas-Kukkonen & Harjumaa, 2009). Social learning (Bandura, 1977) is among the most prominent features, considering how in a system like Twitter the users can see not only that other people are contributing some content, but they also see what that content is. On top of seeing the original contribution activity, the users can also see recommendation activities, when other users like or re-tweet (share again) some posts.

The study was built around promoting healthier eating by means of increasing the intake of vegetables and fruit. The information provided in the study came from a government nutrition recommendation to have at least half a kilogram of vegetables and fruit every day (or “five-a-day” as such recommendations have been promoted for example in the UK). In the experiment situation, the participants were randomly divided into two groups where one group had the task of tweeting and promoting the health message actively while the other group simply had to follow the tweets.

The participants were measured for self-efficacy and health message promoting response efficacy. Based on protection motivation theory (PMT) (Rogers, 1975; 1983), both self-efficacy and response efficacy assessments must be at an adequately high level if appropriate behavioural adjustments are to be seen. In other words, the participants need to have the right level of motivation triggered in order for them to accept the health message. Therefore, the study hypothesized there to be a positive relationship between efficacy appraisal and subsequent health behaviour change.

The elaboration activity, that is, how much and how actively participants were thinking about the health topic they were involved with, was another construct in the theoretical model. The number of relevant thoughts, based on the elaboration likelihood model, is an indication of how people engage in thinking and analytic activities. The activity levels can be described on a scale from ‘low need for cognition’ to ‘high need for cognition.’ High elaboration activity was expected to show not only as higher number of thoughts per se, but particularly as higher number of relevant thoughts. Carrying on from there, higher number of relevant thoughts was expected to have a positive influence on the efficacy appraisals because of the stronger informational element in drawing those appraisals.
Social influence construct in the study comprised a number of indicators based on the social influence factors in the PSD model. Social comparison, recognition, and social facilitation were all present in the study context so that the participants were able to compare themselves to the other participants present in the Twitter environment. As social learners (Bandura, 1977) people are expected to not only notice what and how others do, but also be able to adopt some of those behaviours for themselves. Seeing that others are doing the same things that you are doing (such as tweeting or sharing tweets) and receiving recognition for your actions (such as a ‘like’ or a share of your own tweet) are also factors in bolstering efficacy appraisals. Therefore, the hypothesis in the study was that social influence would have a positive impact on efficacy appraisals as far as the tweeting group was concerned.

The participants were also asked to complete a one-day food diary (Cox, Anderson, Reynolds, McKellar, Lean & Mela, 1998) for the day before the study. The participants existing eating habits would have an understandable impact on the heath behaviour outcome if they were already engaging in the recommended dietary behaviours. The expected impact of such existing healthy behaviour was positive impact on the self-efficacy appraisal as well as on perceived health behaviour change: confirming correct behaviour would boost self-efficacy and also promote healthy eating even further – or at least not have a negative impact on it!

As an outcome variable the study surveyed participant’s perceived health behaviour change, using an open-ended questionnaire method, devised for the purpose, where participants were asked to assess if (and what) impact the study activities had on their own behaviours as regards healthier eating. The responses were coded onto a scale from “no impact” to “behaviour change” thus forming a single indicator score used in the model.

Partial least squares structural equation modelling (PLS-SEM) was used to analyse the data collected in the study. Total sample size was 30 (almost equal division of male and female participants). The results showed a number of differences between the groups in terms of interaction style (tweeting or not tweeting) and also based on the elaboration tendency. Figure 3 illustrates the structural model in Study II.
Subgroup analysis was conducted to observe differences between the two groups (tweeting vs non-tweeting). First of all, for the tweeting group, the significant relationships in our model were from PRVI (pre-test fruit and vegetable intake) to PHBC (perceived health behaviour change), and from SOCI (social influence) to EFFI (efficacy). That is to say, for the tweeting group, existing eating habits weighed more in the outcome variable than for the non-tweeting group. For the tweeters, other variables were not making so much of a difference. In the tweeting group 25% of the variance in the outcome variable PHBC was explained by the PRVI and EFFI constructs. For the non-tweeters, EFFI to PHBC and SOCI to EFFI were significant, which relationships are more in line with the original hypotheses. With this group, some 41% of PHBC variance was explained by EFFI and PRVI.

Observing then the difference made by cognitive style (need for cognition), it is important to point out that while using NfC as a category variable, the scores by no means indicate a clear cut “high” or “low” tendency, but the participant scores were categorised to a relatively broad “higher” and “lower” group with the intention to be able to observe potential direction of effect. The analysis showed significant relationships between PRVI and EFFI, and from PRVI and PHBC. For the lower NfC participants, paths from EFFI to PHBC and from SOCI to EFFI were significant, with 39% of the variance in PHBC explained by EFFI and PRVI.

The study explored the interactions and differences between the independent variables of contribution style (tweeters vs. non-tweeters) and NfC appraisals.
(“higher” vs. “lower”). This enabled us to gain additional insight into how these variables influence each other. NfC was measured by using elaboration activity. The results showed that higher NfC participants in the tweeting group somewhat surprisingly registered fewer relevant thoughts than the lower NfC participants in that group. In the non-tweeting group, the direction was the same (higher NfC participants registering fewer relevant thoughts than lower NfC participants), but the difference was not so marked. When looking at the number of irrelevant thoughts in the same manner, it turned out that the higher NfC participants in the tweeting group produced more irrelevant thoughts than the lower NfC participants in that group. In the non-tweeting group the direction was the same, but the difference, at a glance, negligible.

Fig. 4. Average number of relevant and irrelevant statements per group and NfC category. Group A is the tweeting group, Group B is the non-tweeting group. (Tikka and Oinas-Kukkonen 2017).

An ANOVA on variance of relevant thoughts, irrelevant thoughts, and perceived health behaviour change (PHBC) comparing the contribution styles (tweeting or non-tweeting) and elaboration style (higher NfC and lower NfC) did not reveal statistically significant effect of NfC level or contribution style on PHBC. Therefore, it was only possible to speculate on visible patterns from the data. Higher NfC participants in the tweeting group reported higher PHBC than the
higher NfC participants in the non-tweeting group – a trend that was the reverse with the lower NfC participants in both groups with whom the tweeting group’s PHBC was lower than that of the non-tweeting group. The PHBC scores for both NfC levels came closer to each other in the non-tweeting group. On the whole, simply on the basis of the thought listing data, the implication could be that elaboration activity is not necessarily limited to the one task at hand and having to not only concentrate on the message (as the non-tweeters), the tweeters’ attention and thus elaboration activity was spread wider and thinner.

What can be speculated on the basis of the directions with relevant or irrelevant thought count is the degree of distraction in the tweeter condition. There were more irrelevants and fewer relevants under the distraction of having to produce content while taking it in yourself vs more relevant thoughts and fewer irrelevant thoughts when the only task is to take in the shared messages on a set topic. Yet, higher elaboration participants in the tweeting group report the exercise to have had more of a positive effect on their perceived health behaviour than the higher NfC participants in the non-tweeting group (less distraction). It was necessary, then, to ask whether the more active position also boosted the perceived health behaviour change – after all, when distraction level was lower, the reported PHBC levels were much closer between the higher and lower NfC participants in the non-tweeting group. Where higher NfC group’s PHBC score is not as good in the non-tweeting group, for whatever reason the lower NfC participants report a slightly better PHBC in the non-tweeting condition than in the tweeting condition. The inference to be drawn from this is that the lower NfC participants will have benefited from the condition with no distraction.

4.3 Study III: Role of unobtrusiveness in a persuasive system

The focus of Study III was on the effect of timing of persuasive communications on behaviour and on the user experience of a system. How timing of persuasive messages is managed can affect an end-user’s experience of obtrusiveness, given that system-originated messages can produce interruptions and demand attention at moments that an end-user deems irritating (Bailey and Iqbal, 2008). While one strategy is to identify ideal and opportune moments of communicating a persuasive message (Fogg, 2003; Räisänen, Oinas-Kukkonen & Pahnila, 2008), the study aimed at gaining a broader view on how timing strategies can affect behaviour, behaviour change and the user experience as regards the system. The key research
question in this explorative study was: How do timing strategies affect behaviour change and perceived unobtrusiveness when using a BCSS?

The experiment was conducted using a purpose-built behaviour change app for rehearsing better time-keeping (punctuality). Participants would set time-related tasks for themselves on each of the five experiment days. The participants were exposed to one of two conditions: one groups were asked to define a time slot when they would receive all of the messages and reminders the system had for them, and the second group would receive the same number of messages and reminders whenever the system would send them (seemingly random). The development of the system is described in Tikka, Woldemicael and Oinas-Kukkonen (2016). The experiment also assessed the participants for their self-schema as regards punctuality in order to generate as closely equal experiment groups as possible.

In the results, the interesting aspects in the task success and task satisfaction means over the experiment period involve the beginning and the end of the period: both groups ended up close to the same level of task success and task satisfaction by the end of the experiment. Linear relationships with task success/satisfaction and perceived unobtrusiveness indicated that participants in the random timing group were rating the system more obtrusive as their task success and task satisfaction increased. In the user-defined timing group, the system was rated less obtrusive as the Task Success and Task Satisfaction increased.

To begin with, we had hypothesised that random timing of persuasive messages would be experienced to be more obtrusive than if a system user has control over the timing. The drop-out rate in this experiment was high, and it is impossible to tell what the final reasons were: participants were under no obligation to give an explanation. What is interesting, though, is that of the initial number of participants in each group only 30% completed the experiment in the random timing group compared to 50% in the user-defined timing group. Naturally, one avenue of possibility to explain the difference in the drop-out rate is obtrusiveness.

The results of the ANOVAs in the study were not statistically significant and the sample was small. Still, the direction of the scores pointed to (as predicted) the random timing option to yield a more pronounced experience of perceived obtrusiveness even though at the same time the performance scores improved.

Correlation analysis between the two groups provided some interesting insights. Messages, reminders and evaluation requests coming at random times may yield better performance in terms of task success and task satisfaction, but the trade off is in the experience of obtrusiveness. By contrast, the opposite seemed to be the case when messages, reminders and evaluation requests came at a time of the user’s
choosing. Admittedly, the linearity in this case was weak, but it was observably in a different direction than with the random timing group. A number of questions regarding the role of cognitive load immediately spring from the correlation findings. What should be explored further is the significance of the drop-out rate between the two experiment groups: could this help us determine if the perceived unobtrusiveness was more of a factor in the random timing group than the performance ratings allow us to believe?

The relationship between timing strategies and finding an opportune moment is perhaps best viewed as a continuum with opportune moment in one end and abysmally inappropriate moment at the other. Timing strategies (which in a real system can be more delicate than the two in the present study) will determine where a system lands on that continuum. The ideal is to hit upon the kairos moment and achieve behaviour change with minimal cognitive load, but such rarities apart, we must search for ways of providing an unobtrusive user experience without compromising the behaviour change target.

4.4 Study IV: Tailoring persuasive technology (SLR)

Study IV was interested largely in the opportunities and possibilities of advancing system tailoring with the use of self-schemas and/or transformative learning. Tailoring persuasive systems and messages to users is an important component of systems design (Fogg, 2003; Oinas-Kukkonen & Harjumaa, 2009; Kaptein & Eckles, 2012). To understand the persuasion context and the individuals receiving the behaviour change message should improve the likelihood of successful tailoring of systems to their users. More common approach to tailoring systems to their users has been to target specific change goals or system users’ cognitive styles (Kaptein & Eckles, 2012; Kaptein Markopoulos, de Ruyter & Aarts, 2015; Wheeler, Petty & Bizer, 2005). Psychological traits, such as the ones identified by Petty and Cacioppo (1986a), present with various opportunities for designing tailored content in a persuasive system. In order to complement the available attributes system developers have at their disposal, a beneficial direction in research would be offer persuasive content that matches the end-user’s needs, interests, personality, context and other relevant factors. This would allow for further means and opportunities of utilizing the full potential of modern technology in providing systems that cater for all users as individually as possible. The counterpart of a system matching its user is the question of how malleable users can be towards their behaviour change aspirations and their concept of self. On one hand, a persuasive system can opt to
match a message to the recipient, and on the other, the system can try to influence the person’s thinking as such: his or her attitude and outlook as regards the behaviour change goal.

Study IV is a systematic literature review into the use of two theories that could support persuasion by emphasising the characteristics of the end-user: self-schema theory (Markus, 1977a; Cacioppo, Petty & Sidera, 1982), and transformative learning theory (Mezirow, 2009), and particularly how these theories make an appearance in persuasive technology context. Self-schema theory offers avenues for system tailoring and personalising by approaching behaviour change from the perspective of a person’s schematisism in a given behavioural domain. As an extension of this approach, the SLR looks into the use of Transformative learning theory (Mezirow, 2009) as a potential behaviour change model that has the potential to influence self-schemas. The focus in Transformative learning theory is in an adult learner’s process of changing his or her own approach to situations – effectively offering attitude change. In addition, the study also analysed identifiable Persuasive Systems Design (Oinas-Kukkonen & Harjumaa 2009) features and outcome-change stages as per the Outcome/Change Matrix (Oinas-Kukkonen 2010a, 2010b) in the selected papers. Figure 4 illustrates the search areas in the literature review. As a final result, a total of 20 papers were included.

Study IV, then, asked: how have the theories of self-schema and/or transformative learning been used in persuasive technology research to date?

![Fig. 5. Overview of the literature search (Tikka and Oinas-Kukkonen, 2019).](image-url)
Five records in the included literature search findings presented either self-schema or transformative learning and a persuasion element or information system as key components of the study. Majority of the selected studies had either behaviour change or persuasion present together with the key theoretical components of self-schema or transformative learning, thus satisfying the selection criteria. Figure 5 illustrates the search and selection process for the studies.

![Fig. 6. Search results and selection process for results in Study IV (Tikka and Oinas-Kukkonen, 2019).](image)

In Dijkstra (2008) three specific features of computerized persuasion are discussed that would improve the persuasive quality of such systems. The study (Dijkstra, 2008) does not present any new data towards verifying the presented features, but the theoretical connections and arguments advocate the benefits of matching persuasive features to the individual using the system.

In Pilling and Brandon (2007), and York, Brannon, and Miller (2012a, 2012b) behaviour and persuasion are approached in terms of schema matching. The technology component in the three papers is a website simulation that matches the message delivery to the user personality types. Finally, Wilkerson, Danilenko, Smolenski, Myer, and Rosser (2011) is the only one of the papers where principles of transformative learning have been used as a part of the persuasive system. Wilkerson et al. (2011) do not describe the technology use in detail, and the study generally refers to Fogg (2003) as the basis for the design.

Of the remaining papers, a particularly interesting one is by Samenow, Worley, Neufeld, Fishel and Swiggart (2013), which discussed the concepts of transformative learning and behaviour change alongside presenting a programme
for behaviour change. The paper presents a composite case study that describes a behaviour change programme steps intended to help disruptive physicians change their workplace behaviour in a more appropriate direction. The presented programme is based on the ten-step transformative learning model (Mezirow, 2009.), It does not include computerised element, but as it was the one paper in the collection to discuss both transformative learning and behaviour change (and not pedagogics) the paper was included in the review.

Finally, 14 papers in the selection discussed self-schema and behaviour, largely focusing on the aspects of of predicting behaviour on the basis of schematicism. In these papers there are none that that consider either behaviour prediction or change as regards transformative learning. It would, then, appear that so far theory of transformative learning has mostly remained in the education domain, at least as far as persuasive technology and information systems are involved. Among the fourteen papers there was a small number that focused on how matching messages to schemas would affect message reception and message processing (Brannon & McCabe, 2002; Cacioppo et al., 1982; Pease, Brannon & Pilling, 2006; Wheeler, Petty & Bizer, 2005), but were not expressing a specific behaviour change or persuasion objective.

As regards behaviour change, using schema-matching in persuasion presents an interesting avenue of opportunities for persuasive technology and behaviour change research, as proposed by Dijkstra (2008). In general, matching the persuasion effort to its recipient as closely as possible should make it feasible to achieve effective change. More importantly, when trying to achieve such matches with a wide audience, it is exactly computerised systems that are in a position to do functional solutions (Dijkstra, 2008; Oinas-Kukkonen & Harjumaa, 2009; Oinas-Kukkonen, 2013).

Those five papers that presented a technology component, the persuasive features of the system were described on a relatively superficial level. The publications came largely from areas of psychology, health communications and health marketing, which somewhat explains why technology features may not have been closely described. However, the papers do point to a number of persuasive design principles discussed by Fogg (2003) and more formally organized as design principles by Oinas-Kukkonen and Harjumaa (2009). One prominent feature that stood out from the material was tailoring, which in the PSD model terms refers to matching the information provided by a system to the recipient at some identifiable level, was one identifiable persuasive feature in the analysed papers. In the
reviewed materials, tailoring was typically used with schema matching. Other, more seldom found, features were personalization and self-monitoring.

Majority of the analysed articles examined a specified self-schema on attitudes and/or behaviour: is there a difference in how people with a given self-schema conduct themselves as regards a message in comparison to people who do not have that specific self-schema? The potential for wider use of such matching in persuasive system design seems quite obvious: a focused effort on what makes a message most effective for what type of self-schema allows for a more fine-grained opportunity to offer content an interaction that is more likely to be relevant. In short, based on a number of studies in the analysis, it appears that a matching a person’s self-schema means a message can be received more favourably (Pilling & Brannon, 2007; Cacioppo et al., 1982), and the eventual impact of a persuasive message can increase should the message match the recipient’s self-schema (Brannon & McCabe, 2002; York, et al., 2012a, 2012b). There is also a link between self-schemas and actual behaviour in accordance to a given self-schema, for example exercising, has been established (Kendzierski, 1988; Kendzierski & Sheffield, 2000).

O/C matrix analysis suggests that self-schema can have a role in maintaining a desired behaviour, such as exercise. Such role points to an R-outcome (reinforcement). Various outcomes were observable from the transformative learning studies in the selection, ranging from Wilkerson et al. (2011) (A/B, A/A to Samenow et al. (2013) (all three change types and outcomes at the end of the learning process).

We expected self-schema structures mostly to affect the F- and R-outcomes, and that transformative learning would be connected to achieving A-outcomes, but as the results are somewhat inconclusive. The reviewed research points to the feasibility of at least R-outcome. Self-schemas strengthen over time (Markus, 1977a) and strong self-schemas can mean that a person becomes more resistive to schema-inconsistent information. Following on such thinking, the possibility emerges that strong self-schemas can produce a reinforce/attitude result in O/C matrix terms. There was a notable gap in C-change (compliance), which is technically the perhaps the simplest of the three change types.

### 4.5 Study V: Experience of relevance

Study V was interested in perceived relevance of persuasive systems. The study viewed the topic in terms of explicit relevance and how the UX of a system affected
use continuance of systems, and from the perspective of more latent psychological relevance of self-evaluation. The qualitative study used thematic evaluation at its core, then layering the findings over theoretical frameworks that would help assess and review the findings. Persuasive systems in this study were defined to include any systems that participants perceived to have behavioural impact by design and purpose.

The study was a critical incident technique-based study where participants were asked to think back to memorable events or incidents, whether positive or negative, when using a persuasive system. Participation was done using an online survey with open end text fields for relating the incidents and a small number of more limited question for supportive items.

For evaluating explicit UX level elements in persuasive systems the study used the information systems success factor model (DeLone & McLean, 1992, 2003) and the following model of system enablers and inhibitors (Cenfetelli & Schwarz, 2011). Such previously validated frameworks were helpful in assessing participant comments on user experience factors in the events and incidents they described in their responses.

The other perspective on relevance in the study was self-evaluation. The theme was identified through open coding and thematic analysis of the research data. The data was evaluated against the four identified self-evaluation motives of self-assessment, self-enhancement, self-verification, and self-improvement (Taylor et al., 1995; Sedikides, 1993).

The results provided interesting insights to both perspectives on relevance. For user experience and system success factors, it was interesting to see how few system success inhibitors (Cenfetelli & Schwarz, 2011) were identifiable, but the load of negative experiences was largely on the lack of success factors, or on the unfortunate execution of those success factors. In other words, usability and other quality problems had been identifiable by system users, and these issues showed in the reported use continuance. The results also supported the success factors: when users had drawn attention to the positive UX of a system, the result was seen as a more positive trend in the reported use continuation.

The user commentary that could be linked to self-evaluation purposes was found across a somewhat wider range of open codes and themes. The analysis of the comments allowed for conclusions that it is feasible to see how a part of persuasive technology use – namely, the kind of technology that is based largely on offering feedback – can cater for self-evaluation motivations. Predominantly visible were the categories of self-enhancement and self-improvement, which was
not unexpected given the survey sample: the participants were, after all, people who
had taken such technology into use for some reason and had designs for their
utilization. Self-enhancement is connected to maintaining and boosting positive
sense of self. Such items would come through in any accounts that play down poor
performances or show elation in good ones, such as achieving a set goal. Self-
improvement has a more practical function and naturally goal-oriented training and
other very goal-oriented activity would typically fall into this category: the system
user was using the feedback and the system in order to perform better than before.

Self-validation was seen in comments where participants were seen seeking
confirmation on their behaviour or performance (is it as expected) and to see what
it is. Self-verification was perhaps the smallest of the motivation categories in terms
of comment volume, given the sample and its apparent tendency and drive towards
improving, this may have been case of small representation of people who would
more readily show self-verification activity.
5 Discussion

The present dissertation explores areas of user experience regarding persuasive technology with the view of gaining new knowledge and new insights about elements that might hold back achieving the full potential of such systems. The full potential, of course, is an interesting question in itself, but without going too deep into a philosophical debate regarding the concept, a practical approach would be to see that a system can aim to achieve its full potential when there are no obvious, removable blocks for how a message is delivered, received, and accepted. The first two have hands-on requirements for any system: the design and implementation must work in terms of human factors to such extent that it is possible for a system user to use and utilize the system as intended and as he or she requires in a manner that enables message intake (delivery and reception), and the user must be willing to hear that message and to be willing to consider it at some level (acceptance). The latter item, of course, expands beyond the present dissertation in the sense that it will involve aspects of motivation, cognitive styles, subtle means of influence (such as nudging), etc. – effectively, the whole meeting point of capability, means, and opportunity (Michie, van Stralen & West, 2011).

In the present dissertation the exploration of potential bottlenecks is, broadly, approached from the perspectives of social factors, person specific factors, and system factors (human-computer interaction). At a research level this has been achieved by looking at system users in their social contexts and through social roles, by exploring the effects of cognitive styles and social roles on persuasion outcomes, and by studying the effects of system interaction factors on user experience of persuasive systems. The presented research also aimed at identifying new potential approaches to making persuasive systems more effective and immediately relevant to their users by looking into the theories of self-schema and transformative learning in a literature review.

Study I in the dissertation was concerned with persuasion route and reflection aspects of removing bottlenecks in a persuasion message delivery. The study used a purpose-built gamified persuasive system designed to make the players receive immediate feedback on their performance and as such reflect upon it, and to make them rehearse a decision-making process so that making the desired decision could become automated. The study established a moderating role of rehearsal on the relationship between reflection and perceived persuasiveness of a system: rehearsal can amplify the effect of reflection, as regards perceived persuasiveness. However, rehearsal alone did not reveal a direct impact on immediate health behaviour.
change in the study, despite the participants’ open-ended responses that indicated heightened awareness in increased intention to make better food choices. Instead, the impact in the study on health behaviour change came through the constructs of perceived persuasiveness and reflection (made more effective with rehearsal). The study added to our knowledge regarding the person specific factors by illustrating what type of persuasion mechanisms are at play when aiming to add fluidity to the delivery of a persuasive message via the peripheral route (gamification).

In Study II the focus was on social roles in a persuasion situation, and on the effect of cognitive styles (need for cognition) on message handling, that is, how a message is received. The study contributed primarily to the social factors part in the dissertation in its focus on the impact of assumed social roles. In this study, however, the information processing of the individual participants was also studied, which offered a contribution towards the person specific factors aspect. The results showed how a specific role in an online interaction context affected behaviour change outcomes: people with a higher need for cognition (more tendency to elaborate on messages) were affected by the persuasion context in such way that they seemed more distracted compared to the lower. The experiment situation was such that when one group was generating persuasion content, the other group was merely receiving it. One might expect generating content (searching for information, reviewing other content for sharing potential, etc.) to be a learning experience not only for the eventual recipient but also for the person generating it, the study found, as said, that people with higher need for cognition actually suffered when it comes to persuasive potential of the situation.

As for behaviour change outcomes, the results in Study II showed how participants in the higher NfC segment who were in the active message sharing and content generation group tended to report higher scores for the perceived health behaviour change. What can be concluded from the study is to see how peer support for behaviour change over the Web has tremendous potential, but to utilize it and to reduce possible hindrances and obstacles requires understanding how 1) to identify, in general, what type of activities can be socially influencing, and 2) to identify what effects different interaction styles and behavioural roles can have on receiving and processing information.

Study III was an exercise in identifying what difference message timing strategies in the interaction between a persuasive system and its user could have in terms of perceived unobtrusiveness. As such, the study involves the delivery and reception part of a persuasive communication. Owing to its small sample size, Study III offers indicative insights that can be used as good leads towards
interesting research directions. Namely, the impact of system-originated interruptions on perceived system obtrusiveness was an important indicator of how interaction and information design of a system can affect the user experience even when a user’s performance with the system does not suffer. Study III, thus, informed us of interesting avenues of further investigation as regards interaction design with persuasive systems (system factors aspect).

The systematic literature review that is presented as a part of the present dissertation, Study IV, was set out to review the existing use of two tailoring and attitude formation related theories: self-schema theory (Markus, 1977a) and transformative learning theory (Mezirow, 1995). Tailoring systems to users requires, naturally, an understanding of not only the users but also of feasible and implementable ways of building tailoring in systems, and as such the study offers insights towards the person specific factors in the present dissertation. The study offers us indication of how a person’s self-image has an impact on persuasive message acceptance. The motivation for researching the use of these theories in the context of behaviour change and persuasive technology was to see what the current state was and what indication of potential the existing research could give regarding the usefulness of these approaches. Self-schema as such was of interest because of its potential as something that could be used in tailoring systems to their users in terms of a measurable and identifiable trait (and not a personality factor as such). Meanwhile, transformative learning theory was studied for its potential to affect a self-schema and attitudes. The results unveiled a very limited number of articles that satisfied the search criteria. The articles were, however, of interest and value, as they illustrated examples of matching persuasive content to self-schemas, and how a full process of transformative learning can work in behaviour change. This evidence led to a conclusion that utilizing these theories, particularly self-schema theory, is not only feasible, but that there is research-based evidence of effectiveness.

The final study in the present dissertation, Study V, is an exploration in to identifying factors that affect perceived relevance of a system. The study approached personal from two perspectives: user experience (does the system work for the user) and psychological needs (self-evaluation motivations). As such, the contributions from this study are geared towards the person specific factors and the system factors. It sheds light on how user experience failures can become a blockage for persuasive message delivery and reception, and how personal relevance is a factor in persuasive message acceptance. A Critical incident techniques study, participants in Study V gave open-ended accounts of their
memorable experiences with persuasive technology. Qualitative analysis, namely, thematic analysis, was used to explore the material first without any frameworks beyond the research questions as guidance, then by superimposing two theoretical frameworks on the open findings.

For user experience, Study V used a system success factor model (DeLone and McLean, 1992, 2003; Cenfetelli & Schwarz, 2011) to give a perspective on participants’ positive and negative experiences. The analysis showed the importance of perceived reliability and fluent user interaction with a system at the core of use continuance. Perceptions of weak data quality, unreliable measurements, poor connectivity or anything else that falls below a users’ expectation of what normal operation for a device should be are errors that will affect user experience so much that the persuasive qualities of a system or a device are compromised. Positive experiences tended to be more to notice that a system did, after all, do what it promised in the first place. Personal relevance in the area of psychological needs was identified from the data through comments that suggested systems having a kind of a social role for helping system users gauge if their performance or behaviour is acceptable and as it should be. In addition, there were accounts that referred to simply interested in tracking one’s steps or exercise without any additional commentary as to why such tracking was interesting. The selected framework viewed such accounts from the perspective of self-evaluation: how feedback from persuasive systems was used to satisfy self-evaluative motivations, effectively helping build and maintain self-image.

Relevance as a topic is an essential part of any discourse around persuasive systems. A system or a device that does not fulfil a position it has been acquired for, is not relevant and will not be used. As mentioned already in the introduction of the present dissertation, attrition is a real issue and only systems that are used can be of any help. The results from Study V point to the need to understand that technological systems can serve more than their surface purpose: they can fulfil a social role and they can provide feedback and support for more than the most obvious expression of a behaviour. In Study V the purpose explored was self-evaluation. The system was not only giving feedback so that a person would know if they achieved their target of 10 000 steps on a given day, but to confirm to that user that they have performed to their expectation of who they are.

Overall, the collection of original studies in this dissertation offers insights to a selection of possible obstacles and hindrances that may render a persuasive system average rather than wildly successful. Yet, even as a small selection of issues, the findings are applicable across a wide range of persuasive technology and
behaviour change support system design, and as such offer relevance to both researchers and practitioners alike. Bringing the various topics of social, personal and technological together through these examples in the present dissertation, we can see how attention to one specific aspect may not be enough, and how the relationship between a system user and a system has to be a bit personal.

5.1 Implications to research and practice

While the problem domain with some of the work in the present dissertation is related to nutrition and dietary habits, the research has been conducted in such a way that the theoretical background makes the studies applicable blueprints for research in other domains as well. Likewise, the aim of the research method selection and design has been to gain new knowledge and understanding about persuasion and behaviour change in such a way that allows generalisations across problem domains.

The contributions in this thesis have throughout applied a combination of technology design and behaviour science theory in order to discover not only what works or does not work, but also why that should be. Such an approach is always necessary if the intention is to apply findings and methods across domains – after all, situations alter cases.

5.2 Limitations and future research directions

The presented research to some part suffers from small number of participants in studies. The contributions do, however, discuss the participant numbers: care has been taken to satisfy acceptable n in the PLS-SEM studies, and due caution has been expressed in study II with results interpretation.

With Study II, there ecological validity of a laboratory setting experiment in social media context is naturally a concern, and to expand the findings to offer a veridical view that applies in real-world setting will require further research. The presented work is, as stated, an exploration that now offers a basis for building further experimentation on the topic. Another explorative study offering grounds for further research is Study III, which obviously suffers from a small sample size. This paper would also have benefited from a more direct expression of how its theoretical background led to the explored hypotheses. A further criticism of Study III involves an element very much in the area of further research in this topic: how
much of the response to the manipulation in the study could be accounted to a perceived sense of control for the system user?

Study V in the present dissertation concerns the very multifaceted relationship between a system, its user, the user experience and how the system design supports or does not support behaviour change through UX. This entire context will, undoubtedly, benefit from further explorations into the various aspects of how UX of a system could be harnessed to enhance the persuasive potential of systems and how to identify those pitfalls in system design and implementation that do most harm as regards persuasiveness. Study V expresses one of the main items coming out of this dissertation: personal relevance. Persuasive systems only work if people use them, and unless the systems offer something relevant at all levels, at a level of quality that satisfies that need for relevance, the systems are not going to be used to their full potential. Therefore, more latent aspects of system use, that is, what needs, other than the obvious, do they serve emerge as interesting questions to consider in the future.

Another aspect of the studies presented in this dissertation is the time perspective: like so much of persuasive technology research, the data tends to come from immediately around the experiment time. In order to learn more about the full effects and usefulness of persuasive systems, it will be necessary for the research community to find means for studying effects and effectiveness in a longitudinal manner.
6 Conclusions

This dissertation explored elements of persuasive system success hindrances (bottlenecks), their effect on user experience, user performance and behavioural outcomes. The contributions looked into social factors, person specific factors and system factors related to deploying successful behaviour change support systems by exploring self-image, social role, cognitive styles, and system-user interaction in five studies.

On the whole, the contribution offered by the present dissertation lies in the wide lens that is used in building a rounded understanding of the very different aspects that can affect user experience and success of a persuasive system. The studies and their theoretical bases are such that the results can be taken into consideration in contexts of behaviour change other than the specific ones presented in the studies. A common denominator offering the present dissertation a single thread and runs through all the studies that involve a specified system is the PSD model, which helps the reader of this dissertation view the systems and the studies through a common framework.
List of references


Mullen, M., Shami, N.S., Millen, D.R., & Feinberg, J. (2010). We are all Lurkers: consuming behaviors among authors and readers in an enterprise file-sharing service. Proceedings of the 16th ACM international conference on supporting group work (GROUP’10), 7-10. New York: ACM.
NASA Task Load Index (TLX). https://human systems.arc.nasa.gov/groups/TLX/ (Date of reference 23 June, 2020).


Appendix 1: Measurement instruments in Study I

Table 5. Perceived persuasiveness and their loadings in Study I.

<table>
<thead>
<tr>
<th>Perceived persuasiveness</th>
<th>Loading</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 The game has an influence on me</td>
<td>.890</td>
</tr>
<tr>
<td>2 The game is personally relevant for me</td>
<td>.632</td>
</tr>
<tr>
<td>3 The game makes me reconsider my habits</td>
<td>.940</td>
</tr>
</tbody>
</table>

Table 6. Reflection questionnaire items and their loadings in Study I. *=reverse item.

<table>
<thead>
<tr>
<th>Reflection</th>
<th>Item</th>
<th>Loading</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>I frequently take time to reflect on my thoughts.</td>
<td>.874</td>
</tr>
<tr>
<td>2</td>
<td>I rarely spend time in self-reflection.*</td>
<td>.856</td>
</tr>
<tr>
<td>3</td>
<td>The game makes me reconsider my habits</td>
<td>.940</td>
</tr>
<tr>
<td>4</td>
<td>I often think about the way I feel about things.</td>
<td>.848</td>
</tr>
<tr>
<td>5</td>
<td>I don’t often think about my thoughts.*</td>
<td>.841</td>
</tr>
<tr>
<td>6</td>
<td>I frequently examine my feelings.</td>
<td>.748</td>
</tr>
<tr>
<td></td>
<td>I don’t really think about why I behave in the way that I do.*</td>
<td>.723</td>
</tr>
</tbody>
</table>
Appendix 2: Measurement instruments in Study II

Table 7. Social influence and efficacy questionnaire items and their loadings in Study II.

<table>
<thead>
<tr>
<th>#</th>
<th>Item</th>
<th>Response efficacy</th>
<th>Loading</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Eating at least 5 portions of fruit and vegetables each day will improve my health by boosting my immune system. (1-strongly disagree, 7-strongly agree)</td>
<td>.833</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>My chances of experiencing a healthy immune system in the future, if I do eat at least 5 portions of fruit and vegetables, are…. (1-very low, 7-high)</td>
<td>.697</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>I know for sure that I could adhere to eating at least 5 portions of fruit and vegetables each day.</td>
<td>.720</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>If I intend to take up eating at least 5 portions of fruit and vegetables each day, I know that I can stick to it.</td>
<td>.822</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>I was able to compare my own knowledge on the topic with others.</td>
<td>.604</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>From the tweets I could see that there were other users who were similar to myself.</td>
<td>.694</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Seeing so much information about nutritional recommendations made me want to increase my own fruit and vegetable intake.</td>
<td>.575</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>When more people are aware of what the nutritional recommendations are, I feel I am more aware of what choices I should make myself as regards food.</td>
<td>.827</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>A: Getting a like/re-tweet in this topic indicates that what I shared/tweeted was valid for promoting better eating habits.</td>
<td>.753</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B: A message that gets a like/re-tweet shows that the person tweeting it has valid information to contribute to this topic.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>A: Getting a like/re-tweet tells me that I know about the discussion topic.</td>
<td>.853</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B: A message that gets a like/re-tweet shows that the person tweeting it knows about the topic.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>A: Getting a like/re-tweet for this topic means that it is possible for me, too, to follow the nutritional advice.</td>
<td>.807</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B: Tweets that get a like/re-tweet are more likely to help me follow the nutritional advice.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix 3: Measurement instruments in Study III

Table 8. Punctuality self-schema questionnaire in Study III. Participants answered on an 11 step scale on two dimensions: a) this statement describes me, and b) this is important to my self-image (0=does not describe me at all). Questions were presented in varying order on an online survey tool. Filler items were used in order to disguise the focus of the questionnaire, which was administered at the start of the study.

<table>
<thead>
<tr>
<th>#</th>
<th>Item</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>&quot;Being on time is important to me.&quot;</td>
<td>Schematicism question</td>
</tr>
<tr>
<td>2</td>
<td>I always reserve plenty of time for journeys to meetings or appointments.&quot;</td>
<td>Schematicism question</td>
</tr>
<tr>
<td>3</td>
<td>Being late makes me feel uncomfortable.&quot;</td>
<td>Schematicism question</td>
</tr>
<tr>
<td>4</td>
<td>&quot;I like to start my days early in the morning.&quot;</td>
<td>Schema-related filler</td>
</tr>
<tr>
<td>5</td>
<td>&quot;My calendar is always up to date.&quot;</td>
<td>Schema-related filler</td>
</tr>
<tr>
<td>6</td>
<td>&quot;I’m more productive working late in the evening.&quot;</td>
<td>Schema-related filler</td>
</tr>
<tr>
<td>7</td>
<td>&quot;If possible, I always choose organic foods.&quot;</td>
<td>Unrelated filler</td>
</tr>
<tr>
<td>8</td>
<td>&quot;I’m more productive working late in the evening.&quot;</td>
<td>Unrelated filler</td>
</tr>
<tr>
<td>9</td>
<td>&quot;Exercising is good for me.&quot;</td>
<td>Unrelated filler</td>
</tr>
<tr>
<td>10</td>
<td>&quot;I prefer vegetables to meat.&quot;</td>
<td>Unrelated filler</td>
</tr>
<tr>
<td>11</td>
<td>&quot;I like to stay physically fit.&quot;</td>
<td>Unrelated filler</td>
</tr>
<tr>
<td>12</td>
<td>&quot;Healthy eating is important.&quot;</td>
<td>Unrelated filler</td>
</tr>
<tr>
<td>13</td>
<td>&quot;I don’t feel good if I don’t get enough sleep.&quot;</td>
<td>Unrelated filler</td>
</tr>
<tr>
<td>14</td>
<td>&quot;I always cycle or walk to work.&quot;</td>
<td>Unrelated filler</td>
</tr>
<tr>
<td>15</td>
<td>&quot;Healthy mind in healthy body!&quot;</td>
<td>Unrelated filler</td>
</tr>
<tr>
<td>16</td>
<td>&quot;I try to avoid eating sugars.&quot;</td>
<td>Unrelated filler</td>
</tr>
<tr>
<td>17</td>
<td>&quot;I do better at work if I feel healthy.&quot;</td>
<td>Unrelated filler</td>
</tr>
<tr>
<td>18</td>
<td>&quot;I do physical exercise regularly.&quot;</td>
<td>Unrelated filler</td>
</tr>
</tbody>
</table>

Table 9. Perceived unobtrusiveness questionnaire items in Study III. The participants answered on a 7-step scale (0=do not agree).

<table>
<thead>
<tr>
<th>#</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The system distracted me from doing other things.</td>
</tr>
<tr>
<td>2</td>
<td>Using the system disrupts my daily routines and activities.</td>
</tr>
<tr>
<td>3</td>
<td>Notification messages from the system sometimes had a negative impact on what I’m doing.</td>
</tr>
</tbody>
</table>
Original publications


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Original publications are not included in the electronic version of the dissertation.
735. Salman, Ilfah (2019) The effects of confirmation bias and time pressure in software testing
736. Hosseini, Seyyedrebvar (2019) Data selection for cross-project defect prediction
737. Karvonen, Juhani (2019) Demography and dynamics of a partial migrant close to the northern range margin
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AVOIDING BOTTLENECKS ALONG THE WAY TO FULL POTENTIAL OF PERSUASIVE TECHNOLOGY