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# Informing Design for Sustainable Behaviour

Thesis for the degree of Philosophiae Doctor

Trondheim, April 2014

Norwegian University of Science and Technology
Faculty of Engineering Science and Technology
Department of Product Design

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## PREFACE

This thesis has been submitted in partial fulfilment of the requirements for the degree philosophiae doctor (PhD) at the Norwegian University of Science and Technology (NTNU).

The research has been conducted at the Department of Product Design, Faculty of Engineering Science and Technology, NTNU, with professor Casper Boks as supervisor. The research was performed between January 2010 and January 2014.

The research has been financed by the Faculty of Engineering Science and Technology, NTNU.

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This thesis describes a four years long research project. The progress and results of this project has been affected by the contributions, either directly or indirectly, by a number of people. Without their support, contributions and input, the project could not have been realised.

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### Kunsten at få en idé

Kunsten er ikke
at få en idé.
Enhver kan med letthed
få to-.

Kunsten er den
mellem to eller fler
ganske almind´lige
hverdagsidéer
at se
hvilken en
der er god.

- Piet Hein

(Freely translated)

### The art of having an idea

The art is not
to have an idea.
Anyone could easily
have two-.

The art is
between two or more
quite ordinary
everyday ideas
to see
which one
is true.

- Piet Hein

## READING GUIDE

This doctoral thesis is written for design practitioners and researchers who are interested in how the design of products can make people use them in the most sustainable way. The main purpose of the thesis is to describe how the individual pieces of research described in the published papers, together contribute to answering the research questions and contribute to new insight to the research field. The main content from the publications are also included in the thesis describing one coherent story. Whenever this is done, it is described in the beginning of the sub-chapter and reference is given to the original publication. These publications can be found in full in part II of the thesis. Whenever appropriate, the sub-chapters are ended by a highlighted textbox summarizing the implications for the thesis of the sub-chapter.

The thesis consists of three parts:

Part I contains the main report and is divided into 7 chapters.

- Chapter 1 introduces the topic of the research, the research objectives, questions and limitations; and provides an overview over the main activities throughout the thesis.
- Chapter 2 describes the theoretical background for the thesis, the research field of Design for Sustainable behaviour and the tools that have been developed in this field; and other related theoretical fields that have been drawn upon during the project.
- Chapter 3 presents the research approach and the use of User Research methods during the project.
- Chapter 4 presents the main results of the project with a description of the iterations of the tools developed in the project, the case studies conducted during the project and summaries of the published papers.
- Chapter 5 discusses the results of the research project.
- Chapter 6 concludes the main report by summarizing how the research questions have been answered by the thesis, the conclusions from the research, the contribution to knowledge and recommendations for topics that would benefit from further investigations.
- Chapter 7 contains the list of references.

Part II contains the papers published during the project that are included in this thesis.

Part III contains the Dimension of Behaviour Change cards, which is the final version of the tool developed during this project.

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## ABBREVIATIONS

ANT – Actor Network Theory

ABC theory – Attitude-Behaviour-Context theory

CADM – The Comprehensive Action Determination Model

DBC – The Dimensions of Behaviour Change

DBIM – The Design Behaviour Intervention Model

DfSB - Design for Sustainable Behaviour

DwI – Design with Intent

D4S – Design for Sustainability

ECTS - The European Credit Transfer System

GUI – Graphical User Interface

HCI – Human Computer Interaction

IPCC - Intergovernmental Panel on Climate Change

LCA – Life Cycle Assessment

MOA – The Motivation-Opportunity-Ability model

NAM – The Norm-Activation Model

TIB – Theory of Interpersonal Behaviour

TPB – Theory of Planned Behaviour

UCD – User-Centred Design

UNEP – United Nations Environmental Program

ZEB – Zero Emission Buildings

# PUBLICATIONS ARISING FROM THIS PHD

I changed my name from Zachrisson to Daae when I got married in May 2012. As a consequence, my name appears differently on the publications before and after this event.

## Journal publications

Daae, J., & Boks, C. (2013) *Dimensions of Behaviour Change*, Journal of Design Research (accepted)

Daae, J., Goile, F., Seljeskog, M., & Boks, C., (2013) *Burning for Sustainable Behaviour*. Journal of Cleaner Production (submitted).

Daae, J., & Boks, C. (2013) *Improving the way LCAs deal with variation in the use phase using design for sustainable behaviour research*. The International Journal of Sustainable Engineering, (submitted).

Daae, J. & Boks, C. (2013) *A classification of user research methods for design*. Journal of Cleaner Production, (submitted).

Zachrisson, J., & Boks, C. (2012) *Exploring behavioural psychology to support design for sustainable behaviour research.* Journal of Design Research vol. 10 (1/2), pp 50-66.

## Conference publications included in this thesis

Daae, J. & Boks, C. (2013) *From teaching sustainable product design to teaching sustainable behaviour design*. Proceedings of Cumulus 2013, The 2nd International Conference for Design Education Researchers, Oslo, May 14th – 17th.

Zachrisson, J. and Boks, C. (2011) *Using a guide to select design strategies for behaviour change; Theory vs. Practice.* Proceedings of EcoDesign 2011, Kyoto, Japan, November 30th – December 2nd.

Zachrisson, J. and Boks, C. (2011) *Obtrusiveness and design for sustainable behaviour*, Presented at Consumer 11, Bonn, Germany, July 18th – 20th.

## Conference publications arising from this project but not included in this thesis

Daae, J. & Boks, C. (2013) *A classification of when to apply different user research methods to support design for sustainable behaviour*. Proceedings of ERSCP EMSU 2013, Istanbul, Turkey, June 4th – 7th.

Boks, C., Daae, J., (2013) *Towards an Increased User Focus in Life Cycle Engineering*. Proceedings of the 20th CIRP International Conference on Life Cycle Engineering, Singapore, April 17th – 19th.

Boks, C., Daae, J., (2012) *Design for sustainable behaviour in design education*. Proceedings of the International Conference on Engineering and Product Design Education, Antwerp, Belgium, September 6th – 7th.

Zachrisson, J. and Boks, C. (2011) *Reinforcing preliminary design strategy selection guidelines with insight from Fogg's behaviour grid*. Proceedings of Persuasive Technology 2011. Columbus, Ohio, USA, June 2nd – 5th.

Wigum, K. S, Zachrisson, J, and Boks, C. (2011) *The Role of Product and System Interfaces in Designing Zero Emission Buildings*. Proceedings of ISSST IEEE. Chicago, USA, May 16th – 18th.

Zachrisson, J. and Boks, C. (2010) *When to apply different design for sustainable behaviour strategies?* Proceedings of Knowledge Collaboration & Learning for Sustainable Innovation ERSCP-EMSU conference, Delft, Nederland, October 25th – 29th.

**Conference Posters**

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# 1. INTRODUCTION

Every day we interact with a large number of products. The way we handle the products, the options we consider, the context where we use them, the things we pay attention to, and numerous other aspects of our interaction with products, are strongly affected by the way the products are designed. Whenever a designer creates a new product, he or she makes decisions for how the product will be used, whether he or she intends to or not. “There is no such thing as a “neutral” design” (Thaler & Sunstein, 2008, page 3). As the design inevitably has consequences for how we interact with the product, it is a wasted opportunity not to design the product so it is likely to be used in the most desirable way. This may have consequences; not only for the usability or the user experience of the product, but also for the users themselves or their surroundings.

During the last decades there has been an increasing focus on environmental issues and acknowledgement of the designers’ possibilities and responsibilities, as “the product innovation process forms a new key to reducing environmental impacts” (Tukker, Eder, Charter, & Haag, 2001, page 148). The result has been an increasing incorporation of environmental considerations to design and a proliferation of terminology describing the topic (Bhamra, 2004). The term ‘Eco-design’ - also known as ‘Design for the Environment’, ‘Life Cycle Design’, and ‘Environmentally-Conscious Design and Manufacturing’ (Brezet & van Hemel, 1997), “considers environmental aspects at all stages of the product development process, striving for products which make the lowest possible environmental impact throughout the products life cycle” (Brezet & van Hemel, 1997, page 37). Although, for energy consuming products, the use-phase of the products life cycle is responsible for the largest share of the environmental impact (Brezet & van Hemel, 1997). Traditionally most of the focus has been on reducing the environmental impact of the products’ functions from a technological point of view (Wever, van Kuijk, & Boks, 2008), but in recent literature, increasing attention has been given to the potential for environmental benefits from altering peoples’ behaviour and the way they interact with products (Elias, Dekoninck, & Culley, 2008; Jackson, 2005b; Jelsma & Knot, 2002; Lilley, Lofthouse, & Bhamra, 2005b; Rodriguez & Boks, 2005).

## 1.1. WHAT IS DESIGN FOR SUSTAINABLE BEHAVIOUR?

To understand the title of this thesis, “Informing Design for Sustainable Behaviour”, it is necessary to explain what is meant by the terms “Design”, “Sustainable” & “Behaviour”.

The word **design** is frequently encountered in today’s society. Depending on who uses the word and in which context, it may have very different meanings. It can be both a noun, a verb and an adjective (Lawson, 1997). Herbert Simon considers it to be “any course of action aimed at changing existing situations into preferred ones” (Simon, 1996, page 111). Victor Papanek has an even broader understanding of the word and states that “All men are designers. All we do, almost all the time, is design, for design is basic to all human activity” (Papanek, 1984, page 3). As a contrast, Merriam-Webster defines design as the act “to create, fashion, execute, or construct according to plan” (Merriam-

Webster, 2013). In this thesis, the word design will be used more in accordance with the latter understanding. And even more specifically, the thesis primarily focuses on product design, professionals designing products, or services, systems or surroundings related to them.

In it's purest meaning, the word **sustainable** means that something is "capable of being sustained" (Merriam-Webster, 2013). However, the meaning it often is given in todays media, and which is the meaning applied to it in this thesis, is related to environmental impact of development. The term sustainable development was first introduced in 1987 by the World Commission on Environment and Development (the so-called "Brundtland report"). They defined sustainable development as "development that meets the needs of the present, without compromising the ability of future generations to meet their own needs" (1987, Page 41). They further pointed out that this must be the basis of the goals for economic and social development. This understanding has been further built upon by John Elkington, when he introduced the concept of a triple bottom line (Elkington, 1997). Triple bottom line means that companies should not only measure the economic results of their activities, but also the social and environmental consequences.

The combination of the terms; design and sustainable, describes an area of design and research, commonly known as Design for Sustainability (D4S) (Baumann, Boons, & Bragd, 2002) or Eco-design. "Eco-design (in the US often called 'Design for Environment') refers to the systematic incorporation of environmental factors into product design and development" (Tukker et al., 2001, page 148), whereas D4S "requires that the design process and resulting product take into account not only environmental concerns but social and economic concerns as well" (UNEP, 2009). To reduce the negative impact of the design, the approach often adopts a life cycle perspective (McDonough & Braungart, 2002; UNEP, 2009) similar to the one applied in Life Cycle Assessment (LCA) (Curran, 1996). In the life cycle perspective, environmental impact of the product is considered at all the different stages from the extraction of the raw material, through production, distribution and usage, until the material is disposed of or recycled.

Merriam-Webster defines **behaviour** as "the manner of conducting oneself, anything that an organism does involving action and response to stimulation and the response of an individual, group, or species to its environment" (Merriam-Webster, 2013). As this thesis is concerned with the behaviour of users interacting with products, and in particular, the environmental consequences of this, it is necessary to be more specific regarding the type of behaviour we are dealing with. Paul Stern proposed a definition of environmentally significant behaviour based on its impact: "The extent to which it changes the availability of materials or energy from the environment or alters the structures and dynamics of ecosystems or the biosphere itself" (Stern, 2000, page 408). This definition may be understood as a behavioural perspective of the above-mentioned "Brundtland report" definition of sustainable development.

The importance of the environmental impact of behaviour has recently received increasing acknowledgement and attention. However, already in a United Nations Environmental Program (UNEP) report from 1997, Brezet and van Hemel point out that a significant share of the environmental impact from many consumer products happens during the use phase (Brezet & van Hemel, 1997). Hanssen (1998) found that among the 18 products he investigated, the use phase was responsible for the largest environmental impact for products that transform chemically in their application or consume energy when being used. In 2011, the British House of Lords, published a report investigating the potential and importance of behaviour change. They concluded that "Understanding behaviour and behaviour change are necessary for developing effective and efficient policies in all areas" (House of Lords, 2011, page 5). The 2007 report from Working group III of IPCC (Intergovernmental panel on Climate Change) concluded that there is high agreement and much evidence that "Changes in lifestyle and behaviour patterns can contribute to climate change mitigation across all sectors" (IPCC, 2007a).

This attention has been accompanied by a growing pool of studies estimating the magnitude of environmental consequences caused during the use phase, and from variations in how the products are being used. For instance, there are studies indicating that the use phase of the product is responsible for 80-90 % of the energy demand of cold appliances (Rüdenauer & Gensch, 2007), similarly, 76% of the carbon emissions of a washing machine (Electrolux, 2011) and 60 % of the environmental impact from wood stoves (Solli, Reenaas, Strømman, & Hertwich, 2009). In a study from 1978, Sonderegger found that 46% of the energy consumption of US households could not be explained by obvious physical features, such as number of bedrooms and area of insulated glass. He estimated that 38% of this energy consumption was caused by the lifestyle and 33% by the behaviour of the residents (Sonderegger, 1978). Similarly, Verhallen and Raaij (1981) found that behaviour explained 26 % of the variation in energy use by Dutch households. Dietz et al. estimated that behaviour change of households could result in a 20% reduction of carbon emissions from the households or 7,4% of US national emissions with "little or no reduction in household well-being" (Dietz, Gardner, Gilligan, Stern, & Vandenbergh, 2009).

As a consequence of the increased awareness of the environmental importance of behaviour, there has been a shifting focus in energy efficiency agenda from technology and information campaigns (Wilhite, 2008), towards directing people's behaviour in the desired directions; (Jackson, 2005b) applying a wider variety of approaches. "Behavioural change is fast becoming the 'holy grail' of sustainable development policy" (Jackson, 2005b, page 13). "Information tends to result in higher knowledge levels, but not necessarily in behavioural changes or energy savings" (Abrahamse, Steg, Vlek, & Rothengatter, 2005, page 5). This is not surprising, as it is widely understood in the behavioural sciences that behaviour is a result of a variety of personal and contextual factors (Abrahamse et al., 2005; Klöckner & Blöbaum, 2010; Stern, 2000) and that people often behave differently than they intend (Jackson, 2005b). Alternative approaches for policy makers to affect behaviour have been proposed (House of Lords, 2011; Dough McKenzie-Mohr, 2011; Michie, van Stralen, & West, 2011; Verplanken & Wood, 2006) and in some cases adopted, for instance by the US government (http://www.whitehouse.gov, 2009) or in the behavioural insight team of the UK government (www.gov.uk, 2013). The latter is commonly known as the "Nudge unit", referring to a concept introduced in the book "Nudge: Improving Decisions about Health, Wealth and Happyness" by Thaler and Sunstein (2008), in which they argue for the effect of designing the way choices are presented.

As much of the environmental impact caused by behaviour is related to the use of products, and as this impact will vary depending on how the product is being used (Gill, Tierney, & Pegg, 2010); there is a substantial potential for environmental benefit from altering the way people interact with products. This interaction is strongly affected by the design of the product (Norman, 1988). For instance in a test of the Eco Kettle (www.ecokettle.com), Defra found that on average consumers could save 30% of the energy compared to using their regular kettles, because the design of the kettle changes the way people use them (Defra, 2008). Hence product designers are in a unique position to affect user behaviour. This creates a demand for increased understanding for how this best can be done. "One of the many goals of design research is to better understand the ways in which end users interact with the products of designing" (Kannengiesser & Gero, 2012). This goal has resulted in a rapidly growing field of research, often referred to as Design for Sustainable Behaviour (DfSB) (Pettersen & Boks, 2009). The field may be said to originate from Jaap Jelsma, who in 1997 connected Akrich' (1992) concept of script to the task of reducing environmental impact through the way people interact with products (Jelsma, 1997). The idea behind the 'script' is "a kind of user manual inscribed into an artefact" where the design of the product guides the way it is being used, (Jelsma, 1997) which is strongly related to Donald Normans (1988) concept of affordances. The field as we know it today started about a decade ago (Bhamra, 2004; Lilley, Lofthouse, & Bhamra, 2005a; Lilley et al., 2005b; Rodriguez & Boks, 2005) and has already resulted in a number of PhD theses (Elias, 2011; Lilley, 2007; Lockton, 2013; Pettersen, 2013; Tang, 2010; Tromp, 2013; van Dam, 2013; Wilson, 2013). However, even though this represents a substantial amount of research and literature, increasing our understanding of how products affect behaviour, there has been limited focus on supporting the practical application on the everyday projects of design professionals (Lockton, et al., 2010c).

Human behaviour is a complex domain and may be affected by a number of different factors (Stern, 2000). How this complexity affect the design of products is complicated and needs further investigation (Lilley et al., 2005a). DfSB, as it is understood in this thesis, builds upon a constellation of a research area, where the three main components are User Centred Design, Behavioural Psychology and Sustainability (see Figure 1.1).

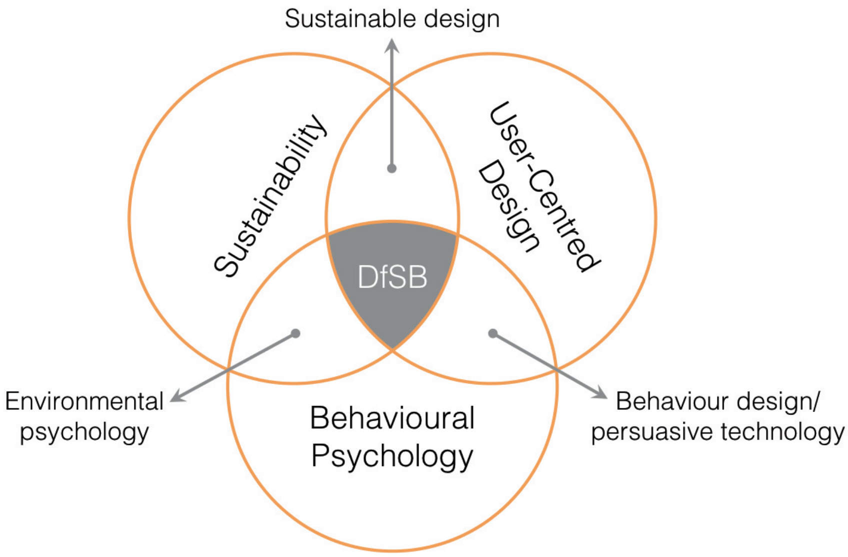



Figure 1.1. Theoretical positioning of Design for Sustainable Behaviour

User-Centred Design (UCD) is a promising approach to deal with the complexity and the need to create design that accommodates the user (Smit, Stevels, & Sherwin, 2002; Wever et al., 2008). It is characterized by a focus on understanding the user and the context, and using this as the key determinant in the decision making process (Courage and Baxter, 2005). Behavioural Psychology is a discipline that has spent considerable effort on uncovering and investigating the various factors that affect human behaviour (Klöckner & Blöbaum, 2010), and has been identified as a promising discipline to inform DfSB with the necessary behavioural understanding (Tang, 2010; Wilson, 2013). Sustainability is as much a goal or target for DfSB as it is a specific academic discipline. It is necessary however, to understand the relative environmental impact of different behaviours and the environmental impact of design solutions compared to the impact of the behaviour it is aimed to alter. To inform these considerations it can be valuable to draw upon the knowledge in Life Cycle Assessment (LCA) of how to make as accurate calculations of the various environmental impacts as possible (Henrikke Baumann & Tillman, 2004). Although, considering the limited attention most design practitioners are able to dedicate to this particular topic, it might be more feasible to apply calculations with more limited boundary conditions, such as User Efficient Design (Elias, 2011).

The DfSB literature contains limited contributions prescribing or supporting the practical integration of this insight into design processes. This lack of focus on making the results of design research easily integrated into design practice is a well-known challenge among many design researchers, and was for instance identified by Renee Wever in his editorial of the special issue on DfSB in Journal of Design Research (2012) - and was part of the conclusion of the review of sustainable HCI by DiSalvo et al. (2010). The contributions that do target this issue, are either primarily inspirational

(Lockton, 2013) or include only some of the aspects of how design affect behaviour (Tang, 2010). These contributions are important for the development of DfSB and the communication of DfSB to design practitioners, but have limitations that indicate the need for additional research. This thesis aims at increasing knowledge of how to inform a UCD process with insight from behavioural psychology to improve DfSB, and at developing a tool that makes this insight readily available to design practitioners. The approach taken to achieve this is a combination of literature review, creative workshops, user studies, iterative tool development, case studies and controlled experiments.

## 1.2. RESEARCH OBJECTIVES AND QUESTIONS

Informed by the insights and as a response to the limitations of DfSB, the main objective of this research project was to explore how insight about the user and the context can support the decisions of how products should be designed to increase the likelihood of it being used in the most sustainable way.

In order to pursue this objective, the main research topic for the project was:

**How can designers be supported in the process of acquiring and translating an understanding of the user and the context into informed decisions about how to design solutions that make people interact with them in the most sustainable way?**

However, as this is a complex question addressing a diversity of topics, it is necessary to break it down into its individual components and investigate these separately. The sub-research questions that were investigated through this research project was therefore the following:

**RQ1: Which attributes of the design of a product affect the way users interact with the product?**

**RQ2: Which characteristics of the user and the context affect behaviour and how can these support the design of behaviour changing products?**

**RQ3: How should the support be presented to the designers, to accommodate its integration into the design process and the ways designers work?**

The first question targets the design of products and how this relates to the user, the second question targets the user and how it relates to the design of products, and the third question relates to how the answer of the two first questions should be presented to support designers (See Figure 1.2).

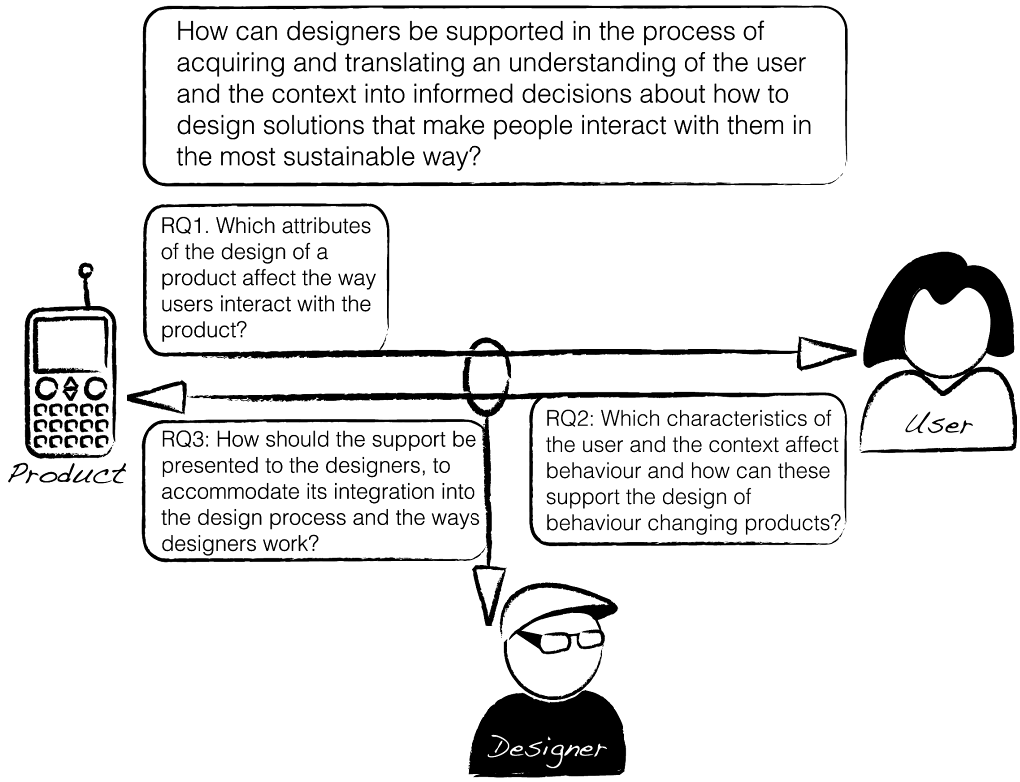



Figure 1.2. The research questions

To structure the investigation of these research questions, the key aspects of each were identified and targeted. The results are described in the published papers (See Figure 1.3, (inspired by Aschehoug, 2012)) and throughout this thesis. A summary of the answers to the research questions can be found in Chapter 6.1.

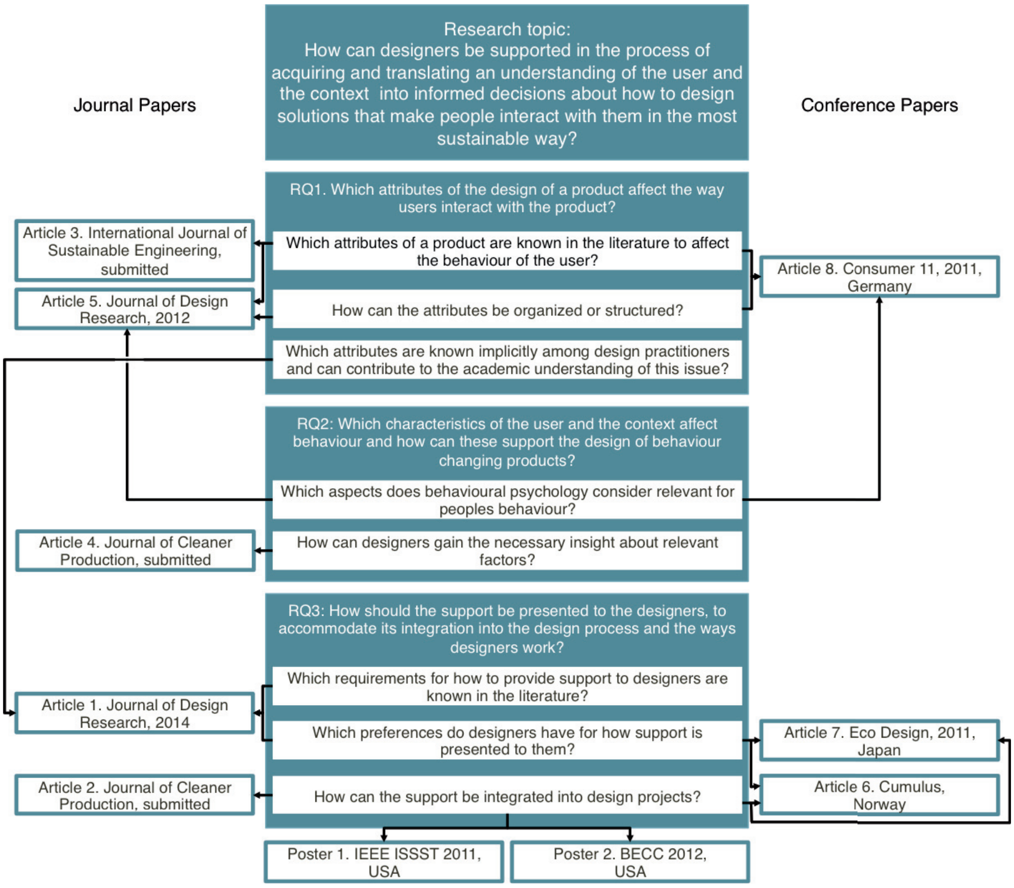



Figure 1.3. Answering the research questions with the papers.

## 1.3. SCOPE

The topic of this research project has been to investigate how a product should be designed to make users interact with it in the desired way. This implies that the focus has been on the situation where a user encounters a product and needs to interact with it to achieve something. To enable an in-depth analysis of this situation, it has been necessary to maintain relatively strict boundaries to this scope and leave a number of related topics out of this thesis. Thus, the main limitations of this thesis are as following:

- As the focus is on how to affect the behaviour of users when they interact with a product, it does not encompass why the user encountered the product in the situation, how it came to be there or the procurement of the product, even though the most sustainable solution may be found in choosing a different product or avoiding it all together. The user experience of interacting with the product and the user's acceptance of the product are directly affecting the user's motivation and willingness to interact with it and is thus included. However, this is different from the motivation for purchasing it, which has been left out of this thesis, apart from one study on purchases of ecological eggs (Chapter 4.2.2).

- All potential ways of affecting behaviour through design are included. This is in contrast to, for example the work done in persuasive technology, where coercion typically is excluded from the consideration.
- The thesis investigates how to affect the behaviour of users to reduce environmental impact and does not include any commercial aspects of the solutions. Questions such as the commercial motivation to achieve the behaviour change, the cost of the solutions, how to convince stakeholders to realise the product, etc. have not been targeted directly. However, the tools developed during the project are meant to be sufficiently flexible to enable these considerations to be included, and in some cases the tools can be used to support them directly. For instance, the tools help designers make informed decisions about how to affect behaviour through their design, hence indirectly support the designers convincing others why the design is a good solution by providing obvious reasons for the design.

## 1.4. DESCRIPTION OF THE PROJECT

This project has consisted of a multitude of activities, in a number of locations, which have contributed to the progress of this project. To provide an understanding of the development of the project, Figure 1.4 contains an overview over the main activities, and where and when they took place.

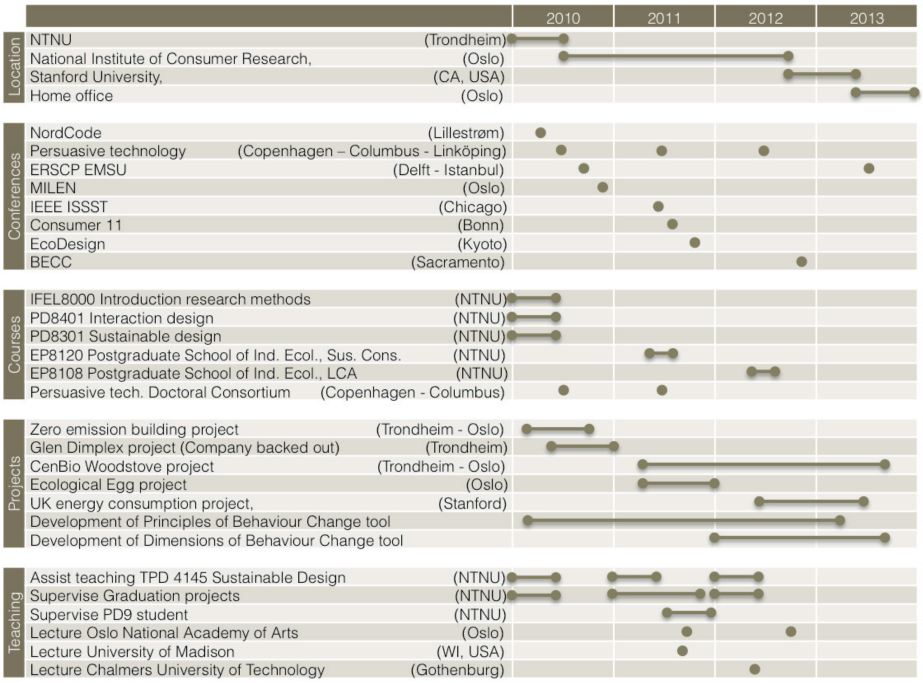



Figure 1.4. Main activities during the project

# 2. THEORETICAL BACKGROUND

As often is the case with design research, this research project draws upon a number of different theoretical disciplines - both from within design research itself, and from social sciences and engineering. In the following sections the field of DfSB is presented, and brief introductions are given to a number of relevant disciplines. A particular emphasis is given to the tools and models within the different fields, as they are considered particularly relevant for this research project. First, the current state of DfSB is presented before descriptions are given of the tools in the DfSB literature. After this, the influence of other considerations and disciplines are described.

## 2.1. THE STATE OF DESIGN FOR SUSTAINABLE BEHAVIOUR

The research field of DfSB has developed substantially the last decade, both in regards to the amount of research being conducted and published; and the diversity in topics, approaches and techniques applied. For instance, some authors primarily focus on environmental sustainability (e.g. Elias, 2011), some on social sustainability (e.g. Lilley, 2007), and others on a combination (e.g. Lockton, 2013).

### 2.1.1. IDENTIFICATION AND STRUCTURING OF DESIGN PRINCIPLES FOR SUSTAINABLE BEHAVIOUR.

A central topic, which has received substantial attention since the field emerged, is the identification and structuring of principles for how the design of products can affect the behaviour of the user. Although there is a difference between identifying design principles and structuring the principles, it is difficult to consider them separately as the structuring is necessary to understand how to distinguish between different principles. Two principles may be considered the same, or different, depending on which properties of the principles the categorization focuses on. In the following description, the primary focus is on the identification of logics for how to structure design principles, rather than the identification in the principles themselves.

One of the first contributions to understanding how the design of products affects behaviour, was Jelsma's dimensions of scripts (1997, 2006). He proposes that a script has a *direction* (how much the behaviour change is in line with the beliefs and values of the user), a *force* (how difficult the script makes it for the user to act differently than what is intended), a *scale* (whether the changes are made directly in the interaction between the user and the product, the function of the product or in the entire practice) and a *distribution* (how much control the user has over the behaviour). These dimensions are essentially an elaboration of the three notions derived from the concept of script proposed by Akrich: in-scription, prescription and de-scription (Akrich, 1992) De-scription is the purpose (for instance: do not forget to bring the hotel key back to the front desk), in-scription is the translation of the de-scription into the product (for instance: heavy weight on the key reminds guests to return the key) and prescription is what a devise allows or forbids the actor to do (for instance: forget to return the key to the front desk or not).

As Jelsma describes both force and distribution as variations of how strongly the product determines the behaviour of the user, it is a bit unclear what the practical difference between the two is. However, this notion of a distribution of control has dominated proposals on the design of how products affect behaviour, although there are variations in the terminology and granularity of the dimension. According to Jelsma and Knot, the concept of scripts "can be more or less compelling, but it will never totally determine user actions" (Jelsma & Knot, 2002, page 124).

In 2005, Lilley et al. expanded this understanding by proposing a distinction between three types of design principles according to how strongly they affected the behaviour (Lilley et al., 2005b). In their structure, the concept of scripts covers the middle part of a spectrum together with what they call Behaviour Steering. On one side they add Eco-feedback, which aims at influencing the behaviour by providing information or feedback, and on the other 'Intelligent' Products and Systems, which takes control of the behaviour away from the user and forces desired behaviour - or blocks inappropriate behaviour. This created a dimension, where on one end the users are in complete control and can choose to read and interpret the Eco-feedback, and further choose to alter their behaviour accordingly or not. On the other end, the users are forced to behave the desired way by the 'intelligent' products or systems. Between these two extremes, the users are guided towards the desired behaviour by the script, but without being forced to do so. The identification of the categories between the two extremes makes it similar to Zaltmans (1974) classification of social change strategies, which includes Reeducative Strategies (communication of fact, feedback), Fasilitation (increase the ease), Persuasive (involve bias in the structuring and presentation) and Power Strategies (involve the use and/or threat of force).

Elias et al. (2007) proposed a variation of this categorization, although a bit less explicitly connected to the force of how strongly the behaviour is affected. He made a distinction between consumer education, feedback and user-centred eco-design. The first two are clearly in the end of the spectrum where the user is in control, whereas the latter is defined as "creating products where the most intuitive and comfortable way of using and interacting with a product or system is also the most environmentally friendly" (E Elias et al., 2008) making it closer to the understanding of scripts.

Wever et al. (2008) proposed a similar categorisation as the one proposed by Lilley et al. (2005b) but included Behaviour Steering in the script category and suggested to phrase Forced Functionality instead of 'intelligent' Products and Systems, creating a clearer reference to the lack of control this type of principles allows the user to have. Bhamra et al. (2008) elaborated the distribution proposed by Lilley et al. by splitting it up into seven parts; Eco-information, Eco-choice, Eco-feedback, Eco-spur, Eco-steer, Eco-technology and Clever Design. The Eco-feedback strategies are similar to those of Lilley et al. apart from that simple information has been extracted and given the name Eco-information. The intelligent product and systems are similar to the Eco-technology and the strategies Lilley et al. call scripts and behaviour steering resemble Eco-choice and Eco-steering. In addition Bhamra et al. added Eco-spur and Clever Design, which are not included in the structure of Lilley et al. Eco-spur is meant to reward the intended behaviour, whereas Clever Design creates the desired end result without changing the user behaviour.

Based on the categorization by Bhamra et al. and Wever et al., Lidman and Renström (2011) proposed a categorization, dividing the distribution of control into four categories; Enlighten (providing information or educating the user), Spur (encourage or tempt the user), Steer (guide the user) and Force (compel the user). In addition they proposed a category called Match, which does not aim to affect the behaviour of the user and thereby does not naturally have a position within the distribution of control.

There are also two other categorizations, which have slightly different perspectives, but apply the same rationale. One is found in the introduction to the Design with Intent toolkit (Lockton, et al., 2010b). Instead of describing how the product is affecting behaviour, Lockton et al. describe three different ways to perceive the user: *Pinball* (do not think at all), *Shortcuts* (take shortcuts and make choices based on how the options are presented) and *Thoughtful* (take every opportunity to learn more about the world around them and their impact on it). These three categories describe the user perspective of the two extremes and the centre part of the distribution of control as described above.

The other category was proposed by Tromp et al. (2011), and attempts to describe how products affect behaviour from how the user experience it. They suggest a two dimensional landscape, where the dimension of force is combined with a dimension of salience. The dimension of force is described with Persuasive or Seductive principles in one end and Decisive or Coercive principles in the other, creating a distribution similar to the one described above.

As the logic in these distributions is similar, the difference seems mainly to be a question of naming. Basically the Distribution of Control (or Force (Jelsma, 1997; Tromp et al., 2011), Axis of Influence (Lilley, 2007) or "Spectrum of Control" (Lockton, 2013)) can be considered as a scale where the user has complete control on one end, and the product has complete control on the other end. In the end where the user is in control, the design strategies focus on providing the user with information or feedback. This information will in most cases have to be registered, interpreted, understood and reasoned upon before a behaviour change is possible. On the other end of the scale are design strategies that either force the user to behave in a certain way, or eliminate the users behaviour by acting automatic. As the user does not have any influence, these strategies may require limited or no attention from the user to change the behaviour. Between these two extremities are strategies with a varying degree of division of control. Solutions may range from simply enabling a certain type of behaviour, to guiding or steering the behaviour in the intended direction by making the desired behaviour easier, or the undesired behaviour more difficult. A comparison of the different versions of this distribution proposed in the literature can be seen in Figure 2.1.

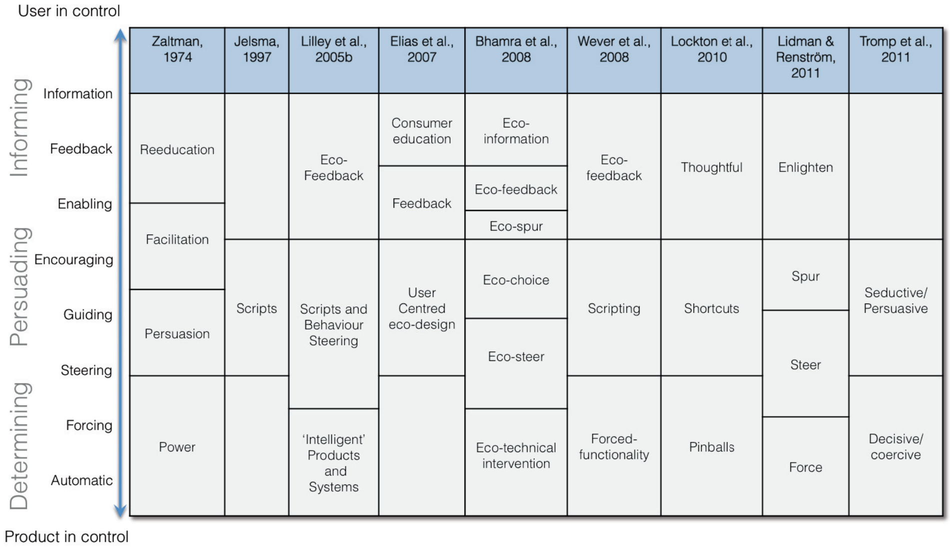



Figure 2.1. Variation of the distribution of control described in the literature.

Although the distribution of control has been the most common way to structure the behaviour changing design principles in the literature, it has by no means been the only one. Jelsma (1997) also proposed the dimensions of Scale and Direction. The dimension of Scale is similar to Rodriguez' and Boks' (2005) distinction between "product level" and "system level", where they distinguish between solutions that only concerns the product itself, and solutions including multiple products or services.

Tromp et al. (2011) also proposed a different dimension, namely Salience, which they combined with the dimension of Force to create a two dimensional landscape. By Salience they propose that a design can vary on a scale from implicit to explicit, and thereby result in different amounts of awareness or attention required from the user. This dimension is similar to the dimension of Obtrusiveness, which was proposed earlier the same year (Zachrisson & Boks, 2011a). This dimension, ranging from Unobtrusive (which the user easily can ignore and may not be aware of) to Obtrusive (which demands attention or action) was also combined with the distribution of control, and thereby creating a similar landscape to the one proposed by Tromp et al. (2011) (see Figure 2.2).

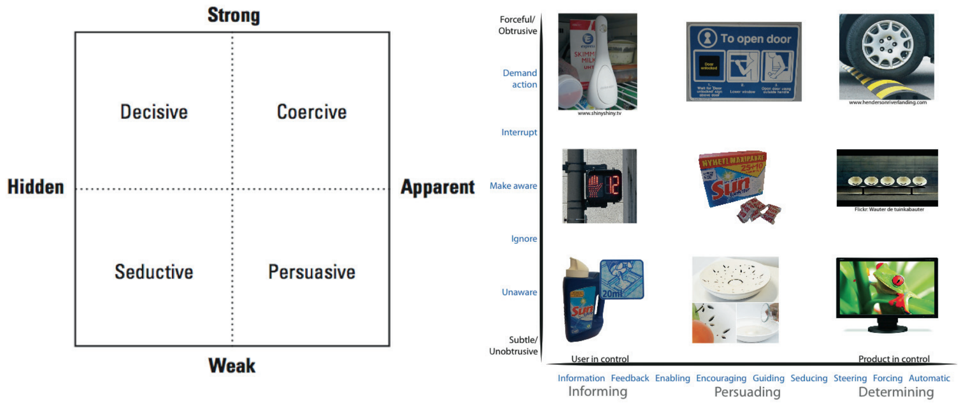



Figure 2.2. Comparing Salience-Force (Tromp et al., 2011) with Obtrusiveness-Control (Zachrisson & Boks, 2011)

Among the design principles proposed in literature, there is one that is problematic to position within any of the proposed dimensions; the adaptation of the design to the behaviour. It does not of focus on behaviour change as such, but rather on changing the product to achieve the desired outcome, while still allowing the users to maintain their behaviour. This principle was possibly first described by Rodriguez and Boks (2005), and is what Wever et al. (2008) called Functionality matching. This is also similar to what Bhamra et al. (2008) called Clever Design and Lidman and Renström (2011) called Match. There are also similarities to what Elias et al. (2008) called User-Centred Eco-Design, although this concept can also include behaviour change.

### 2.1.2. CASE STUDIES

Chapter 2.1.2 is adapted from the original text in Daae & Boks, *DfSB as a support for LCA*, submitted to IJSE.

Along with the growth and development of the DfSB research field, an increasing number of case studies can be found in the literature. These studies do not only exemplify the application of the theoretical frameworks of the authors, but also contribute with new insights to the factors affecting behaviour and in some cases the potential and limitation of different design principles. However, the investigation of how the design of products can affect behaviour is not limited to the DfSB literature. Relevant case studies have been published also within fields such as Environmental Psychology, Sustainable HCI and Persuasive Technology, although it can often be unclear, and in many ways also irrelevant, which "literature" a particular publication belongs to. Table 2.1 presents an overview over 28 case studies of how the design of products may affect behaviour. This overview primarily focuses on the DfSB literature, but several studies have been included from other disciplines. Common for all the included studies, is the collection of empirical data regarding how the behaviour of people may be affected by the design of products. For a study to be included, it must contain information about how the information was gathered, which product or behaviour it focuses on and what the outcome of the study was. There is a clear distinction between studies that investigate behaviour to identify the target problem and studies assuming a target problem and test possible ways of affecting it. A few studies include both these perspectives and describe the entire process from the initial investigation of the problem to the testing of possible solutions. Undoubtedly more studies may be found, in particular in related disciplines such as Environmental Psychology, but the overview provides an indication of the variation and the type of the relevant studies.

The overview presented in table 2.1 indicates the potential of a database of DfSB case studies. Such a database could prove valuable, not only by simplifying the process of aligning future case studies with the excising literature, point out successful approaches and comparing the results, but it could also facilitate meta analysis and increase the understanding of how behaviour best can be affected by product design. This could in turn prove useful, not only for DfSB researchers, but could potentially help researchers in other disciplines, such as LCA, to make more qualified assumptions of how products are being used. A standardised way of reporting the findings would provide a great benefit, not only for this purpose but also for the general usability of such a database.

Table 2.1. DfSB case studies

| REFERENCE | PRODUCT | TARGET BEHAVIOUR | STUDY SET-UP | TARGET PROBLEM | PROPOSED DESIGN SOLUTIONS | TESTING SET-UP | RESULT |
|---|---|---|---|---|---|---|---|
| Rodriguez and Boks (2005) | Electrical appliances. | Turning off appliances/ standby. | 10 participants; user diary, photos and interviews. Video recording of product usage. Shadowing 5 participants, recording time of product use. | 70% do not notice appliances are on, 40% cannot bother switching off, 40% listened to TV without watching. | Product adjusts to user behaviour or use of other products, blind (mute) button, feedback about energy use. | - | - |
| (Lilley, 2007) | Cell phone. | Social sustainable phone use. | 11 participants; user diary, 4 days. 5 participants; survey and interview. 258 participants; survey. | Problems with inappropriate topics or language, speaking too loud, loosing distinction between private & public and real & virtual, lack of awareness of surroundings, cameras intrude on privacy. | Phone advising use, phone display embarrassment, sound proof hands-free, real-time streaming. | - | - |
| (Edward Elias, 2011) | Refrigerator. | Opening/ closing of refrigerator doors. | Motion triggered camera for 9 and 18 days in 2 households. | Door opened most open when taking something out, loading, searching, using removed item, and doing something else. | Internal glass door. | Testing of prototype in one household: 10 days. | Measured: 43% reduction of user related losses, potential saving of 25-50 kWh/year. |
| (Jäger et al., 2009) | Refrigerator | Energy consumptio n. | 6 families evaluated 3 concepts. | The concepts must be easy to use, provide direct feedback on the history of the usage and instruct towards behaviour change. | Timely triggers, emotional appeal and cooperation & social pressure. Leverage children is positive, when done carefully. | Measurements with sensors at 4 families of 2 days. | Humidity correlates with door opening, temperature with energy consumption. |
| (Tang Tang & Bhamra, 2012) | Refrigerator and freezer. | General usage. | 18 families; survey, observation and 24h video recording, post-survey, interview. | Leave the door open while doing other things, forget to close the door, spoiled food in the back. Easier to change product than habits, lack of motivation to change, lack of information of impact. | Box for all breakfast items, a bottle drawer, hooks on door. | - | - |
| (J. Sauer, 2004) | Vacuum cleaner. | Adjust suction power. | - | People don't adjust the suction power on the vacuum cleaner. | Resetting the suction power, variation in instructions and on-product information. | 36 participants used a vacuum cleaner. | Reset function and ecological instruction have an effect but information does not. Attitude and knowledge does not have an effect, but habits are important. |
| (J. Sauer, Wiese, & Rüttinger, 2002) | Vacuum cleaner | Adjust suction power. | - | People don't adjust the suction power on the vacuum cleaner. | On-product information, icon for optimal suction power and position of control. | 40 participants vacuum cleaning a room. | Control on the handgrip result in more frequent adjustment than control on th body. The icons for optimal suction po had effect only with control on the handgrip whereas information only wh close to the control. Habits have a str effect. |
| (Wever et al., 2008) | Energy meter. | Usability problems. | Survey. | Problems with complex button combinations, difficult language and abbreviations, only possible to operate when plugged-in and difficult to perform basic tasks. | Focus on essential functions (energy cost), improved physical set up, LED feedback of consumption. | Lab testing of prototype. | Prototype 4 times quicker than old, less use of manual, better usability. |
| Broms et al., 2009) | Energy meter. | Raise awareness of energy consumptio n. | 9 participants; interview and observation. | Visibility, place and complexity are crucial for integration into our behaviour. | A "clock" showing energy consumption for different hours during the day. | 10 prototypes installed in homes for 3 months. | - |
| (Selvefors, Karlsson, & Rahe, 2013) | Energy meter | Use of online feedback system. | - | - | Eliq Online energy meter with web portal. | 15 participants completed 12 months baseline measurements,6 months use of Eliq Online, 6 months follow up and 3 | Significant correlation between frequency of use of the web portal and reduction in energy consumption. Households with high frequency reduced consumption by 9%. Also increase in motivation, perceived curtailment, investment |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | | most participants. |
| (S. S. Van Dam, Bakker, & van Hal, 2010) | Home energy managemen t system (HEMS) | Reduced energy consumptio n due to feedback. | - | - | The system consists of a sensor, a sending unit and a display, monitoring, registering and providing feedback about energy consumption. | 304 participants used the HEMS for 4 months. 11 months later 189 responded to survey | Initially 7,8% reduction of energy consumption, but this was not sustained after 11 months. But there is great variation between participants and some are more receptive. |
| (Arroyo, Bonanni, & Selker, 2005) | The sink. | Saving usage. | - | People consume too much water. | Sink design with "just-in-time" feedback, positive reinforcements and social validation. | 10 participants in one-time pilot and 15 participants in 2 months study, observations and bi weekly survey. | Users got quickly accustomed to the intervention and wanted more feedback. |
| (Kuijer & de Jong, 2009; Matsuhashi, Kuijer, & de Jong, 2009) | Bathing | Water consumptio n. | 16 participants, diary study for 2 weeks, idea probing and group session. Follow up interviews 3 months later. | Bucket washing consumes 90% less than shower, and sink-shower combination 35% less. Shorter showers results in stress, No behaviour change after 3 months. | Sink-shower combination to simplify sink washing. | - | - |
| Matsuhashi et al., 2009) | Bathing | Water consumptio n. | 3 participants from Japan, 3 from India and 3 from the Netherlands: Survey, cultural probe and interview. One and a half month duration. | Large variation in practice between cultures. Several combinations but only Dutch only shower, only Japanese only bade and only Indians only use bucket. The more running water, the more water is consumed. | - | - | - |
| (De Jong & Mazé, 2010) | Cooking | - | 6 households: 1 Moroccan, 1 Iranian, 1 Surinamese, 1 Vietnamese and 2 Dutch. Observation, interview and survey; 10 weeks. | Large differences in how and where people shop and water consumption. Those who eat alone save left overs for later, which families throw away as there is not enough for everyone. | - | - | - |
| (L. McCalley & Midden, 2002) | Washing machine | Increase energy conservation behaviour. | - | People don't use the most energy efficient programs on the washing machine. | Feedback, with and without support of goal setting, self-set and experimenter set. | 100 participants, 20 trials. Computer simulated washing machine. | Feedback alone has no effect, but supported with goals, it results in 21,9% and 19,5% reduction. |
| (Lidman, Renström, & Karlsson, 2011) | Washing machine | Dosage of detergent | 15 participants; sensitising booklet, focus group, collage creation. | Detergent dosage is habitual, there is a need for feedback of dosing and cleanliness, guestimates of dosing, size of package affect dosing, desire for convenience, | 4 prototypes. 1: Measurement cup with plastic frog, if too much detergent, frog drowns. 2: Chart to guide does according to laundry weight, scale and measuring cup. 3: Package where only right amount will pour out. 4: Detergent tablets. | 16 households, 4 for each prototype; 1 month monitoring of dosing, 1 month compulsory use of prototype, 3 month voluntarily use. Finally, in depth interviews. | Prototype 1: High effect, also on long term. Fairly well accepted. Prototype 2: Very high effect, low long-term effect, high acceptance. Prototype 3: High effect, good long-term effect, well accepted. Prototype 4: Very high effect. Low long-term effect. High acceptance. |
| (L. T. McCalley, de Vries, & Midden, 2011) | Washing machine | Average amount of energy per wash | - | People use more energy than they need to by choosing "wrong" programs. | Four conditions: Goal setting, yes or no, and foot-in-the-door (first small then larger compliance), yes or no. | 121 participants divided in the four groups. 10 test trials and 20 actual trials on computer simulated control panel. | Significant saving for goal setting alone. Foot-in-the-door inhibits response to the goal. |
| (Juergen Sauer, Wiese, & Rüttinger, 2003) | Water kettle | Energy and water consumptio n. | - | People boil more water than they need. | On-product information, task instructions and kettle design. | 48 users used a kettle. | Information and instructions affected behaviour. Cup sized kettle reduced water consumption, but not transparent. Habits, beliefs and environmental concern affect results, but knowledge did not. |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| (Kuijer & de Jong, 2010; Kuijer & Jong, 2012) | Thermal comfort | Energy efficient ways to experience thermal comfort | Literature study, Japan; 4 interviews 2 observations, the Netherlands; 60 workbooks and interviews. | Personal heating more efficient than space heating and requires less planning, timing and skills, houses are often badly insulated, people dislike the air from heaters, balance ventilation and temperature. | Small cherry pit filled pillow heated in the microwave oven, to provide personal heating. | 60 users used product for 2 days; Video interview. | Hygiene issues with microwave oven, limited heat properties of product, product hard to bring around, changes must happen together with building design and climatic systems. Potential for attractive body insulation. |
| (I. N. Pettersen, 2013) | Thermal comfort | Residential heating. | Interview with 5 representatives at producer and 3 at energy providers and public organization. | Efficiency vs sufficiency, focus on thermal comfort, resistance against retrofitting, | Tailored advice to what to buy and how to interact, reduce need for active heating, renewable energy, temperature zones, adapt heating to activities, better mental models. | - | - |
| (Wilson, 2013) | Thermal comfort | Open window while heating is on. | Interview and guided tour of 7 households | Thermal comfort varies greatly and is based on freshness, light, physicality and sound. Heating is essential, affected by social expectations, often routines, lack of feedback and knowledge. | Prototype providing feedback of the status of the heating system in tandem with the status of their window. | 2 focus groups with prototype and user trials with prototype installed in 2 households for 4 months with pre and post interviews. | Feedback improved understanding of consequences and how the system works but limited behaviour change. Receptiveness to information decreased towards the end of the trial. Use of ambience well received. |
| (Renström, 2013) | Thermal comfort | Use of central heating system. | Two studies: Diary study and survey with 35 participants. Annotation activity, generative exercise, interview and survey with 30 households. | Heating systems are difficult to understand and use, inadequate feedback, uncertain how much control they have, use of additional heating or cooling artefacts, poor understanding of amount of energy heating or hot water consume. | - | - | - |
| (I. N. Pettersen, 2013) | Dishwashing | Use of dishwasher. | Interview with 5 representatives at producer and 2 others | Reduce pre-rinsing, make pre-rinsing less wasteful, run full machines, choose right program. | Skill transfer at sales point, improved eco-labels, separate reusable and dirty items, flexible interior, optimal default, better mental models. | - | - |
| (I. N. Pettersen, 2013) | Audio-visual media usage | Interaction with televisions. | 9 interviews with representatives at producer and 2 others. | Intensity of use (what equipment at the same time), under what contextual conditions, the applied settings, duration of use, choice of product and lifetime of product. | Information of product properties at point of sale, improved eco-labels, improve display technology, improve experience of smaller screen, alternative business models, different viewing modes, avoid stand by mode, shift to alternative activities. | - | - |
| (Hielscher, Fisher, & Cooper, 2008) | Hair care. | Hair cleanliness. | In depth interviews with 24 women and 12 hair-care experts. | Perception of cleanliness is culturally dependent, and may be described on a scale from too dirty to too clean. | - | - | - |
| (Dillahunt, Becker, & Mankoff, 2008) | Motivating environmental behaviour. | Attachment to virtual polar bear. | - | - | Animation of polar beer. The more environmental actions participants do, the more ice. No action – less ice. | 10 participants; one week. 10 participants in control group. Initial survey. | Significantly more fulfilled commitments, higher environmental concern and greater care than control group. Not more commitments. |
| (Daae and Boks, 2014) | Wood stove | Burning firewood in a sustainable way | 18 ethnographic studies with wood stove users | People reduce air vaults in the wrong order, reduce air too fast, don't close the door, close air completely, light the fire from the bottom, burn unsuitable material. | Prototype with combined air lever closing primary air on first part of movement and indication for position of ignition, fast burning and slow burning, thermometer with indication when air should be adjusted and simplified user manual. | 10 participants lighting fire in the prototype and 10 participants in a regular oven, in a lab. Maintaining fire until 80% of wood mass is burned. | Only half of the participants using the prototype paid attention to the design and were affected. Those burned more correctly, gained less soot on the glass door, emitted less fine particles and CO2, but not significantly. |

### 2.1.3. DFSB TOOLS

“Ideally industrial designers should be equipped with a decision-making tool, enabling evaluation of alternatives in order to choose the strategies best suited for each project” (Pettersen & Boks, 2008b, page 124). The last years increased attention to DfSB research has, among other things, resulted in the development and proposal of an increasing number of tools. Although these tools serve as a variation of purposes and may not be meant to fulfil Pettersen and Boks’ request, it is still valuable to understand their potential to support an informed selection of design principles. The following sections contain the construction of a list of requirements for such a tool and a brief introduction to the various published DfSB tools and an evaluation of their fulfilment of the requirements.

#### 2.1.3.1. TOOL REQUIREMENTS

Chapter 2.1.3.1. is adapted from the original text in Daae & Boks, *Dimensions of behaviour change*, JDR, 2013.

Before designing anything, it is necessary to understand the requirements for the new design and investigate if they are fulfilled by any existing solutions. This is also true when designing a design-tool. The following paragraph is a review of requirements for design tools found in the literature. This forms the basis for the list of requirements that will guide the evaluation of the existing tools and methods, although the majority of them were not specifically developed to support the decision making process of DfSB.

In 1992, John Chris Jones observed that the literature on the process of creative thinking is “extensive, but none too helpful” (Jones, 1992, page 28). Since this observation was made, the literature has continued to expand not only in quantity, but also in the variation of perspectives and directions. In 2008, Nigel Cross pointed out that there has been a substantial growth in new, unconventional methods, which attempt to bring rational procedures into the design process. Although not embraced by everyone, the need for new methods is growing with the increase in complexity for many modern design projects (Cross, 2008). According to Cross, the new methods tend to formalize certain procedures and externalizing design thinking. The formalization of procedures may reduce the occurrence of oversight and widen the solution space, whereas the externalization of design thinking frees your mind to think creatively and aids all the members of the design team to understand what is going on. He distinguishes between “Creative Methods, which are intended to increase the solution space and remove mental blocks, and “Rational Methods”, which are intended to improve the quality of design decisions. The contribution of these methods are in line with Jones observation that the “enemies of originality are mental rigidity and wishful thinking” (Jones, 1992, page 29).

However, even though there has been a substantial increase in both the quantity and usefulness of this literature, there is still a lack of methodological support for identifying the most suitable design methods (Ernzer & Birkhofer, 2002). When reviewing the literature presenting development of new design methods and tools, there seems to be limited discussion about how the methods or tools should be designed to support the way designers work and the translation of this into requirements for how the tool should be designed (Brandt & Messeter, 2004; Buur & Soendergaard, 2000; Desmet, 2002; Elias, 2011; Halskov & Dalsgaard, 2007; Lockton, et al., 2010c; Lucero & Arrasvuori, 2013). An exception is the work by Lofthouse (2006). In her investigation into how eco-design tools should be designed to support the needs of designers, she found that designers tend to look for tools that combine guidance, information and education. The tools should contain numerous examples, be as visual as possible and contain a minimum of text. When text is needed, it should be written in a non-scientific language. The tool should be possible to use without spending too much time, be referred to when required and fit into the designers' usual way of working. It is also crucial that the tool focuses on design and not on strategic management or retrospective analysis of existing products. Although Lofthouse's investigation focuses more on traditional eco-design issues, such as information about environmental impact of materials and processes, many of the requirements may be relevant for the context of behaviour change too.

There are also a few other publications relevant for understanding how designers use tools, what makes certain tools particularly valuable and the reasons why other tools are not applied. An extensive contribution is the doctoral thesis by Matthias Lindahl on "Engineering Designers Requirements on Design for Environment Methods and Tools" (Lindahl, 2005). Even though this research focuses on engineering designers and not product designers, it is still likely to be relevant in the context of Design for Sustainable Behaviour as both groups thinks creatively about the design of products and many of the tools Lindahl investigates also are used by product designers. However, there are also differences between the type of work the two types of designers do and how they do it, which may affect their requirements for methods and tools. This should be taken into consideration when evaluating the applicability of Lindahl's conclusions.

In his research Lindahl investigated which methods and tools designers use, obstacles they experience with using particular methods and tools, and the requirements they have for the methods and tools they use. His main focus was to find out how Design for Environment methods and tools should be designed to become more commonly used. However, he also investigated the use of several other types of design methods and tools. His reason for this was the assumption that "the basic requirements for a method or tool to become utilized are the same" (Lindahl, 2006, page 488) and it strongly increased the basis from which he could extract data.

In his thesis Lindahl (2005) presents a list of 32 requirements ranked according to their importance for a tool to be utilized. He concludes that all these requirements can be summarised into four major requirements. A method or tool must be (1) easy to adopt and implement, (2) facilitate designers to fulfil specified requirements, (3) reduce the risk that important elements in the product development phase are forgotten and (4) must reduce the total calendar time to solve the task. He points out that if "the method or tool helps designers to fulfil the specified requirements, it will also most likely help them to reduce the calendar time as well as the number of working hours needed to accomplish the product development" (Lindahl, 2005, page 37). In addition, he identified the three main purposes designers have to utilize methods and tools. The methods or tools "(1) facilitate various kinds of communication within the product development process, (2) integrate knowledge and experience into the methods and tools as a know-how backup and (3) contribute with structure in the product development" (Lindahl, 2005, page 59).

The importance of ease of adoption and implementation was confirmed by a study by Knight and Jenkins (2009). They examined the eco-design tools designers' use in their practice and found that the tools should be clear and visible, and should be both useable and useful for the design community. Through their study they also found that the tools can be classified into three categories: "Guidelines", providing broad support but little detail, "Checklists", providing in-depth but narrow application at selected stages in the process, or "Analytical tools", providing detailed and/or systematic analysis at specific stages of the process. All three types of tools were considered to be useful, but when asked to rank the tools, "Checklists" were considered to be most applicable in their companies, followed by "Guidelines".

By extracting the identified requirements and ranging them according to their relative importance, a list of requirements for a tool to help designers make informed decisions about which behaviour changing design strategies to use, was created (see table 2.2).

Table 2.2. Requirements for the requested design tool

| Must | |
|---|---|
| Nr 1. | Help designers to design products that are more likely to be used in the desired way by using the tool, than without the tool. |
| Nr 2. | Help designers understand which design principles they should apply to change the behaviour of their target group. |
| Nr 3. | Increase the designers understanding of different aspects of how the product affects the behaviour of the user |
| Nr 4. | Be easy to use for product designers, fit into designerly ways of working |
| Should | |
| Nr 5. | Be possible to understand how to use in 15 minutes |
| Nr 6. | Be inspiring for designers |
| Nr 7. | Be in a format that makes it suitable for discussion and collaboration |
| Nr 8. | Should be experienced as suggesting rather than dictating |
| Nr 9. | Remind the designers of the aspects of a product that affect the way users interact with it |
| Could | |
| Nr 10. | Be suitable to bring to meetings with clients to help the designers explain their decisions |
| Nr 11. | Be experienced as primarily visual |
| Nr 12. | Be written in a non-scientific language |

#### 2.1.3.2. DESIGN WITH INTENT

Perhaps the DfSB tool that has received the most attention is Design with Intent (DwI), which is developed by Lockton et al. (2010b). The tool was primarily developed to support DfSB but is also intended to be generally applicable to any design aiming at behaviour change (Lockton, et al., 2010a). The toolkit consists of 101 patterns or principles for influencing behaviour. The patterns are structured into 8 lenses according to the "worldviews" of how the designer approaches behaviour change (Lockton, et al., 2010b). The eight lenses are: Architectural, Errorproofing, Interaction, Ludic, Perceptual, Congnitive, Machiavellian and Security. Each pattern is presented on a separate card, and consists of a title, a question pointing out the function of the pattern, and an example of an application of the pattern with a short description and a picture (see Figure 2.3) (Lockton et al., 2010b).


Figure 2.3. Example of a Design with Intent pattern card (Lockton et al., 2010b)

The DwI tool is proposed to be used in a number of different ways (Lockton, 2013); going through the cards to get inspiration, analysing existing behaviour change solutions, frame your problem in terms of a target behaviour, random inspiration or build on models of the user. The latter proposed way of using the cards build upon a categorisation of three different types of users, presented on an additional card. This categorisation proposes that users can be considered as either 'Pinball' (users don't think much but are pushed and pulled in different directions), 'Shortcut' (users want to get things done as easy as possible and with the least effort) and 'Thoughtful' (users think analytically about what and why they are doing) (Lockton, et al., 2010b). Various versions of the DwI tool have been tested through a number of workshops and applications in projects, and evaluated by a large number of users. This has indicated that the toolkit both supports generation of large numbers of ideas and improves the users understanding of how design influence behaviour (Lockton, 2013).

Design with intent is easy to use and understand, is inspiring and stimulates creativity. It suggests numerous approaches that may be applied to affect behaviour and thereby supports generation of ideas, but provides limited guidance to when particular approaches may be appropriate and how the designer should evaluate the approaches. The only such support is a broad classification into three types of users; Thoughtful, Shortcuts and Pinball.

#### 2.1.3.3. USER EFFICIENT DESIGN

User Efficient Design is a method or process developed by Elias et al. (2009) consisting of a proposed DfSB design process. Elias (2011) proposes that a project to improve the energy efficiency of usage of a product should go through three phases, and for the third phase he proposes a five stage process (see table 2.3).

Table 2.3. The User Efficient Design Process (Elias, 2011)

<table>
<tr><td colspan="2">Phase 1. Identify and Record User Behaviour<br>Video and observation studies of users in their typical environment</td></tr>
<tr><td colspan="2">Phase 2. Quantify User Behaviour<br>Calculate the impact of this user behaviour in terms of energy usage; present a ranked list of priority behaviours</td></tr>
<tr><td rowspan="5">Phase 3. Design a Better Product<br>Create a product which reduces this impact</td><td>Stage 1. Explore the Problem and Identify Causes<br>Identify what causes the behaviours to use energy</td></tr>
<tr><td>Stage 2. Design Product Features<br>Create product features that tackle each user behaviour</td></tr>
<tr><td>Stage 3. Create Combinations<br>Combine the best features into single designs</td></tr>
<tr><td>Stage 4. Conduct a Design Feasibility Study<br>Assess the feasibility of these designs and select one or two to use</td></tr>
<tr><td>Stage 5. Detailed Design Development<br>Conduct the detailed design work for the chosen final designs</td></tr>
</table>

The overall approach and steps in this process are very similar to a typical human-, or user-centred design process the way it is described in the literature (e.g. Courage & Baxter, 2005; ISO-9241-210, 2010; Steen, 2008). However, this structured description in the context of DfSB is a valuable contribution and among the details in some of the stages, there are nuances and elements that differ from traditional user-centred design processes. Perhaps the most interesting and valuable of these, is the way he analyses the energy consumption of particular behaviours and distinguishes between 'Theoretical minimum', 'Intrinsic losses' and 'User-related losses' (see Figure 2.4). The magnitude of the latter determines the urgency of addressing a particular behaviour.

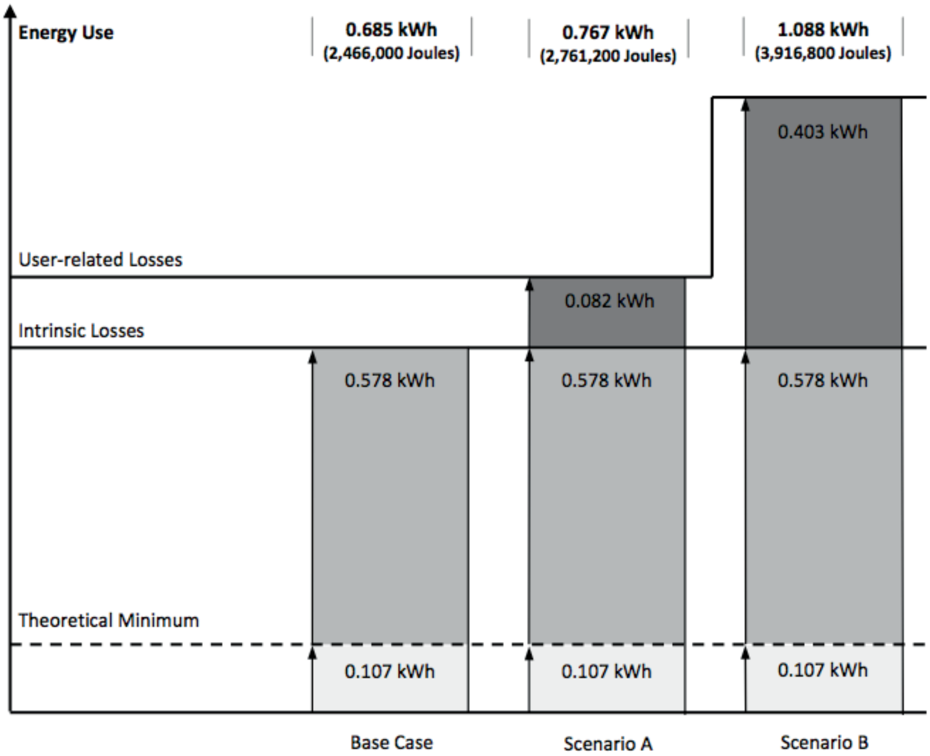



Figure 2.4. Analysis of types of energy consumption (Elias, 2011)

The User Efficient Design process was developed and tested in a project redesigning a refrigerator (Elias et al., 2007). Based on the findings from the process, Elias (2011) built a prototype of an improved refrigerator with an internal transparent door, manual instead of automatic light switch and redesigned shelves on the door. When comparing usage of the prototype with a conventional refrigerator, Elias (2011) found that the user related losses could be reduced by 43%.

User efficient design is fairly easy and quick to understand and provides a process to support the design and helps designers determine which behaviour they should target. However, it does not provide any guidance to how to improve the design.

#### 2.1.3.4. THE DESIGN BEHAVIOUR INTERVENTION MODEL

The Design Behaviour Intervention Model by Tang and Bhamra (Tang, 2010; 2012) is a further development of a model they originally presented earlier (Bhamra et al., 2008; Tang & Bhamra, 2008). The model suggests the type of behaviour changing design principles that should be applied at different stages of a behaviour change process and in particular in the formation of habits, by combining a number of different theoretical models. It combines Triandis' Theory of Interpersonal Behaviour (Triandis, 1977), Anderson's theory of development of cognitive skills (Anderson, 1982) and design strategies along the distribution of control (Lilley, 2009), and point out the level of forcefulness and points of intervention (see Figure 2.5).

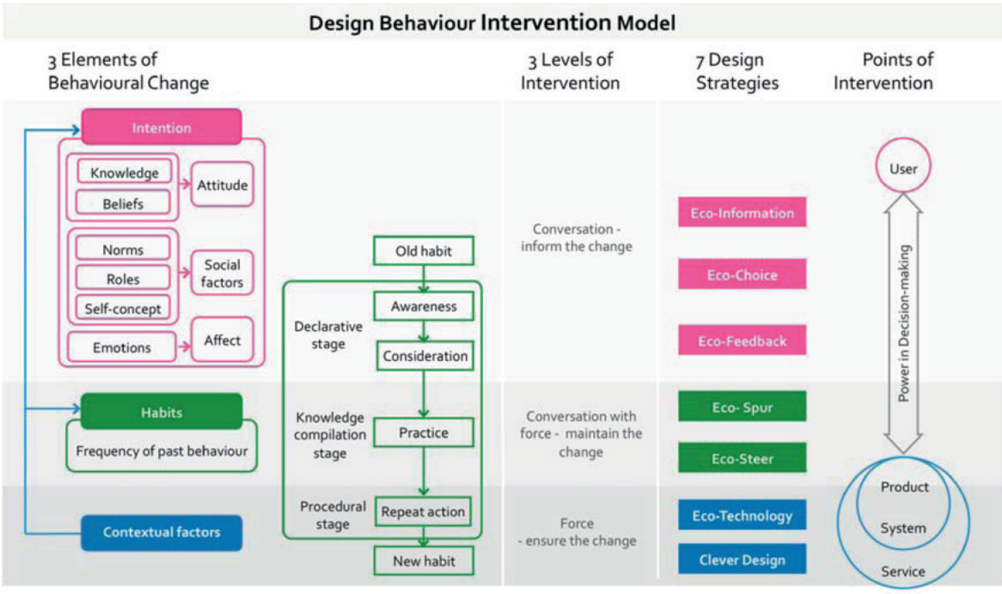



Figure 2.5. The Design Behaviour Intervention Model (Tang & Bhamra, 2012)

In a case study demonstrating the feasibility of reducing environmental impact by modifying consumer behaviour of using a refrigerator, Tang and Bhamra report that the "DBIM has been shown to be a useful and inspirational tool for gaining deeper understanding of consumers and making informed decisions about which strategies to apply" (Tang Tang & Bhamra, 2012, page 11).

The DBIM model provides an indication of how much control the user or the product should be given to target particular factors that may affect behaviour, and makes a connection to the development of habits and the target of the intervention. However, it does not provide explanation for the connections, possibly limiting the understanding and learning effect for the user. It is also questionable how easily it can be applied in practical design projects.

#### 2.1.3.5. CONSTITUENTS OF BEHAVIOUR AND HABIT FORMATION

Another model describing the formation of habits, is the Constituents of Behaviour and Habit Formation model by Hanratty, et al. (2012). The model illustrates the transition from behaviours being determined by a number of factors, and in particular the hedonic-, gain- and normative goals proposed in the Goal Framing Theory (Lindenberg & Steg, 2007), through repetition under similar context, becoming more automatic and requiring less repetition. Finally the behaviour may become completely habitual and happen without awareness from the user.

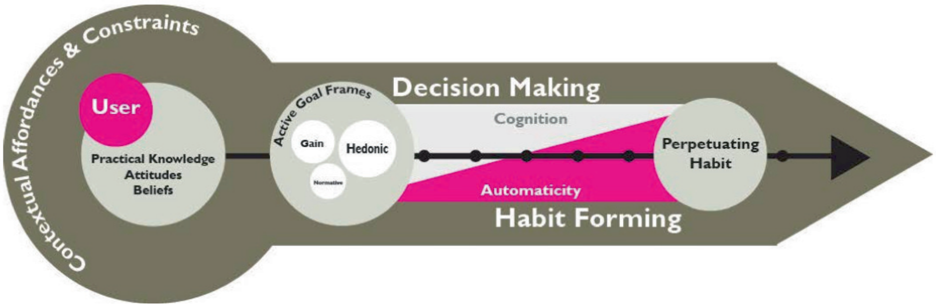



Figure 2.6. The Constituents of Behaviour and Habit Formation

The Constituents of Behaviour and Habit Formation model illustrates the transition from a conscious decision making process to an automatic habitual process, but does not provide any information about how to facilitate the transition.

### 2.1.3.6. PATHWAYS OF SUSTAINABLE BEHAVIOUR

In 2013, Renström et al. presented a map of the different paths a user can follow to reduce the environmental impact resulting from interaction with an artefact (see Figure 2.7) (Renström, et al., 2013). The framework is built on the notion that the type of behaviour is crucial for successfully determining how products should be designed to alter the behaviour. By drawing upon and expanding the categorizations of different types of behaviour presented by Ölander and Thørgersen (1995) and Fogg and Hreha (2010) they suggest that there may be five different paths users can follow to behave more sustainable. The first path suggests that the user can use the artefact differently, either by change the style of use, adapt use situation or curtail the use. The second path suggests that the user can use a second artefact that mediates the use of the primary artefact, either by changing the style of using the primary artefact, change the use situation or curtail the use of the primary artefact. The third path suggests that the user can use a second artefact that regulates the primary artefacts resource use, and thereby doesn't require alteration in the way the product is used. The fourth path suggests that the artefact should be maintained and repaired to function optimally and the fifth path suggests that the user acquires a new artefact that has less impact than the alternatives.

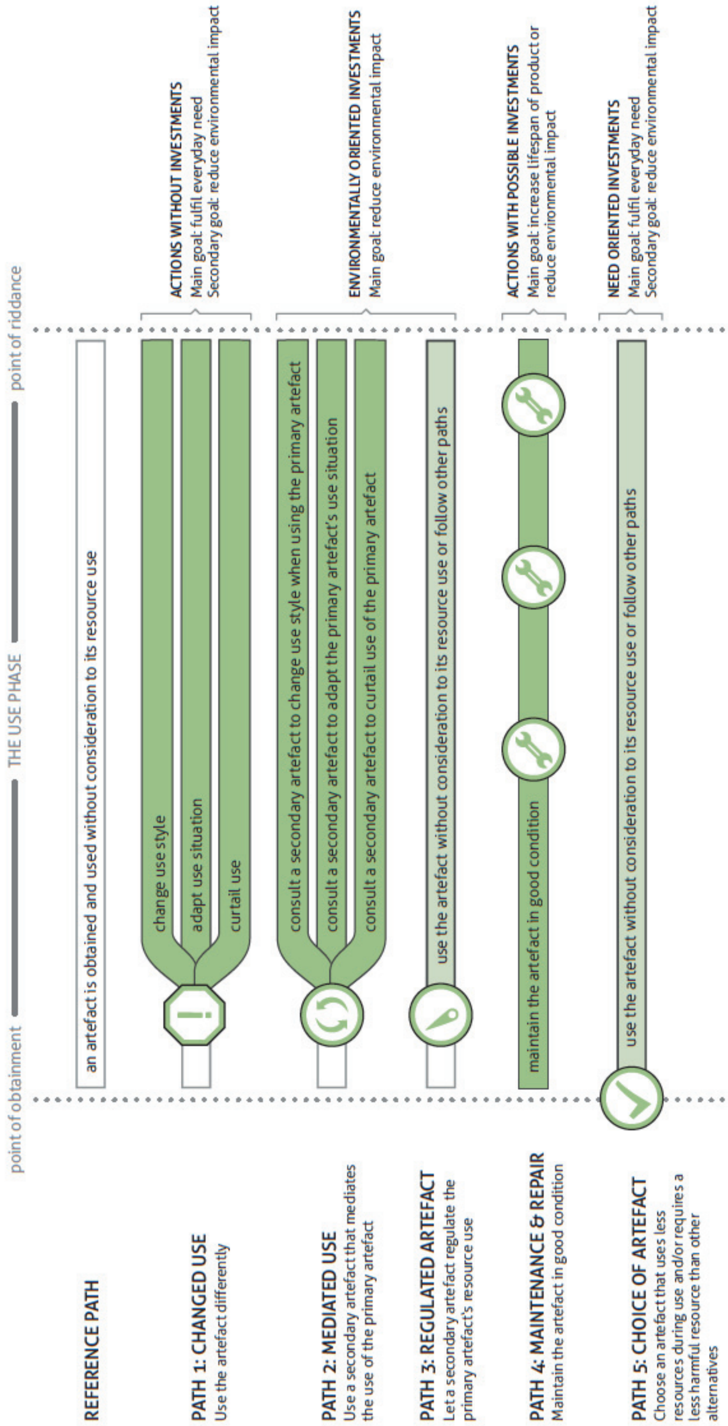



Figure 2.7. The Map of Pathways to Sustainable Behaviour (Renström et al., 2013)

Renström et al. (2013) argue that the proposed paths can inform a designer's choice of design principles and present some general reflections regarding the type of design principles that are most suitable for each path. However, they acknowledge that this is a preliminary framework that needs additional development before it can provide the intended support to designers.

The Map of Pathways to Sustainable Behaviour provides a promising starting point for categorization of different ways behaviour may change and in the paper where the map is presented, a number of reflections are made upon the type of strategies that are suitable for each path. For this to effectively work as a tool for designers, the recommendations still remain to be integrated into the map in an intuitive and obvious way. As the tool is at an early stage of development, it is unclear to what degree the map will help designers consider more approaches to affect behaviour and how well it will remind designers of the different aspects of how a product affect behaviour.

#### 2.1.3.7. SUMMARY OF THE TOOLS

As can be seen in the preceding sub-chapters, there are already a variety of tools described in the DfSB literature. However, none of the tools provide designers with the desired support and fulfil the requirements. They either describe the situation on a level too elevated and theoretical, are not developed into formats that are easily applicable in design projects and are rather to consider as models than tools, or have other aims than supporting informed decisions. It can thus be concluded that there is a need for additional tool development, which this thesis attempts to provide.

### 2.1.4. REBOUND EFFECTS

A well known challenge when reducing the energy consumption of products, or in other ways make products more efficient, is the risk that the improvement leads to an increase in some other consumption - and thus diminishes the environmental benefit. For instance, a household may spend the money they save on the reduced energy consumption on another energy intensive activity (Abrahamse et al., 2005). If this family saves money on consuming less renewable electricity, and spends it on a flight to a distant location, the net environmental impact of the efforts to save energy might actually become negative. This phenomenon is known as the rebound effect, and is defined by Hertwich (2005, page 86) as "a behavioural or other systemic response to a measure taken to reduce environmental impacts that offsets the effect of the measure". Hertwich further distinguishes between weak rebound effect (the efficiency is reduced), strong rebound effect (most of the expected savings do not materialize) and backfire effect (the result is increased energy demand), although he also argues that ripple effect might be a more suitable term, as the unexpected effect might also improve the energy efficiency.

There are several categorizations of different types of rebound effects described in literature. Sorrell (2007) distinguishes between direct and indirect rebound effects. The direct can be either income/output effects where the increased income or reduced cost from energy saving results in increased consumption, or a substitution effect where a decrease in consumption of something results in an increase in another. The indirect effects can be divided into embodied energy, which is the energy demanded to achieve the reduction in demand, or secondary effect where savings from the purchase of the efficiency measurements result in increase in consumption of something else or the reduced demand result in reduced prices, and thus increased demand. Greening, et al., (2000) presents a similar categorization, but calls the effects income effect, substitution effect, secondary effect, transformational effect and market-clearing price and quantity adjustments. A type of rebound effect, not directly included in either of these categorizations is the time use rebound, which can be defined as "the new activities a consumer engages in as a result of a less environmentally harmful product or service being substituted for an existing activity" (Jalas, 2002, page 118).

Taking all possible rebound effects into account when working with DfSB creates an overwhelmingly complex situation that easily can result in questioning whether it is possible to do anything at all. Controlling rebound effects can easily result in ethically questionable solutions, by for instance limiting the freedom of the users (see Chapter 2.1.5 for elaboration on ethical considerations), or expand beyond the reasonable scope of DfSB by dramatically changing values or norms, or changing fundamental structures of society. Even such attempts of controlling rebound effects may fail, as they can result in other unexpected effects. Pettersen (2013) argues that an advantage of the sociological approach to DfSB is that it is suited to capture why and how rebound effects occur, as it acknowledges that practices do not exist in a vacuum. This is an opinion that may be questioned as this approach to DfSB typically result in larger structural changes than the psychological approach to DfSB, and thus may be harder to predict and control. It is also questionable if the interconnectedness of a practice or behaviour is more acknowledged by the sociological than psychological approach. (Further details on the discussion of these two approaches can be seen in Chapter 2.1.6).

DfSB researchers and designers should be aware of the rebound effect and try to take it into consideration as far as possible, but at the same time be critical about aborting promising efforts because of these rebound effects as they always are uncertain. Thorough testing of solutions before implementation in society may also provide insight into the magnitude of potential rebound effects and possibly how to deal with them.

### 2.1.5. ETHICAL CONSIDERATIONS

Part of the evolvement of the DfSB focus and concern has been directed towards the ethical considerations of affecting people's behaviour, and both designers and researcher are encouraged to reflect upon the moral aspects of their design decisions (Pettersen & Boks, 2008a). In this context, ethics can be understood "as a rational, consistent system for determining right and wrong, usually in the context of specific actions or policies" (Berdichevsky & Neuenschwander, 1999, page 52). In her thesis, Lilley (2007) identified three key questions when considering the ethics of DfSB:

1. Should products be designed with the intention of creating behavioural change towards more sustainable use patterns?

2. Are products that encourage or persuade more or less morally acceptable than those that coerce or force?

3. How can we begin to assess the ethical dimensions of behaviour changing products?

These questions point out several aspects of behaviour change through design that may be subject to ethical considerations. For this thesis, the core question is how these considerations affect type of design principles we apply to achieve the desired behaviour change. Strategies that promote increased understanding of cause and effect, and which empower and benefit the individual, are generally considered ethical (Wilson, 2013), making principles where the user is in control relatively unproblematic. This is however, only under the condition that the information is truthful and doesn't manipulate the user into an incorrect understanding (Berdichevsky & Neuenschwander, 1999; Lilley & Lofthouse, 2010). Principles towards the end of the control spectrum where the user has little or no control over the interaction are more problematic (Lilley, 2007). Some authors argue that this type of principles may be seen as unethical and can be seen as a threat to autonomy and freedom (Pettersen & Boks, 2008a) and it is completely excluded from persuasive technology as it is defined by Fogg: "an attempt to change attitudes or behaviour or both (without using coercion or deception)" (Fogg, 2003, page 15).

These types of principles may also be seen as unethical because the users may be pushed into behaving in ways they object against and the responsibility for the behaviour becomes unclear. As long as the user consciously behave in certain ways, they may be held morally responsible for their actions, potentially together with the one who persuaded them to behave that way (Berdichevsky & Neuenschwander, 1999). If the users do not have control over the interaction, it is more questionable whether they can be held morally responsible for the consequences. As "artefacts are not able to make deliberate decisions about their influences on human action" (Verbeek, 2005, page 214), this naturally falls on the person who designed the product (Jelsma, 2006). Berdichevsky and Neuenschwander (1999) created a map to analyse whether designers could be considered morally responsible for the way their products are used (see Figure 2.8).

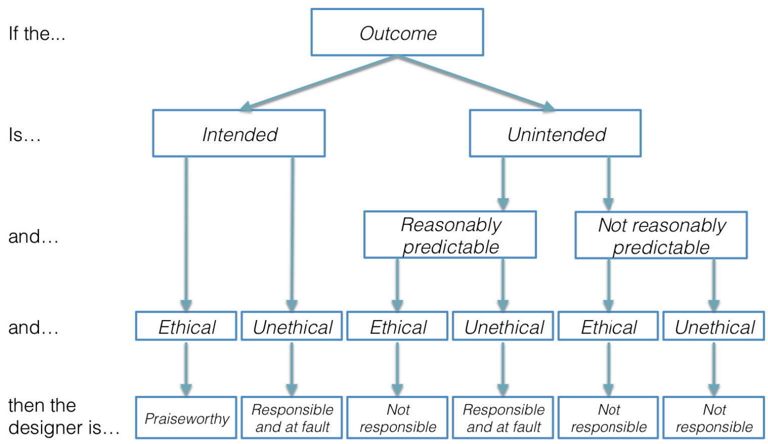



Figure 2.8. Responsibility of intended and unintended outcome. (Berdichevsky & Neuenschwander, 1999).

"80% of a product, service or system's environmental cost is determined at the design stage" (UK_Design_Council, 2002). However, many of the decisions made at the design stage, which affect the environmental impact of the product - are made by other circumstances or people than the designer. Thus the product designer cannot be said to be responsible for all of the impact, and is often not in the position to change many of the decisions that have the largest impact. However, the designer is still one of the key actors in the development of a product and thereby one of the people who are in a position to direct the development of the products and affect the ethical and environmental impact they cause (Wilson, 2013).

This discussion focuses on the consequences of the behaviour and not the behaviour itself. This notion builds upon the principle that the end justifies the means (often attributed to Niccolo Machiavelli (1532). However, it may be argued that the validity of justifying the means by the end must be weighed against the cost of individual liberty (Brey, 2006). The willingness to sacrifice individual freedom for the sake of a greater good, may differ between stakeholders (Pettersen & Boks, 2008a). People may also disagree about what is morally positive and negative (Wilson, 2013). Furthermore, even though we accept products taking control over behaviour as it is for the greater good, it becomes problematic once the same principles are applied not to reduce environmental impact, but to achieve other goals that might be less commonly acceptable (Berdichevsky & Neuenschwander, 1999). Even though the understanding of how to affect behaviour through design has been developed with the intention of achieving commonly accepted environmental or social benefits, there is always the possibility that it may be misused and applied to direct the behaviour in directions that may be beneficial for a company or some people, but not for everyone else (Fogg, 2003).

To support the practical application of these ethical considerations in design processes, Lilley and Lofthouse (2010) developed a weighted matrix (Figure 2.9). They also developed a checklist asking probing questions about the designers intent, validity of the targeted behaviour, the level of control exerted by the product, service or system, whether this can be justified in relation to the perceived severity of the behaviour targeted, privacy and security issues related to data collection, transfer and storage, accuracy, reliability and trustworthiness, and the overall impact on stakeholders who may use the product or system or be affected by its use either directly or indirectly.

*Part A : Evaluation of Behavioural Issues Identified*

| | IMPACT | | | EFFECT | | PERMANENCY | |
|---|---|---|---|---|---|---|---|
| *Behaviour identified through user observation studies* | *L* | *M* | *H* | *Short Term* | *Long Term* | *Reversible* | *Irreversible* |
| | | | | | | | |

*Part B: Ethical Evaluation of Re-designed Product / System*

| | | IMPACT | | | EFFECT | | PERMANENCY | | OCCURANCE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *How could the product/system be used?* | *What would be the impact/consequences of this behaviour on stakeholders?* | *L* | *M* | *H* | *Short* | *Long* | *Reversible* | *Irreversible* | L | M | *H* |
| | | | | | | | | | | | |

Figure 2.9. Weighted matrix part A and B (Lilley & Lofthouse, 2010)

An alternative checklist, specifically developed for persuasive technology was presented by Berdichevsky and Neuenschwander (1999). This checklist identifies eight principles for how to make persuasive technology ethically unproblematic, culminating with what they term "the golden rule of persuasion":

Table 2.4. Principles of ethical persuasive design and "the golden rule of persuasion".

| | |
|---|---|
| 1. | The intended outcome of any persuasive technology should never be one that would be deemed unethical if the persuasion were undertaken without the technology or if the outcome occurred independently of persuasion. |
| 2. | The motivations behind the creation of a persuasive technology should never be such that they would be deemed unethical if they led to more traditional persuasion. |
| 3. | The creators of a persuasive technology must consider, contend with, and assume responsibility for all reasonably predictable outcomes of its use. |
| 4. | The creators of a persuasive technology must ensure that it regards the privacy of users with at least as much respect as they regard their own privacy. |
| 5. | Persuasive technologies relaying personal information about a user to a third party must be closely scrutinized for privacy concerns. |
| 6. | The creators of a persuasive technology should disclose their motivations, methods, and intended outcomes, except when such disclosure would significantly undermine an otherwise ethical goal. |
| 7. | Persuasive technologies must not misinform in order to achieve their persuasive end. |
| 8. | (The Golden Rule of Persuasion) The creators of a persuasive technology should never seek to persuade a person or persons of something they themselves would not consent to be persuaded to do. |

As can be seen from this brief review of the ethical considerations in the literature, individual freedom is valued highly and receives substantial attention. A perspective that may be underrated is the designers' moral obligation to do what they can to reduce environmentally harmful behaviour. For instance, as there is scientific consensus of the manmade effect on climate change (Anderegg, et al., 2010; Cook et al., 2013; IPCC, 2007b; Oreskes, 2004), it may be considered immoral of a designer to leave the user in control when knowing, or expecting, that the user's behaviour will result in an increased environmental impact. From this perspective, it may be considered ethically preferable to force users to behave in desired ways, compared to allowing them to behave undesired. The challenges the world is facing are sufficiently acute and dramatic (IPCC, 2007b) to reconsider the importance of personal freedom. However, if designers are going to act according to this standpoint, it is crucial that they have good evidence for both the importance of enforced behaviour and the likelihood of success.

### 2.1.6. PRACTICES VS BEHAVIOUR

It is widely acknowledged in the recent DfSB literature that the task of reducing the environmental impact of people's behaviour through the design of products may benefit from drawing upon existing models and theories from social sciences (e.g. Lockton, 2013; Pettersen, 2013; Wilson, 2013). However, there is no consensus about which theoretical perspective can contribute with the most suitable and useful models and insights. The two dominating perspectives are those of behaviour models from social psychology and practice theory from sociology. The exploration of how each of these perspectives may contribute to the development of DfSB has resulted in a diversity in the literature that can be considered to represent two different schools.

### 2.1.7. PRACTICE THEORY

Practice theory may be considered to originate from the work of Bourdieu (1977) and has been important for the sociological understanding of how and why people interact with their surroundings. Substantial attention has been given to its potential contribution to the understanding of how society may be transformed in more sustainable directions (e.g. Spaargaren, 1997). This perspective has also lead to criticism of the way design locks people into their unsustainable lifestyles (E Shove, 2003) and propositions of how design could be informed by practice theory (Shove, 2006; Shove, et al., 2008; Shove, et al., 2007), which has had a strong influence on the current development of DfSB. However, it has been questioned whether Shoves description of design is out-dated and thus making the criticism less valid (Wilson, 2013).

In practice theory, the basic unit of analysis to understand why people act the way they do is the action, or practice, itself (Giddens, 1984; Schatzki, 1996). A practice can be defined as "a routinized type of behaviour which consists of several elements, interconnected to one other", such as cooking, working or bathing (Reckwitz, 2002, page 249) and is inherently social as we learn them from each other (Scott, et al., 2012). One way of structuring these elements which has been identified as useful for designers (Kuijer & De Jong, 2011) is into images, stuff and skills, which was introduced by Shove et al. (Pantzar & Shove, 2010; 2007). This understanding of the concept of practice has been dominating the recent investigations into how design processes can be informed by practice theory, such as the work by Scott et al. (2012) on bathing or Kuijer and Jong (2012) on thermal comfort.

### 2.1.8. BEHAVIOURAL MODELS

"Understanding, explaining and changing human behaviour are the main objectives of psychology in general" (Klöckner & Blöbaum, 2010, page 574) and has received substantial attention from the psychology literature at least since the 1930s (e.g. Corey, 1937). A result of this attention has been the development of a large number of behavioural models, attempting to explain the reasons for human behaviour by identifying and structuring different factors that may affect the behaviour (Jackson, 2005b). Several of these models and studies attempt specifically to explain environmentally significant behaviour (e.g. Bamberg & Möser, 2007; Klöckner & Blöbaum, 2010; Stern, 2000). The perspectives, insights and vocabulary from this research have strongly influenced the emergence and development of the DfSB field.

Some researchers have even applied specific behavioural models directly in their research and used them as fundaments from which they have developed their own frameworks and approaches (Bhamra et al., 2008; Tang, 2010).

In contrast to practice theory, where the basic unit of analysis was the practice, the behavioural models focus on the individual and build upon the notion that the reasons for behaviour can be broken down into individual factors (P Stern, 2000). By identifying these factors and the relation between them, the models that explain why people behave the way they do and possibly also improve our ability to predict and affect the behaviour (Jackson, 2005b). Although the complexity of the different models vary both with regards to the number of included factors and the interaction between these, there seems to be consensus in recent literature that behaviour can be affected by a number of different factors (e.g. Sopha & Klöckner, 2009; Stern, 2000; Vlek & Steg, 2007). The models that attempt to give a comprehensive overview over relevant factors and their interaction, tend to include a combination of intentions, norms, emotions, constraints and habits (Klöckner & Blöbaum, 2010; Stern, 2000; Triandis, 1977), although the exact labels used for the different factors and the categorization varies.

It is possible to argue for the use of both practice theory and behavioural psychology. However, as both are simplifications of reality, neither is capable of capturing all the aspects and nuances of people's behaviour. "This means that there is no "right" way to understand and intervene in behaviours, but there may be ways of approaching the task that are more effective or efficient depending on the issue and context (Chatterton, 2011, page 6).

In her comparison of the different fields that may inform DfSB research, Pettersen (2013) identifies a number of strengths and weaknesses of Practice Theory and Social Psychology, in addition to Rational Choice Theory, ANT and System Innovation Theory. Pettersen concludes that Social Psychology is strong at conceptualizing micro level dynamics, but is discarded for its "lack of attention to the interplay between humans and technology and how it changes over time" (Pettersen, 2013, page 55). Practice theory is preferred as "its scope takes in both the interplay between humans and technology and system level dynamics between practices" (Pettersen, 2013, page 55).

I concur with Pettersen's statement that improving the effectiveness of how people interact with products is limited to incremental environmental improvements, and that there is a need for more radical alterations of our lifestyles. Whether sociology is better suited than psychology to inform this kind of alterations, as Pettersen concludes, is an ongoing debate In addition, as Pettersen points out; "approaches resulting in more radical innovations may however conflict with existing manufacturing schemes" (Pettersen, 2013, page 46). To solve the environmental challenges the world is facing today, we need both the improvements that can easily be implemented immediately and we need to make the more fundamental changes. Both psychology and sociology have relevant and interesting perspectives that can contribute to this transition. As Chatterton (2011), page 8 buts it: "the different viewpoints can be seen as complementary and as simply different ways of looking at the same thing".

However, the goal of this research project is to investigate how to affect the behaviour of a user when interacting with a specific product, which corresponds with the micro-level Pettersen identifies as the strength of social psychology. The behavioural models from social psychology provide nuanced and mature frameworks for identifying and analysing the various factors that can affect the interaction between users and products in given contexts. Practice theory considers practices to be connected in systems (Pantzar & Shove, 2010) and does not focus on specific interaction at a specific product-user level, and do not provide a similarly detailed and nuanced framework for analysing the factors affecting the interaction. Behavioural models from social psychology are therefore, in line with for instance Wilson (2013), considered a more suitable perspective to inform the design of products aimed at resulting in a particular behaviour.

## 2.2. SUPPORTING DISIPLINES

The previous discussion about whether DfSB should build upon a psychological or sociological understanding of how behaviour is created is typical for the DfSB research. Similar to much other design research, DfSB is a multidisciplinary field building upon insight, perspectives and methods from several scientific disciplines and traditions. The following chapters give brief introductions to a number of the most relevant fields this project has drawn upon. A particular emphasis has been given to the tools and methods from the various fields.

### 2.2.1. BEHAVIOURAL MODELS FROM SOCIAL PSYCHOLOGY

Chapter 2.2.1. & 2.2.1.1. is adapted from the original text in Zachrisson and Boks; When to apply different design for sustainable behaviour strategies?, presented at ERSCP-EMSU in Delft in 2010, which was later reworked and published in Zachrisson and Boks; Exploring behavioural psychology to support design for sustainable behaviour research, JDR 2012.

The social psychological understanding of behaviour builds on the notion that it is possible to understand the reasons people behave the way they do and identify the individual factors that may affect the behaviour. Corresponding to the substantial attention this topic has received over the years, a large number of, more or less diverse, theories have been developed. Provided that the theories are validated, or at least not falsified, by empirical evidence, they can offer two kinds of benefits. “Firstly, they can provide heuristic devices for exploring the nature of specific behaviours and for identifying the factors that might be important to policymakers who are attempting to influence those behaviours” (Jackson, 2005b, page 22). Secondly, they can “provide a conceptual and theoretical framework for carrying out detailed empirical research on the structure of specific behaviours, and the role of interventions in influencing those behaviours” (Jackson, 2005b, page 23).

To summarise, structure and communicate the theories of the various factors that can affect behaviour, and their interplay, many of the theories have resulted in the development of behavioural models. The models, and underlying theories, vary greatly in their complexity and the number of included factors. This variation is a result of which factors the authors consider most significant for the behaviour, and is greatly affected by the specific behaviour, or aspects of the behaviour, which the model aims to explain.

Some models, such as the Norm Activation Theory (Schwartz, 1977), the Theory of Planned Behaviour (Ajzen, 1991) and the Value-Belief-Norm theory (Stern, et al., 1999) contain relatively few factors and present narrow views on the causes for behaviour. However, when studying such models, it is crucial to be conscious about the purpose and scope of the model. For instance, the Norm Activation Theory is a theory aimed at explaining altruism (Schwartz, 1977; Stern et al., 1999) and the Value-Belief-Norm theory aim at explaining environmentalism (Stern et al., 1999), which is defined as “the propensity to take actions with pro-environmental intent” (Stern, 2000, page 411). Theory of Planned Behaviour attempts to identify the considerations that guide human behaviour (Ajzen, 2006), but do acknowledge that the applicability of the theory require “a strong link from intentions to behaviour”(Ajzen, 2006, page 5). Many models purposefully limit the number of factors they include, knowing it makes it a less perfect description of reality, but increasing the opportunities to test and apply the theories. "Theories that incorporate virtually every known social-psychological construct and process not only lack parsimony but, more important, they are likely to generate confusion rather than real understanding" (Ajzen & Fishbein, 1980, page 150).

Other models, such as the Theory of Interpersonal Behaviour (TIB) (Triandis, 1977), the Motivation,-Opportunity-Ability model (MOA) (Ölander & Thørgersen, 1995) and the Comprehensive Action Determination Model (CADM) (Klöckner & Blöbaum, 2010), include a larger variety of factors, increasing the potential accuracy and granularity of describing the actual situation, but also making the models more complex to apply. For instance, Jackson (2005b) suggests this as a reason why the Theory of Interpersonal Behaviour has been applied less frequently than the Theory of Planned Behaviour, even though it appears to have additional explanatory value. The challenge thus becomes to find the model with the optimal balance between precision and usability.

#### 2.2.1.1. BEHAVIOURAL FACTORS

Regardless of the complexity level of the model, they all contain a combination of (some of) the following behavioural factors, which depending on the situation and person, are found to have some influence over people's behaviour. The models also present the various factors as categories, or at least interconnected, often affecting each other in addition to directly, or indirectly, affecting the behaviour of the user.

A category of factors tends to address the users determination or desire to behave in a certain way and often includes factors such as intentions, attitudes and beliefs. Some behavioural science traditions, such as Rational Choice Theory, consider people primarily as rational beings, also known as Homo Economicus (e.g. Doucouliagos, 1994), and believe that people's behaviour primarily is determined by what they believe they benefit the most from (Scott, 2000). However, numerous studies have found that the correlation between what people want to do and what they actually do in many cases can be limited (Ajzen & Fishbein, 1977), even though it is far from irrelevant (e.g. Grob, 1995; Homer & Kahle, 1988) as can be interpreted from some publications (e.g. Hargreaves, 2011; Shove, 2010). Ajzen and Fishbein (1977) found that for an attitude to have any effect on predicting behaviour, the attitude and behaviour have to be on the same level of specificity. Stern (2000) proposed that the relative prediction power of the attitude depends on how strongly the behaviour is affected by the context. When the context affects the behaviour strongly, positive or negative, the attitude has little influence on the behaviour. But when the context effect is small or neutral, the attitude of the user plays a significant role for the behaviour. Some authors (e.g. Pfister & Böhm, 2008; Triandis, 1977) considers emotions or affections to be a separate category of factors, whereas others (e.g. Klöckner & Blöbaum, 2010) includes this as a part of attitudes.

Another category of factors that is related to the deliberate behaviour of users consists of factors such as values or personal norms. This category differs from the previous by its stability over time (Klöckner & Matthies, 2012), and the evaluation of the moral aspects of the behaviour (Schwartz, 1977). Klöckner (2010), page 7 defines values as “the most basic and abstract assumptions about what should be done, what is good, and what is bad”, and personal norms as ”domain specific feelings of moral obligation to act”. Some authors (e.g. Schwartz, 1977; Stern et al., 1999) propose a fairly directly connection between values or norms and behaviour, whereas other authors (e.g. Klöckner & Blöbaum, 2010; Triandis, 1977) indicate a more indirect relationship.

The likelihood of people behaving a particular way is also affected by how much effort they believe they have to exert or their opportunity to behave that way. This is often termed perceived behavioural control (e.g. Bamberg & Möser, 2007) or subjective constraints (e.g. Frey, 1988), and normally includes both the users task knowledge, personal capabilities and the other external aspects the users believe affect their opportunity to behave that particular way. Some authors (e.g. Frey, 1988; Klöckner & Blöbaum, 2010) distinguish between subjective and objective constraints. The latter “preclude or inhibit people's ability to participate in particular activities and that they exist independently of individual's perception” (Tanner, 1999, page 147) and can thus include constraints the user is unaware of, or exclude constraints that are erroneously perceived to affect the behaviour.

Several models that attempt to provide something in the direction of a comprehensive understanding of the factors affecting behaviour (Klöckner & Blöbaum, 2010; Stern, 2000; Triandis, 1977) acknowledge that people are social beings and that their behaviour can be affected by the presence of others, others expectations, and their own self-concept and roles. This category, frequently called social norms or social factors are often considered to affect the intentions rather than the behaviour directly, similarly to the personal norms or values.

A type of factors that has received substantial attention (Klöckner & Matthies, 2012) and a crucial factors for understanding behaviour (Verplanken & Aarts, 1999; Verplanken, Aarts, Knippenberg, & Moonen, 1998) is habits. Habits can be defined as “behaviours that are performed with a minimum of cognitive effort” (Jager, 2003). Klöckner and Matthies (2012) identified three different approaches to understanding how the automatic process works; associative or connectionist, heuristic, and schema or script-based. The associative or connectionist approach explains that habits are cognitively represented by strengthened neural connection, which becomes stronger the more often a specific situational cue is processed. The approach thereby assumes a fundamentally different system for how habits affect behaviour and how other types of behavioural factors affect behaviour. The heuristic approach considers habits to be “nothing but extremely simple, efficient decision rules that allow people to make comparatively good decisions with comparatively little effort in information processing. The more important the decision is or the higher the motivation to involve in a decision, the more sophisticated the decision rules become” (Klöckner & Matthies, 2012, page 795). The schema or script approach treats habits as a blueprint of the appropriate way to behave in certain situations and thereby enables limited effort put into information intake and processing. The two latter approaches are thus fundamentally different from the first, by considering habits as part of the same decision making process as deliberate decision-making.

Never the less, there seems to be consensus regarding the main aspects of how a habitual behaviour develops (Jager, 2003; Klöckner & Matthies, 2012; Klöckner, Matthies, & Hunecke, 2003; Triandis, 1977; Verplanken & Wood, 2006). A habitual behaviour starts as a normal behaviour and is determined by some combination of the other behavioural factors. As the behaviour is repeated under similar circumstances, it becomes increasingly automatic and thus both less affected by the other factors and less conscious to the person performing the behaviour. Jager (2003) also found that the likelihood of repeated behaviour, and thereby developing habits, increase the more positive the experienced outcome of the behaviour is.

To structure and support the process of informing the design of behaviour changing products by the insight about behavioural factors identified by social psychology, it was advantageous to select an appropriate behavioural model. To ensure as comprehensive an understanding of the behavioural factors as possible, the model should ideally include and explain all the different types of behavioural factors that may be significant for determining behaviour. Simultaneously, to ensure the ease of integration and understanding, the model must present a clear structure and obvious relation between the different factors. One natural candidate, which has already been identified as a promising model to inform DfSB (Bhamra et al., 2008; Tang, 2010; Wilson, 2013) is TIB (Triandis, 1977). Tang and Bhamra (2012) integrated this model in their Design Behaviour Intervention Model (see Figure 2.5) where they proposed a connection between certain levels of the distribution of control with particular behavioural factor.

Tang and Bhamra argue that Triandis' Theory of Interpersonal Behaviour is a promising model as it considers behaviour "as a result of interactions between individual cognitive and contextual factors in shaping such processes" (Tang & Bhamra, 2012, page 2), and for its equal attention to the individuals attitude, social factors and emotions in forming intentions, which may or may not turn into actions depending on the habits. It also acknowledges the individuals cognitive limitations, includes contextual factors and habits, and thereby indeed providing a fairly comprehensive overview of the behavioural factors. Wilson (2013) augmented the model with Verplanken's (2005) understanding of habit. Never the less, the model does have some limitations, which may make it sub-optimal for informing DfSB. It does not distinguish between subjective and objective constraints, considering everything as contextual factors, nor between personal and social norms, which both may be relevant regarding how the design of a product affects how it is used.

A model that does include these distinctions is the Comprehensive Action Determination Model (CADM) by Klöckner and Blöbaum (2010) (see Figure 2.10). This model is based on four theories that have been acknowledged for their strength of explaining behaviour, but also criticized for not integrating all the factors that may influence the behaviour. The theories are the Theory of Planned Behaviour (TPB), the Norm-Activation Model (NAM), the theoretical concept of habit and the Ipsative Theory of Behaviour. By combining the theories, Klöckner and Blöbaum aim at removing the limitations and creating a model encompassing both the internal and external factors. They tested the CADM model in an empirical study together with TPB and NAM, and a combination of the two, which had been introduced earlier in an attempt to explain more factors. The conclusion was that the CADM explained the variation significantly higher than the other models (Klöckner & Blöbaum, 2010)

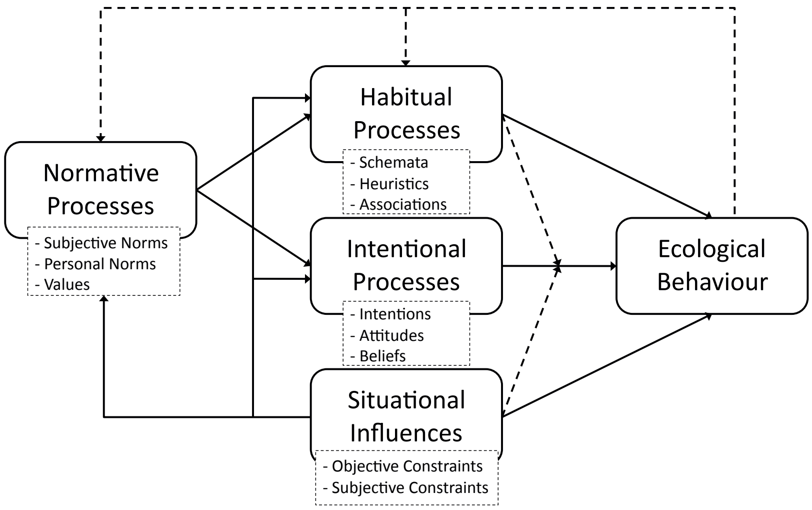



Figure 2.10. The Comprehensive Action Determination Model (Klöckner & Blöbaum, 2010)

The CADM explains that individual, sustainable behaviour is directly determined by influences from three possible sources: habitual, intentional and situational. The habitual processes consist of schemata, heuristics and associations (Klöckner & Blöbaum, 2010). The Intentional processes consist of intentions, attitudes and beliefs. These are connected in a hierarchical structure where intentions are affected by attitudes, which again are affected by beliefs (Klöckner, 2010). And the Situational influences are divided into subjective and objective constraints. In addition to affecting the behaviour directly, the situational influences also affect the habitual, intentional and the normative processes. The normative processes have an indirect effect on the behaviour through affecting the habitual and intentional processes, and consist of personal norms that are affected by subjective/ social norms and values (Klöckner & Matthies, 2012).

Behavioural psychology advocates that it is possible to understand the reasons for behaviour and to identify the individual factors that affect behaviour. A number of factors have been identified in the literature and have resulted in the creation of a number of behavioural models. Some models deliberately focus on particular factors and effects on behaviour, whereas other models aim at comprehensive explanation of behaviour and include a multitude of different factors. The more factors a model includes, the more complex the model tends to become. The challenge is thus to find the right balance between comprehensiveness and complexity. In this thesis, the CADM model was chosen to identify and structure the behavioural factors. Although there are some factors the CADM does not treat separately, for instance 'affect', which in the CADM is considered as a part of the intentional factors, it does provide an easily comprehensible overview over a majority of the relevant factors and thereby a promising framework to guide DfSB. However, whether the research is guided by the TIB or the CADM probably does not signify a crucial difference, as the primary purpose of the models in the context of DfSB is to identify the relevant factors and, to a certain degree, the relation between them. As the two models in question are relatively similar, it is unlikely that the preference of one over the other will lead to substantial alterations in the research.

### 2.2.2. PERSUASIVE TECHNOLOGY

The quest for changing attitudes or behaviour is also the topic of a field known as *Persuasive technology*. The field was first introduced by Cialdini (1993) and has since developed into a field of research, primarily within the information technology industry. Fogg (2003) defined persuasive technology as "an interactive product designed to change attitudes or behaviors, or both, by making a desired outcome easier to achieve". He also stresses that persuasive technology should not force the user into certain behaviour. Fogg describes strategies for persuasion according to their function, and has identified seven of them: *Reduction, Tunneling, Tailoring, Suggestion, Self-monitoring, Surveillance* and *Conditioning*. In addition he points out that technology can persuade on two levels. If the sole purpose of the product is to persuade, it is persuasion on a macro level. If persuasion is incorporated as an element in the product, it is on a micro level (Fogg, 2003). Oinas-Kukkonen and Harjumaa (2008, 2009) expanded the persuasive strategies identified by Fogg to 28 strategies, and structured them according to how they are meant to persuade the user (see Table 2.5). They distinguish between four types: *Primary task support, Dialogue support, Credibility support* and *Social support.*

Table 2.5. Persuasive systems by Oinas-Kukkonen and Harjumaa.

| Category | Strategy | Description |
|---|---|---|
| Primary task support | Reduction | A system that reduces complex behaviour into simple tasks helps users perform the target behaviour and it may increase the benefit/cost ratio of a behaviour. |
| | Tunnelling | Using the system to guide users through a process or experience provides opportunities to persuade along the way. |
| | Tailoring | Information provided by the system will be more persuasive if it is tailored to the potential needs, interests, personality, usage context, or other factors relevant to a user group. |
| | Personalization | A system that offers personalized content or services has a greater capability for persuasion. |
| | Self-monitoring | A system that helps track one's own performance or status supports in achieving goals. |
| | Simulation | Systems that provide simulations can persuade by enabling them to observe immediately the link between the cause and its effect. |
| | Rehearsal | A system providing means with which to rehearse a behaviour can enable people to change their attitudes or behaviour in the real world. |
| Dialogue Support | Praise | By offering praise a system can make users more open to persuasion. |
| | Rewards | Systems that reward target may have great persuasive powers. |
| | Reminders | If a system reminds users of their target behaviour, the users will more likely achieve their goals. |
| | Suggestion | Systems offering suggestions at opportune moments will have greater persuasive powers. |
| | Similarity | People are more readily persuaded through systems that remind themselves in some meaningful way. |
| | Liking | A system that is visually attractive for its users is likely to be more persuasive. |
| | Social role | If a system adopts a social role, users will more likely use it for persuasive purposes. |
| System credibility support | Trustworthiness | A system that is viewed as trustworthy (truthful, fair, and unbiased) will have increased powers of persuasion. |
| | Expertise | A system that is viewed as incorporating expertise (knowledge, experience, and competence) will have increased powers of persuasion. |
| | Surface credibility | People make initial assessments of the system credibility based on a first-hand inspection. |
| | Real-world feel | A system that highlights people or organization behind its content or services will have more credibility. |
| | Authority | A system that leverages roles of authority will have enhanced powers of persuasion. |
| | Third-party endorsements | Third-party endorsements, especially from well-known and respected sources, boost perceptions on system credibility. |

| | | |
|---|---|---|
| | Verifiability | Credibility perceptions will be enhanced if a system makes it easy to verify the accuracy of site content via outside sources. |
| Social support | Social learning | A person will be more motivated to perform a target behaviour if he or she can use a system to observe others performing the behaviour. |
| | Social comparison | System users will have a greater motivation to perform the target behaviour if they can compare their performance with the performance of others. |
| | Normative influence | A system can leverage normative influence or peer pressure to increase the likelihood that a person will adopt a target behaviour. |
| | Social facilitation | System users are more likely to perform target behaviour if they discern via the system that others are performing the behaviour along with them. |
| | Cooperation | A system can motivate users to adopt a target attitude or behaviour by leveraging human beings' natural drive to co-operate. |
| | Competition | A system can motivate users to adopt a target attitude or behaviour by leveraging human beings' natural drive to compete. |
| | Recognition | By offering public recognition (for an individual or a group), a system can increase the likelihood that a person or group will adopt a target attitude or behaviour. |

As a way to analyse and structure behaviour change, Fogg has developed a grid of behaviour changes. The first version (Fogg, 2009a) considers the type of change on one axis and the duration or trigger of the change on the other. It results in 35 types of behaviour change. The grid was later refined (See Figure 2.11) and contains 15 combinations of the type of change (new behaviour, familiar behaviour, increase behaviour, decrease behaviour or stop behaviour) and the duration of it (one time, period of time, permanently) (Fogg & Hreha, 2010). The purpose of the grid is to help understand what kind of change one is aiming for and possibly the steps one needs to go through to achieve complicated behaviour changes.

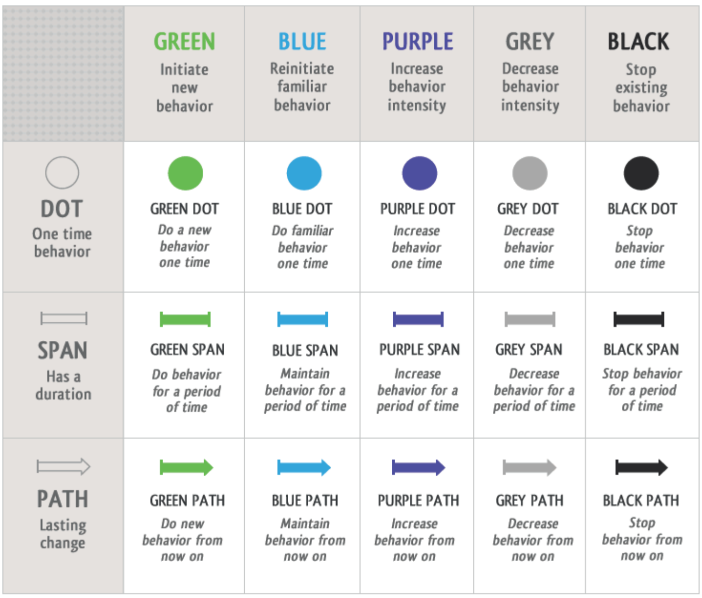



Figure 2.11. Fogg behaviour grid.

Fogg has also presented a behavioural model for persuasive technology (Fogg, 2009b). This model, which has strong similarities to Motivation-Ability-Opportunity behaviour model (Ölander & Thørgersen, 1995), prescribe that for a behaviour to take place, the user has to be triggered while being sufficiently motivated and able. The more effort the behaviour requires (the less able the user is), the more motivation is required. This relation between motivation and ability creates a threshold, which is unique for every person and situation. As long as the situation is above the threshold, a trigger can activate the behaviour (see Figure 2.12).

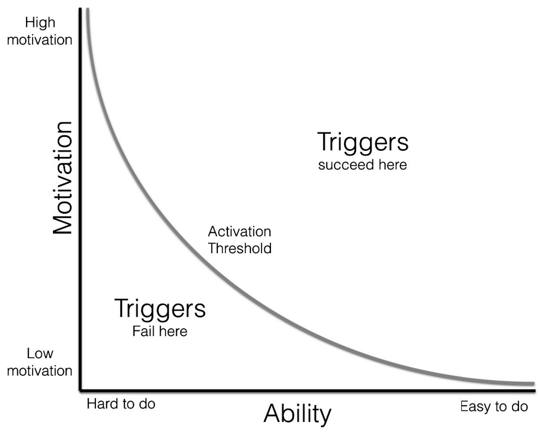



Figure 2.12. Illustration of Fogg's behavioural model

Another model from Persuasive Technology that has received attention recently is the Hooked or ATARI model by Eyal (2013a). Although this model is less academic and scientific than the other models described in this thesis, it does draw upon a lot of social psychology and behavioural understanding. And most importantly, it provides an easily understandable and applicable presentation of the creation of habits, which often is considered complex and difficult to deal with in design projects. ATARI stands for "A hook has 4 parts; Trigger, Action, Reward and Investment", and the model proposes that to create a habit, it is necessary to provide the user with and internal or external trigger, the user needs to perform an action and receive a variable reward. The user then needs to make an investment that makes it more likely that the user will repeat the action the next time he or she encounters the trigger (See Figure 2.13). Although the majority of this is in line with the general understanding of how a habit is created in social psychology, there are aspects that may be questioned. For instance the requirement of an investment may not strictly be a requirement for a habit to form, even though it doubtlessly increases the likelihood for repeated action in particular situations. However, as the model is presented as a tool to help web-pages get its users to repeat their actions, it may be of value.

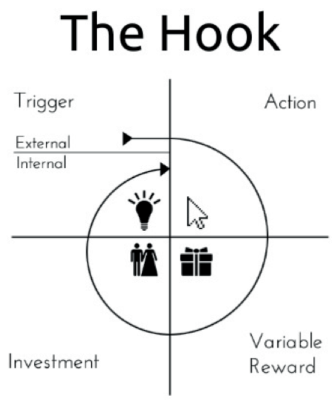



Figure 2.13. The ATARI model (Eyal, 2013b)

Persuasive Technology is closely related to DfSB, although it distinguishes itself primarily on three different aspects; it does not inherently focus on sustainability, it rejects the parts of the control spectrum where the user has little control and it focuses on Graphical User Interfaces (GUI) and digital products. Although the practical integration of models from Persuasive Technology in design projects tends to be difficult, they provide easily understandable presentations and valuable understanding of behaviour change.

### 2.2.3. INFORMING POLICY INTERVENTIONS

The field of informing policy interventions may not be an academic direction in the same sense as behavioural psychology and persuasive technology, but rather a caption given to a constellation of theoretical directions from marketing, political science, economics, etc. all aiming at supporting policy makers affect behaviour more efficiently. Policy makers are often influenced by rational choice theory (Pettersen, 2013) which builds on the assumption that the individual makes informed decisions to maximize their well being (Scott, 2000). This perspective guides policy makers to ensure that people have adequate information to make their choices and that the market works properly (Jackson, 2005a), frequently resulting in attempts of using economic incentives or information campaigns to influence behaviour, but which has shown to have limited long term effect on people's behaviour (Dough McKenzie-Mohr, 2011). In recent years, a number of alternative frameworks or theories have evolved for how policy makers might affect behaviour more effectively, often building on social psychological theories, and which may contribute with valuable insights for DfSB too.

One perspective, which in some cases has received substantial attention from policy makers (http://www.whitehouse.gov, 2009; www.gov.uk, 2013), is called libertarian paternalism and was introduced by Thaler and Sunstein (2008). They argue that there is a great potential of affecting people's behaviour through choice architecture, signifying the way the alternatives are presented. By adjusting the sequence, description or context of the choices, the user can be nudged in the desired direction, while still maintaining their individual freedom and autonomy.

A more process oriented, step-by-step approach is called Community Based Social Marketing, and was introduced by Doug McKenzie-Mohr (Doug McKenzie-Mohr, 2000). In this approach he argues that it is necessary to target the reasons why people don't behave the desired way, to successfully alter their behaviour. When doing so, he prescribes a five step approach (Dough McKenzie-Mohr, 2011).

1. Determine specifically which behaviour to target.

2. Identify the barriers that impede people from engaging in the activity and what would motivate them to act. Consider both internal and external factors.

3. Develop strategies for lowering barriers or increasing motivation.

4. Pilot-test the strategies.

5. Implement broad and evaluate.

McKenzie-Mohr suggests a number of strategies for how to lower the barriers or increase motivation, commitment (from good intention to action), social norms (building community support), social diffusion (speeding the adoption of new behaviours), prompts (remembering to act), communication (creating effective messages), incentives (enhancing motivation to act) and convenience (making it easy to act).

A similar overview of techniques policy makers can apply to affect behaviour more efficiently is the MINDSPACE report published by the UK institute for government (Dolan, et al., 2010). Also drawing upon a broad psychological understanding of the various factors that may affect behaviour, they created a checklist of nine robust and non-coercive techniques policy makers may apply.

Table 2.6. MINDSPACE (Dolan et al., 2010).

| | |
|---|---|
| *Messenger* | we are heavily influenced by who communicates information |
| *Incentives* | our responses to incentives are shaped by predictable mental shortcuts such as strongly avoiding losses |
| *Norms* | we are strongly influenced by what others do |
| *Defaults* | we „go with the flow" of pre-set options |
| *Salience* | our attention is drawn to what is novel and seems relevant to us |
| *Priming* | our acts are often influenced by sub-conscious cues |
| *Affect* | our emotional associations can powerfully shape our actions |
| *Commitments* | we seek to be consistent with our public promises, and reciprocate acts |
| *Ego* | we act in ways that make us feel better about ourselves |

Although this is largely overlapping with the techniques proposed by McKenzie-Mohr, it presents a slightly different perspective as it is formulated from the viewpoint of the target user, whereas McKenzie-Mohr applies a more neutral perspective in this brief overview. A slightly more complex tool to support the inclusion of the psychological understanding of the factors affecting behaviour, is the Behaviour Change Wheel (Figure 2.14) (Michie et al., 2011).

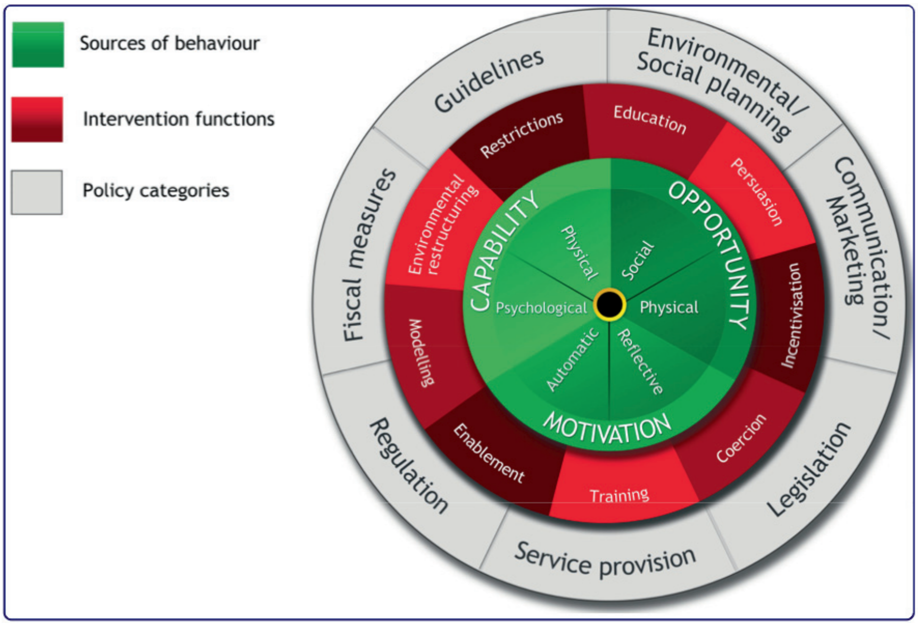



Figure 2.14. The Behaviour Change Wheel (Michie et al., 2011)

The Behaviour Change Wheel was developed as a response to the need for a framework to support policy makers, which was comprehensive, coherent, and had a clear link to an overarching model of behaviour. The wheel aims at forming a basis for a systematic analysis of how to make the selection of interventions and policies by linking the choice of intervention functions with the behaviour change techniques (Michie et al., 2011).

Although the type of challenges and the available means of affecting behaviour differs substantially between DfSB and policy makers, it may never the less be valuable to draw upon this insight. In particular the overviews of possible approaches may contribute with interesting perspectives that are normally not included in DfSB and may thus provide new opportunities for affecting behaviour.

### 2.2.4. SHIKAKEOLOGY

Shikakeology is one of the most recent contributions to the constellation of academic disciplines focusing on behaviour change and has emerged during the last few years, primarily in Japan. Matsumura describes shikakeology as "an approach to change, induce, nudge, and trick attitudinal and actional behavior to solve social or personal issues" (Matsumura, 2013). He further elaborates by pointing out three factors that define a shikake:

1. A shikake is an embodied trigger for behaviour change.

2. The trigger is designed to induce a specific behaviour.

3. The behaviour solves a social or personal issue.

A shikake can consist of both physical and psychological triggers. The psychological triggers affect our preferences whereas the physical triggers might either work directly by enabling people to understand the usage and results, or indirectly as an ignition for a psychological trigger (Matsumura, 2013). The physical triggers can further be divided into Feedback (haptic, scent, sound, and visual) or Feedforward (default option, metaphor, and signifier) and the psychological triggers can be divided into Motivation (challenge, dissonance, negative expectations, positive expectations, reciprocity, reward, scarcity, self-consistency and self-esteem) and Social effect (being watched, social norm and social proof) (Matsumura & Fruchter, 2013). Matsumura and Fruchter (2013) initiate, and indicate future elaborations of, an investigation of which triggers that are successfully used in combination, which could provide guidance to development of new shikake design.

Although it is unclear how shikakeology differs from the already existing approaches to behaviour change and what the new contribution is, it is almost always valuable to consider a problem from a variety of perspectives. The intended categorization of when different triggers have proved successful may be a valuable tool for future developments also in DfSB.

### 2.2.5. SUSTAINABLE HCI

Sustainable Human Computer Interaction (HCI) is a subset within the wider HCI field, which was first introduced by Eli Blevis in 2007 under the name "Sustainable Interaction Design" (Blevis, 2007; Lilley, 2007). Sustainable HCI can be defined as: "applying HCI methods, perspectives, and techniques to issues of environmental health and sustainability" (Froehlich, 2011, page 19). Blevis introduces both the potential of HCI contributing to prolonging the lifespan of computers and related products and thereby reducing the environmental impact associated with the rapid obsolescence of these products and making people behave in more sustainable ways. Shortly after this was published, the two directions were crystalized more clearly by the introduction of the terms; Sustainability in Design and Sustainability through Design (Blevis, 2007). The former of these categories focuses on the environmental impact of the products themselves, the material in the product etc. This perspective is similar to traditional eco-design. The latter of the categories focuses on how HCI can support sustainable lifestyles and decision-making, and thereby making it more closely connected to the field of DfSB. However, depending on how the boundaries of Sustainable HCI are defined, it tends to focus on computers, information systems and technology-driven approaches (Mankoff, et al., 2007).

One of the most interesting and substantial contributions to the sustainable HCI literature is the PhD thesis on feedback mechanisms by Jon Froehlich (2011). Through a thorough investigation of studies investigating feedback mechanisms and their effect in the literature, he identified what he called "the eight dimensions of the eco-feedback design space" (Figure 2.15) (Froehlich, 2011, page 98).

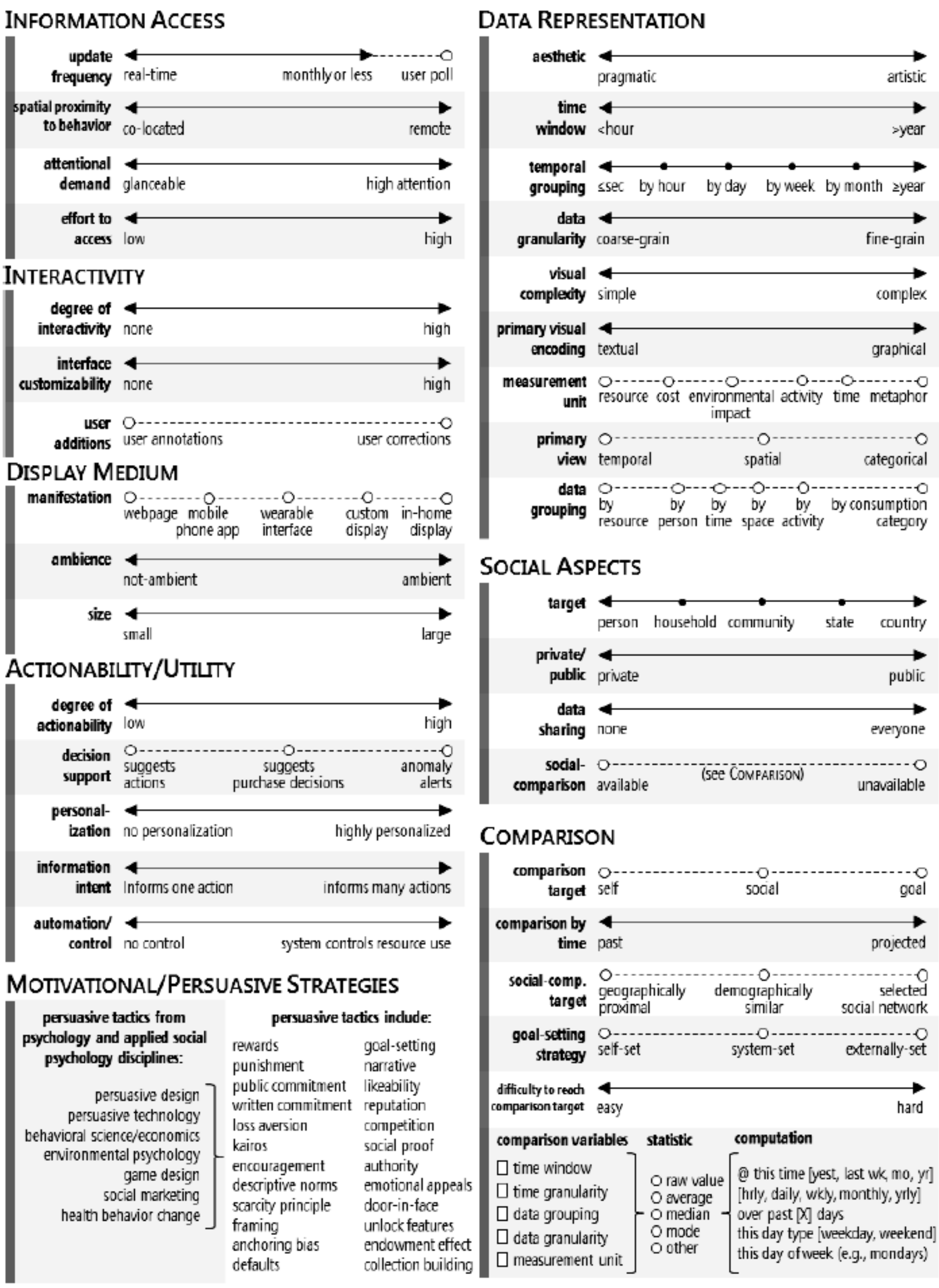



Figure 2.15. The eight dimensions of the eco-feedback design space (Froehlich, 2011)

Froehlich states that the dimensions serve three goals. The first goal is to provide designers with a tangible structure of eco-feedback, exposing assumptions and providing a way of comparing strengths and weaknesses. The second is to uncover opportunities and provide a structure for exploring possibilities, and the third is to provide a common vocabulary to discuss and analyse eco-feedback (Froehlich, 2011).

Sustainable HCI can be considered to be positioned somewhere between DfSB and Persuasive technology, in the sense that it does focus on GUI, but has a distinct sustainability goal and has a less strongly expressed rejection of forcing the user. Froehlich's analysis and structuring of feedback mechanisms are very thorough and can almost directly be applied also on physical products, and thus has a potential to be of great value for DfSB.

### 2.2.6. USER CENTRED DESIGN

User Centred Design (UCD) has often been pointed out as a promising approach for DfSB (Lilley, 2007; Tang, 2010; Wever et al., 2008) and Renström et al. (2013, page 6) even defined DfSB as: "a use-centred and user-centred development process that supports the design of artefacts, enabling users to evade avoidable resource consumption during the artefacts' use phases". User centred design originates from the 1980s (Vredenburg, et al., 2002) when it became apparent that much insight could be gained by studying users and their interaction with computers when developing new products (Norman & Draper, 1986). Since then, user centred design has become one of the most influential directions within product design. A large number of approaches and techniques have been developed throughout the years, aiming at providing new types of insight and perspectives of how users interact and relate to products.

As there are several directions within UCD, and a diversity of opinions of the details of how it should be applied and how the users should be involved. However, there seems to be consensus about the general aspects of what UCD is. Preece, et al., (2002) explained a user-centred approach as when "the real users and their goals, not just technology, should be the driving force behind development of a product". The ISO standard (ISO-9241-210, 2010) uses the term Human-centred rather than User-centred as they wish to include more stakeholders than just the typical users, but do acknowledge that the terms often are used synonymously. In this standard, Human-centred design is defined as an "approach to systems design and development that aims to make interactive systems more usable by focusing on the use of the system and applying human factors/ergonomics and usability knowledge and techniques" (ISO-9241-210, 2010, page 2). The ISO standard (ISO-9241-210, 2010, page 5) further presents six principles a Human-centred approach should follow.

1. The design is based upon an existing understanding of users, tasks and environments.
2. Users are involved throughout design and development
3. The design is driven and refined by user-centred evaluation
4. The process is iterative
5. The design addresses the whole user experience
6. The design team includes multidisciplinary skills and perspectives.

There are a large number of tools and methods available to gather information about the user and the context, and to involve the user in different stages of the process. Many of the user centred research methods are adopted from other disciplines, but are simplified to make them more suitable for commercial needs. This is done because it is more important to get results fast rather than ensuring academic accuracy in the design field (Aldersey-Williams, et al., 1999). According to Preece et al. (2002) there are five basic methods for gathering data, namely questionnaires, interviews, focus groups and workshops, naturalistic observation and studying documentation. Combinations of variations of these create a landscape of numerous methods with different strengths and weaknesses.

UCD is in many ways essential for DfSB and one might go as far as positioning DfSB as a sub-direction within UCD. Almost all DfSB researchers apply UCD thinking and techniques in their projects. In particular the application of user research methods to gather insight about the target group and user testing methods to evaluate the effectiveness of prototypes is invaluable to the efforts of reducing environmental impact of product usage.

### 2.2.7. LIFE CYCLE ASSESSMENT

Chapter 2.2.7. is partly adapted from the original text in Daae & Boks, *Improving the way LCAs deal with variation in the use phase using design for sustainable behaviour research, IJSE, 2014.*

There are several ways to calculate the environmental impact of a product or activity, but perhaps the most comprehensive is Life Cycle Assessment, which has been developed since the 1960s (Curran, 1996). “Life-cycle assessment (LCA) is a systematic, analytical process for assessing the environmental implications of product systems from raw material extraction through product manufacture, use, and end of life.” (Lloyd & Ries, 2007, page 162). ISO 14040 (2006) defines four phases of an LCA study:

1. A goal and scope definition phase
2. An inventory analysis phase
3. An impact assessment phase
4. An interpretation phase.

The complexity of the study is dependent on the goal and scope definition. Ideally, one might wish to include all the relevant aspects affecting the process and thus gain a perfect calculation of the environmental impact. However, this will easily result in an unmanageable mass of data and make the assessment too complex to handle. Depending on the goal of the study, it is therefore necessary to limit the study by deciding on the boundary condition (which processes to include), the type of environmental impact to consider and the level of detail for the study (Baumann & Tillman, 2004). These decisions guide the creation of the system model of the inventory analysis where the environmentally relevant flows of the system are considered. Environmentally relevant flows are typically use of scarce resources and emission of substances considered harmful (Baumann & Tillman, 2004). A challenge related to the inventory analysis, which has received substantial attention, is commonly known as the ‘allocation problem’ (Cederberg & Stadig, 2003; Frischknecht, 2000; Suh, et al., 2010). It occurs when several products share the same processes and the environmental load from those processes are to be expressed in relation to only one process (ISO 14040, 2006). It can occur in three basic cases (Baumann & Tillman, 2004): a process can result in several outputs, a process can have several inputs and a product can be recycled into another product. Should for instance the emissions from cattle be allocated to the milk or beef production? Typically there are two approaches to solve the allocation problem (Suh et al., 2010); one can divide the emission between the two products based on a partitioning coefficient (partitioning) or one can subtract the inputs and outputs for one process from the other (system expansion).

In the inventory analysis data are collected for all the activities in the system and the resulting impact is calculated. This forms the basis for the impact assessments, where the impact of the environmental loads quantified in the inventory analysis is described or indicated (Baumann & Tillman, 2004) and the relative importance of the environmental stressors is determined (Hertwich & Hammitt, 2001). According to Baumann and Tillman (2004), this is done by first Classification, where the inventory parameters are sorted according to the environmental impact they contribute to, and then the Characterisation, where the relative contributions of the emissions or resource consumption are calculated. The results form the "basis for conclusions, recommendations and decision-making in accordance with the goal and scope definition" (ISO 14040, 2006, page VI). Today, there are several directions within LCA research with different approaches to target boundaries and allocation methods, dynamic LCA, spatially differentiated LCA, risk-based LCA, input-output based LCA and hybrid LCA (Guinée et al., 2011).

The topic of this thesis is related to a challenge for LCAs, namely the variation in how products are being used and thereby the uncertainty related to the environmental impact of the use phase. For products where the use phase is responsible for a significant share of the total impact, this may have a large effect on the results of an LCA and be particularly important to address. "Parameters which cause the largest spread in the model outcome should be given priority" (Huijbregts, 1998). Uncertainty and variability has received significant attention in the LCA literature and is a central aspect of the reliability and quality of the assessment. "LCA practitioners should explicitly define the uncertainty that are included in a study and discuss the reasons for and potential implication of omitting other types of uncertainty" (Lloyd & Ries, 2007, page 172). Nevertheless, the uncertainty related to variations in the use phase does not seem to have received attention proportional to the potential impact of the variations. Instead, "product life cycle engineering studies typically rely on average use-phase parameter values to estimate impact" (Cheah, 2013, page 553).

Huijbregts (1998) presented a categorization establishing to which extent different tools are suited to address different types of uncertainty and variability. In Huijbregts' categorization, the uncertainty of how a product is being used in real-life can be considered as either a 'parameter uncertainty', as it is caused by incomplete or lack of data, or 'variability in objects/ sources', as it is stemming from inherent variations in the real world and differences between comparable sources (Huijbregts, 1998). According to his recommendation, both 'parameter uncertainty' and 'variability in objects/sources' can be addressed through probabilistic simulation, expert judgements/ peer reviews, additional literature research, additional measurements or correlation and regression analysis. However, in reality applying these recommendations to the problem of variations in the use phase may be challenging. In order to conduct a probabilistic simulation, correlation or regression analysis, it is necessary to have access to sufficient data. This kind of data is often not available on how people interact with their products.

There may be several reasons why this data is not already readily available; likely reasons are that it is very resource intensive, and difficult to collect sufficient amounts of data about human behaviour in a reliable way. Each subject's behaviour would have to be studied individually, in a way that captures the behaviour without affecting it. This will also be a challenge if additional measurements are to be conducted.

Although LCA is a very thorough and powerful method to assess the environmental impact of a product, it is rarely, if ever, seen applied in DfSB projects. The primary reason for this is probably the required time and knowledge to conduct the LCA. Even when using supporting software, such as Simapro (http://www.simapro.co.uk/, 2013), the process is often time consuming and requires both extensive knowledge and collection of impact data or access to databases. As DfSB researchers rarely has the competence or resources to do a full LCA, it may be an alternative to use a simplified tool, such as Eco-it (http://eco-it.software.informer.com/, 2013) of the Solid Works sustainability plug-in (http://www.solidworks.com/sustainability/, 2013). These simplified tools are by no means capable of providing assessments with the same accuracy as a LCA is capable of. But they can still give an indication that may be valuable to make the right design decisions to ensure reduced impact of the entire life cycle of the product and not only of the use phase, which is common today.

DfSB might possibly also contribute to LCA by providing methods and data to deal with the uncertainty related to the variations in the use phase. As accurate measurements of the behaviour of statistically representative populations are unfeasible, an alternative could be to conduct small-scale studies, which would not provide precise data, but enable improved estimates of the behaviour. For this purpose, the methods and experience from DfSB might prove useful. Also, if a database of DfSB case studies were developed, this could help improve the understanding of particular behaviours, and thus also support more informed estimates. A potential side effect of products designed to achieve particular behaviours, might also be a reduction in the variations, and thus simplify the estimates for LCAs.

### 2.2.8. SUSTAINABLE DESIGN

"Environmentally responsible design (…) was introduced in the 1960s (…) as a response to the over-styled and consumerist approach that design –and especially industrial design - had taken" (Dewberry, 1996, page 2). Dewberry (1996) identified a number of different terms used to describe different levels of environmentally responsible design; green design tends to focus on one or two particular areas of environmental impact, eco-design or life-cycle design tries to reduce impact of all stages of the products life cycle and sustainable design tries to satisfy design criteria within a complex system of sustainable development. She points out that there also was a geographical variation of the terms used for design with a sustainable focus. In the USA, design for environment was popular, was Australia the term eco-design was common, whereas sustainable design was a more global term. Whether these distinctions are commonly known in the design community today is questionable as the field has developed much since the mid 90's (Boks & McAloone, 2009), and in this dissertation the term sustainable design will be used as a general term for design with a sustainability focus.

There is a growing attention to drivers and approaches for sustainable design, although there is a resistance to adaptation by many companies (Verhulst, 2011). Stevels (2009) identified that this is due to one or more of the following reasons: prejudice or doubt of the contribution to the bottom line, priority conflicts in the environmental domain, lack of priority in the value chain and distraction in the world outside of the companies. On the other hand, Bhamra (2004) summarised 9 reasons why organizations implement eco-design: 1. Cost savings, 2. Legislative regulations, 3. Competition, 4. Market pressure, 5. Industrial customer requirements, 6. Innovation, 7. Employee motivation, 8. Company responsibility and 9. Communications with stakeholders. McAloone (1998) found that when companies integrate eco-design in their design process, it is crucial that the timing is right and that the environmental decisions are made early enough in the process before the design specification is written, that the top management is committed and that there is sufficient enthusiasm in the organization to sustain the focus on environmental consciousness. Verhulst (2011) developed a conceptual model for the implementation process for sustainability criteria in the product development process, identifying four explanatory constructs; resistance against change, internal communication, empowerment of the employees and organizational structure.

To support the integration of environmental focus into product design, a substantial variation of tools have been developed during the years. Baumann et al. (2002) identified that the tools are targeting with four different levels of the product development process. Level 1 deals with the product development process and its tools as such. Level 2 deals with the process in the context of companies. Level 3 deals with the process in a product chain perspective. Level 4 deals with the relation to policy making. In this thesis, the focus will be on the tools of level 1.

The tools can be "ranging from guidelines and checklists to one-score screening indicators and full life cycle assessments" (Schischke, 2005, page 1). In recent years, a number of digital tools have also emerged, for instance Solid Works sustainability module (www.SolidWorks.com, 2013), which enables the designer to get environmental data directly from the 3D-modelling program. One example of a checklist type tool, is the "Ten golden rules of Eco Design" (Luttropp & Lagerstedt, 2006): 1. Do not use toxic substances and utilise closed loops. 2. Minimise energy and resource consumption. 3. Use structural features and high quality materials to reduce weight. 4. Minimize energy and resource consumption in the use phase. 5. Promote repair and upgrading. 6. Promote long life, especially for products with significant environmental impact outside of the use phase. 7. Invest in better materials, surface treatments or structural arrangements. 8. Prearrange upgrading, repair and recycling. 9. Promote upgrading, repair and recycling by using few, simple, recycled, not blended materials and no alloys. 10. Use as few elements as possible.

Many of the tools are closely connected to LCA and often enable, or support, designers when doing simplified assessments of the different phases of the products life cycle. One such tool that is commonly used is the 'Material cycle, Energy use and Toxic emission (MET) matrix', which is an analytical tool intended for assessment in the early stages of a product development process (Baumann & Tillman, 2004). The tool consists of a table, with a column for each of the three types of impact (material, energy and toxic) and a line for each phase of the products life cycle (van Hemel & Brezet, 1997). Another life cycle focused tool which has received substantial attention is the LiDS-wheel (Figure 2.16) (Van Hemel & Brezet, 1997), which identifies 8 phases of a product life cycle and provides suggestions to ways of reducing the environmental impact for each phase. In addition, the designer can rate the impact on each of the categories, creating a "spiderweb" representing the environmental impact of the product. By rating both the new design and alternatives, this tool provides a visual and easily readable comparison of the alternatives. It should be noted however, that all of these tools focus on the technological aspects of the product and not on behaviour, even though the LiDS-wheel does have a category that addresses the use phase.

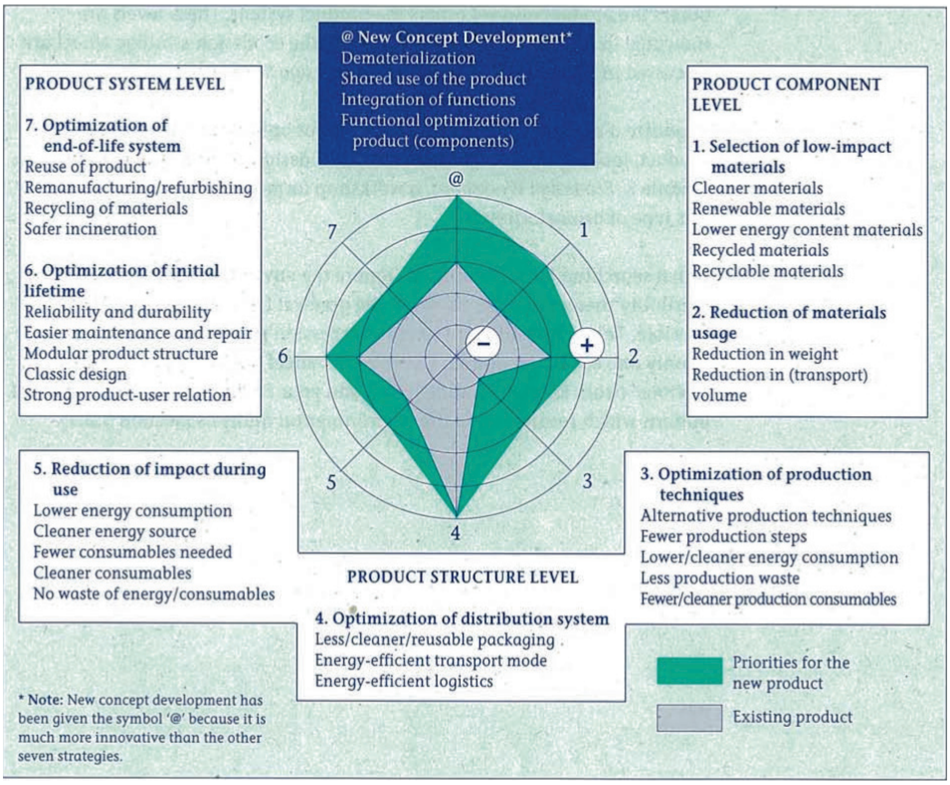



Figure 2.16. The LiDS-wheel (van Hemel & Brezet, 1997).

Lofthouse (2006) investigated the requirements designers had for eco design tools. She concluded that it is important to develop a holistic tool combining guidance, education and information, with well-considered content, appropriate presentation and easy access (Figure 2.17). In response to the requirements she had identified, she developed the "Information/inspiration" tool, which is an online tool where the designer can choose to navigate through an "information route" with the categories; general, materials, recycling, production, use and packaging, or an "inspiration route" with the categories; materials, form, energy, function, parts and packaging. By providing the information in the form of "nuggets" and multiple examples for inspiration, she received positive feedback from the testing of the tool.

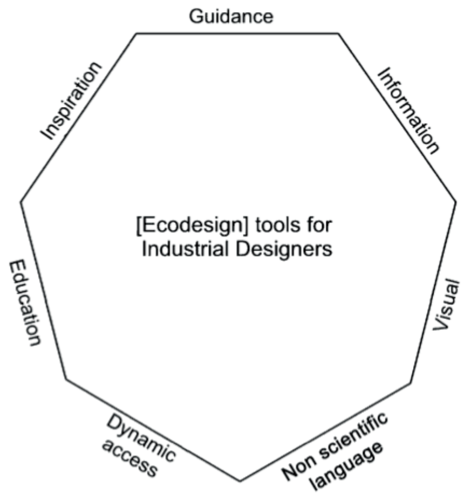



Figure 2.17. Lofthouse requirements for eco-design tools (Lofthouse, 2006).

The substantial work that has been given to the understanding and development of sustainable design is a valuable source of information for the development of DfSB tools. Although there are several aspects that differ between the two directions, for instance the focus on the entire life cycle and the physical aspect of the design vs the focus on the use phase and the behavioural aspects of the design, the end goal is closely related and many of the opportunities and challenges are the same. As a consequence, the identification of the requirements for tools in DfSB builds upon the experience and knowledge from sustainable design.

## 2.3. CONCLUSIONS OF THE BACKGROUND

DfSB literature identifies, structures and describes a large number of behaviour change strategies and principles. As human behaviour, and the choice of the behaviour changing strategies that are likely to result in the desired behaviour, is a complex topic, there is a need to support designers' decisions of how they design behaviour changing products. User centred design has been pointed out as a promising direction to gather the required insight about the user and the context (Wever et al., 2008), and has been applied in a number of case studies. Both sociology and behavioural psychology have been identified as promising frameworks to represent how behaviour is determined. But for the specific challenge of affecting the behaviour of the user at the moment of interacting with a product, behavioural psychology seems the most suitable. The efforts to understand and affect behaviour have resulted in the development of a number of tools and methods, which have been presented both in the DfSB literature and in a number of other related fields. However, there has been limited discussion about what the understanding of the user and the context actually tells us about which design principles to apply, and none of the tools and methods seem to fulfil the requirements that have been identified to support this challenge for designers. This also seems to be the case for the related disciplines, although several of them include relevant tools and approaches that can be valuable for the further development of DfSB. The purpose of this thesis is thus to contribute with additional insight to these challenges and develop tools that can support designers in the desired ways.

# 3. RESEARCH APPROACH

The overall structure of this research project has consisted of identification and development of theoretical guidelines and experimental testing of these in actual design projects. This combination of generalised knowledge and practical application is supported by Stappers (2007). He points out that design research can be particularly fruitful "with an eye for generalization and an eye for application" (Stappers, 2007, page 87). As this project has encompassed different types of investigation, a variation of research methods has been applied, including literature research, creative workshops, ethnographic studies, surveys, practical case studies, laboratory experiments and controlled comparative studies.

Robson (2002) distinguish between Descriptive studies (providing description of a phenomenon), Explanatory studies (provide causal explanation of a phenomenon) and Exploratory studies (explore a phenomenon). Graziano and Raulin present exploratory research as one of lower constraint making relatively few demands for structure and precision in the procedures. The level of constraint refers to the demands for adequacy of the information and how it may be processed (Graziano & Raulin, 2004). Lower constraint research, also known as qualitative research, "is most appropriate when the question concerns the natural flow of behaviour in natural settings" (Graziano & Raulin, 2004, page 130) and is frequently used in the social sciences.

The contrasting research tradition, quantitative research, is also frequently applied in some of the social sciences, but is often more associated with the natural sciences. Quantitative research is based on the notion that everything can be described according to a numerical system, (McQueen & Knussen, 2002), employ experimental methods and emphasise the measurement and analysis of causal relationships between variables (Golafshani, 2003). Golafshani (2003) identify four features of quantitative research: 1) the emphasis is on facts and causes of behaviour, 2) the information is in the form of numbers, 3) the mathematical process is the norm for analysing the data and 4) the final result is expressed in statistical terminologies. Qualitative research seeks to understand a phenomenon in a context specific, real world setting (Golafshani, 2003), emphasise on process and meaning (Sale, et al., 2002) does not apply quantification and statistical procedures (Golafshani, 2003) and the data typically consist of a text describing the phenomenon.

Epistemologically the two directions are also different. Quantitative research is based on a positivistic perspective, where "all phenomenon can be reduced to empirical indicators which represent the truth" (Sale et al., 2002, page 44) and which exist independent of human perspective. Qualitative research is based on interpretivism and constructivism and believes that "there are multiple realities and multiple truths based on one's construction of reality" (Sale et al., 2002, page 45). This has consequences both for the type of methods used by the two directions (Golafshani, 2003; Preece et al., 2002) and the way they consider validity and reliability.

Validity and reliability are measurements of the quality of the data (Graziano & Raulin, 2004). Reliability refers to "the extent to which an experiment, test, or measuring procedure yields the same results on repeated trials" (Merriam-Webster, 2013) whereas validity refer to the accuracy of the measurement and whether it measures what it is intended to measure (Graziano & Raulin, 2004). However, based on the epistemological differences, this understanding of the quality of the research only makes sense from a quantitative research perspective. Because of the differences in purpose of the research, Goalfshani even claims that "the concept of reliability is irrelevant in qualitative research" (Golafshani, 2003, page 601) and some researchers have argued that the same is true for validity. From one point of view, this makes sense as the world is considered to be constantly changing and the results from qualitative research are not considered generalizable (Golafshani, 2003). However, qualitative researchers also need to be able to assess the quality of the research, and commonly terms as credibility, neutrality, conformability, transferability and trustworthiness are used for this purpose (Golafshani, 2003). "In lower-constrained research, validity depend more on the researcher's clarity of thought" (Graziano & Raulin, 2004, page 134). One way of strengthening studies may be to triangulate multiple methods (Patton, 2002).

According to Graziano and Raulin (2004) it is most productive to apply an exploratory approach to the early stages of a research topic. As the investigation of how design of products can result in more sustainable behaviour is a rather new field of research and it concerns natural behaviour in natural settings, the main part of this research project will be exploratory, primarily applying qualitative methods. However, as some types of investigation are most suited to quantitative methods and perspectives, the type of methods and approach used in the different parts of this project depend on the type of data targeted. For instance, some parts of this research project can be considered to have explanatory aspects, for instance the analysis of why people don't burn their firewood optimally (see Chapter 4.2.4 and Paper 2). The ethnographic studies were highly exploratory, but the analysis of what they did that had the large negative impact and the reasons why they behaved this way, may be seen as explanatory. Similarly is the comparative study of how people burn firewood in the two wood ovens (also Chapter 4.2.4 and Paper 2), a typical example of quantitative research, although it is triangulated with some qualitative methods, as advocated by (Golafshani, 2003).

Before providing an overview of the user research methods applied in this project (Chapter 3.1.5), a general introduction is given to user research methods commonly applied in user centred design, and an analysis of the type of insight different methods are most suited to investigate.

## 3.1. USER RESEARCH METHODS

Chapter 3.1 – 3.1.4. are adapted from the original text in Zachrisson and Boks; A classification of user research methods for design, submitted to JCP.

As previously pointed out, DfSB emerges from a user centred design tradition and the DfSB literature almost uniformly both advocate and build upon insight about the target users and behaviour as a key determinant for design decisions. Studies of how users interact with products, can aid researchers and designers in finding the specific information they are looking for, but it also creates a challenge for them. Due to the amount and variation in methods, it can be difficult to obtain an overview over the methods and to understand when the different methods would be most valuable to apply. In an attempt to remedy this, several reviews have been made, presenting selected methods or approaches (e.g. Aldersey-Williams et al., 1999; Blomberg, et al., 1993; Courage & Baxter, 2005; Kujala, 2003; Maguire, 2001; Muller & Kuhn, 1993; Preece et al., 2002; Sanders, 2006; Steen, 2008). These reviews present descriptions of how and at what stage in the process different methods should be applied. Several of them also have illustrations, or highlight certain aspects of the methods in tables, to ease comparison. Preece et al. (2002) states that there are five basic methods for gathering data, namely questionnaires, interviews, focus groups and workshops, naturalistic observation and studying documentation. It can be argued that some methods, for example probes or empathic design, are not really combinations of any of these. However, such a simplification may aid the understanding of how different methods are related to each other.

Even though there is extensive literature on user-centred methods, little information is presented of what they actually can tell us about the user, the situation or the context. By reviewing a number of the most common user research methods and structuring them according to what type of insight they are most suitable to investigate, this review aims to give insight on what type of information they may provide. To structure such a review, it is necessary to have a common framework of possible insight the various methods can provide. In order to accommodate the goal of behavioural change, the CADM (Klöckner & Blöbaum, 2010) (See Figure 2.10) was chosen as source of such a framework.

The collection of user research methods was gathered by reviewing relevant literature with overviews and descriptions of user centred design methods. As the focus is to create an overview over methods that provide insight about the user, only the methods that aim at gathering information about the user or context were included. Methods that are meant to communicate the results of the research or translate the results into design solutions were not included. The focus is on identifying the factors that are affecting the behaviour, not on investigating the behaviour itself.

Two effects that some of the descriptions refer to, which may influence the truthfulness of the information provided by participants, are social desirability and prestige response bias. Social desirability occurs if the participant prefers to answer what he thinks is most socially acceptable rather than the truth. If the participant answers what he thinks the researcher wants to hear, it is called prestige response bias (Courage & Baxter, 2005). Courage and Baxter (2005) discusses these factors in relation to interviews and questionnaires, and claim that the risk for them can be avoided if the researcher is aware of them, and is careful in the way the question is formulated. It is however reasonable to believe that they can affect all types of research where a user is involved, although Blomberg et al. (1993) points out that lack thereof is one of the advantages of observations compared to techniques where the user talks about the behaviour.

There are two properties of behavioural factors identified by the CADM, which may be significant for how they could be investigated. One of these was pointed out by Jackson (2005) when he identified that the factors can either be internal or external. The internal factors are embedded within the user and include factors such as attitudes, values, habits and personal norms. The external factors are embedded outside the user, and include institutional constraints and social norms. As the internal factors are embedded within the user, it is necessary to gain information from the user to investigate these. The external factors however, can be investigated without direct input provided by the user. But this does not necessarily exclude the possibility of investigating the external factors through input provided by the user.

The other property concerns whether the factor is conscious or unconscious to the user. Klöckner et al. stated that habits should be considered unconscious, as they are conducted without deliberate thinking. Thus people are most likely unable to provide information about this (Klöckner et al., 2003). Similarly, Frey (1988) points out that there can be unconscious reasons why the subjective possibility set overextend or underextend the objective possibility set. Thus, objective constraints can also be considered to be unconscious for the user and something the user cannot provide information about. It should be noted that in the field of psychology, the term unconscious is used about something the subject is not consciously aware of.

Based on these properties, it is possible to deduce two basic assumptions for how the different factors can be investigated:

- Only the factors the user is conscious about can be investigated through information provided by the user.

- Only external factors can be investigated without direct information provided by the user.

By dividing the factors according to the properties and highlighting the two assumptions, a matrix indicating how the assumptions affect the investigation of the factors can be organised as done in Figure 3.1. The included factors are the ones identified by the CADM (Figure 2.10).

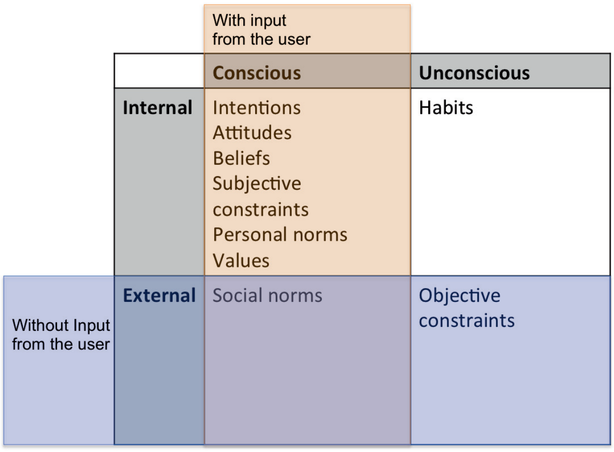



Figure 3.1. A matrix of internal & external, and conscious & unconscious factors.

The methods that have been included in this review are listed in Table 3.1.

Table 3.1. Methods included in the review.

| 4.1: Techniques for communicating with the users: | 4.2: Techniques for investigating what the users do: | 4.3: Techniques investigating both what the users do and communicating with the users: |
|---|---|---|
| Interview<br>Focus group<br>Survey<br>Verbal protocol<br>Conjoint technique<br>Wants and needs analysis<br>Card sorting<br>Group task analysis<br>Probes | Observation<br>Studying documentation<br>Video Ethnography<br>Shadowing<br>User testing<br>Empathic design<br>Culture-focused research | Applied ethnography<br>Contextual enquiry |

The methods are divided into three categories, according to how they are used to gather information. Each method is presented with a description and a summary of what the literature describes as its purpose. After all the methods in a category are presented, there is a discussion of the potential for the individual method for investigating the factors identified by the factor matrix (Figure 3.1). This discussion is based on the identification of aspects in the description or purpose that qualifies or disqualifies the method for investigation of certain factors.

### 3.1.1. TECHNIQUES FOR COMMUNICATING WITH THE USERS.

These methods are based on information provided by the user, which gives access to internal factors. But as the information only is provided by the user, it is necessary to be aware that the information is subjective and may be affected by factors such as social desirability and prestige response bias. These techniques are also not suitable to provide information about factors that the user is not consciously aware of.

Table 3.2. Techniques for communicating with the users.

| Description of the method | Purpose described in literature |
| --- | --- |
| An Interview is a dialogue between a researcher and one or more respondents. (Aldersey-Williams et al., 1999; Courage & Baxter, 2005; Preece et al., 2002). | Interviews are suitable to provide information about individual actions, motivations, reconstruction of decision-making processes (Aldersey-Williams et al., 1999), needs, thoughts, experiences (Courage and Baxter, 2005), attitudes and beliefs (http://www.Usability-first.com). They can provide rich, detailed data, and give a holistic view of the system (Courage and Baxter, 2005). Individual interviews are more suitable to investigate sensitive topics than methods involving more people (Aldersey-Williams et al., 1999). |
| A Focus Group is a group discussion about a product or a topic (Aldersey-Williams et al., 1999; Courage & Baxter, 2005; Gibbs, 1997; Preece et al., 2002). | Focus groups can provide information about both explicit and implicit needs and reactions (Aldersey-Williams et al., 1999). It is useful to gain consensus or highlight areas of disagreements within the group (Preece et al., 2002), generate ideas or discover problems, challenges, frustrations, likes, dislikes, opinions, attitudes, preferences, initial reactions and priorities (Courage and Baxter, 2005). |
| Surveys or Questionnaires are series of questions requiring direct responses, often multiple-choice or rating on a scale (Preece et al., 2002, Courage and Baxter, 2005, Maguire, 2001). | Because the possibility to distribute the questionnaire, it is useful to get input from a large group of people (Preece et al., 2002). As surveys can be completely anonymous, they may be more suitable than interviews to investigate sensitive information. The questionnaire can provide information about what users want or need, the population and their characteristics, what they like or dislike, (Courage and Baxter, 2005) and current work practices and attitudes (Maguire, 2001). |
| In Verbal Protocols the subject explains what he or she is thinking, either by talking aloud while they are performing a task, or explaining what and why he or she was doing afterwards (Love, 2005). | This technique is used in combination with observation and can give information about what a subject was thinking about, reasons for the way he or she behaved a certain way, or about particular feelings about a certain task (Love, 2005). |
| Conjoint Techniques are based on presenting multiple design features to subjects simultaneously, and subsequently asking them to rate combinations of features (Aldersey-Williams et al., 1999). | Because subjects rate combinations of features, this method can give information about how much subjects value individual features (Aldersey-Williams et al., 1999). |
| Wants and Needs Analysis is done by asking a group of subjects to brainstorm about what they want or need in a product they are familiar with (Courage and Baxter, 2005). | The result of this can be a prioritized list of the type of features and characteristics a subject wants or needs in a product (Courage and Baxter, 2005). |
| Card Sorting is conducted by writing features of the product or system on cards and asking subjects to organise them or sort them into meaningful groups (Courage and Baxter, 2005). | Through this technique it is possible to gain insight about how a subject believes a product functions and thereby the conceptual model the user has of the product or system (Courage and Baxter, 2005). |
| Group Task Analysis is a technique where a small group of users figures out the steps involved in a performing a particular task (Baber, Borras, Ltd, Hone, & MacLeod, 2008; Courage & Baxter, 2005; Crystal & Ellington, 2004). | The task analysis aims at explaining about the steps and the sequence a task consists of, the users' goal, the information needed, problems they encounter, preferences (Courage and Baxter, 2005), description of observable behaviour (Baber et al., 2008), and/or constraints imposed by nature and what the user knows (Crystal and Ellington, 2004). |

| | |
|---|---|
| In Probes or Diary Studies, participants are given packages containing different tools to document their lives and experiences, such as a camera, a questionnaire, diaries, etc. (Love, 2005; Lucero, Lashina, & Diederiks, 2007; Maguire, 2001; Steen, 2008). | By giving participants probes, they are enabled to provide a personal record of (Love, 2005), and report on their daily lives and experiences (Steen, 2008). |

#### 3.1.1.1. DISCUSSION ABOUT THE TECHNIQUES FOR COMMUNICATING WITH THE USERS.

According to the factor matrix, the methods described in Table 3.2 may have the potential to investigate all the internal, conscious factors: Beliefs, attitudes, intentions, personal norms, subjective constraints and values. Based on their descriptions, this can be true for a number of the methods. Interviews, focus groups, surveys, verbal protocols and probes are all described as general techniques for acquiring input from the user, without any limitations to what the focus of the investigation is. Although some methods may be more suitable than others depending on the purpose and situation. For instance, group techniques will be less suitable for investigating sensitive topics than techniques that address only one user at the time.

On the other hand, some of the methods aim at acquiring specific information from the user. Conjoint techniques focus on investigating the relative importance of product features according to users. This may provide insight about the attitude, personal norms and values, as all these are related to the user preferences. The Insight will however be very specifically connected to the features of the product in focus.

Want and need analysis is a similar method, but focuses on the users inventing new features, rather than evaluating existing ones. It is not obvious if this will reveal other factors or address factors more deeply, although the user has more freedom using this method. Nevertheless, this technique will also focus on factors strongly connected to the product features.

Card sorting aims at revealing how the user believes that a product functions. This technique aims specifically at the beliefs of the user, but is also limited to the beliefs concerning the product and how this functions.

Group task analysis is similar to card sorting, but focuses on a group figuring out the steps involved in a task, instead of organizing already defined steps. Similarly to the difference between conjoint techniques and want and need analysis, it is not clear what effect the involvement of imagination will have for the investigation. Also this technique investigates believes only about the specific task.

As the insight provided by the four last techniques are so specifically related to the product or task in question, their usefulness might be limited in projects where more general insight is needed.

### 3.1.2. TECHNIQUES FOR INVESTIGATING WHAT THE USERS DO.

These methods gather information about the user or the context indirectly, either through observing behaviour or studying other relevant information. This allows access to information that the user may be unaware of, but cannot investigate factors that are embedded in the mind of the user.

Table 3.3. Techniques for investigating what the users do.

| Description of the method | Purpose described in literature |
|---|---|
| Observations consist of watching and recording users' behaviour, either in the natural context or in a lab setting. (Aldersey-Williams et al., 1999, Blomberg et al., 1993, Preece et al., 2002, Love, 2005). | The method can identify illogical behaviour, measure performance time, insight about difficulties of tasks (Aldersey-Williams et al., 1999), the natural occurring behaviour (Love, 2005) and behaviour that can be hard for the user to describe or explain (Preece et al., 2002). "What people say they do and what they actually do may be different (Courage and Baxter, 2005). |
| Studying Documentation consists of reading about formal or informal rules, regulations and standards (Preece et al., 2002). | This may provide information about formal constraints in the context of the usage, and prescribed procedures (Preece et al., 2002). This can help understanding norms or values in a group. |
| Video Ethnography is a type of observation where the behaviour of the user in the natural context, is recorded on video. (Aldersey-Williams et al., 1999; Brun-Cottan & Wall, 1995; Kujala, 2003; Kumar & Whitney, 2003). | It is useful to identify and analyse work related activities (Aldersey-Williams et al., 1999), user-based technological requirements, common comprehension in the development team of the users' perspectives (Brun-Cottan and Wall, 1995), making comments about the activities and recognizing patterns in the behaviour (Kumar and Whitney, 2003). |
| Shadowing is a technique where the researcher is following users in their daily activities over a long period of time, and documenting their behaviour by video recording or note taking (Aldersey-Williams et al., 1999, Brun-Cottan and Wall, 1995). | The technique can provide insight about what people really do (Aldersey-Williams et al., 1999) and it can verify and correct an evolving understanding of their behaviour (Brun-Cottan and Wall, 1995). |
| User Testing are tests where users perform predefined tasks while being observed and recorded (Aldersey-Williams et al., 1999, Preece et al., 2002, Sanders, 2006). | The user test is meant to provide information about performance time, errors and aspects the user finds difficult, but it can also help explain why users behaved the way they did (Preece et al., 2002). |
| Empathic Design is a technique using observation, role-playing, playing with prototypes, or other techniques to gain empathy for the user and try out the behaviour in a certain context (Aldersey-Williams et al., 1999, Steen, 2008). | Through this technique, the researcher can get input about users' experiences and emotions towards the surroundings, in different or future physical, social or cultural contexts (Steen, 2008). |
| Culture-Focused Research uses measures like census-taking and demographic data to look at general patterns of daily life, for instance value systems or social structures and relationships (Kumar and Whitney, 2003). | This cannot only provide demographic information, but also insight about behaviour, beliefs and goals (Kumar and Whitney, 2003). |

#### 3.1.2.1. DISCUSSION ABOUT THE TECHNIQUES FOR INVESTIGATING WHAT THE USERS DO.

Based on the factor matrix (Figure 3.1), these techniques (Table 3.3) may be suitable for investigating the external factors: social norms and objective constraints. There are differences between these two factors, which affects how they can be investigated. Social norms are conscious to the user whereas objective constraints are defined to be unconscious to the user. The conscious aspects of the objective constraints are included in the subjective constraints. In addition, the objective constraints are found in the physical world around the behaviour, whereas the social norms are found in the society around the user. As the social norms are a non-physical factor, they cannot be directly observed. Thus, techniques based purely on observation, such as observation, video ethnography, shadowing, user testing and empathic design, will primarily be suitable to investigate objective constraints. The understanding of the behaviour that these methods create, can give the researcher hints about other factors as well. However, not all objective constraints can be observed either. Rules or regulations for instance would be hard to observe, but could rather be investigated through studying documentation or culture focused research. But these would only affect the behaviour if the user were aware of them, and would thus be included in the subjective constraints too. The two latter methods could also uncover information about social norms when this is included in the documentation.

### 3.1.3. TECHNIQUES INVESTIGATING BOTH WHAT THE USERS DO AND COMMUNICATING WITH THE USERS.

As these methods combine observation with information provided by the user, the factor matrix (Figure 3.1) predicts that they should be suitable to investigate all the factors that are external or conscious to the user.

Table 3.4. Techniques investigating both what the users do and communicating with the users.

| Description of the method | Purpose described in literature |
|---|---|
| Applied Ethnography or Field Study is a technique where the researcher observes usage of products in its natural setting, and tries to understand why the user behaves the way he does in the given situation. The technique includes observation, interview and video analysis (Blomberg et al., 1993; Sanders, 2006; Steen, 2008; Steen, Kuijt-Evers, & Klok, 2007). | The purpose is to understanding how people use products (Steen, 2008) with focus on observing the behaviour in the natural situation, understanding it in the social and cultural context, how the user creates meaning (Blomberg et al., 1993), and understanding the users implicit or non-verbal needs (Kujala, 2003). |
| Contextual Inquiry or Contextual Design is a technique where the researcher joins the user in his work as his apprentice, in the natural context. (Beyer & Holtzblatt, 1999; Courage & Baxter, 2005; Holtzblatt & Jones, 1993; Kujala, 2003; Steen, 2008). | This technique can provide details and motivations that are implicit to peoples' work because they have become habitual, who the user really are, how they work (Beyer and Holtzblatt, 1999) and insight into the context of the usage situation (Courage and Baxter, 2005). |

#### 3.1.3.1. DISCUSSION ABOUT THE TECHNIQUES INVESTIGATING BOTH WHAT THE USERS DO AND COMMUNICATING WITH THE USERS.

As both methods in Table 3.4 are described as general investigations of the user and the context, there is no indication that either of them have limitations to investigating the factors identified by the factor matrix. On the contrary, the combination of observation and dialogue may improve the level of detail and nuances that can be investigated through the methods.

There may also be an additional benefit of this combination. According to the factor matrix, habits are a problematic factor to investigate. Klöckner et al. (2003) also acknowledged this problem. Habits are both internal and unconscious, and none of the assumptions cover this combination. However, Beyer and Holzblatt (1999) identify that contextual inquiry has the potential to uncover habits because it may gain insight into factors that are implicit to the user. The combination of investigating what the user thinks and seeing what the user does, may indeed make it possible to identify which behaviours are habitual or not. If this is so, applied ethnography should also have a similar ability to investigate habits. The same might be true if other methods with different focuses are combined. This is known as triangulation (Love, 2005).

Another way to investigate habitual behaviour is through longitudinal analysis. This is a technique where the researcher conducts repeated assessment of the same people over a period of time to monitor change or development. The assessment techniques can be anything from video interviews to physical measurements (Aldersey-Williams et al., 1999; Love, 2005). It can provide information about changes in mental or physical functioning or capabilities (Aldersey-Williams et al., 1999), development of habits or changes in attitudes (Love, 2005).

### 3.1.4. RESULTS OF THE REVIEW

Figure 3.2 aims to summarise the conclusions from the review by matching the methods with the factors discussed in the previous sections. As pointed out in the review, some of these methods are general whereas others can only investigate the aspects of the factors that are closely related to the topic of the investigation. Triangulation of methods may result in the possibility to investigate more factors than just the sum of the factors the methods initially could investigate.

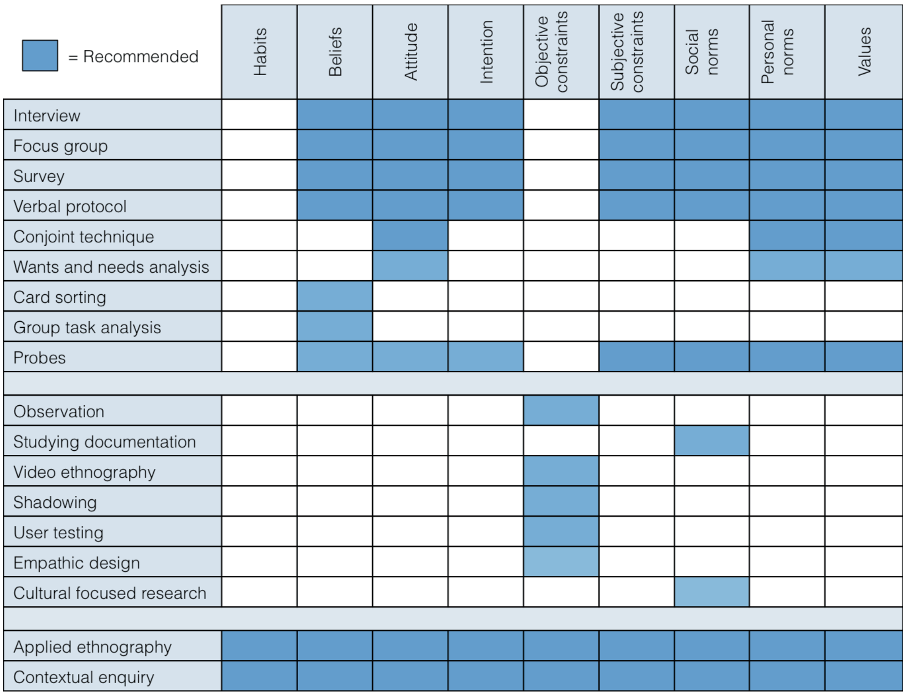



Figure 3.2. Matching methods with factors.

### 3.1.5. THE METHODS APPLIED IN THIS PROJECT

The varying nature of the investigations in this project has required the application of a number of different methods. Some of the investigations have been user research related and have applied methods described in the previous sub-chapter, whereas other investigations have focused on collecting already existing knowledge, gathering other types of data or evaluating results. Table 3.5 contains a summary of the main methods applied in this project. Some of these methods are complex and could be separated into individual components - for instance the inclusion of oral feedback or evaluation surveys in some of the workshops and projects - but are maintained as they are because they together contribute with the relevant information and it may be difficult to separate the results of each method.

Table 3.5. The main methods used in this project.

| Method | Topic | Description | Result | Chapter / Paper |
|---|---|---|---|---|
| Literature study | DfSB dimensions and principles. | Reviewing DfSB literature to identify dimensions and principles that affects how a product affects behaviour. | Four dimensions were identified: Control, Obtrusiveness, Empathy and Direction. | Chapter 2.1.1 / Paper 5 |
| Literature study | Behavioural models and factors. | Reviewing social psychology literature to identify a promising behavioural model describing the factors affecting behaviour, and investigation of these factors. | The CADM is identified as a promising model. It describes that behaviour can be affected by Habitual, intentional and situational factors, and indirectly normative factors. | Chapter 2.2.1.1 / Paper 5 |
| Literature study | Requirements for design | Reviewing design research literature to identify relevant requirements for | The identification of a number of requirements, among them | Chapter 2.1.3.1 / |

| | | | | |
|---|---|---|---|---|
| | tools. | development of DfSB tools. | that the tool must have many examples, be primarily visible, have simple language, etc. | Paper 1 |
| Investigating workshop | DfSB dimensions | Workshops with design practitioners, investigating which aspects of the design of a product they believe affect the behaviour of the user. | The identification of 55 dimensions, which could be divided into 9 dimension categories. | Chapter 4.1.2.1 / Paper 1 |
| Creative workshop | New woodstove | Workshop with Jøtul employees to generate ideas for how a wood stove could be designed to make people use it in the desired way. | Single air adjustment lever with indications for correct positions, thermometer with indications when to adjust the lever, and a simplified user manual. | Chapter 4.2.4.3 / Paper 2 |
| Applied ethnography | Investigate how people use their woodstoves | Video recording and interview about woodstove use of 17 participants. | Rich data about how and why people use woodstoves, translated into four personas. | Chapter 4.2.4.1 / Paper 2 |
| Applied ethnography | Investigate energy consumption in households | Interviews about energy consumption and guided tour of the energy consuming appliances in 10 UK homes. | Rich data about what people believe consumes energy and their willingness and constraints for reducing it. | Chapter 4.2.3 |
| Student design project | Evaluating Tool 1, 1st iteration. | Some application in various redesign-projects by 36 3rd year students in an Eco-design course. | Large need for improvement, especially on usability, integration in design project and how visual and inspiring it is. | Chapter 4.1.1.1 / Paper 6 |
| Student design project | Evaluating Tool 1, 2nd iteration. | Graduation project on oral health care. Applied to generate ideas and guide the selection of concepts. | Some need for improvement, especially simplifying description of behavioural factors and support on how to integrate in design projects. | Chapter 4.1.1.2 / Paper 7 |
| Student design project | Evaluating Tool 1, 3rd iteration. | The main topic in redesign-projects by 35 3rd year students in an Eco-design course, focusing on dishwashing, laundry, disposal of special waste in homes, food waste and energy consumption while sleeping. | The tool should be more inspiring and less dictating. | Chapter 4.1.1.3 / Paper 6 |
| Comparative workshop | Evaluating Tool 1, 4th iteration | 15 participants at the Persuasive 2011 conference generated ideas to solve a behaviour design problem, first without then with the tool. | The tool is too rigid and should include the identification of principles the users will not accept. | Chapter 4.1.1.4 |
| Comparative workshop | Evaluating Tool 2, 2nd iteration | Full day workshop with 12 designers and design students at Stanford working in pairs to solve a behaviour design problem. Two pairs with tool 1, two pairs with tool 2 and two pairs with a control tool. | The effect of the individual variation among the designers had larger effect than the variation in the tools, making it impossible to draw conclusions from the results. | Chapter 4.1.2.3 / Paper 1 |
| Comparative workshop | Comparing Tool 1, 5th iteration and tool 2, 1st iteration. | Full day workshop with 46 students at TUDelft solving one of three behaviour design problems in teams of two or three. First half with and half without the tool, then new problems and all teams had the tool. The teams generated ideas and created concepts. Evaluation by comparing number of ideas and approaches used in concepts, and survey | The teams with the tool used significantly more unique approaches in their concepts, than the teams without the tool. The survey showed that the tool was received fairly well. | Chapter 4.1.2.4 / Paper 1 |
| Lab experiment | Compare prototype with conventional woodstove | 20 participants lighted a fire in either a conventional woodstove or a prototype. They maintained the fire until 80% of the mass of the wood had burned. The behaviour was monitored, and temperature development and emissions of $CO_2$, CO, $O_2$, $NO_X$ and PM were measured. | Half of the participants using the prototype were affected by the new design. They behaved more in line with the desired behaviour than the others, and had lower emissions, although the results are non-significant. | Chapter 4.2.4.5 / Paper 2 |
| Natural field experiment | Ecological egg purchases | Comparing the sales of ecological eggs from two grocery stores, with no manipulation, posters informing about animal welfare and stickers with "animal welfare label". | None of the manipulations had any effect on the sales of ecological eggs. | Chapter 4.2.2 |

# 4. RESULTS

A number of different types of results have been produced in this research project. As the main goal of the project was to develop tools to help designers make informed decisions about how they design behaviour changing products, several of the main results are related to the development of these tools. In summary, the project has provided answers to the research questions (Chapter 6.1), resulted in fourteen papers, two conference posters, two design tools (Chapter 4.1.1 & 4.1.2) and four case studies (Chapter 4.2), in addition to the case studies conducted by students more or less drawing upon this research. This chapter contains the description of the development of the tools and case studies, and abstracts of the publications that are included in this thesis.

## 4.1. TOOLS DEVELOPED IN THIS PROJECT

During this project, two tools have been developed to support the design of behaviour changing products. The first tool, Principles of Behaviour Change, was developed through 5 iterations and formed the basis from which the second tool, Dimensions of Behaviour Change, was developed through 2 iterations (see Figure 4.1). This chapter contains the description of each of these iterations, including the collection of the new insight that lead to the development and the description of how each iteration was evaluated. A complete version of the final tool can be found in Part III.

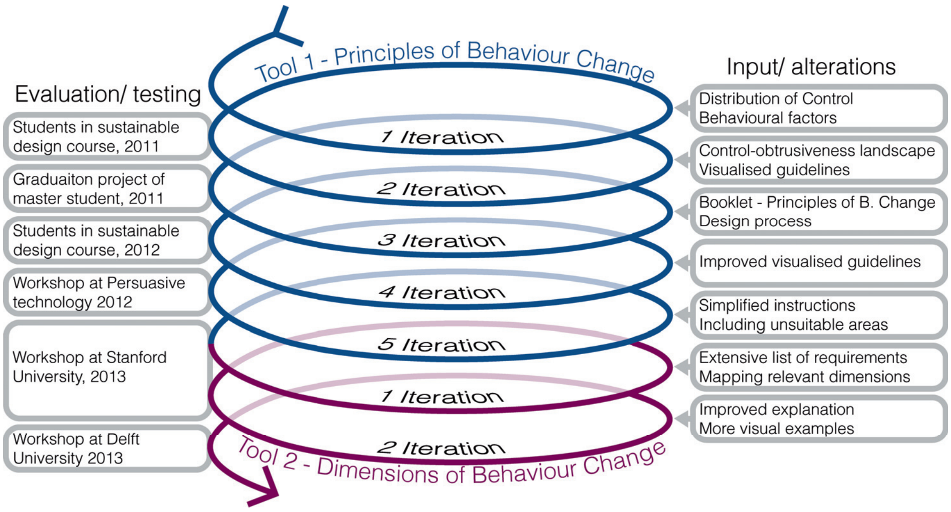



Figure 4.1. The five iterations the Principles of Behaviour Change and two iteration of DBC.

### 4.1.1. TOOL 1 - PRINCIPLES OF BEHAVIOUR CHANGE

The starting point of this project was to investigate how the insights from behavioural psychology can inform the selection of design principles to affect behaviour. The results of this investigation were summarised in a condensed and simplified guide connected to, first, the distribution of control and later to the landscape of control and obtrusiveness.

In the first iterations, this material was evaluated without having undergone any extensive design process.

#### 4.1.1.1. TOOL 1 - 1ST ITERATION – DISTRIBUTION OF CONTROL AND CADM

This first part of Chapter 4.1.1.1. is adapted from the original text in Zachrisson and Boks, 2010; When to apply different design for sustainable behaviour strategies?, presented at ERSCP-EMSU in Delft in 2010, which was later reworked and published in Zachrisson and Boks, 2012; Exploring behavioural psychology to support design for sustainable behaviour research, JDR 2012.

The initial development of a tool to support designers in making informed decisions about which behaviour principles they should apply in their projects, was based on a literature review of behavioural psychology. By investigating how the various factors identified by behavioural models could be affected by the design of products and variations in how much control the user had over the interaction, a number of observations or recommendations could be developed. The results were presented as a set of guidelines, but no significant effort were yet made to present them in a why that could be easily applicable for designers. The analysis and guidelines were presented at the ERSCP-EMSU conference at Delft University in the Netherlands in 2010 (Zachrisson & Boks, 2010) and was later reworked and published in Journal of Design Research (Zachrisson & Boks, 2012).

As described in chapter 2.2.1.1 an assessment of behavioural models from social psychology resulted in the identification of the CADM (Figure 2.10) (Klöckner & Blöbaum, 2010) as a promising framework to guide the exploration of the various behavioural factors. The CADM explains that there are three direct types of factors affecting individual, sustainable behaviour; habitual factors, intentional factors and situational influences. In addition the behaviour is affected by normative factors, which affects the behaviour indirectly by influencing the intentional and habitual processes.

**Situational influences** are constraints and possibilities created by the context or the product itself. The way the product is designed, or the way the context around affects the interaction with it, determines the constraints and/or possibilities the user experiences when using the product. It also affects the user's perceived behavioural control. Are there limitations or possibilities among the capabilities of the user? Are there aspects in the usage situation or the context of the usage that enable or limit certain types of behaviour? This is already a topic of user centred design literature (Preece et al., 2002) and is commonly integrated in design processes (Maguire, 2001); understanding the context can predict the effectiveness of design strategies.

According to the CADM, situational influences consist of objective and subjective constraints. Objective constraints are something that is actually constraining. Subjective constraints are something that is perceived to be constraining. No matter if the constraints are real or only perceived, they can strongly affect a user's behaviour, including the amount of attention the user is able or willing to give the interaction with a product. For instance, if a product is designed to be used while the user is driving a car, it is crucial that the product is possible to operate with only one hand and suddenly can be left alone without this causing any problems. It is also important that the interaction with the product does not require much attention or reasoning from the user, as he/she should focus on driving. Both these concerns are already identified and included in standard design processes and will directly say something about the applicability of different strategies. However, as earlier described, there seems to be a tendency that the more control the user has, the more cognitive load the interaction requires. Based on this assumption, the understanding of how much attention the interaction with the product can demand, can be a strong indicator of how much control the user should have.

An important source to understand the **intentional processes** is the Attitude-Behaviour-Context theory (ABC theory) by Stern (2000). The theory discusses how contextual factors affect the influence attitudes have on behaviour. The contextual factors consist of external factors, such as laws and regulations, community expectations and global variations (e.g., interest rate and oil prices), but also of the capabilities and constraints provided by the technology and built environment (Stern, 2000). This is similar to what Klöckner and Blöbaum (2010) call situational influences. Stern implies that when the context affects the behaviour strongly, positive or negative, the attitude has little influence on the behaviour. But when the context effect is small or neutral, the attitude of the user plays a significant role for the behaviour. He describes this as an inverted U-shaped function (Figure 4.2).

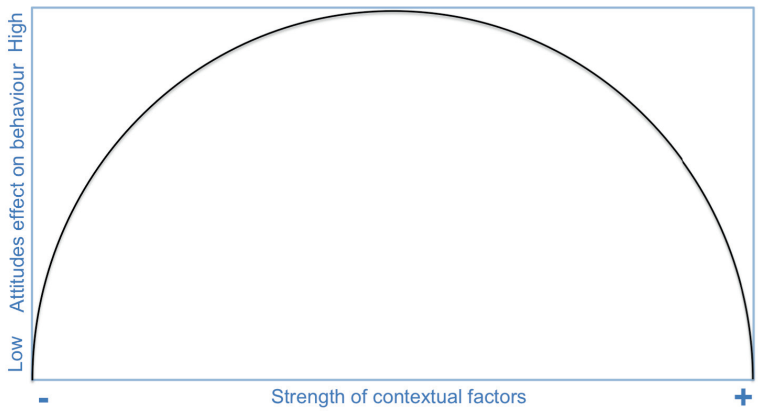



Figure 4.2. Illustration of the ABC theory.

In other words: if the external factors or the design of the product make it very easy to behave in a certain way, or sufficiently difficult to prevent behaving that way, users will behave this way no matter what their attitude is towards the behaviour. The opposite is the case when the context makes the behaviour difficult. If something is impossible to do, users will not do it, no matter how much they want to. To illustrate this with an example, imagine a situation where a person might or might not travel to work by bus. If there are no bus routes available, one cannot travel by bus even if a strong wish to do so exists. Alternatively, if one does not have any other means of transportation, one needs to take the bus even if one resents doing so. However, if both bus and car are equally available and convenient, one's preference may determine the choice of travel.

The intentional factors in the CADM are interconnected in a hierarchical structure. "The intentional processes capture all aspects of deliberate decision making based on knowledge and beliefs about product characteristics, the resulting attitudes about it, and forming an intention to buy a certain product" (Klöckner, 2010, page 6). This relation between the factors also seems apparent if the logic reasoning in the ABC theory should be applied on intentions or belief. Based on this, it can be assumed that the ABC theory really discusses how the strength of the context affects deliberate behaviour decisions.

This points out an interesting aspect of the distribution of control. As the strategies leave varying degrees of control to the user, it is reasonable to assume that it will be beneficial to use strategies where the degree of control for the user is corresponding with how much the user's intentions, attitudes or beliefs are in line with the intended behaviour. The following section aims at investigating what the ABC theory implies, described from the viewpoint of design for sustainable behaviour. From this perspective, the strength of the contextual factors can be seen as how strong it forces the user to behave a certain way. For the sake of the analysis, the distribution of control is simplified and separated into the three different main parts; informing, persuading and controlling.

At the informing end of the spectrum, the user is completely in control but receives information or feedback about the behaviour or the consequences of it. For this to be effective the user has to take in the information, and be willing to change the behaviour. This implies that the user should have a positive attitude or be motivated to perform the intended behaviour. This is supported by the finding that feedback is only effective if the user has a goal that the feedback helps to achieve (McCalley & Midden, 2002). It is of course possible to try to change the beliefs of the user, and thereby the attitude and intentions, by providing the user with information. How likely this is, will depend on how strong the beliefs of the user are and whether the user is open for changing beliefs or not (Verplanken & Wood, 2006).

At the persuasive part of the spectrum, the user is still in charge, but the product takes more control by making the desired behaviour easiest or most intuitive. These strategies can be assumed not only to be effective on users with a positive attitude but also on users who do not have a particular attitude. If the desired behaviour is easiest, this is what the user can be expected to do, as long as no effort is made to behave in another way. If someone chooses to make such an effort, it can be assumed that a negative attitude exists towards the intended behaviour. This could either be because of a belief that the intended behaviour is wrong, or simply because a positive attitude exists towards an opposing behaviour. This effect was also identified by Stern (2000), who suggests that "environmental significant behaviour can also be affected by non-environmental attitudes".

The determining strategies take the control away from the user by restraining certain behaviour or automatically performing actions. This can either be apparent to the user or be done without the user being aware of it. Because the behaviour is not the result of the user's attitude, it can be assumed that this strategy can be effective for all the above-mentioned attitudes. There are however a number of potentially negative consequences of taking the entire control away from the user. As pointed out by Jelsma (1997), users may feel manipulated and forced, which may result in resistance to, or alteration of the product. Other consequences may be related to the users' awareness of the consequences or feeling of responsibility, and ethical and moral implications (see chapter 2.1.5). These potential rebound effects and ethical implications should be taken into consideration if applying strategies from the determining end of the spectrum. However, "there does not appear to be any hard and fast answers to the underlying moral concerns of influencing behaviour through design" (Lilley, 2007).

Summarising the three attitudes identified above:

'Positive users' are users that are willing to make an effort to behave sustainably. Example: Hotel guests will make sure that towels are hung appropriately to avoid that they will be changed, even if they are wet or slightly dirty.

'Neutral users' are not willing to make an effort, but don't mind if their behaviour is sustainable. Example: Hotel guests will hang towels they do not mind using again if they remember to do so, but they do not really mind if they forget.

'Negative users' have beliefs or attitudes that make them negative towards the intended behaviour. This can either be directly towards the goal (in this case sustainability), they want to act un-sustainably as a principle, or they might just have other priorities such as comfort or economy. Example: Hotel guests will always leave towels on the floor to have them changed, in order to get the maximum out of the money they have paid to the hotel.

It should however be noted that it is an oversimplification to categorise a person's attitude simply as either positive, neutral or negative. In reality, unlimited variations exist of how positive or negative a person's attitude is towards a given behaviour. The above analysis is in other words only a logic construct to help investigate how likely the effectiveness of a strategy is, depending on its division of control. The resulting hypothesis of the relation between user attitudes and the division of control can be simplified as done in the following model (Figure 4.3). This model is based on the viewpoint that "if the investigator chooses to observe a single action with respect to a given target in a given context in order to obtain correspondence, the attitude also has to be very specific" (Ajzen & Fishbein, 1977, page 913). In other words, it is important to identify the attitude of the user towards the specific behaviour of interest, and not the general value of the user. This may result in varying attitudes from the same user depending on the behaviour in focus. Therefore, if this should be used as input for selection of design strategies, it is important to investigate attitudes towards the specific, intended behaviour.

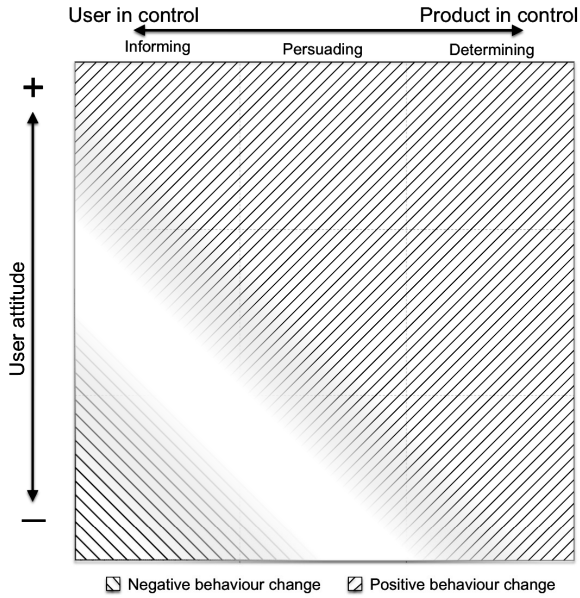



Figure 4.3. The consequence of users attitude and their level of control.

As described in chapter 2.2.1.1, the CADM identifies three types of **habitual processes**; schemata, heuristics and associations. For the purpose of this analysis it is assumed that all three habitual processes can be treated the same way and considered as simply being habits. There are several reasons for this. First of all, the literature describing strategies for breaking habits (Jackson, 2005b; Jager, 2003; Robertson, 1967; Verplanken & Wood, 2006) does not make a distinction between the different habitual processes. As this literature is the primary source for the analysis, it is a challenge to make such a distinction. In addition, the automated effect the habitual processes have on the behaviour is the same and it is suggested that the formation of all of them have to go through the step of successfully performing the behaviour (Klöckner & Matthies, 2012). If future research uncovers properties of the different habitual processes that are crucial for the selection of design strategies, another analysis should be conducted including this distinction.

Before analysing habits, is it important to be aware of an aspect pointed out by Jager. "The habitual behaviour in question has been performed for the first time at a given moment" (Jager, 2003, page 4). In other words, before the behaviour has become habitual, it is affected by the same factors as any other behaviour and is subject to the situational and intentional processes. This will also be the case if the habit is broken and the behaviour no longer is habitual (Jager, 2003). Accordingly, habits should be addressed in two different manners. In the cases of 'bad' habits, it can be relevant to break the habits and make the behaviour subject to situational and intentional processes. In case of 'good' behaviour, it can be relevant to ensure repetition by making it habitual. Or as Verplanken and Wood (2006) point out, interventions can disrupt old habits and establish new ones.

The creation of habits is assumed to go through three stages; firstly, the declarative stage, in which facts about the skill domain are interpreted. Secondly, the knowledge compilation stage, where knowledge is converted into a procedural form and can be directly applied without further interpretation, and finally the procedural stage, where knowledge can be applied more appropriately and the process can be speeded up Anderson (1982). Both Klöckner and Matthies (2012) and Jager (2003) identify that repetition is crucial in the formation of the habit. Jager also points out that the context around the behaviour should be similar from one time to another and the direct outcome of the behaviour should be satisfying for the user. "The closer the reinforcement follows after performing the behaviour, and the more often a reinforcement follows after performing behaviour, the stronger the stimulus-response relation or script gets" (Jager, 2003). Even though the design of the product can support the formation of circumstances that might trigger the script, this is a complex matter as the context of the behaviour is often hard to control. The positive reinforcement is however something that could be created by the product and therefore is a factor to look for in the choice of design strategies. This type of strategy is referred to by Bhamra et al. (2008) as eco-spur, or by (Lockton et al., 2010a) as rewards.

The automatic, unconscious nature of habits can make them difficult to change (Verplanken & Wood, 2006). Before a habitual behaviour can be changed, it is necessary to make the behaviour subject to conscious deliberation by 'breaking' the habit (Jager, 2003). There are several different strategies and approaches for breaking a habit. Verplanken and Wood present three interventions for policy makers to change habits, Downstream, Downstream-plus-context-change and Upstream. Downstream interventions are information campaigns, and are argued to have limited ability to change behaviour. If the information is presented at the moment when the circumstances that trigger the habit are being changed, they are much more likely to be effective. These are referred to as Downstream-plus-context-change interventions. The most effective interventions however, are Upstream interventions, where something in the performance environment is being changed (Verplanken & Wood, 2006). The latter one is also recognized by Jager, who points out that removal of a stimulus, might stop the "script" from being activated. He also identifies that change in the experienced outcome of the behaviour or making the behaviour impossible will break the habit (Jager, 2003). Another approach to breaking habits was proposed by Robertson (1967) in his classification of innovation according to its affect on established patterns. He classified innovations into three categories: continuous, dynamically continuous and discontinuous. Continuous innovations are minor alterations of products, such as fluoride toothpaste, and have the least disrupting influence on established patterns. Dynamically continuous innovations are the creation of a new product or the alteration of an existing, such as an electrical toothbrush, and have more disruptive effect. Discontinuous innovations are establishments of totally new product types, such as the introduction of a new chewing gum, which makes brushing of teeth unnecessary. This will establish totally new habits.

From an interaction design point of view, this classification points out what might already be implicitly understood. The more innovative, or different from the previous, the interaction with a product is, the stronger is its ability to break a habit involving the product. This idea of removing the triggers for the habit is the same as Jager, and Verplanken and Wood identified above. The product, or the way to interact with it, can be among the factors that trigger a habitual behaviour and, because the product is often in the focus of the user, it can in fact be considered as one of the most important factors. In other words, the new product's ability to break old habits will be related to the novelty of the interaction with the product. The opposite should also be true. If the aim is to maintain a habit, a new product should avoid novelty in the interaction.

According to the CADM, the **normative processes** do not affect the behaviour directly, but are affecting both 'intentional processes' and 'habitual processes' (Klöckner & Blöbaum, 2010). Personal norms are stable over time and are representations of one's value system and mediated by social norms (Klöckner & Matthies, 2012). Schwartz (1977), page 274 states that norms affect attitudes as "evaluations of acts in terms of their moral worth to the self". In other words, norms will affect the choice of design strategies by being the criteria the user applies to evaluate whether a given solution is acceptable or not. This can disqualify the strategy, even if it otherwise would be likely to have the desired effect, if it for instance violates the user's value of freedom by forcing certain behaviour. It can also be experienced as a positive reinforcement of a habit, if the user experiences that the behaviour or the outcome of it supports his/her values or norms.

The summary of these observations can be presented as a set of design guidelines (Table 4.1).

Table 4.1. Summary of the guidelines.

| Principle | Rationale | Example |
|---|---|---|
| Situational Influence and Intentional Processes | | |
| The more cognitive workload a user can manage given a product context, the more control the user can be allowed to have over the interaction | Strategies where the user is in control often require more attention because the user has to consciously understand and interpret more. | When designing a car stereo, it may be a good idea to avoid providing the user with too much information or feedback from the system, as the attention should be focused on the driving. |
| The more a person's beliefs, attitudes and intentions are in line with the intended behaviour, the more control of the behaviour can be given to the user. | A user can only be expected to make an effort to do something, if he/she is motivated to do so. | You can only expect a person to buy ecological eggs because of information about animal welfare, if the person thinks animal welfare is important. |
| Habitual Processes | | |
| To create or maintain a habit, the experience of using the product, the interaction with the product and the context around the interaction should be as stable as possible. The user should also be given positive reinforcement as often and as closely related to the behaviour as possible. | If a user gets a positive experience by doing something, and repeats it multiple times under similar conditions, it may become automatic and a habit is created. | If a room is to be refurbished, but it is desirous to maintain that the users unconsciously turns off the light when leaving a room, the experience of turning off the light should be maintained by choosing the same or similar type and position of the light switch. |
| To break a habit, make the user aware of the behaviour and make it less desirous to behave so. The user may become aware of the behaviour by changing the experience, making it more difficult or impossible, or through a completely new way of interacting. The behaviour can become less desirous if positive experience from the behaviour is removed, or negative is added. | To break a habit, the user should be made aware of what he/she is doing and be motivated to change it. | To prevent car use during commuting, free parking at work can be removed, and information can be provided about how much money, time, and/or environment that can be saved by using bikes or busses instead. By removing the free parking, the commuter is made aware of the behaviour. Providing motivation for finding alternative ways of commuting may then change the former habit. |

| Normative Processes | | |
|---|---|---|
| The product, interaction, outcome or behaviour should not violate the user's values or norms. The values and norms can determine what the user finds acceptable, for instance how much control a product may have. | The values and norms determine what a user thinks is right or wrong. If these are violated, the user will probably not accept the design. | A person, who considers it to be a personal right to choose to use a seat belt or not, may not be willing to have a car that forces the driver and all the passengers to use it. Instead of successfully changing the customer's behaviour, he or she will choose another car. |

**Evaluation**

To conduct an evaluation of the initial guidelines, collect feedback of how designers experienced them and inform further development, the guidelines were integrated into the course material for an 7,5 ECTS sustainable design course for 3rd years design students at the institute of product design, NTNU. The course had in previous years had a more traditional life-cycle focus and this was the first year the course had an explicit behaviour change component. A total of 36 students, about half from product design and half from industrial ecology or exchange students, were divided into 8 groups. During the semester, each group should analyse an existing product, investigate the environmental aspects of it, and propose a redesign. The products chosen by the groups were; mouth wash, toothbrush, thermo cups, diapers, razors, and bathroom cleaning product. In addition to the traditional focus on materials properties, recyclability, product life time, etc. the students were obliged to also consider the behavioural aspects of the products, using the guidelines.

The result of this first exposure of the guidelines to design students was the identification of a substantial improvement potential of the guide. Generally the students found the idea of designing products in such a way that interaction with them result in reduction of environmental impact both exciting and challenging. It was obvious that the students needed guidance to support their understanding of when different types of design principles were likely to result in the desired behaviour. At the same time, both the feedback from the students and the results of their projects illustrate the shortcomings of how the guidelines attempt to provide the students with this information. The guidance should be presented in an easier to understand, more visual and more intriguing way, to ease the integration into design projects. Although the principle of behaviour changes was considered inspiring, the students found it difficult to apply in practice in their projects. As a consequence of the relatively demanding, uninspiring and "dry" way the initial version of the guidelines, the behavioural aspects of the design projects received less attention both in the project, report and final redesigns, than could be expected.

#### 4.1.1.2. TOOL 1 - 2ND ITERATION – IMPROVING THE GUIDELINES

Chapter 4.1.1.2. is adapted from the original text in Zachrisson and Boks, 2011; Obtrusiveness and design for sustainable behaviour, presented at Consumer 11 in Bonn, Germany.

One of the main developments of the guidelines between the first and the second iterations, was that they were somewhat expanded by the introduction of obtrusiveness, as another dimension than the distribution of control. The notion of considering the obtrusiveness of design solutions is not novel. Understanding and controlling the amount of attention a product or feature demands from the user has been a topic of inquiry the last decades (Horvitz, et al., 1999; Matthews, et al., 2004; McCrickard, et al., 2003; McCrickard & Chewar, 2003). Some of this research has been directed towards reducing the obtrusiveness to make a design easily acceptable or fitting for particular situations (Hansson & Ljungstrand, 2000; Hansson, et al., 2001; Weiser & Brown, 1996). Others have aimed at understanding how variations in obtrusiveness may be appropriate according to the situation. DS McCrickard et al. (2003) identify that when designing alerts in a computer system, there are often three conflicting design objectives; "interruption to primary tasks, reaction to specific notifications, and comprehension of information over time". They point out that "there should be a balance between attention and utility (McCrickard et al., 2003). McCrickard and Chewar (2003) present a framework for this "attention-utility trade-off". This framework is illustrated by a cube with interruption, reaction and comprehension as the three dimensions (see Figure 4.4) and can be used as a tool to analyse the obtrusiveness of an alert. Where in this framework the appropriate alert should be positioned, depends on the urgency, importance and type of information that is to be conveyed. The way information is presented affects how it will be adopted (Roberts & Baker, 2003). Fischer (2008) explains this by the understanding that "the information needs to capture attention and be understood before it can become effective".

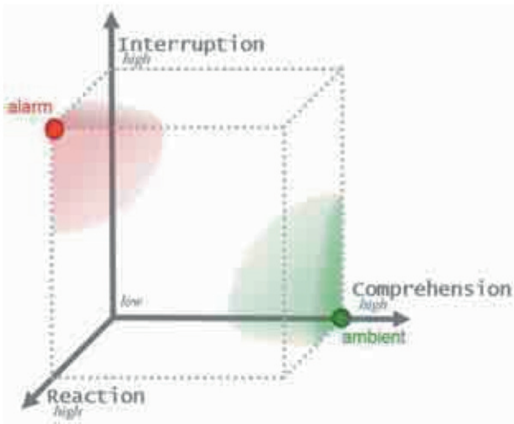



Figure 4.4. Attention-utility trade-off (McCrickard & Chewar, 2003). A three dimensional space created by the axis: Interruption, Comprehension and Reaction.

Matthews et al. (2004) also recognize the need for determining how much attention a design should require. They describe variation in the notification level where "notification levels represent relative information importance" (page 247). The more important a stimulus, the more attention it should consume" (Matthews et al., 2004). They define five notification levels; "ignore, change blind, make aware, interrupt, and demand action". These represent a scale, from notifications that should demand no attention to notifications that demands attention and requires that the user performs an action to stop the alert. Also McCrickard and Chewar (2003)) point out that urgent, important information should be presented in a way that immediately draws the users attention.

Drawing the attention of the user is also a key feature of one of the most promising strategies to break habits, identified by social psychology. “A vital ingredient for changing habits is to ‘unfreeze’ existing behaviour to raise the behaviour from the level of practical to discursive consciousness” (Jackson, 2005b, page XI). By changing something in the situation around the habitual behaviour, the person may become aware of the behaviour and thus the habit may be broken (Jager, 2003; Verplanken & Wood, 2006). For this to be effective it is important to focus the attention of the user to the situational cues, to avoid the habits from blocking the attention (Klöckner & Matthies, 2004). “Attention- grasping facilities are likely to cause behavioural changes that should be stable and observable over a longer period of time” (Holland, et al., 2006, page 778). However, obtrusive designs may also have negative effects on the user and be harder to accept. Users may experience intrusive interference as both annoying and distracting (Pettersen, 2009). In an experiment aiming at making students conserve water and energy by placing informational signs in university showers, Aronson and O'Leary (1982) found that “making the signs more obtrusive increased compliance but also increased resentment” (page 219).

The potential of controlling the attention of the user has also been identified as a dimension of which strategies for behaviour change may be distributed. In 2006, Jelsma presented a paper describing different properties of a script. He defines a script as “a material structure that, by its specific layout, exerts force on the actions of its user” (Jelsma, 2006, page 223). One of the properties he identifies is the “force” of the script, which he describes as “restricting the opportunities for undesired use, or strengthening the stimuli for desired use” (Jelsma, 2006, page 223). By varying the strength of the Obtrusiveness and design for sustainable behaviour stimuli, the product may require more or less attention from the user and thus have various degrees of obtrusiveness.

A shift from a one-dimensional distribution of strategies to a two dimensional space may prove to have a number of advantages. First of all, it will enable a higher granularity of the design strategies by adding an additional property, by which the strategies may be identified. This may enable a distinction between different strategies, which would not be possible on a one-dimensional distribution. This will not only open up for more precise identification of the strategies, but also potentially enable a more precise recommendation of strategies for a given situation. Secondly, the additional dimension describes properties of the strategies that were not identified by the first dimension. This additional property enables a more precise understanding of how the various strategies may affect the behaviour of the user and thus contribute to a better chance for achieving the intended behaviour change. The literature review of the effects variations in obtrusiveness may have on the user, can be summarised as following:

• The higher the importance or urgency, the more obtrusive the strategy may be.

• Habits may be broken by making the person aware of the habitual behaviour. For a strategy to achieve this, it should be obtrusive enough to gain the attention of the user.

• The more obtrusive a strategy is, the grater is the chance that it will be experienced as annoying or distracting by the user.

This second part of chapter 4.1.1.2. is adapted from the original text in Zachrisson et al. 2011; Using a guide to select design strategies for behaviour change; Theory vs. Practice, presented at EcoDesign 2011 in Kyoto, Japan.

The feedback and experience from the first iteration initiated further development of the guidelines. The guidelines were presented in a shorter, more concise format and accompanied by graphs, illustrating the guidelines (see Figure 4.5). However, the understanding of the potential and implications of including obtrusiveness was not fully developed before the new format of the guidelines were tested. In this iteration, obtrusiveness is thus included more as a supporting aspect than an equal dimension with the distribution of control.

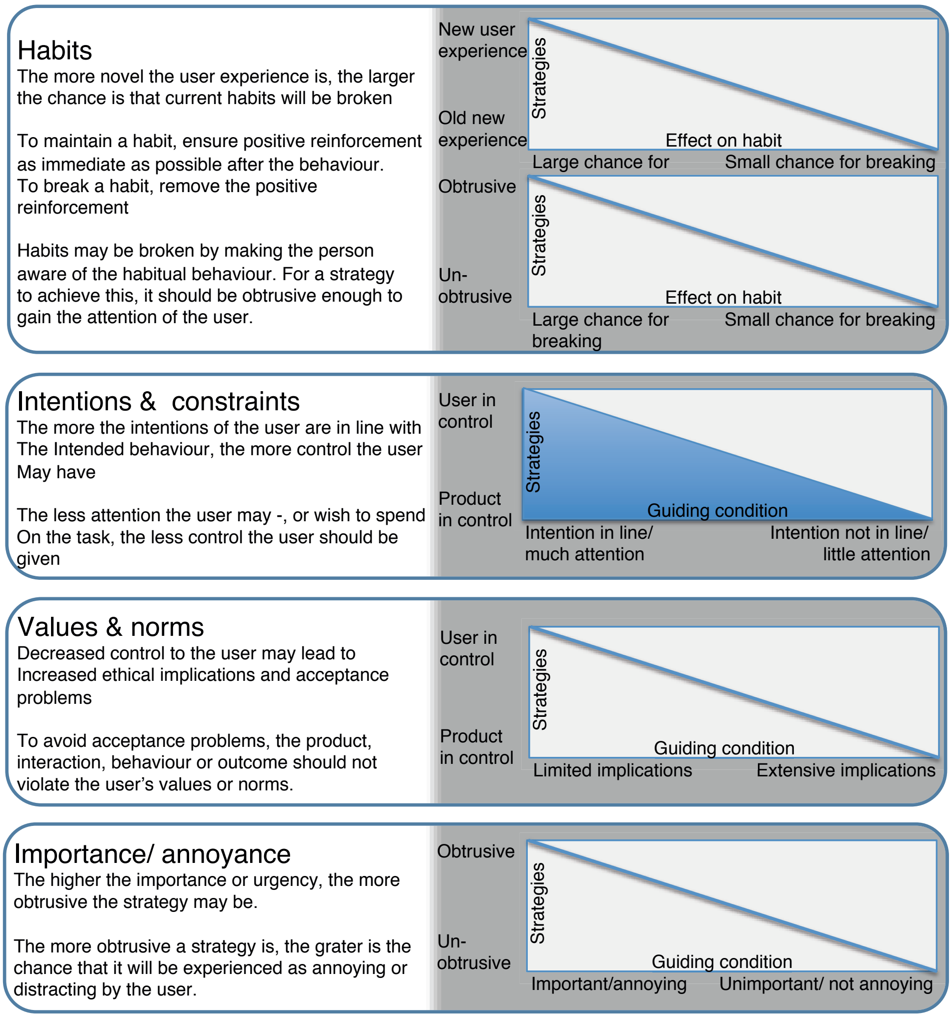



Figure 4.5. Guidelines with illustrating graphs.

**Evaluation**

The 2nd iteration of the guidelines were applied in a graduation project by a master student at the Institute of Product Design, NTNU in collaboration with Philips Research in Eindhoven, The Netherlands. The topic of the project was sustainable behaviour in the context of oral health care. In this project the oral health care practices of a target group of Norwegian or Dutch citizens within the age of 25-35 and 50-65 was investigated by using a combination of several user-centred-design research methods: interview, observation, video recording, cultural probing, survey, generative sessions and a blog analysis. This resulted in a rich base of information concerning how the oral health care was conducted and the various factors that affected this behaviour. Structuring and analysis of the data could then be used as the input for the guidelines and should enable the identification of the type of design principles that would be most likely to have the intended effect. The scope of the project made it suitable to evaluate the structure of the guide, as it included an extensive user research and aimed to translate this into behaviour changing design solutions.

The exercise of structuring the data and applying the guidelines identified a number of problematic aspects of the guidelines although it also provided valuable support during the project. Early in the project, it became apparent that it was unclear where in the process of designing for behaviour change, the guidelines were supposed to be applied. This became particularly clear when preparations were made for a creative workshop to generate ideas for design solutions. Either, the guide could be used to limit the selection of possible design strategies before generating ideas, or it could be used to evaluate the ideas and identify their potential after they had been generated. The advantage of limiting the solution space before generating ideas could be to have a more focused idea generation process and avoid a lot of time and energy being spent on ideas that easily could have been dismissed beforehand. On the other hand, such a narrowing of the solution space could exclude the potential of promising concepts being inspired by ideas that originally were unsuitable. In this project, the guide was primarily used to evaluate the ideas after the workshop. However, the overview of the different factors that may affect behaviour was used as a checklist during the user studies and preparation of the workshop, to make sure that all the factors had been investigated. This may perhaps also be a third way of using the guide, which might prove to be valuable also in future versions. To ease the use of the guide, there is a need to explain where it is intended to be used in a design process.

The behavioural factors identified by social psychology can be difficult to grasp for designers within the limited time they normally have at their disposal. One of the primary reasons for this is probably the level of detail and distinction between different concepts that are unfamiliar for designers. For instance, it cannot be expected that designers are familiar with the difference between the different forms of habits: schemata, heuristics and associations. Such distinctions may be unnecessarily complicated, as the guide also does not distinguish between the different types. Rather than trying to distinguish between attitude, beliefs and intentions, it might be sufficient to figure out the intentional factors, or "what the user wants". After all, the factors are connected in a hierarchical structure where intentions are affected by attitudes, which again are affected by beliefs (Klöckner, 2010). It might, however, be useful to distinguish between these three when analysing how a particular intention may be changed. By understanding the hierarchical relation, one can affect intention by addressing the underlying attitude, and similarly affecting attitudes by addressing beliefs. A simple explanation of these relations should be included in the guide.

In addition to experiencing difficulties with structuring the information according to all the individual factors identified by the CADM, the format of the recommendations given by the guide was experienced as unclear and a bit hard to grasp. In particular the illustrations were not clear and should be presented in a simpler manner.

As the guidelines identify promising design strategies according to specific information about the user or the context, the recommendations will vary depending on the target group and which factors one identifies as the steering once. There may be variation in which part of the behaviour it is relevant to address and which factors affect the behaviour the most. The designer will have to select the most important ones and use these as the input to the guide.

Also, in some cases the suggestions by the guidelines may be in conflict. This can be illustrated by a case from the project. A group of users was characterized by their value of having to control the world around them. According to the guide, this indicates that the designer should strive to find solutions where the user is in control. However, within this group a number of users believed that they should rinse their mouth thoroughly with water after brushing their teeth, to improve the oral healthcare. This is a misconception, as it actually is desirable to leave the remains of the toothpaste in the mouth to gain maximum benefit from the fluoride. As the user therefore wants to do the opposite of the desirable behaviour, the guide suggests design principles where the user does not have much control. The two suggestions from the guide are in conflict as the designer is recommended to make sure the user is in control, and take away the control of the user.

To ensure that it is clear which part of the process of designing a behaviour change the guidelines are meant to address, an overview over a design process with the relevant areas highlighted could be accompanying the guidelines. To cope with the challenges related to the understanding for the behavioural factors, it could be possible to maintain the distinctions of the CADM, but only consider the factor categories instead of the individual factors. There is however a potential challenge with reducing the number of factors, as valuable nuances between the factors might be lost. The understanding can also be improved by adjusting the names of the factors. This might be achieved by using more everyday language and possibly substitute single words with short, descriptive sentences. It is crucial that the designer feels comfortable with the terminology, all while it is important to maintain the distinctions and the precision of the original terms.

#### 4.1.1.3. TOOL 1 - 3RD ITERATION – PRINCIPLES OF BEHAVIOUR CHANGE

Chapter 4.1.1.3. is adapted from the original text in Daae and Boks, 2013; From teaching sustainable product design to teaching sustainable behaviour design, presented at Cumulus 2013, Oslo, Norway.

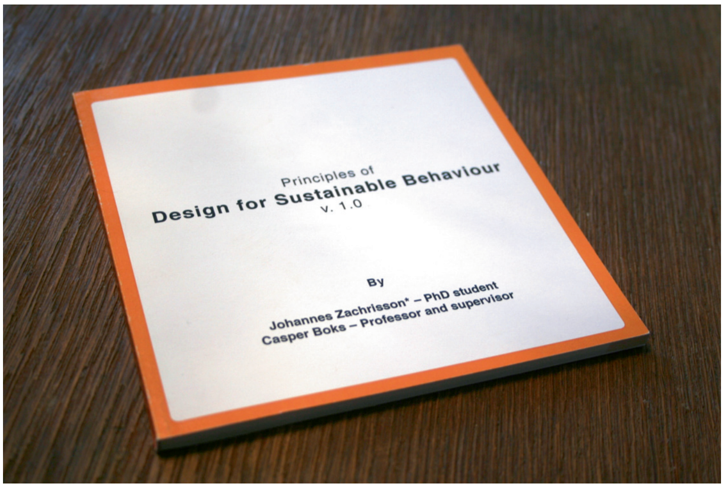



Figure 4.6. The Principles of Behaviour Change Booklet.

The need for additional support, both in understanding when in the design process, how the guidelines should be applied in a design project and better explanation of the guide itself, and of simplified language, resulted in the development of a booklet; Principles of Behaviour Change. In addition to simplify application of the guidelines in design projects, the booklet was developed as teaching material for the eco-design course at NTNU, the spring of 2012. The booklet is structured around a proposed design process (see Figure 4.7), where each step of the process is described in a separate chapter. Previous versions of the design processes had been developed earlier (Zachrisson & Boks, 2011b; Zachrisson, et al., 2011), and the version included in the booklet represented the essence of these.

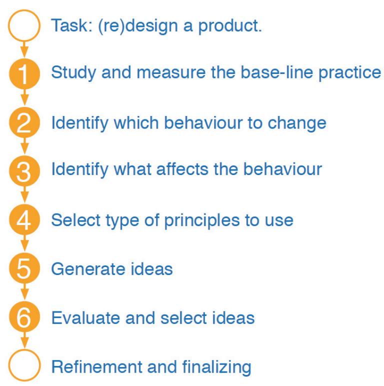



Figure 4.7. The design process of Principles of Behaviour Change.

Although the figure illustrates a linear process, the sequence, number of iterations, or even in- or exclusion of steps may depend on the project and the preferences of the designer. A summary of the steps proposed in the booklet are as follows:

**Step 1: study and measure the base-line practice**

This step explains how to choose the right methods to gather the most relevant information for a specific project, and why that is an important decision. There are numerous different methods and tools to gather information about the user and the usage situation, and which tools are most suitable for a particular project depends on a number of factors, such as the time and resources available, the competence available in the team, the accessibility of the target group, the goal of the research, etc. Although methods useful for a DFSB oriented project are similar to those commonly used in 'regular' user-centred design projects, the methods described in the booklet require some specific information about what goes on in the mind of the user, what goes on around the user and what the user actually does, which is described in more detail in steps 2 and 3. There may also be things the user does or that affect behaviour, which the user is unaware of. To investigate this it is necessary to combine methods or use methods that investigate both aspects, such as applied ethnography or contextual enquiry. This step also highlights the importance of researching previous, similar studies, as user research can be expensive and time consuming.

**Step 2: identify which behaviour is to be changed**

Once the information about the user and the context has been gathered, one needs to determine which behaviours to change or maintain. As the goal is to use design to reduce avoidable environmental consequences related to behaviour, it is valuable to identify those behaviours that both cause significant environmental impact and are possible to affect through design. The larger the potential impact reduction and the easier it is to affect it through design, the easier it will be to achieve environmental benefit. A natural starting point can be to identify the behaviours that have the largest total impact on the environment. Ideally this should be quantified, for instance through multiplying the energy consumption caused by the behaviour with the duration of the consumption. If quantification is problematic, it may be possible to consider the effects relative to each other more qualitatively. The interesting element is to identify how much energy could be saved with a different behaviour, while still achieving the goal. It is important to consider the entire practice, as there might be low hanging fruit also outside the core behaviour. If it has been possible to calculate the actual impact of the behaviours, this information can be used after the project to estimate the achieved improvements and thereby the successfulness of the behaviour changes.

**Step 3: identify what affects the behaviour**

When trying to change the behaviour of people and how they use products, it is necessary to realise that behaviour can be affected by a number of different factors and often a combination of several factors. The information gathered during the user studies can be analysed to identify the most important factors for your target group, by identifying the main reasons for why they behave the way they do. One way of understanding and structuring the factors is by dividing them into four different groups:

- What the user wants: What does the user intend to do? What does the user believe are the consequences of the behaviour? What is the attitude of the user towards these consequences? For instance the environmental impact, the effect is has on other people, the cost, etc.

- The influence of the surroundings: Which constraints are caused by the context around the use of the product? Do the surroundings make certain behaviours easier or more difficult to do? Does the product itself direct the user towards certain behaviour? Are there elements in the surroundings that affect the behaviour of the user and the interaction with the product?

- The habits: Are there things the user does without necessarily being aware of it? These can either be simple, stand-alone actions or routines consisting of sequences of several actions.

- What the user thinks is right or wrong: Which values does the user have, and which ones are most important? What does the user think is morally right or wrong to do? Is the user affected by any cultural or community values that may prescribe or forbid certain behaviours? This structure will form the basis for the selection of design principles in step 4.

The factors in these four groups may all affect the behaviour of the user in different ways and may be of importance for how a product should be designed in order to realise the affect that the designer is striving for. It is also possible that the users will have to be divided into groups according to which factors are most important for them or differences in the factors, such as different attitudes towards the consequences. The booklet suggests that one way of doing this can be by making personas representing the different user groups. Though there are other ways to do this, using personas is explicitly suggested, as they are relatively common.

**Step 4: select type of principles to use**

In this fourth step it is explained how there are numerous design principles that are directed towards behaviour change, but that some design principles likely will work better for certain users and in certain situations, than for/in others. To identify which principles may be more likely than others to be successful in a specific project, this section of the booklet includes a guide intended to help identify the most promising types of design principles according to the result of the analysis in step 3. For this it makes use of a landscape that allows sorting design principles based on two parameters: the degree of control that a product allows the user to have over his or her behaviour, and degree of subtlety or obtrusiveness that is designed into the solution (Figure 4.8).


Figure 4.8. The landscape of Obtrusiveness and Control

The guide continues with an elaborate discussion on which level of control and obtrusiveness may be appropriate based on the results of the analysis in step 3. It uses simple diagrams to illustrate how this choice can be made (Figure 4.9).

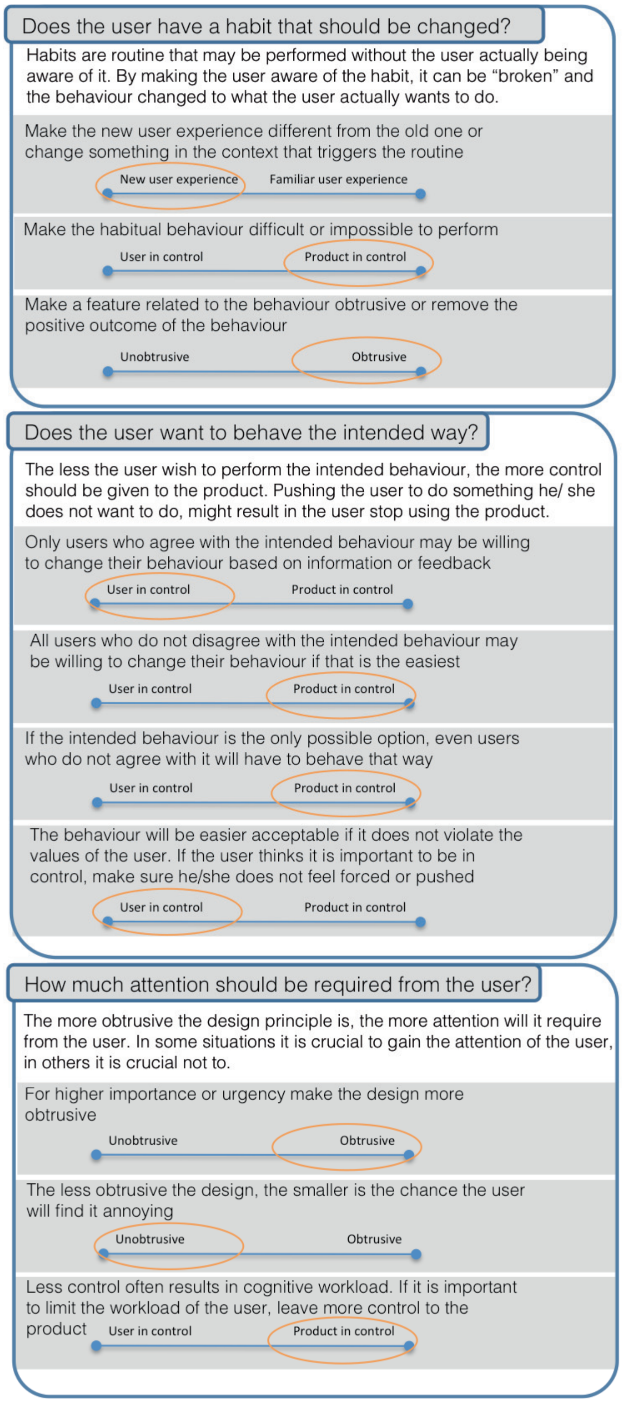



Figure 4.9. Illustration of the guidelines in Principles of Behaviour Change.

Once the designer has decided which principles to use, the same control- obtrusiveness landscape as depicted in Figure 4.8 can be used to summarise the results, in order to get an overview, communicate them and include them in the design process. Figure 4.10 shows how, based on user research done in previous steps, it can be visualised what solutions on a certain part of the landscape may be most appropriate for affecting the behaviour of the identified personas.

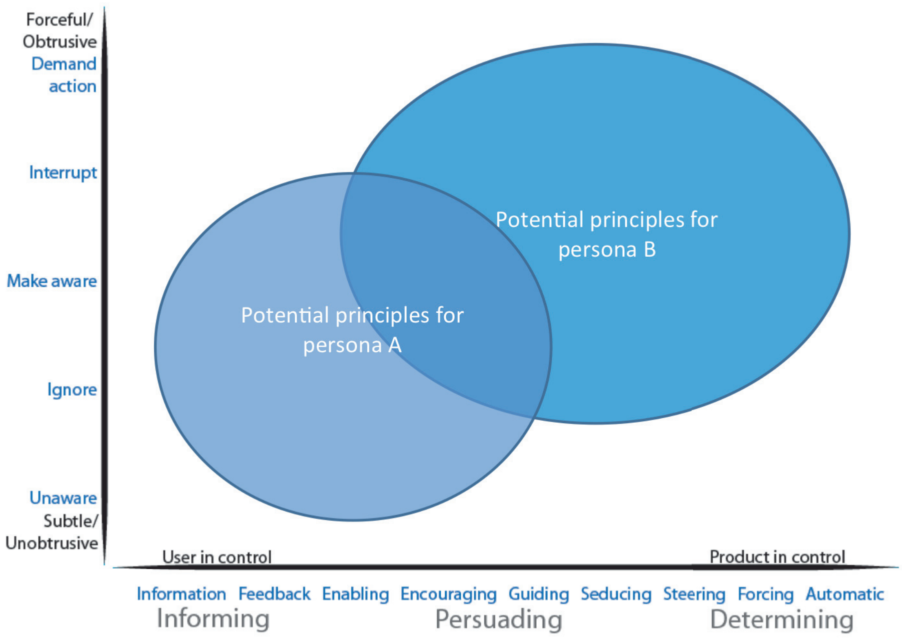



Figure 4.10. Example of application of the guidelines on the landscape.

**Step 5: generate ideas**

Once the requirements for the new design have been identified, idea generation follows. This creative problem solving step is basically the same as in any other design process; commonly used methods include brainstorming, creative workshops, Forced Functions, etc. The purpose is to figure out how the product could be designed to fulfil all requirements, both regarding behaviour change and other requirements the design project might have such as price, durability, aesthetics, ergonomics etc. Whether the idea generation should focus on the identified areas in the landscape, allowing for a focused idea generation process, or whether a more general idea generation process should be the basis for selecting appropriate ideas that fit to the identified areas, is left up to the preferences of the individual designer.

**Step 6: evaluate and select ideas**

After ideas have been generated, it is often a challenge to evaluate the ideas in a structured way and actually identify which ideas are most promising. In a regular design project, this is often solved by assessing how ideas will fulfil a list of requirements, typically formulated as 'musts, shoulds and coulds'. The same can be done regarding the requirements derived from the desired behaviour change, but to ensure that the ideas actually solve the original challenges it might be useful to evaluate based on the personas and the guide, rather than merely the requirements or design dilemmas derived from these. Once the most promising ideas have been selected a regular user centred design process can be followed, which usually includes concept development, prototype building, user testing and final detailing. The booklet explains how designers should be aware that it can be problematic to test whether changes in behaviour are actually accomplished in a traditional user test and might require more longitudinal testing outside a laboratory context.

**Evaluation**

Similar to the first iteration, the 3rd iteration of the tool was also applied in the teaching of the sustainable design course at NTNU. However, instead of being a minor aspect that should be considered in addition to all the more traditional sustainable design aspects, as had been the case in 2011, DfSB became the core of the course and the traditional sustainable design aspects received substantially less attention in 2012. The structure of the lectures, assignments and interim reports was aligned with the structure of the booklet, and ensured a correspondence between the information the students were given, what they were doing and what they were delivering. This, not only made it natural for the students to follow the suggested design process from the booklet, but also enabled us to guide the different steps and ensure that the students maintained the desired behavioural focus. The formal properties of the course were the same as they had been in 2011. This time there were 35 students divided into the 8 groups, half from product design and half exchange students or from industrial ecology. The topics the student chose to work on this time were, dishwashing, laundry, disposal of special waste in homes, food waste and energy consumption while sleeping.

From a teaching and result perspective, this approach to introducing DfSB was a success. All the groups had a distinct behavioural focus, the user studies were both better informed and conduced, all the groups clearly acquired a broader perspective, both in terms of stakeholders to analyse, and in terms of solutions considered. The end results the groups produced focused on behaviour change and almost all included discussion of how and why the solution would lead to the desired behaviour change. Some of the groups even built mock-ups and were able to test their solution and "measure" the behaviour change. Never the less, the experience from the students also pointed out a number of aspects of the tool that would benefit from further revision. First and foremost, the booklet turned out to be too extensive and detailed for the students. It contained too much text, appeared too strict and dictating and the students did not experience it as sufficiently inspiring. A promising approach might be to include more dimensions than obtrusiveness and control, which could provide additional insight from more perspectives and allow the designers to chose the ones they feel are relevant for each particular project.

#### 4.1.1.4. TOOL 1 - 4TH ITERATION – WORKSHOP AT PERSUASIVE 2012

Shortly after the conclusion of the sustainable design course where the 3rd iteration of the tool had been applied, the opportunity arose to arrange a one and a half hour workshop at the Persuasive Technology conference in Linköping, Sweden. The workshop was considered a promising opportunity to get feedback from designers and researchers who had more experience with behaviour change through design, although less product design focus, than the students at NTNU. 15 participants at the conference joined the workshop and were divided into four groups. As the topic of the conference focused on behaviour change on digital media, a brief presentation was given as an introduction to the topic of DfSB and a number of examples of how to achieve behaviour change through physical design. The last part of this presentation introduced the challenge of how to design a wood stove, to make people burn firewood in the most sustainable way and a summary of what a desired behaviour would include. A brief presentation was also given of three different personas, which differed both in the way they use their wood stove, their interest in burning firewood and their general environmental focus. Each of the groups were then given a print-out of the description of the personas, some paper and markers, and given the following challenge; "How would you, based on your experience, describe the types of principles that could be expected to affect these personas, and the types that cannot".

After 15 minutes, the groups gave a brief summary of their conclusions to the rest of the participants and there was a brief discussion about the challenge. A second presentation was then given, explaining the landscape of obtrusiveness and control (Figure 4.8), a revised version of the guidelines (Figure 4.11) and how these could be combined to identify the most promising type of design principles for each persona, similar to the description in the Principles of Behaviour Change booklet.

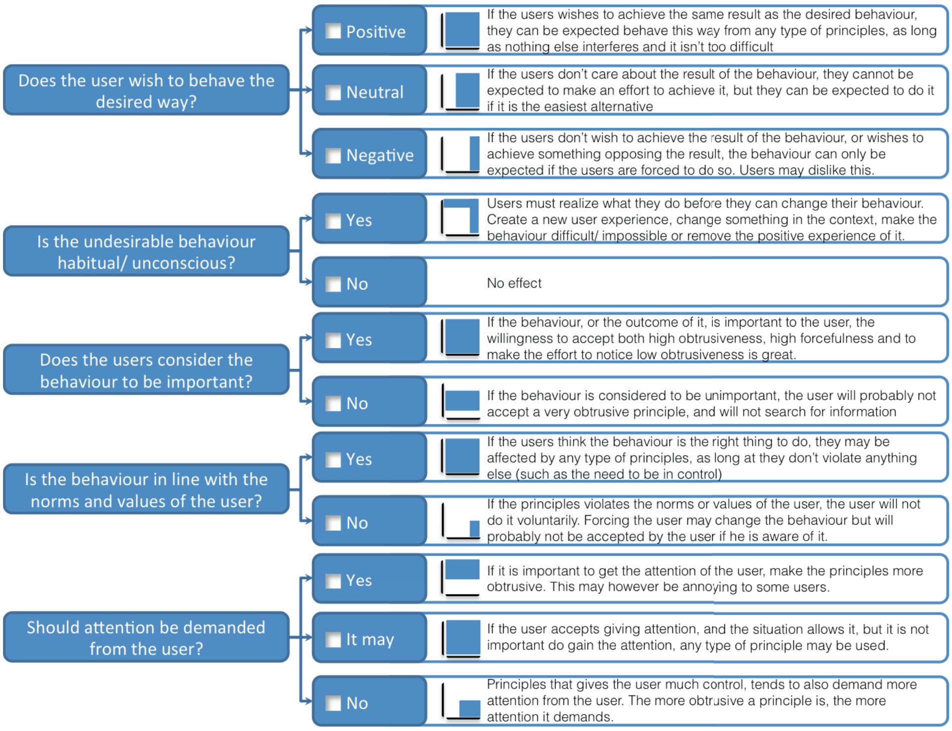



Figure 4.11. Guidelines for the landscape.

Each group was given a print out of the landscape, guidelines and some "empty" landscapes, consisting only of the axis for obtrusiveness and control and without the examples. The groups were then asked to use the guide to select the type of principles they believe would make each of the personas behave the desired way. After another 15 minutes, there was a new round of presentation and discussion about the guide and the experience of working with it.

The conclusion from the results and discussions was that the landscape provided a valuable support in considering different types of principles. The guidelines were also valuable, although some of the participants felt they were too rigid and preferred to read through them and then work on the landscape, rather than combine the guide and the landscape directly. It was also both reported and observed that in the second session, where the participants had the guide, the discussions were much more focused on the challenge than they had been in the first session. An important comment from one of the groups, which found support among the rest of the participants, was that it might be just as important to identify the areas that are unlikely to result in the desired behaviour change as the ones that are likely to do so.

### 4.1.1.5. TOOL 1 - 5TH ITERATION – WORKSHOP AT STANFORD 2013

After the 3rd and 4th iteration of the tool, the repeated usability issues made it apparent that it would be beneficial to make more fundamental changes to the tool than what had been done so far. It was thus decided to focus the efforts on creating a new tool based on the experience from the first tool (Chapters 4.1.1.1 – 4.1.1.4), rather than to continue the fine-tuning of the first tool. However, to enable comparison, a study was designed including both tools (described in Chapter 4.1.2.3) and a "final" version of Principles of Behaviour Change was needed. As preparation for this workshop the experience from the 4th iteration was used to inform the development of a 5th version, aiming at being self explanatory and suitable for use in a workshop. To reach this aim, the examples positioned in the landscape needed some explanatory text to ensure it was clear how the examples represented their respective part of the landscape (Figure 4.1.2).


Figure 4.12. The landscape of control and obtrusiveness, with examples and explanations.

Further, the guidelines for the landscape were updated with indications for the types of principles that cannot be expected to be acceptable, in addition to the recommendations, as was suggested in the evaluation of the 4th iteration (Chapter 4.1.1.4). The evaluation of this tool is described in Chapter 4.1.2.3.

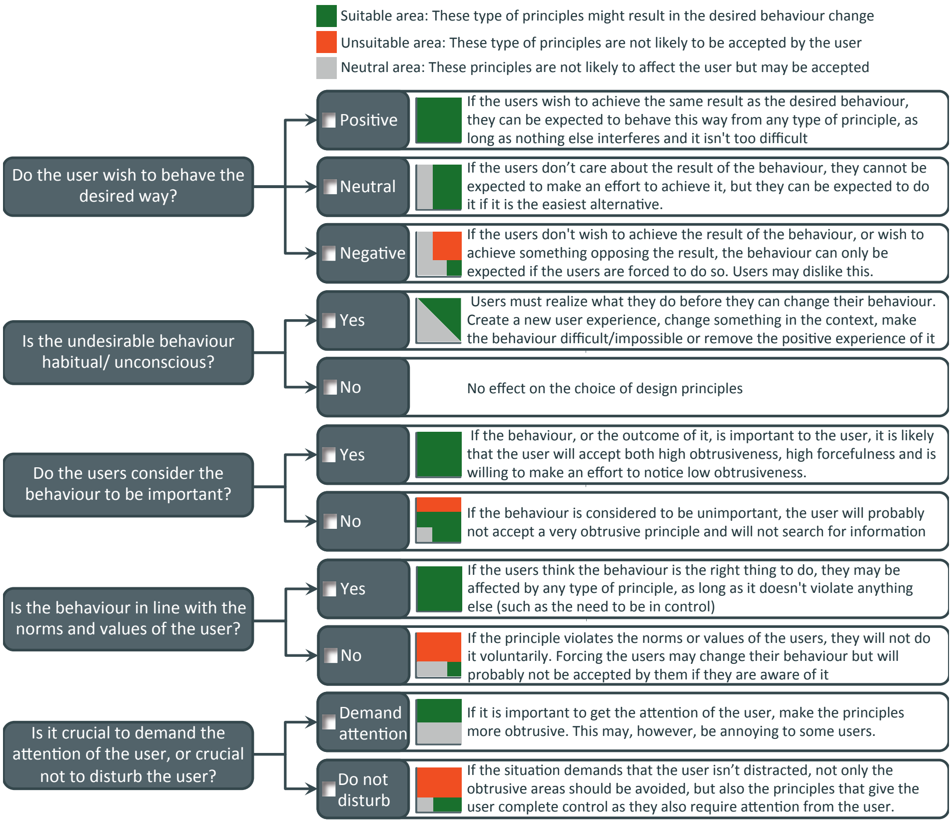



Figure 4.13. Updated guidelines.

And finally, as the previous iterations had showed that it could be useful with guidance on how the landscape and guidelines could be used in a design process, but with as limited text as possible; a guide was created (Figure 4.1.4) combining short instructions and illustrations. This was based on a poster explaining the suggested design process that had been presented at a conference a few months earlier (Part II, Poster 2).

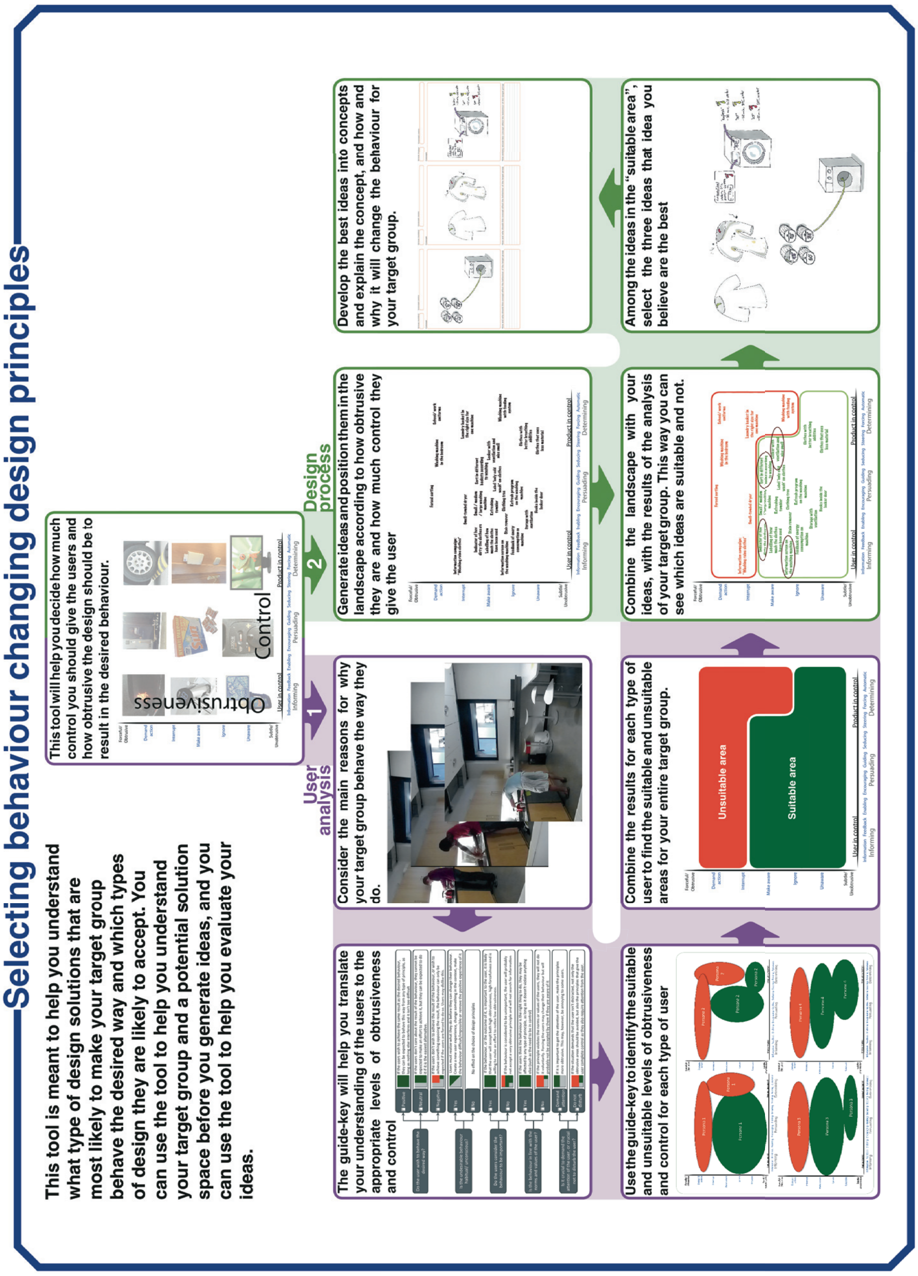



Figure 4.14. Guide to Principles of Behaviour Change.

(As previously mentioned, the evaluation of this iteration is described in Chapter 4.1.2.3)

### 4.1.2. TOOL 2 - DIMENSIONS OF BEHAVIOUR CHANGE (DBC)

Chapters 4.1.2 – 4.1.2.4. is adapted from the original text in Daae & Boks, *Dimensions of behaviour change*, JDR, 2013.

The testing and evaluation of the Principles of Behaviour Change tool resulted in evolvement and improvement of the tool, but also identified a number of more fundamental alterations that could improve both the usability and support value of the tool. The most important are the repeated dismay caused by the rigidity and lack of inspiration from using the tool, and the potential value of considering more aspects of how the behaviour of users is affected by the design or products. As a consequence, it was determined to create a new tool, still building upon the content and insight from the previous tool, but rethinking both the format and the approach of the tool. To structure the development of the new tool, a formal list of requirements was created, based on a literature review and experience from the previous tool (Chapter 2.1.3.1). To increase the variation of perspectives for how design can affect the behaviour of the user, an investigation was undertaken to identify relevant dimensions the design could be adjusted along.

#### 4.1.2.1. IDENTIFICATION OF DIMENSIONS - METHOD

In the literature, a number of dimensions, among them the distribution of control and obtrusiveness that formed the basis for the previous tool, were identified (Chapter 2.1.1). However, according to the information provided in the literature, the proposed dimensions are motivated by the understanding and intuition of the researchers. To inform a more elaborate discussion on the identification and relevance of dimensions and how to utilise them, we chose to gather empirical data through a hybrid of creative workshops and expert interviews. Expert interviews are frequently applied in empirical research and can contribute to theoretical reflection and practical aid (Bogner, et al., 2009). The purpose of combining this with the setting of a creative workshop was to let the participants think more freely and creatively around the topic. This was believed to be relevant as it was assumed that the participants might not have thought explicitly about topic before, even if they were assumed to have substantial understanding of it. As experts, we chose design practitioners, professionally employed at different design agencies and companies located in Oslo and Trondheim. Our empirical data was collected during a pilot test and four workshops that lasted for about two hours and had between 2 and 6 participants (see Table 4.2). All participants held a master's degree in industrial design and work with product and interface design on a daily basis.

Table 4.2. Companies included in "the Dimension Workshops".

| | No. of participants | Type of company | Company size |
|---|---|---|---|
| Workshop 1 | 6 | 3 different companies | All of them are large |
| Workshop 2 | 3 | Communication technology manufacturer | Large |
| Workshop 3 | 4 | Design agency | Small |
| Workshop 4 | 2 | Design agency | Small |
| Workshop 5 | 5 | Design agency | Medium |

This method allowed us to investigate which dimensions design practitioners themselves consider relevant. Although most designers may not explicitly have considered the question before in the context of designing for sustainable behaviour, experienced designers can be expected to have an extensive, implicit understanding of how to affect user behaviour as they design user interfaces. By comparing the dimensions identified through this approach with the ones found in literature, a broader understanding of the problem can be achieved. Similarities between the two sets may be understood as a support for the validity of the sets, whereas differences may raise questions about the validity and the reasons for the differences, but can also indicate novel contributions.

The primary purpose of the workshops was to investigate which dimensions the design practitioners considered relevant to understand how a design affects the behaviour of its users. In other words, it was our aim to uncover as many dimensions as possible along which a designer can manoeuvre when designing a product aimed at changing behaviour. It was not our intention to research which dimensions would be useful more often than others, as that is considered to be depending on the context of the design problem. It was assumed that designers often implicitly or explicitly use product semantics or inscribe scripts in their designs, to make people use them in a particular way; however, designers might not include this explicitly in their design processes. The challenge would therefore be to make the designers reflect upon their understanding from a common starting point without providing too much information that might bias the results. At the same time, the pilot test (workshop 1) made clear that it was necessary to provide the designers with considerable guidance to understand the challenge, get them started and generate meaningful reflections.

To give the participants an introduction into the topic and a common starting point, each workshop started off with a presentation, consisting of the following steps:

1. Introduction of the potential for environmental benefit from alteration of how people interact with products.

2. Presentation of a large number of pictures of products that can affect the behaviour of users, with an explanation of how these could represent different principles for affecting behaviour.

3. An explanation of the need to distinguish between principles, and to facilitate the process of matching the choice of principles with the intended behaviour change.

4. A suggestion that one way of distinguishing between different principles is to consider how they affect the user, for example according to how much they allow the user to determine their behaviour themselves. We used a large number of illustrations to clarify this to the workshop participants.

5. The designers were challenged to suggest which other dimensions, according to their own experience, could be identified to distinguish (i.e. understand the difference) between principles that can be expected to lead to behaviour change. They were asked to individually write the suggestions on post-its and try to formulate them as word-pairs on opposite sides of a scale. We chose to let the participants consider the principles in terms of dimensions with opposite extremes, to keep the results in a similar structure compared to the previous proposals in the literature. To support the process, a number of picture pairs were shown and it was suggested that they could compare them, as exemplified before, to get started. When the initial rate of writing on the post-its declined, the picture pairs were replaced by a collection of 63 different pictures of products that might affect the behaviour of the users in order to provide additional examples and provide new inspiration.

6. When the designers felt that they had exhausted the most obvious dimensions, after 15-30 minutes, the post-it writing process was stopped. The designers were then asked to explain their suggested dimensions to the rest of the group and the facilitator posted the post-its on a wall. During this process, the overlapping dimensions were clustered and the overall variation of dimensions was discussed. Each designer was then given five stickers, and was asked to attach them to the dimensions they thought were the most intuitive and important to determine when different principles could be expected to change behaviour or be accepted.

7. The last part of the workshop consisted of a discussion about how the understanding of behaviour change through design, how the dimensions should be presented to support designers in their work and how much guidance they should be given to understand the implications of different principles. One central topic in this discussion was the number of dimensions to include. More dimensions could potentially improve the understanding of when different principles should be used but will also require more effort. To help the designers consider alternative ways in which the information could be presented, they were shown five alternative ways of guiding the selection of principles according to the distribution of control, and the obtrusiveness of the principles.

One alternative consists of simple statements and indication of the recommended area of the dimensions, one presented information about expected consequences of principles from different parts of the landscape in the corresponding areas, one presented a flow diagram, where the reader is guided to recommendations by answering questions about the user and the context, one asked simple questions about the user and the situation, and provides recommendations directly according to the answers and one presented bullet-points of the expected consequences of principles along the two dimensions.

#### 4.1.2.2. IDENTIFICATION OF DIMENSIONS - RESULTS

The pilot showed that the designers needed some guidance to really understand the task at hand and start generating ideas. This might be due to the theoretical nature of the task, something which most of the participants, according to themselves, rarely were confronted with, but also the novel way of thinking. The latter is apparent from the feedback received from the participants after the workshop, where all groups claimed to have enjoyed the different perspectives the topic provided on how users are affected by product design. However, once the participants understood the way of thinking, all the groups generated multiple suggestions to relevant dimensions.

There seems to be a relation between the number of participants in the workshops and the number of dimensions they proposed, as the two workshops with the most participants proposed about twice as many dimensions as the three smaller groups. However, this difference may also be explained by factors such as group dynamics, individual qualities, differences in how they normally work, etc. In all the workshops several dimensions were suggested multiple times by different participants, and was therefore reduced to a single dimension that did not overlap any other dimensions. Table 4.3 shows the number of participants in each workshop and the number of independent dimensions suggested in each workshop.

Table 4.3. Number of participants and dimensions generated.

| | *Workshop 1* | *Workshop 2* | *Workshop 3* | *Workshop 4* | *Workshop 5* |
|---|---|---|---|---|---|
| *Number of participants* | 6 | 3 | 4 | 2 | 5 |
| *Number of dimensions* | 41 | 20 | 19 | 19 | 37 |

Between the different workshops several dimensions were overlapping. After removing the identical ones, the combined outcome of all the workshops was a list of 55 independent dimensions, which may be seen in Table 4.4.

Table 4.4. All dimensions generated during the workshops.

| *No.* | *Dimension* | *No.* | *Dimension* |
|---|---|---|---|
| 1 | User in control vs product in control | 29 | Trendy vs not trendy |
| 2 | Encourage vs impose | 30 | I know I do something vs the worlds knows it |
| 3 | Passive user vs active user | 31 | Environmentally concerned vs not environmentally concerned |
| 4 | Users responsibility vs others responsibility | 32 | Competition vs no competition |
| 5 | Helpful vs annoying | 33 | Fulfilment of dreams vs survival |
| 6 | Obvious vs hidden | 34 | Much info/output vs little info/output |
| 7 | Information vs simplify | 35 | Opposing information |
| 8 | Consequences for me vs for others | 36 | Meaningless vs meaningful |
| 9 | Simple vs complicated | 37 | Polite vs impolite |
| 10 | Emotional vs rational | 38 | Neutral sender vs non-neutral sender |
| 11 | Instructions vs feedback | 39 | Aesthetics vs usability |
| 12 | Fun vs meaningful | 40 | On my way vs far away |
| 13 | Force vs guide | 41 | Opt in vs opt out |
| 14 | Wish vs should | 42 | Correct vs incorrect mental model |
| 15 | Invite vs deter | 43 | Force controlled usage vs punishment |
| 16 | Large consequence vs small consequence | 44 | Open and inviting vs secretive and mysterious |
| 17 | Primary function vs disconnected | 45 | Preventing vs reducing consequences |
| 18 | Rarely vs frequent usage | 46 | Stigmatizing vs elevating |
| 19 | Always vs particular situations | 47 | Reduce usage vs increase usage |
| 20 | Information vs overruling | 48 | Perfect vs improved |
| 21 | Choice vs no choice | 49 | One culture vs another |
| 22 | Long term vs short term consequences | 50 | Social norms vs individual norms |
| 23 | Convince vs demand | 51 | Individual freedom vs greater good |
| 24 | Good vs bad conscience | 52 | Engineering spec. vs usability spec. |
| 25 | Physical vs intellectual consequence | 53 | Dosage vs continuous |
| 26 | User agree vs don't agree | 54 | Central function vs additional function |
| 27 | Reward vs don't reward | 55 | New product vs adjust old product |
| 28 | Easy vs overkill | | |

As is apparent from the number of dimensions identified, the participants were able to consider numerous perspectives on how behaviour may be affected by design. However, identifying the most important ones turned out to be more challenging for the workshop participants. The general response was that they felt the importance of the dimensions depended too much on the designers preferences and the type of product that should be designed, and that it thus was almost impossible to prioritise them from a general perspective. The general response was that it would be good to have a rather wide selection of dimensions and let the designers choose the once they felt were most suitable for their project.

The results of the question regarding how the dimensions should be presented, confirmed the results of the literature review and experiences from the earlier tool. The tool should be easy and quick to understand and implement, support collaboration, be experienced as inspiring, and be flexible and allow the designers to feel that they are in control and apply parts of the tool without having to apply the rest. Several of the designers also mentioned that it would be very valuable if the tool could support the designers not only to design products that are likely to lead to the desired behaviour change, but also support the designers in convincing their clients to accept the proposed design solutions.

After conducting the workshops, it was obvious that the dimensions suggested during the workshops were on several different levels and partly overlapping. Keeping in mind the goal of developing support for aiding designers' understanding of DfSB and how this may aid the selection of suitable design principles, it was necessary to structure the dimensions in a clear and logic way. This was done by the authors in several iterations, striving to achieve as meaningful categorization as possible. A number of challenges were encountered. First of all, no obvious theoretical framework to guide the structuring process was available, leaving room for several approaches, depending on which logic is used to interpret and distinguish between the proposed dimensions. Secondly, one will always run the risk of losing information or nuances in the process of categorizing or structuring. The larger the categories, the more likely it is that important nuances are lost as common elements of multiple dimensions are combined. Finally, proposing the concept of dimensions as a suitable way to present the different ways a product might affect the behaviour of the user posed some challenges in itself. Some of the dimensions suggested a continuous description along a scale, whereas others may be more suitable for a more discrete description, or even represent different logical concepts that are not necessarily opposing. However, the concept of dimensions along a scale between opposing mechanisms was maintained to explore its potential, partly in search of uniformity with dimensions that have become more or less established already (control and obtrusiveness). Efforts were made to maintain the essence of all the dimensions and reduce loss of information as far as possible.

Table 4.5 presents a proposal for how the results of the workshops may be tabulated and structured. In this proposal, the dimensions from the workshops are categorised according to their topic. By considering the effect these different categories may have on the user, all the categories are translated to a comparable format and a set of nine distinguishable dimensions are proposed.

In this process, seven of the 55 originally proposed dimensions were not included in the structuring. These dimensions were excluded because it is unclear how they were meant to affect the behaviour of the user. Four of the dimension categories are to some extent known from existing literature.

Table 4.5. Categorization of the dimensions.

| *Dimensions from the workshops* | *Description of the dimensions* | *Proposed dimensions* |
|---|---|---|
| Choice vs no choice<br>User in control vs product in control<br>Convince vs demand<br>Encourage vs impose<br>Information vs overruling<br>Force vs guide<br>Individual freedom vs greater good<br>Opt in vs opt out<br>On my way vs far away<br>Simple vs complicated<br>Information vs simplify<br>Forced usage vs punishment | Shall the user or the product determine the behaviour?<br><br>Allow the user freedom of choice of action<br>vs.<br>Forcing the user by giving product control | Control (known from literature; e.g. Jelsma, 1997, Lilley et al. 2005, Elias et al. 2007 |
| Passive user vs active user<br>Obvious vs hidden<br>Open and inviting vs secretive and mysterious | How much attention shall the design demand?<br><br>Demand attention or action from the user<br>vs.<br>Use a subtle or obvious approach to reach a goal | Obtrusiveness (known from literature; Zachrisson and Boks, 2011, Tromp et al., 2011) |
| Helpful vs annoying<br>Invite vs deter<br>Polite vs impolite<br>Stigmatising vs elevating<br>Reduce usage vs increase usage<br>Reward vs don't reward<br>Good vs bad conscience<br>Much info/output vs little info/output | Should the desired behaviour be promoted or the undesired discouraged?<br><br>The design leads the user towards the desired behaviour<br>vs.<br>The design leads the user away from the undesired behaviour<br>(Discrete scale) | Encouragement (novel) |
| Fun vs meaningful<br>Emotional vs rational<br>Competition vs no competition<br>Wish vs should | Does the design focus on rational or emotional purpose?<br><br>Motivate the user through fun (hedonic)<br>vs.<br>Motivate the user through meaning (rational) | Meaning (novel) |
| User agree vs don't agree<br>Meaningless vs meaningful<br>Primary function vs disconnected<br>Central function vs additional function<br>Trendy vs not trendy<br>Environmentally concerned vs not concerned | Is the desired behaviour in line or opposing the wishes of the user?<br><br>The user is motivated to perform the behaviour<br>vs.<br>The user is not motivated to perform the behaviour | Direction (known from literature; Jelsma, 1997) |
| I know I do something vs the worlds knows it<br>Social norms vs individual norms<br>Consequences for me vs for others<br>Users responsibility vs others responsibility | Is the user focusing on themselves or others and what others think?<br><br>Play on the user's concerns about himself<br>vs.<br>the user's concerns about others | Empathy (known from literature; mentioned by Tromp et al., 2011) |
| Physical vs intellectual consequence<br>Fulfilment of dreams vs survival<br>Large consequence vs small consequence<br>Neutral sender vs non-neutral sender | How important does the user consider the behaviour to be?<br><br>Make the user feels strong pressure<br>vs<br>Use weak pressure | Importance (novel) |
| Instructions vs feedback<br>Long term vs short term consequences<br>Preventing vs reducing consequences | Should the design target the user before, during or after the interaction?<br><br>The user experiences it now<br>vs.<br>The user experiences it later | Timing (novel) |
| Always vs particular situations<br>Rarely vs frequent usage<br>Dosage vs continuous | How often will the user encounter the design?<br><br>The user is always affected<br>vs.<br>The user is sometimes affected | Exposure (novel) |

| | |
|---|---|
| Easy vs overkill<br>Perfect vs improved<br>One culture vs another<br>Opposing information<br>Engineering spec. vs usability spec.<br>New product vs adjust old product<br>Aesthetics vs usability | Not usable? |

The dimension category Control (corresponds with Force, Distribution and Control), Obtrusiveness (corresponding with Salience) and Direction are reasonably well known from literature, whilst empathy has been touched upon by Tromp et al. (2011) who refer to the consideration of collective versus individual concerns. These four dimension categories represent 25 of the 55 dimensions identified from the workshops. The rest of the dimensions have been categorised in five dimension categories novel to design research, at least in the context of sustainable behaviour change: Encouragement, Meaning, Importance, Timing and Exposure. It should be noted that the categorisation of dimensions is an exercise in progress; further research will be needed to determine if this categorisation is both correct and meaningful.

Interestingly, the dimension Scale, known from literature, cannot be satisfactorily identified from the 55 dimensions derived from the workshops. This may be seen as an indication that the nine proposed dimension categories do not provide an exhaustive picture of all relevant dimensions. However, considering that Scale is described as the level of complexity and does not directly say anything about how the behaviour of the user is affected, its lack of a corresponding dimensions may be a natural consequence of the goal of the workshops: to identify how a product can affect the behaviour of the user, and not to what extent.

At this stage it was not our goal (nor is it likely possible) to arrive at a set of mutually exclusive categories of dimensions. Therefore, the number and naming of the proposed dimensions are ambiguous to a certain extent, and overlap may exist between the categories proposed here. For example, one can argue that encouragement, as in ‘designing in’ an architectural element or consequence that encourages a user to use a product in a certain way, is a strategy that belongs to the well-known control spectrum. We have however also chosen to name Encouragement as a separate, novel dimension, as it does not affect how much control the user has over the behaviour, but affects the users motivation to perform it. Encouragement is about motivations, whereas control is about affordances or usability. Similarly, providing Meaning, or playing on Empathy, can also be regarded as ways to encourage users towards a behaviour, but are proposed as separate categories because they represent different perspectives. Whereas Encouragement represents the variations between strongly discouraging and strongly encouraging, Meaning represents the variation between motivating rationally by making the user feel it is the right thing to do and emotionally by making the desired behaviour pleasurable. Empathy represents a scale of solutions to influence behaviour ranging from making the user aware of, or consider, others, to allow for a purely egocentric perspective.

As such, the distinction between the nine different dimensions was the result of an attempt to find a meaningful balance between granularity and level of aggregation. If the number of dimensions had been reduced further, important distinctions and nuances had been lost, as categories would have to be combined. If the number of dimensions had been increased, clear enough distinctions between the categories may have become difficult.

It should however be noted that the results achieved through the study described in this paper, may have been affected by the way the topic was presented in the workshops. As the designers needed some guidance to understand the question at hand, it was impossible to avoid giving examples and descriptions that may have affected their way of thinking. However, an effort was made to reduce this as much as possible. The designers' experience of the novelty of the approach and the time limitation of the workshops makes it likely that there is further potential for finding additional dimensions. Nevertheless, the amount and variety of the proposed dimensions provides reassurance that the most significant dimensions were identified.

#### 4.1.2.3. TOOL 2 - 1ST ITERATION – MEETECOID

To enable designers to draw upon the results of this research and, potentially, design products that are more likely to be used in the most sustainable way, the results of the research need to be translated into a format that is usable for designers. The literature review on how to design design-tools for designers, the experience from the previous projects and the information gathered through the workshops contains substantial information about how a tool should be designed to support designers.

There are two aspects of the design of the tool that affect whether the tool is suitable to fulfil its purpose or not; the content and the format. In the literature there are numerous design tools available, covering a great variety of formats. A few of the requirements describe aspects that are directly related to the format, which may support the selection of an appropriate format. However, it should be noted that this only to a limited degree can support the choice of format as it often is more a question of how it is applied to the format than which format it is applied to.

The first choice to make is whether the tool primarily should be physical or digital. A clear advantage with the digital format, as pointed out by some of the workshop participants, is the opportunity of interacting with the tool, providing input to customise the tool and navigate in the information, similar to Fogg's behaviour wizard (http://www.behaviorwizard.org/wp/). However, some workshop participants commented on the collaborative and inspirational advantage of a physical tool. Even though it might be argued that these attributes also can be included in a digital format, it was decided to create a physical tool.

Also within the physical format, there are numerous alternatives. A version of the previous tool had been developed into a booklet. However, feedback from students working with this tool indicated challenges regarding the ease of integration in their regular way or working and that they found the booklet format not so inspiring (Chapter

4.1.1.3, Paper 6). An interactive, physical tool, such as the Behaviour Change Wheel (Michie et al., 2011) (Figure 2.1.4) is a format with great potential due to its dynamic format, but was considered to complicated due to the complexity and amount of information the tool needed to contain. Another alternative could be a poster, such as the Cradle to Cradle Map (Argumentenfabriek, 2010), but a card format was preferred due to its discrete nature and dynamic potential for use in workshops (Lockton, 2013). However, as Lockton points out, a small card format only facilitates one person reading it at a time. To support collaboration, and enable presentation of the relatively substantial amount of information needed for each card, it was decided to make relatively large cards (A5 format in landscape).

Designing the tool in a card format, making it easy to understand, and creating an inspiring and primarily visual experience, all suggest that the content should have as little text as possible. At the same time, it must contain sufficient information to provide the designers with the necessary support. As the tool is meant to support product designers in general, it cannot be required that they have explicit experience with behaviour change. Thus, the tool needs to present an overview over design principles in addition to the dimensions, which then can be used to adjust how the principles are experienced by the user.

The complete discussion of the requirements of the tool can be seen in Chapter 2.1.3.1 and is summarised in Table 2.2. See Table 4.6 for a summary of the evaluation of the tool formats.

Table 4.6. Evaluation of tool formats.

| | Disadvantages | Advantages |
|---|---|---|
| Digital format | Potentially less inspiring and suited for collaboration. | Opportunity of interacting, providing input to customise the tool and navigate in the information. |
| Booklet | Uninspiring and difficult to integrate into the redular way of working. | Enables lots of information. |
| Interactive physical tool | Too complex for the amount of information needed. | Enables interaction. |
| Poster format | Difficult to bring along and not very flexible. | Enables lots of information and overview. |
| Card format | Only suited for one person if the cards are small. | Descrete and dynamic. |

The first iteration of the tool, meetECOid consists of two cards presenting the tool and how it should be used, one card presenting 16 different principles for affecting behaviour through design and nine cards presenting the other dimensions separately (Figure 4.15).

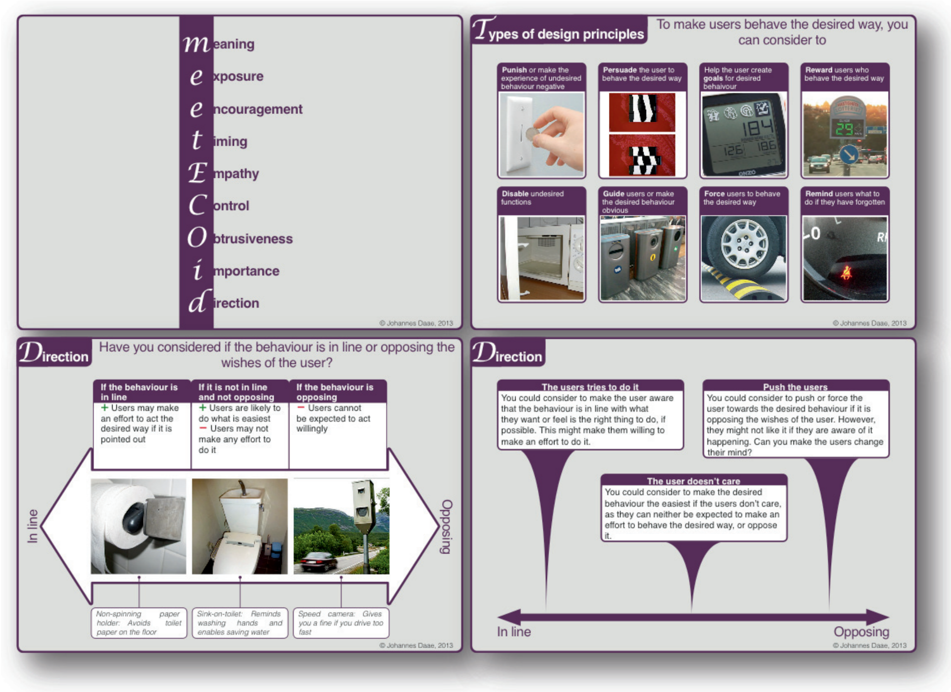



Figure 4.15. Example of meetECOid cards; front side, 8 principles and front and back of a dimension card.

Each dimension is presented as a line spanning between two extremes. An example is given for each extreme and for the area between. Each example is illustrated both by a photo of a product, that may affect the user by the specific state of the dimension, and a brief explanation of how the product on the photo may affect a user's behaviour. To help the designers understand the potential consequences of the different parts of the dimension, a number of likely advantages and disadvantages are briefly stated for each extreme, and in some cases also for the central part of the dimension. This has been elaborated a bit further on the back-side of each of the dimensions cards, providing additional support for designers who feel the need for it.

### Evaluation

To test the meetECOid tool and investigate how designers experienced working with it compared with the 5$^{th}$ iteration of the Principles of Behaviour Change, a study was conducted at Stanford University in April 2013. The focus of the study was to evaluate the usability, user experience and potentially the behaviour changing quality of the resulting design solutions for each of the two tools.

The study consisted of an 8 hours workshop, in which 12 designers worked in pairs to design water kettles that would make the users only boil the water they need. Two pairs worked with "Principles of Behaviour Change", two pairs worked with "meetECOid" and two pairs worked with a dummy tool to create a control group the tools could be compared against. The dummy tool consisted of a general user centred design approach divided into 7 steps and a number of pictures of products affecting behaviour (Figure 4.16). Throughout the workshop, the participants were aware that there were three different tools in use. Half of the designers were students or practitioners with several years of design experience and the other half were less experienced students. The participants for each team were randomized, apart from that each team consisted of one experienced and one less experienced designer.

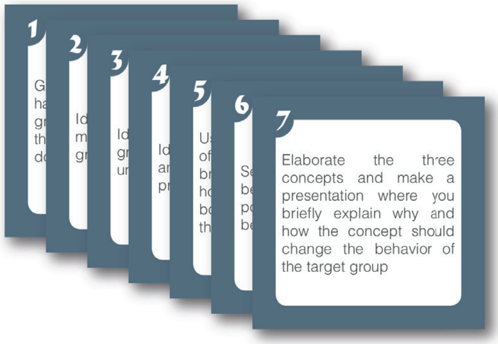



Figure 4.16. The dummy tool

First the participants were given an introduction to the value of behaviour changing design and a number of examples of products affecting behaviour. They were then shown three short video interviews of people using a water kettle to boil a cup of tea and talking about their behaviour and thoughts on energy consumption. All three of the user overfilled the kettle, but only one did so extensively and expressed a lack of concern for wasting energy. After the videos, the participants were divided into pairs and asked to design solutions that would make all the three users stop boiling more water than they actually needed. The teams were then given 5 hours to use the tool they had been given to generate and evaluate ideas, and finalise three concepts. For the three final concepts, they should also describe why and how it would affect the behaviour of the target group. Before they presented their concepts to the others, each of the participants filled in a survey about the experience of using the tool they had been given. Finally a presentation was given, where all the three tools were explained ending with a plenary discussion and comparison of the tools.

The initial plan was to evaluate the tools based on the results of the survey, the quantity of ideas each and the diversity of design principles each pair produced, the precision and appropriateness of the descriptions of the concepts, and the likelihood of the concepts changing the behaviour and being accepted by the target group. As it was not feasible to build and test the concepts in reality, the intention was to randomize the concepts and have a panel of DfSB researchers evaluate their potential of affecting the behaviour and being accepted by the target group. However, it was almost impossible to distinguish the quality of the results from the different teams. When the pilot for this evaluation was conducted, and one DfSB researcher was asked to evaluate the concepts, he was unable to make any distinct ranking of the concepts. It was thus decided to abandon this aspect of the evaluation. There may be several reasons for this outcome, but a likely explanation is that the small sample of two groups with two designers in each was too vulnerable for individual variation in the skills, attitude and experience of the participants. The same appears to be the case for the evaluation survey, as there was a substantial discrepancy between the scores the tools received in the survey and the feedback the participants gave. This may also have been affected by variation in interpretation of the rating scales used in the survey, although a standard 1-5 scale was used, where 1 represented the least and 5 represented the most agreement with the statements in the survey. The most reliable and useful outcome from the test was thus the comments given in the discussion afterwards, where all the participants had been introduced to all the tools and they shared their opinions and experiences. As in previous iterations, the Principles of Behaviour Change received criticism for being too rigid and not inspiring enough. Many of the participants were enthusiastic about the variation in perspectives included in the meetECOid, but it turned out that it was ambiguous how the tool actually should be applied and it should have more examples and less plain text.

#### 4.1.2.4. TOOL 2 - 2ND ITERATION – THE DIMENSIONS OF BEHAVIOUR CHANGE

The relative failure of evaluating the tools at the Stanford workshop, combined with the feedback given about the meetECOid tool, motivated a second iteration. The feedback suggested some minor adjustments to the tool, in particular regarding the explanation for how the tool should be applied. In addition, the tool should also be more visual with more examples and a different name should be considered, as the acronym; meetECOid had caused some questions and confusion.

In the first iteration of the tool, it was suggested that the tool should be included in a three step process; 1. Identify the behaviour you want to change and your target groups. 2. Identify the main reasons why your target groups behave the way they do. 3. Generate ideas for how you can change the behaviour by applying design principles and adjusting the principles according to the dimensions. The feedback from the previous iteration indicated that the relation between design principles and dimensions was unclear. Especially as the distribution of control was considered intuitive and thus a natural starting dimension, but the majority of the principles were derived from research focused on this dimension and thus rather indicated particular amounts of control than invited variation of it. It was therefore determined to utilize the distribution of control as the core dimension describing the principles, rather than as one of the dimensions they should be adjusted along. To avoid confusion, it was determined to rather focus the explanation on the application of the tools and not include the initial steps of determining target behaviour and analysing the target group. The additional information on the back side of each dimension card was altered, so instead of consisting of explanatory text, it contained brief explanations accompanied by examples. The name of the tool was also altered to; Dimensions of Behaviour Change (DBC) (Figure 4.17. For the complete tool, see Part III).

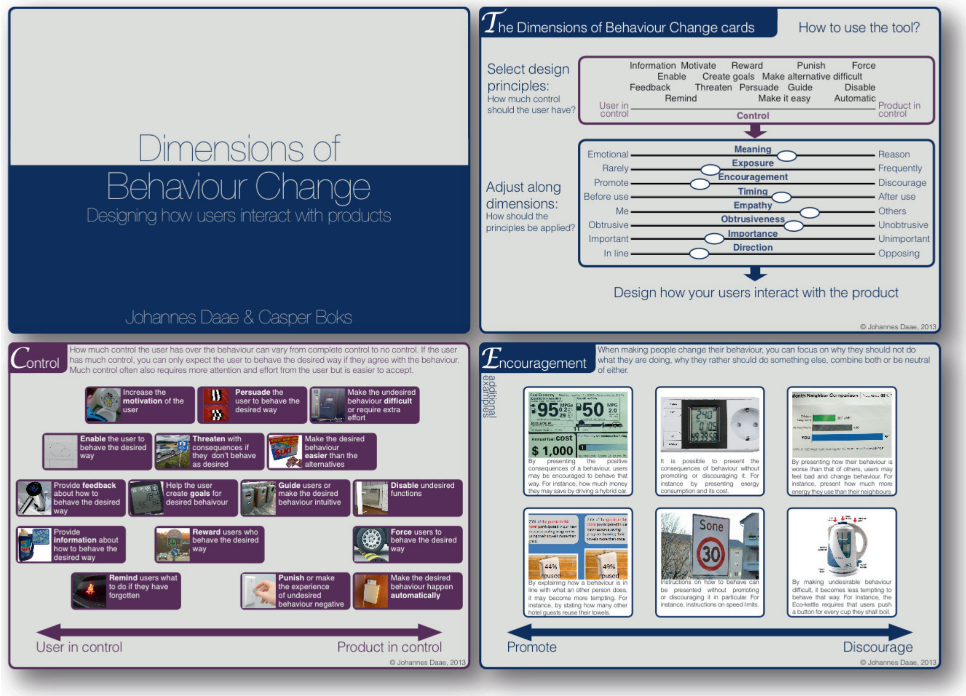



Figure 4.17. Example of DBC cards; front side, user instructions, 16 design principles on distribution of control and back of a dimension card with additional examples.

### Evaluation

The experience from the Stanford study indicated a number of adjustments of the testing protocol to enhance the evaluation of the tool. First and foremost, the number of teams working in each condition should be increased, to reduce the effect of individual variation among the participants. To achieve this, the number of participants should be increased and a more homogenous group of participants should be recruited. In addition, rather than trying to compare and evaluate several tools simultaneously, the new tool should be isolated and compared to teams working without a tool at all. Feedback from the participants of the Stanford study also indicated that including design for a specific target group complicated the design task without necessarily providing too much benefit. Removing this condition simplified the task and could allow less time for the design challenge. It also indicated that it could be relevant to investigate the effect of repeated use of the tool, as time and effort was spent on understanding the tool in the beginning of the session. To reduce the risk of particular properties of the design challenge affecting the results, more than one design challenge should be included in the study.

Based on these experiences, a new study was designed. This time the workshop was arranged at Delft University of Technology. 46 students, all in the last year of the Bachelor study, half from industrial design and half from aerospace engineering, participated in the workshop. The students were randomly divided into 18 teams with at least one design student in each team, and split into two rooms with 9 teams in each. The teams were given one of three design challenges, a bunch of post-it's and markers, and two hours to generate ideas and select the three best ideas, repeated in two sessions. These ideas should be presented with a drawing and an explanation why and how it should result in the desired behaviour. In the first session, half the teams got the DBC tool. In the second session all the teams got the tool (see Table 4.7).

Table 4.7. Design of the Delft study.

<table>
<tr><td colspan="2"></td><td>Design a solution that makes people unplug their cell phone chargers when it is not being used for charging the phone.</td><td>Design a solution that makes people only boil the amount of water they need in a water kettle.</td><td>Design a solution to avoid the heating being turned on and a window being open at the same time, in the same room.</td></tr>
<tr><td colspan="5">Introductory lecture about why behaviour change is important</td></tr>
<tr><td rowspan="2">Session 1 (2 hours)</td><td>Teams get the tool but no introduction (Room 1)</td><td>Team 1,2,3</td><td>Team 4,5,6</td><td>Team 7,8,9</td></tr>
<tr><td>Teams get no tool (Room 2)</td><td>Team 10,11,12</td><td>Team 13,14,15</td><td>Team 16,17,18</td></tr>
<tr><td colspan="5">Lunch</td></tr>
<tr><td colspan="5">Lecture with introduction to the tool</td></tr>
<tr><td rowspan="2">Session 2 (2 hours)</td><td>Teams have experience and uses tool for second time (Room 1)</td><td>Team 7,8,9</td><td>Team 1,2,3</td><td>Team 4,5,6</td></tr>
<tr><td>Teams have experience and uses tool for the first time (Room 2)</td><td>Team 16,17,18</td><td>Team 10,11,12</td><td>Team 13,14,15</td></tr>
<tr><td colspan="5">Students fill out survey</td></tr>
<tr><td colspan="5">Presentations and discussion</td></tr>
</table>

After another two hours, the students filled in a survey where they were asked to evaluate a number of statements about the tool on a scale from 1 to 5, where 1 signified "strongly disagree", 2 "disagree", 3 "neither agree nor disagree", 4 "agree" and 5 "strongly agree".

In addition to counting the number of ideas generated by the teams, the presented ideas were analysed to identify the type and number of behaviour changing approaches applied. This allowed for an evaluation whether the tool helps the students consider a greater variation of ways to affect behaviour. In doing so, not only the total number of approaches among the three concepts developed by each team for a problem was counted, but also the number of unique approaches. As it could be expected that the teams would apply the same approach to more than one of the concepts for a challenge, it was interesting to know how many different approaches they applied. The number of unique approaches is thus to be understood as the number of approaches, not double counting if an approach has been applied more than once by a team for the same challenge. This may be the most interesting measurement of success, as it represents the actual variation in how the students try to affect behaviour.

As each team generated ideas and developed the three ideas they believed would be most successful into concepts, the data from the workshop contains nine concepts from each of the three design challenges for each of the four conditions, in addition to the ideas on post-it's survey results.

To compare the results, each concept was analysed and the approaches applied to affect the behaviour of the user were identified. This included both the approaches that were obvious from the design and the once targeted in the descriptions. In this process, efforts were made to avoid awareness of the condition it was generated under and thereby reduce the risk of bias. For each team, in each condition, the total number of approaches was recorded, while the overlapping approaches were removed, resulting in the number of unique approaches.

In addition, the number of ideas generated by each team, in each condition was measured. This was done by counting the number of post-it's and removing the ones that obviously did not contain an idea, but had been used for categorization, testing markers, etc.

When testing the equality of means of two independent, continuous, non-normal, distributions, the Wilcoxon rank-sum test is appropriate (Walpole, et al., 2002). The result was that teams that did not have the tool in the first session on average generated 56% more ideas than the teams that had the tool in the first session, and the Wilcoxon rank-sum test gave rank sum of w=171, a unit of normal distribution of z=2,211 and significance level of p=0,027, making it a significant result. In the second session, the teams that used the tool for the first time generated 63% more post-it's than the teams that used the tool for the second time, and rank sum w=136, unit of normal distribution of z=1,903 and a significance level of p=0,057, making it non-significant (see Figure 4.18 for details).

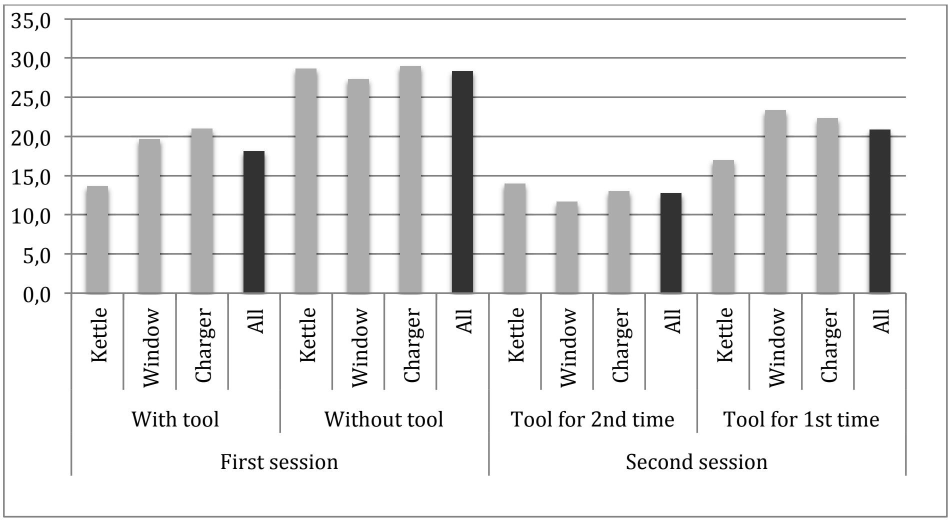



Figure 4.18. Ideas generated on average per team.

However, even though the teams that did not have the tool generated the most ideas, they had the smallest variation both of total and unique approaches. In all the three conditions where the teams used the tool they had on average between 5,8 - 5,9 approaches in total and 4,7 – 4,9 unique approaches. The teams that did not have the tool used on average 3,8 approaches in total and 3,2 unique (see Table 4.8/ Figure 4.19). Thus, the teams that used the tools in the first round applied 55% (w=153, z=-1,76, p=0,0784) more approaches in total, which is not a significant result. But they applied significantly (53%, w=153, z=-2,116, p=0,0343) more unique approaches than the teams that did not have the tool (see Figure 4.19). In the second session, both the teams that used the tool for the first and second time applied 5,8 approaches in total (w=153, z=0,86, P=0,3898) and the teams that used the tool for the first time applied 4% (w=153, z=1,237, p=0,2162) more unique approaches than those that used it for the second time, giving non-significant results.

Table 4.8. The number of approaches used per group.

| | | *Teams with tool both sessions* | | | | | | | | | | | *Teams with tool only second session* | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Avg. | St.dev. | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | Avg. | St.dev. |
| Session 1 | Total | 4 | - | 7 | 4 | 5 | 8 | 2 | 9 | 8 | 5,9 | 2,47 | 4 | 5 | 5 | 5 | 3 | 4 | 3 | 3 | 2 | 3,8 | 1,09 |
| | Unique | 4 | - | 6 | 4 | 4 | 5 | 2 | 8 | 6 | 4,9 | 1,81 | 3 | 3 | 5 | 4 | 3 | 4 | 3 | 2 | 2 | 3,2 | 0,97 |
| Session 2 | Total | 4 | 5 | 5 | 7 | 6 | 4 | 6 | 5 | 10 | 5,8 | 1,86 | 6 | 6 | 6 | 5 | 5 | 6 | 5 | 6 | 7 | 5,8 | 0,67 |
| | Unique | 3 | 5 | 4 | 6 | 5 | 3 | 4 | 3 | 9 | 4,7 | 1,94 | 5 | 6 | 5 | 4 | 3 | 6 | 4 | 5 | 6 | 4,9 | 1,05 |

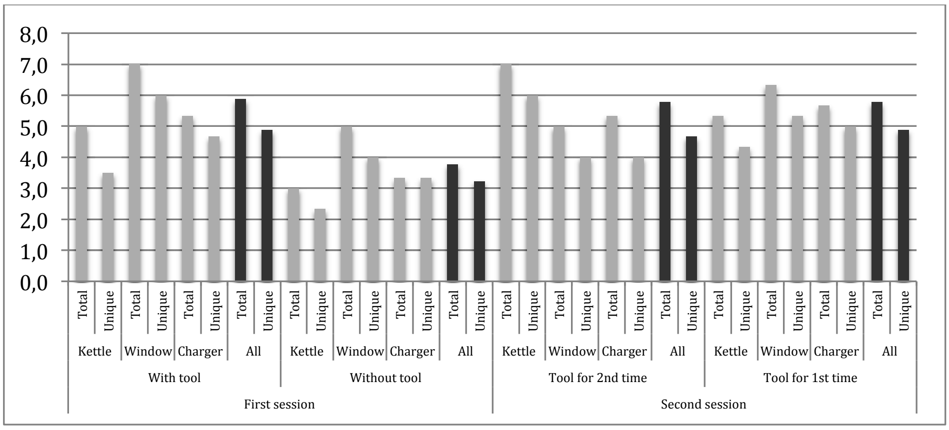



Figure 4.19. The number of approaches used per group and challenge on average.

The results of the survey indicated that the students in general were positive to the tool and felt it supported them in the design challenges (see Figure 4.20). For every question the answers ranged from 2 and 5, which not surprisingly, indicates that the tool worked better for some students than for others. However, as all categories are above 3 and many of them are close to 4, the majority of the students thought the tool had a positive effect on their work. For the questions regarding how inspiring the tool was, how well it supported the collaboration and discussion in the team, how well it helped them understand how a product can affect behaviour and how well it helped them consider new aspects of the design, the score is almost 4 on average and was supported by the finding that the teams with the tool used a greater variation of approaches to affect behaviour. This was also supported by several of the students who commented that the tool helped them understand and consider the perspectives that could help them design better solutions. On the other hand, the question regarding the ease of use and how well the tool supported the decisions of how the design should be, scored just above 3. The former of these indicates that the usability of the tool could be improved further. The latter may indicate that the tool does not support this process well enough, but can also be a consequence of the limited time the students had, and thereby the superficial way they applied the tool.

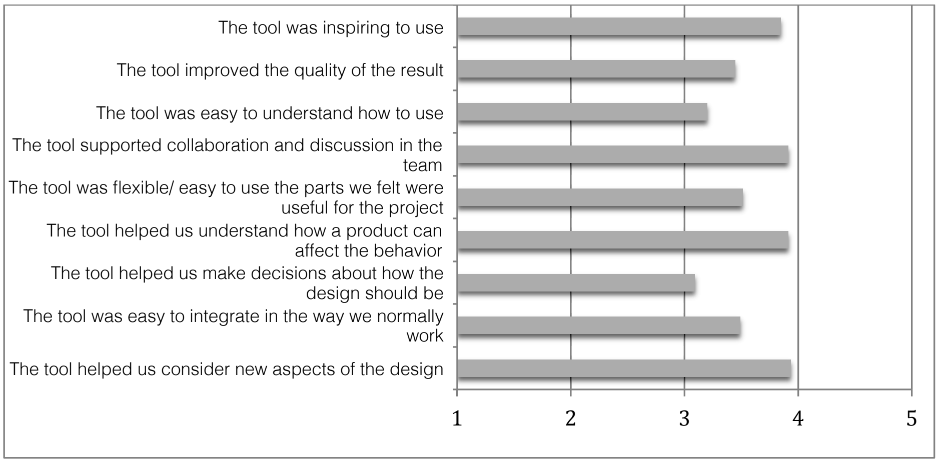



Figure 4.20. The evaluation of the tool by all the students.

### 4.1.3. CONCLUSION FROM TOOL DEVELOPMENT AND RECOMMENDATIONS.

The process of developing a tool to help designers make informed decisions about the type of design principles to apply in their projects went through seven iterations, first developing one tool and then another based on the first. The purpose of the repeated evaluations is not only to provide input to the next iterations, but also to monitor whether the process is moving in the desired direction. The final iteration of DBC was tested in an experiment attempting to evaluate the tool under relatively controlled conditions with a relatively large population and consider as many of the requirements for the tool as possible. Although the last test indicate that the tool is well received and supports the designers in the desired ways, it also indicates that further improvements could be desired. In particular regarding the usability of the tool and how it provides the support to the designers. However, by considering the results of the evaluation and comparing it with the previous iterations, it can be concluded that the last version of the tool is a substantial improvement from the first one and, although it still has an improvement potential, represents a fairly good solution to the initial goal and the requirements (see Chapter 2.1.3.1).

## 4.2. DFSB CASE STUDIES

Whereas the iterations of the design tool in the previous chapter focused on the development of the tool itself, the support it provides the designers and how the designers experience working with it, it is also relevant to investigate how well DfSB actually result in the desired behaviour change. Ideally this investigation should be made for every iteration of the tools and be part of evaluating how well the tools provide the desired support, compared to other tools. However, this is very time and resource intensive, as this type of evaluation requires creation of prototypes or other representation that allow users to interact with them on a sufficiently realistic and sophisticated level in order to evaluate the behavioural effect. To access the necessary resources, it is often necessary to collaborate with companies, which creates interesting opportunities, but also causes the risk of delay or abortion of the project beyond the control of the researcher. During this PhD project, I succeeded in participating in four case studies. All of them were in collaboration with companies or organisations and a number of other researchers. The ZEB, SIFO and Stanford projects had been initiated by others, which made it impossible to apply the tools directly. However, they still provide relevant insight and experience, which contributed to the development of the tools and the understanding of how to achieve behaviour change through design. In contrast, the CenBio Woodstove project, was almost entirely controlled by me and enabled not only a complete user centred DfSB process, but also the direct application of the Principles of Behaviour Change tool, which was under development at the relevant phase of the project.

### 4.2.1. THE ZERO EMMISSION BUILDING PROJECT

Chapter 4.2.1. summarises a paper by Wigum, Zachrisson, and Boks (2011) "The Role of Product and System Interfaces in Designing Zero Emission Buildings", presented at ISSST IEEE 2011. My contribution to this study consisted of participating in the planning, conducting one of the building investigations, contributing to the analysis of the results and co-authoring the paper.

This study was initiated by the Research Centre on Zero Emission Buildings (ZEB), which is one of eight research centres as part of a Norwegian national strategy in response to climate change. The vision of the ZEB centre is to eliminate greenhouse gas emissions caused by buildings and the purpose of this study was to explore the importance of the design of the heating and ventilation interfaces in low emission buildings and identify potential improvement. For this purpose, five buildings were visited and the user interfaces of the heating and ventilation systems were investigated. All the selected buildings were built between 2005 and 2010 and represented innovative, low impact solutions. The buildings were located in Oslo and Trondheim and consisted of one residential building, two medium size office buildings and two service buildings.

The study revealed three main challenges related to the interface and energy consumption: 1. There is a mismatch between visual signals, information, affordances, etc. and desired behaviour, 2. There is a lack of motivation for individual efforts, and 3. The conceptual models of the system needs to be conveyed better. Further, the studies revealed three types of users of the buildings, which should be approached differently. The first type of users is defined as persons related to the building and is in control of energy and electricity consumption. The second type of users is defined as the main group of users of the building as such. This group will often have no overview or control of the building in terms of its energy consumption. The third type of active users, are professional service personnel or other people related to maintaining the building; e.g., cleaning or repairing. The daily users (type 1 and 2) of the building must have information and some knowledge about preferable behaviours and know what effect undesired behaviour will have on the energy consumption and indoor climate quality, whereas the third type of users must understand how the technological systems of the specific building work, and know how the different functions (heating, ventilation, cooling, and lighting) are interrelated. It is crucial that there is good communication between the operator (type 3) and the other users, and most importantly those who is in control of the energy consumption (type 1).

Although the results of this study are unsurprising, they confirm the importance of targeting interventions according to the target group, as there is a large variation in the type of information, assumed knowledge, motivation, etc. that is relevant for different types of user.

### 4.2.2. THE SIFO, ECO LABEL OF EGGS PROJECT

Chapter 4.2.2. summarises a report by Schjøll, Borgen, and Alfnes (2013) "Consumer preference for animal welfare when buying eggs". My contribution to this study consisted of participating in the planning and design of the experiment and survey, designing the stickers and posters and some contribution to the practical work in the stores.

The purpose of this experiment was to investigate Norwegian consumers' perception of animal welfare when buying eggs, and the effect of positive and negative information. The experiment was conducted as a natural field experiment in two grocery stores, from the "REMA 1000" chain. A natural field experiment is an experiment where the subjects naturally undertake the tasks and don't know they are in an experiment (Harrison & List, 2004). In August 2011, REMA 1000 altered the package design of their battery eggs and from January 2012, they stopped selling battery eggs at all. By conducting the experiment in November-December 2011 and compare sales data from the entire period, it was possible to monitor and compare the effect of both the altered package design and the experimental manipulation.

The alteration in the package design may easily be considered as an example of negative information, and was most likely a strategy from REMA 1000 to position themselves in the Norwegian grocery store market. Prior to August 2011, the battery egg cartons had a neutral design, with no description of the animal welfare (see Figure 4.21). The new design, not only presented the text "battery hens" in white letters on back background, reminding of the warnings on cigarette packages, but they also included the following text (translated from Norwegian): "*From 2012, you will only get eggs from hens living in non-cage systems at REMA 1000. Eggs from hens in enriched cages, like these, will not be available in REMA 1000's stores. Battery hens live in cages with little possibilities to move around freely. Hens living in non-cage systems can move free indoors in environments that look like the natural environment* *for the hen. This leads to good health and animal welfare. REMA 1000 knows that you are interested in quality. We believe animals that are happy give the best commodity*".

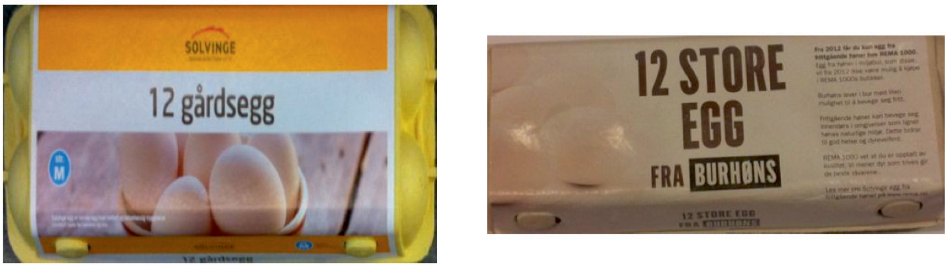



Figure 4.21. Design of battery egg cartons before August 2011 (left) and after (right).

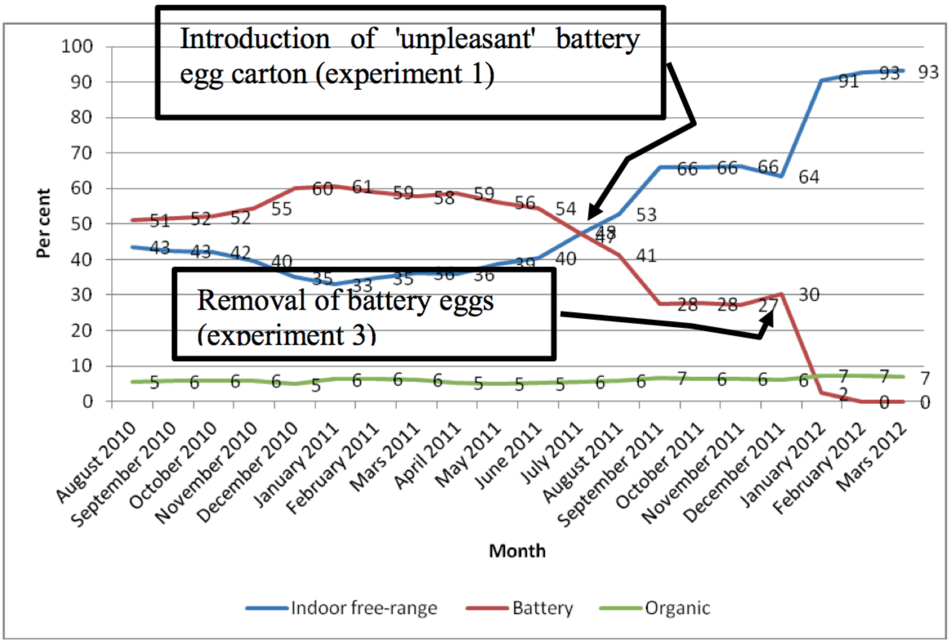
In contrast to this negative information about the animal welfare of battery eggs, the experiment provided positive information about organic eggs consisting of a poster and a sticker for the egg cartons. The poster contained the following text (translated from Norwegian): "*Organic eggs – Happier hens. REMA 1000 does not sell eggs from hens living in cages after January 1, 2012. If you would like even better animal welfare you choose organic eggs*". The stickers were 3.5 cm long, 1,5 cm high and should be positioned on the front side of the egg cartons and contained the text "better animal welfare" (see Figure 4.22).


Figure 4.22. The design of the poster and sticker on egg carton.

The experiment was conducted during a five-week period at two REMA 1000 stores in Oslo. Week 1: no manipulation, week 2: posters, week 3: posters and stickers, week 4: stickers, week 5: no manipulation. In addition to monitoring the sales data from the two stores, a survey was conducted for two hours a day at the counter each store, during the entire five-week period. Although many costumers did not want to participate in the survey, 811 responses were collected. The survey consisted of 12 attributes of eggs, which the participants were asked to evaluate on a scale from 1 (not important) to 4 (very important).

**Results**

The sales data of egg from REMA 1000 for the period from before the alteration of the carton design to after they stopped selling battery egg, shows a clear effect of the




negative information and an almost perfect symmetry between the sales curve of battery and indoor free-range egg (see Figure 4.23).

Figure 4.23. Percentage of indoor free-range, battery and organic egg sales at REMA 1000.

However, the positive information from the experiment showed no significant effect on the costumer's choice of eggs (see Figure 4.24). This is confirmed when comparing the sales figures with a control store.

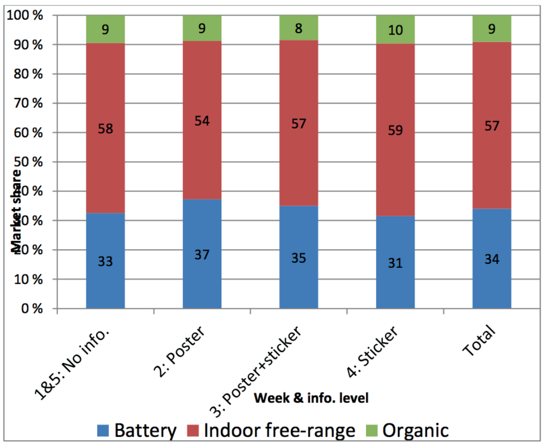



Figure 4.24. Market share of the different egg types in the two test stores, during the experiment.

The survey found that there is a correlation between the type of egg people buy and which aspects of the egg they consider most important (see Figure 4.25). People who buy indoor free-range or organic eggs consider animal welfare as the most important factor, whereas people who buy battery eggs consider number of eggs in the carton as the most important. There were no large effects of household or consumer characteristics, gender, age or education.

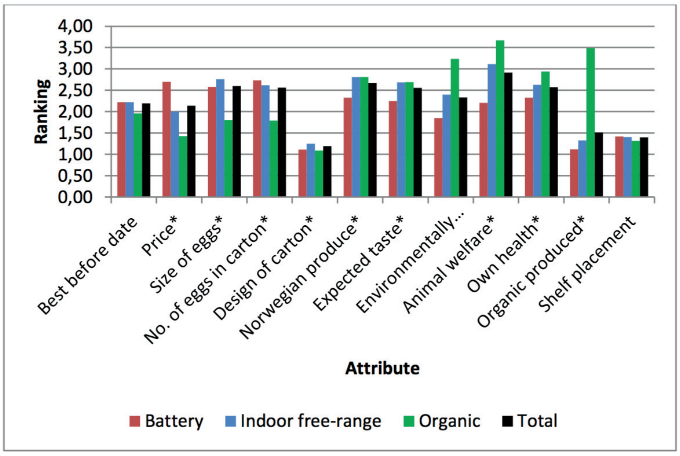



Figure 4.25. Importance of factors by type of egg purchased. Factors with *have importance scores that differs significantly between the groups. ("Do not know" answers are excluded).

(Schjøll et al., 2013) concludes that negative labelling of animal welfare affects consumers more strongly than positive labelling and recommends both commercial actors and governments to use labelling systems that point out the products with the lowest animal welfare.

Based on this study, the conclusion of the larger effect of negative compared to positive labelling seems obvious. However, as the alteration in the design for the negative information was much greater, and was accompanied by a substantial advertisement campaign in a multitude of media, it is likely that this has affected the results. Although it is not unlikely that the effect of telling people that what they are doing is bad (buying battery eggs) is more powerful than suggesting that they can do even better (buy organic), it is also possible that the design alteration and attention given in the negative information was sufficient to break peoples egg-buying habits, whereas the sticker and poster was not. As previously stated, the more altered a new product is from the previous, the more likely it is that habits concerning the product are broken and new may be formed (Robertson, 1967), and the alterations we had the opportunity to do in this project were insufficient.

### 4.2.3. THE STANFORD PROJECT

As the project is still ongoing and is being conducted for a commercial actor that wants to avoid that competitors obtain detailed insight into their activities, the following description is fairly brief and the conclusions are generalised. The description is also primarily focuses on the part of the project I contributed to.

In 2012, Stanford ChangeLabs started a project for a British energy provider, investigating how the energy consumption of British households could be reduced. To gather information about the relevant challenges and opportunities, I conducted ethnographic studies together with two Stanford students. We visited 10 households, interviewed them about their energy consumption, their attitude towards energy usage and their provider, what they believed consumed the most energy, how they thought it might be possible for them to save energy, what made it difficult and generally about their life situation. In addition, we were guided around in their homes and took pictures of the various energy consuming appliances, with particular focus on the energy monitoring systems, the smart-meters and energy displays, for the households who had installed these.

After returning to Stanford, we downloaded and structured the insights from the ethnographic studies through a series of workshops, together with three other Stanford students and professor Banny Banerjee. In the workshops, the impressions and understanding from each of the home-visits were thoroughly discussed to identify the key tendencies, with focus on the challenges, opportunities and drivers. After a few months, a second ethnographic trip was conducted by three other students, visiting 13 more households to investigate more details on the preliminary findings from the first round and get the first impressions for some of the initial solution ideas. The second ethnographic trip, targeted a slightly wealthier pool of households, as the initial round had found that several of the participating households had very low income, resulting in fairly low consumption and small opportunities to affect their own situation. Although the solution-space included the households with these limitations too, it was relevant to get additional input from less economically stressed households.

The analysis from the second ethnographic trip confirmed several of the initial findings and identified a few new once. The key findings can be summarised as following:

- People ignore the eco meter. This is due to a combination of limited perceived behavioural control, attention deficit and lack of focus on energy consumption.
- Disconnection between energy consumption and cost. Most people don't really understand the mechanisms in the energy market, they have a lack of real time feedback and the bill design is too complicated.
- People don't know how much each appliance consumes. There is a lack of technology to provide the information, it is difficult to disaggregate energy consumption into "point-sources" throughout the home and people don't really care.
- People don't know what they could have done differently. There is a lack of available information or people cannot be bothered to do the necessary research.
- People don't feel the effect of their efforts. They don't get sufficient information about the variations in their consumption over time and the billing system causes a delay to the savings.
- Kids don't follow their parents saving efforts. They have different values and concerns, they don't see the bill and lack motivation.
- Existing infrastructure is hard to change. For instance halogen light or single point of heating with manual thermostat.

- It is considered normal to have drafts so people don't think about doing anything about it.

These challenges were translated into “how might we’s”, which are starting points for generating ideas to solve them and is a method commonly used at Stanford d.school. Solution ideas were generated both at a number of internal workshops and a larger workshop where a number of external participants were invited to give “fresh eyes” to the problems. The results of these workshops were developed into concepts, which will be tested and evaluated.

The extensive gathering of data provides an interesting starting point for analysis of the problem space and identification of promising solutions. The relatively unstructured approach to the analysis, by talking through each interview in great detail, is very thorough and uncovers a number of opportunities which might have been lost through less extensive techniques. However, this method is very time consuming and has a structural problem, as it is hard to get an overview and the vast number of findings easily becomes chaotic.

### 4.2.4. THE CENBIO, WOODSTOVE PROJECT

Chapter 4.2.4. is adapted from the original text in Daae et al. (2014); Burning for Sustainable Behaviour, Journal of Cleaner Production.

To date, no case studies exist that focus on how improvement of the design might reduce the environmental impact caused by sub-optimal interaction with woodstoves. For countries like Norway, emissions from this practice represent a significant environmental impact and woodstoves are an important heating source. In Norway, about 72% of the households have access to a woodstove (SSB, 2011a) and 57% actively use it as a heating source (Haakonsen & Kvingedal, 2001). In total, burning of firewood provides 17% of the total energy consumed by Norwegian households (SSB, 2011a).

Burning firewood as an energy source has a low environmental impact compared to electricity with the average Nordic electricity mix (Solli et al., 2009), which is the most commonly used energy source for heating in Norway and provides 78% of the energy consumption of the households (SSB, 2011a). It has long been assumed that firewood is carbon neutral as the amount of CO2 released when burned is assimilated during growth (Bright, Cherubini, & Strømman, 2012). This is not entirely correct due to the emissions related to production and transportation of the firewood (Solli et al., 2009). It is also incorrect to assume that carbon neutrality equals climate neutrality due to the time the CO2 is in the atmosphere before the tree has grown back and assimilated it again (Bright et al., 2012), and the decreased heat accumulation of de-forested areas due to the perturbation of the surface reflectivity, known as the albedo effect (Cherubini, et al., 2012). Burning of firewood is also responsible for a large number of other emissions (Ozil, et al., 2011). In Norway, burning of firewood is responsible for 42% of the emissions of fine particles (PM TSP)(SSB, 2011b), 21% of the polycyclic aromatic hydrocarbons (PAH) and 34% of the dioxins (SSB, 2013).

The majority of the environmental impact of the entire lifecycle of a woodstove happens during the use phase. Solli et al. (2009) found that the use phase is responsible for 60% of the environmental impact within all categories. In particular the start-up and end phase of the burning process are crucial (Ozil et al., 2011). The emissions are dependent not only on the type and condition of woodstove and firewood, but also how the user interacts with the stove (Haakonsen & Kvingedal, 2001; Karlsvik & Oravainen, 2009; Solli et al., 2009).

In the beginning of 2011, a project was initiated to investigate the potential of reducing the emissions from woodstoves by improving the design of the user interface. This project also provides good conditions for controlled testing and evaluation of a recently developed tool to support this kind of design challenges. The initiative was a collaboration between Sintef and the Norwegian University of Science and Technology as part of CenBio, a collaboration between a number of industry partners and universities, aiming at enabling sustainable and cost-efficient bioenergy. The project was conducted together with a Norwegian woodstove producer, Jøtul, who would contribute both with technical advice, participants to workshops, and the prototype and woodstove for the final testing. The project consisted of three separate phases:

• A user research phase, where it should be investigated how and why people burn firewood the way they do.

• A design phase, where the results from the user research phase should be translated into a design proposal and subsequent prototype.

• A testing phase, where a prototype of the design proposal should be compared with a conventional woodstove in a controlled user test.

#### 4.2.4.1. USER RESEARCH PHASE: METHOD.

The design approach applied in this project is based on User Centred Design (ISO-9241-210, 2010), which in short builds upon the notion that understanding of the user and the context form a basis for design decisions. Only few studies have investigated how people burn firewood (Fisher, et al., 2011; Gras, et al., 2002; Meyer, et al., 2008; Scott, 2005). These have focused on measuring emissions resulting from behaviour, and to a certain degree on what the users did, but contain limited information about why the users behaved that way. As this is essential information for a DfSB process aimed at altering behaviour, it was considered necessary to systematically gather data about how and why people burn firewood the way they do. To do so, applied ethnography was used, which is a technique where the researcher observes usage of products in its natural setting and by interviews and analysis tries to understand why users behave the way they do. The goal is to understanding how people use products (Steen, 2008) with focus on observing the behaviour in the natural situation, understanding it in the social and cultural context, how the user creates meaning (Blomberg et al., 1993), and understanding the users' implicit or non-verbal needs (Kujala, 2003). This is a technique that has the potential of investigating factors affecting the behaviour of the user, which are both conscious and unconscious to the user, and are embedded both within the user and externally (Daae & Boks, 2013).

In the beginning of 2012, 17 participants, who all used woodstoves on a regular basis, were recruited in the area around Oslo, Norway. These 11 men and 6 women between 29 and 80 years old included dwellers in apartments, houses and semidetached houses. All participants were visited at home, video recordings were made of the participants firing up the woodstove, and semi-structured interviews addressed why and how they had done this the way they did, as well as other firewood energy and sustainability relate issues. Throughout each interview, which lasted on average one hour, the participants were asked to maintain the fire in the woodstove, allowing for observation of adjustment of the air vaults and reloading of wood, in cases where this was done. Particular attention was given to identifying the extent to which the participants used the woodstove in line with the recommendations for how this should be done to have as low environmental impact as possible. For a modern woodstove, this can be summarised as following:

Only burn wood of good quality, with less than 20% moisture, and never anything else, apart from firelighters to get the fire started. Start by putting some logs at the bottom and smaller wood on top of that together with some firelighters. Light the fire and open both the primary air (the air that is emitted underneath the wood) and the secondary air (the air that is emitted further up, on the back of the burning chamber), and for some woodstoves, the door should also be ajar in the beginning. Once it burns properly, and the secondary burning process has started (flames can be seen around the holes emitting the secondary air), the door and the primary air should be closed. The user can then adjust the burning intensity by adjusting the secondary air, it is however important to avoid the flames being extinguished (Karlsvik & Oravainen, 2009; Mytting, 2011).

#### 4.2.4.2. USER RESEARCH PHASE: RESULTS

As expected from the choice of method, the user research resulted in an extensive and rich base of information. A summary was made of each interview and formed the basis of the creation of four personas (Cooper, 2004). Creating this type of archetype users as a representation of characteristics identified through user research is a technique that has been widely used in design research for several decades (Prutt & Adlin, 2005). The way personas are created vary from a representation of the essence of substantial user research and "defined with significant rigor and precision" (Cooper, 2004, page 124) to a much more ad-hoc approach advocated by design research guru Don Norman (2005), where he argues that personas do not need to be realistic, real or accurate, as long as they accurately characterize the user base. The personas created for this project may be considered a hybrid of Cooper's and Norman's versions. Short versions for the more elaborate descriptions used for the project are:

• Persona 1. A user who sees burning firewood as a hobby, is very knowledgeable but still eager to learn;

• Persona 2. A user who believes he knows everything, but does many things wrong;

• Persona 3. A user, who enjoys burning firewood but finds it difficult and is insecure, is interested in learning but does not care too much;

• Persona 4. A user who does not care and just wants everything to be as easy as possible.

In addition to the development of the personas, an overview was made of various recorded elements of behaviours that were not in line with the recommendations for optimal burning. These included burning wood that is too moist, use paper and cardboard to start the fire, kindle the fire from the bottom of the wood instead of from the top, not giving flames sufficient air when firing up, reducing the air too much while burning, closing the secondary air while leaving the primary air open, and leaving the door ajar too long.

#### 4.2.4.3. THE DESIGN PHASE: METHOD

The goal for the design phase was to design a woodstove that would make all the personas use it more in line with the recommended way, and would be accepted by all the personas. To support this process the personas and the list of sub-optimal behaviours were used as input to idea generation, analysis and evaluation, and finally concept development.

Before starting to generate ideas for how to improve the design of the woodstove, the personas and potential solution space were analysed. To do this, the 3rd iteration of Principles of Behaviour Change, as described in Chapter 4.1.1.3, was applied. To generate ideas, a workshop was arranged at Jøtul in May 2012 with seven participants from their product development, marketing and the technical departments. At the start of the workshop, the results from the user research and the personas were presented. The participants were then asked to brainstorm ideas for how to make people use a woodstove more in line with recommended behaviour, particularly targeting the list of sub-optimal behaviours. To keep the challenges simple the personas were given limited emphasis during the idea generation, although it was brought up from time to time to spur the generation of additional ideas.

#### 4.2.4.4. THE DESIGN PHASE: RESULTS

By analysing the results from the design workshop and excluding overlapping ideas, a number of distinct ideas were identified. These ideas were positioned in the landscape, according to how much control and attention they demanded from the user. Figure 4.26 shows some of the ideas positioned in the landscape.


Figure 4.26. The ideas in the landscape.

As suggested by the Principles of Behaviour Change, the next step was to identify those areas of the landscape that will potentially result in a desired behaviour change which is acceptable (green) or not acceptable (red) for the different personas (see Figure 4.27).

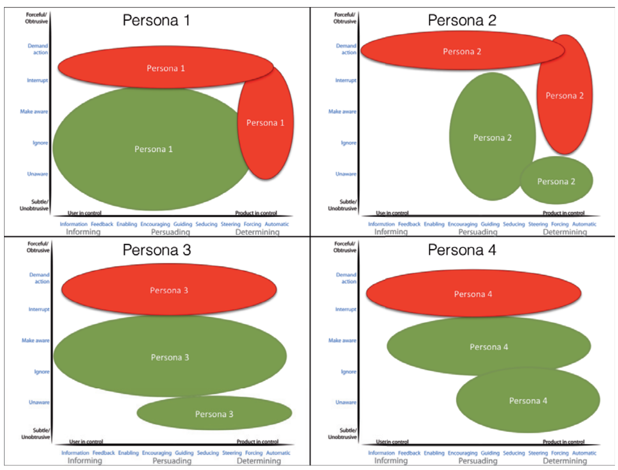



Figure 4.27. The landscape for each of the personas (green = potentially affect behaviour, red = probably not accepted).

Combining results from the steps represented by Figure 4.26 and Figure 4.27 allowed identifying the most suitable ideas, which were evaluated in collaboration with the technical experts at Jøtul on basis of their feasibility and how easily they could be included in a prototype. As a result, it was determined that the prototype should include a combination of the following ideas:

- It should have one lever, to make it impossible for the user to close the secondary air but leave the primary air open. When the lever is pulled all the way out, both air vaults are completely open; when it is pushed in a bit, the primary air closes but the secondary air is kept open. The further it is pushed beyond this point, the more the secondary air closes, until it is pushed all the way in and the secondary air is completely closed.
- To help the user understand the different positions of the lever, icons should be provided at the position where 1) both primary and secondary air are completely open (to be used during ignition), 2) primary air closed but secondary air completely open (to be used for rapid burning), and 3) primary air closed and secondary air is almost, but not completely closed (to be used for slowest possible burning).
- It should have a thermometer on the window at the front of the woodstove, indicating when the air should be adjusted.
- It should have an easily readable, illustrated user manual.

#### 4.2.4.5. THE TESTING PHASE: METHOD

To enable evaluation of whether the design concept would actually result in behaviour that is more in line with the recommendations, Jøtul built a prototype of the concept based on one of their existing woodstove models. The burning properties of the woodstoves should be as similar as possible to allow a direct comparison. It was thus determined to start off by two identical woodstoves and adjust one of them in line with the concept. Instead of changing a conventional woodstove with separate levers for primary and secondary air into the desired combined lever, the prototype was based on the only existing model that actually had a combined lever, and separate the levers on the 'conventional' woodstove instead. This would still allow the evaluation of the effect the combined lever had on the behaviour, but was technically easier to build. It was also believed that it would be easier to have letters indicating the different levels on the lever and a legend just above the lever, instead of icons directly on the lever. This turned out to be an unnecessary alternation, as the icons probably could have been added directly to the lever. The thermometer was positioned on top of the woodstove instead of on the window as the available thermometer registered the temperature directly at the surface and would be too strongly affected when the door was opened (see Figure 4.28).

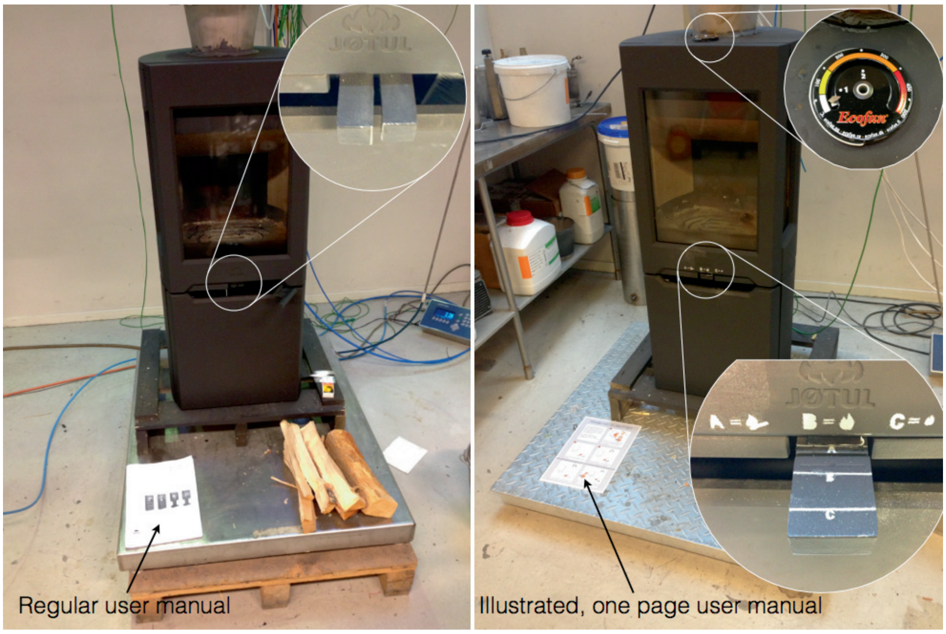



Figure 4.28. Left: the conventional woodstove, Right: the prototype.

The two woodstoves were transported to the lab of the Department of Energy and Process Engineering at NTNU, where the testing was conducted. The facilities at this lab allowed measurement of the emissions and temperature development when testing the woodstoves. Instead of performing experiments on preheated stoves as specified in the Norwegian standard (NS 3058-2:1994) it was decided to perform the experiments on "cold", room tempered stoves. Cold stoves producers significantly more emissions in the initial start-up phase due to the heat necessary for the heating of the construction itself. Choosing a cold stove as a reference would therefore probably produce larger differences in terms of emissions making it easier to distinguish good and bad stove lightning. Several other deviations from the Norwegian standard were also made, mainly related to fuel type, testing time, fuel charge. In the current work ordinary birch was used as fuel while the standard prescribes pieces of spruce in a given arrangement. Also, since most particle emissions are produced early in the burning period, it was decided to run each experiment until 80% of initial mass had been consumed.

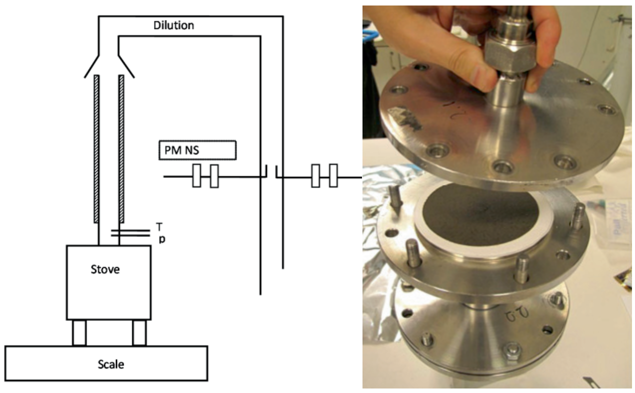



Figure 4.29. Experimental setup, spruce test fuel and filter sampling unit, according to NS 3058.

In August 2013, 20 participants, who all used woodstoves on a regular basis, were recruited in the area around Trondheim, Norway. The 11 men and 9 women ranged between 30 and 81 years old. In each test, a participant would come to the lab, answer a few questions about their woodstove experience and burning habits, and light a fire in one of the woodstoves. No explanations were given of how to operate the woodstove, but before lighting the fire, the participants were asked to explain what they believed the purpose was of the different parts of the woodstove. Direct questions about parts of the woodstove, for instance about the position of the lever(s) for the air vault or how to open the door, were answered. During the burning process, the test leader paid attention to what the participant did, but without commenting on it. After the test, the participants of the prototype were asked specifically about whether they had noticed (and used) the different steps on the air vault lever, the thermometer or the user manual, and what they thought of it.

To enable a direct comparison between tests, the woodstoves had to be cold and empty of ash before each test. Thus, it was only possible to conduct one test in each woodstove per day, alternating daily which woodstove was used first and last. For every test, the participants were provided with three firelighters, a matchbox and 2.2 kg (+/- 0.02 kg) of wood in some smaller and some larger logs, with a moisture varying between 17.5% and 20.9%. Some participants needed more than the three firelighters, and were given additional ones. The testing lasted until 20% of the mass of the wood was left in the woodstove. Measurements were made every minute of the emissions of $CO_2$, CO, $O_2$, and NOx. In addition, the weight of the remaining wood and temperature development in the smoke was recorded, and the total fine particle (PM) emissions were measured.

When it comes to compare differences in environmental impact the largest variations are expected to be found on the particle emission levels. Figure 4.30 illustrates particle emissions from a typical behaviour for a stove with new combustion technology tested according to the Norwegian standard (NS 3058-2:1994) on a preheated stove (Seljeskog, et al., 2013). For the same stove the burn rate is varied by adjusting the air supply handle(s) for the main combustion air. Depending on the amount of air, low and high burn rates are then achieved. As particle emissions are measured on a filter sampling the total burning period, it is not possible to provide proper explanation concerning the effect of only the initial lighting period. Typically for wood stoves is that the particle emissions increase as a power function, when the burn rate decreases.

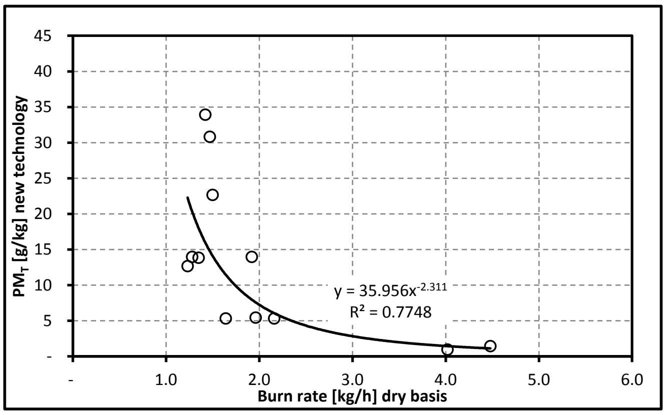



Figure 4.30. PMt in [g/kg] vs. dry basis burn rate of wood [kg/h].

### 4.2.4.6. THE TESTING PHASE: RESULTS

None of the participants that used the prototype consulted the user manual and the few who noticed the thermometer, thought it was part of the measuring instruments and not something they should pay attention to. However, half of the participants using the prototype noticed the icons and letters before or during the beginning of the burning process, and they all used it actively both by adjusting the air according to the icons and by naming the letters when talking about what they were doing. Among the participants who did not notice the icons, four out of five were very enthusiastic about them when they were asked about them after the test. They also said they believed they would have interacted differently with the woodstove, if they had noticed them before the test. Only one participant was uncertain about their meaning and thought it would not have affected her if she had noticed them in the beginning of the test.

The way the participants used the woodstoves was analysed to evaluate to what extent their behaviour was in line with the recommendation. Particular attention was given to whether the participants had lighted the fire from the top, closed the primary air after it burned properly, adjusted the secondary air and achieved a successful secondary burning. These criteria, together with other observations and the general evaluation of what the participants had done, formed the basis for rating their behaviour on a scale from "not at all" in line with recommended behaviour to "identical" (see Table 4.9). Based on this evaluation, it is apparent that the five participants who noticed the icons behaved identical or quite in line with the recommendations. They also closed the primary air, adjusted the secondary air and achieved good secondary burning.

Table 4.9. The number of participants performing particular actions and how much they were in line with the recommended behaviour.

| The conventional woodstove | | | | | |
|---|---|---|---|---|---|
| Lighted the fire “from the top” | Yes | 4 | | | |
| | No | 6 | | | |
| Closed primary air after it burned properly | Yes | 2 | | | |
| | No | 8 | | | |
| Adjusted secondary air | Yes | 4 | | | |
| | No | 6 | | | |
| Good secondary burning | Yes | 6 | | | |
| | No | 4 | | | |
| How similar was the behaviour to the “ideal” | | | | | |
| Similarity with recommended (1= not at all, 5 = identical) | 1 | 2 | 3 | 4 | 5 |
| No. of tests | 3 | 4 | 1 | 2 | 0 |

| The prototype | | Noticed the icons | Did not notice | | |
|---|---|---|---|---|---|
| Lighted the fire “from the top” | Yes | 3 | 2 | | |
| | No | 2 | 3 | | |
| Closed primary air after it burned properly | Yes | 5 | 1 | | |
| | No | 0 | 4 | | |
| Adjusted secondary air | Yes | 5 | 1 | | |
| | No | 0 | 4 | | |
| Good secondary burning | Yes | 5 | 3 | | |
| | No | 0 | 2 | | |
| How similar was the behaviour to the “ideal” | | | | | |
| Similarity with recommended (1= not at all, 5 = identical) | 1 | 2 | 3 | 4 | 5 |
| Tests not noticing the icons | 2 | 1 | 2 | 0 | 0 |
| Tests noticing the icons | 0 | 0 | 0 | 3 | 2 |

The measured emissions from the test show substantial variations in all categories (see Table 4.10).

Table 4.10. The emissions from the tests. The prototype tests are on the grey lines. * Participants who became aware of the icons.

| *Test nr.* | *Time (min)* | *Wood usage kg/h* | *PM g/h* | *PM g/kg* | *O2 vol%* | *CO vol%* | *CO at 13 $O_2$ vol%* | *NOX* | *NOx at 13 $O_2$ vol%* | *$CO_2$ vol%* | *Lambda* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 34 | 2,46 | 6,48 | 2,64 | 10,43 | -- | -- | 81,10 | 61,40 | 9,99 | 1,99 |
| *2 | 34 | 2,43 | 4,14 | 1,71 | 9,97 | -- | -- | 72,70 | 52,73 | 7,85 | 1,90 |
| 3 | 35 | 2,47 | 7,04 | 2,85 | 10,54 | -- | -- | 72,30 | 55,30 | 7,10 | 2,01 |
| 4 | 42 | 2,00 | 5,29 | 2,65 | -- | -- | -- | -- | -- | -- | -- |
| 5 | 31 | 2,81 | 3,14 | 1,12 | 10,13 | 0,10 | 0,07 | 68,80 | 50,60 | 7,70 | 1,93 |
| 6 | 33 | 2,58 | 15,44 | 5,98 | 13,45 | 0,07 | 0,07 | 38,55 | 40,85 | 3,81 | 2,78 |
| 7 | 53 | 1,63 | 3,74 | 2,30 | 11,52 | 0,13 | 0,11 | 41,30 | 34,85 | 6,19 | 2,22 |
| 8 | 35 | 2,47 | 6,65 | 2,69 | 11,69 | 0,14 | 0,12 | 50,61 | 43,50 | 5,85 | 2,25 |
| 9 | 50 | 1,72 | -- | -- | 8,88 | 0,23 | 0,15 | 66,00 | 43,60 | 9,11 | 1,73 |
| *10 | 40 | 2,13 | 6,03 | 2,84 | 12,43 | 0,07 | 0,06 | 49,93 | 46,61 | 4,90 | 2,45 |
| *11 | 39 | 2,18 | 2,87 | 1,31 | 10,33 | 0,11 | 0,08 | 61,52 | 46,13 | 7,54 | 1,97 |
| 12 | 44 | 1,96 | 4,00 | 2,04 | 10,46 | 0,12 | 0,09 | 58,69 | 44,50 | 7,27 | 1,99 |
| 13 | 38 | 2,25 | 5,11 | 2,27 | 10,57 | 0,12 | 0,09 | 69,78 | 53,50 | 7,11 | 2,01 |
| 14 | 23 | 3,73 | 13,23 | 3,55 | 10,15 | 0,19 | 0,14 | 75,40 | 55,59 | 7,45 | 1,94 |
| *15 | 39 | 2,12 | 6,07 | 2,86 | 12,32 | 0,08 | 0,07 | 50,03 | 46,11 | 5,04 | 2,42 |
| 16 | 55 | 1,53 | 7,32 | 4,79 | 14,04 | 0,10 | 0,12 | 31,90 | 36,70 | 3,05 | 3,02 |
| 17 | 49 | 1,69 | 12,63 | 7,48 | 13,15 | 0,21 | 0,22 | 32,15 | 32,80 | 4,04 | 2,68 |
| 18 | 33 | 2,59 | 10,45 | 4,03 | 12,28 | 0,12 | 0,11 | 44,79 | 41,09 | 5,06 | 2,41 |
| *19 | 33 | 2,53 | 8,74 | 3,46 | 10,70 | 0,19 | 0,15 | 54,62 | 42,42 | 6,90 | 2,04 |
| 20 | 67 | 1,26 | 10,05 | 7,91 | 15,47 | 0,07 | 0,10 | 15,31 | 22,10 | 1,34 | 3,80 |
| Avg. | 45 | 2,02 | 6,74 | 3,73 | 11,65 | 0,14 | 0,12 | 52,70 | 43,19 | 6,16 | 2,38 |
| St.dev. | 11,05 | 0,38 | 3,65 | 1,34 | 1,40 | 0,06 | 0,04 | 15,29 | 8,11 | 1,97 | 0,32 |
| Avg. | 36 | 2,44 | 7,78 | 3,09 | 11,37 | 0,12 | 0,10 | 56,11 | 46,17 | 6,18 | 2,21 |
| St.dev. | 7,63 | 0,54 | 4,17 | 1,31 | 1,20 | 0,05 | 0,03 | 13,63 | 6,76 | 1,39 | 0,29 |
| *Avg. | 37 | 2,28 | 5,57 | 2,44 | 11,15 | 0,09 | 0,07 | 57,76 | 46,80 | 6,45 | 2,16 |
| *St.dev | 3,24 | 0,19 | 2,23 | 0,89 | 1,15 | 0,05 | 0,04 | 9,60 | 3,72 | 1,39 | 0,26 |

To investigate if the difference in the emissions from the conventional woodstove and the prototype, or the participants who noticed the icons, is significant, we used the Wilcoxon rank-sum test. The Wilcoxon rank-sum test is useful when the purpose is to find the equality of means of two independent, continuous, non-normal, distributions (Walpole et al., 2002). The result of this test is that none of the differences are significant (see Table 4.11).

Table 4.11. Comparing the measured emissions. W = the rank sum, z = the unit of normal distribution and p = the significance level.

| | *Conventional woodstove* | | | |
|---|---|---|---|---|
| | PM g/kg | CO at 13 $O_2$ vol% | $NO_x$ at 13 $O_2$ vol% | $CO_2$ vol% |
| *Prototype* | w=190<br>z=-0.245<br>p=0.8065 | w=136<br>z=1.004<br>p=0.3156 | w=190<br>z=-0.572<br>p=0.5675 | w=190<br>z=-0.245<br>p=0.8065 |
| *Only participants who noticed the icons* | w=105<br>z=0.333<br>p=0.7389 | w=78<br>z=1.368<br>p=0.1712 | w=105<br>z=-0.734<br>p=0.4629 | w=105<br>z=-0.067<br>p=0.9468 |

However, the reliability of test is low when the sample size is small (Cohen, 1988). The small sample size also makes the non-significant results of the test less surprising, as significance would require a very large effect. To test the statistical power of the results, assuming a normal distribution, a two sample t-test for mean difference identified that there would be 80% probability of significant results for PM with 91 participants in each group and for CO with 194 participants (Table 4.12).

Table 4.12. Statistical power & N per group for 80% probability of P<0.05.

| | *Conventional woodstove* | | | |
|---|---|---|---|---|
| | PM g/kg | CO at 13 $O_2$ vol% | $NO_x$ at 13 $O_2$ vol% | $CO_2$ vol% |
| *Prototype* | Power = 0,068<br>N = 447 | Power = 0,063<br>N = 476 | Power = 0,052<br>N = 3487 | Power = 0.05<br>N = 374710 |
| *Only participants who noticed the icons* | Power = 0,111<br>N = 91 | Power = 0.,073<br>N = 194 | Power =0.052<br>N = 2454 | Power = 0.051<br>N = 7422 |

In addition, there are also other indications from the testing results that suggest that the prototype resulted in better burning processes than the conventional woodstove. After each test, the ash was removed from the woodstoves, but no other cleaning was done. Before the testing, both woodstoves were almost unused and consequentially had completely clean glass at the sides and on the door. During the testing, the glass surfaces on the conventional woodstove gradually got increasingly opaque, whereas glass on the prototype stayed clean (see Figure 4.31).

Figure 4.31. Soot on glass door after the testing. The conventional woodstove to the left and the prototype to the right.

When considering the burning intensity of the wood and the emissions of particles, it is also apparent that all measurements from the participants who noticed the icons are centred around the same area, whereas the other measurements are much more spread out (see Figure 4.32). This observations is also supported by the smaller standard deviation for the participants that noticed the icons, for almost all the emissions.

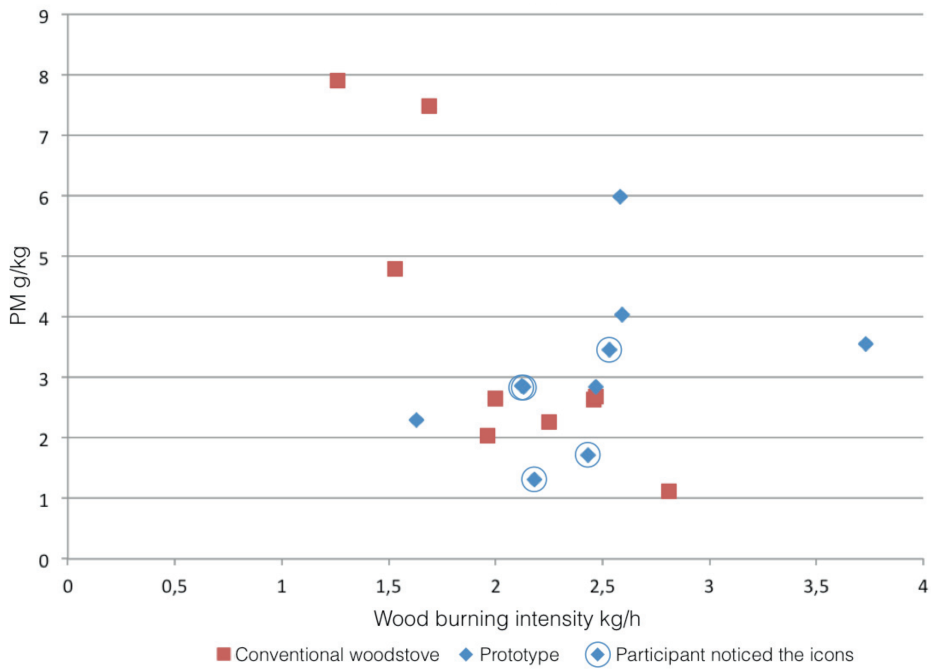



Figure 4.32. Plot of PM g/kg and Wood burning intensity kg/h.

It is possible to draw some conclusions concerning the chosen method for lighting the stove, by dividing measured particle emissions into low and high emissions. Lightning from the top seems to be clearly better than both conventional lightning either from the bottom or using a small standalone kindling fire. Table 4.13 shows the number of participants that achieved high or low particle emissions depending on how they lit the stove. As much as 83% of the participants that lighted from the top achieved lower than average particle emissions. The same figures for those who lighted from the bottom or used a small standalone kindling fire are 67% and 55%, respectively, with an average of 57% if we assume that lightning from the bottom and using a standalone kindling fire are two conventional approaches.

Table 4.13. Particle emissions depending on how the stove was lit divided into all used categories, i.e. top, bottom and small kindling fire; number of participants and percentage.

| | | *Type of lighting* | | | |
|---|---|---|---|---|---|
| | | Top | Bottom | Small kindle fire | Bottom & small kindle fire |
| *Particle emissions* | Lower than average | 5 (83%) | 2 (67%) | 6 (55%) | 8 (57%) |
| | Higher than average | 1 (17%) | 1 (33%) | 5 (45%) | 6 (43%) |
| | Total | 6 (100%) | 3 (100%) | 11 (100%) | 14 (100%) |

Figure 4.33 illustrates how a poor start-up due to unsuccessful lighting can affect the overall combustion quality over the whole cycle, here illustrated by the temperature in the chimney and the CO2/CO content of the flue gas. If the lighting of the stove is done in such a way that the main wood logs actually do not catch fire, it can affect the whole combustion cycle. The result is low temperature in the chimney, low CO2 emissions and high CO emissions. Low stack temperature, low CO2 and high CO concentrations are typical signs of low-quality combustion normally resulting in high particle emissions.

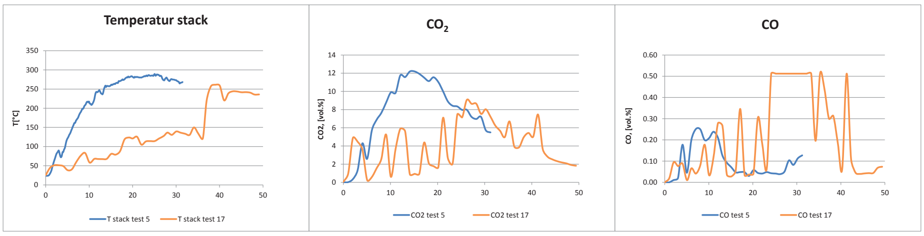



Figure 4.33. Typical examples of good and bad combustion quality, i.e. low and high particle emission, over the whole batch period for case 5 (good) and case 17 (bad).

### 4.2.4.7. DISCUSSION

In this section, two aspects of the research will be reflected on: first, the potential of using behaviour changing principles to enable more sustainable use of wood stoves, and secondly, the research methodology used.

Based on the results, one can interpret that this study support the hypothesis that the design of woodstoves can make people use them more in line with the recommendations and potentially reduce the emissions. Given the small sample and the number of non-controlled behaviours that affect the emissions and contribute to the spread in the measurements, a significant result would almost be remarkable, and there is a clear effect, even if it is non-significant. If for instance comparing the average PM emissions, the participants who noticed the icons on the prototype emit only 65% as much as the conventional oven. Assuming that this result did not occur by chance but is representative for the population and this design was applied to all ovens in Norway, one sixth of the PM emissions in Norway could be eliminated. If this is true, the effect of the relatively small adjustments is impressive. In other words, the result of the test indicate that it may be worth conducting a large scale experiment to find out if the results are representative for the population.

At the same time, when analysing the ways the different participants lighted the fire and the emissions resulting from the burning process, it becomes apparent that how quickly the user achieves a good burning process has a very strong effect on the results. Participant 6 and 15-20 all had some problems getting the fire to burn properly and spent a long time before they achieved a proper secondary burning process, if any at all. These participants also represent, with one exception, the participants who had the highest PM/kg emissions, although two of them were among the participants who noticed the icons and behaved more or less according to the burning recommendations. This not only shows the importance of getting a good burning process going quickly, but also indicates that it may be better to light the fire from the bottom properly, than attempt to light it from the top with multiple trials and errors. This finding may also explain why participants' behaviour that was according to recommended firing behaviour did not see significantly lower emissions compared to that of the other participants.

This result also points out that it is worthwhile to explore further how the design of ovens may be improved and do further testing without the variation in the way the participants lighted the fire. The primary function of the combined lever was to simplify the air adjustment and avoid the situation where the wrong air valve is closed. Possibly the thermometer could have simplified this even further, but as none of the participants noticed this, the test is unable to evaluate this aspect. However, further simplification of the adjustment of the air valves, and possibly other aspects of the interaction with the woodstove, are undoubtedly possible and potentially valuable.

The icons added to this effect by providing the users basic information about what the different positions of the lever. The test shows that the majority of the participants were both responsive and enthusiastic about this type of support. This effect may be enhanced further, for instance by having a longer movement of the lever, to make it easer to make small adjustments to the secondary air, and possibly improve the use of icons to better communicate the usefulness of the area between the two extremes for the secondary air.

The fact that only half of the participants using the prototype noticed the icons, non noticed the thermometer and non consulted the simplified user manual, is in line with the known challenges connected to affecting a habitual behaviour (Jager, 2003, Verplanken and Wood, 2006, Klöckner and Matthies, 2004, Jackson, 2005). In the context of the woodstove, this presents a challenge, as a design that would be obtrusive enough to break the habits of the users is unlikely to be accepted by the users. Thus, the way the behaviour changing aspects of a new woodstove are presented, would benefit from additional research. The lack of attention given to the user manual may also be a consequence of the lack of attention user manuals often are given. The thermometer was interpreted as one of the many measuring tools attached to the woodstove, and thus may have had more effect if applied in a non-lab setting.

The user centred methodology applied in this project is time and resource consuming, but does prove to provide a number of positive effects. It is of course possible that designers could have generated the same concepts based on their intuition and personal experience, but the rich data from the user studies also supported the interpretation and analysis of the results of the testing, and provided a framework to interpret the participants behaviours and opinions. In retrospect, is it apparent that the efforts made in the design process was sufficient, but that the reliability of the results would have benefited from additional testing. Possibly a second session where the participants were made aware of the new design aspects of the prototype, would have contributed with valuable new insight. Such a scenario would not have been unrealistic considering that people normally are more familiar with the woodstove they have at home.

The use of Principles of Behaviour Change to evaluate the likelihood of the ideas resulting in the desired behaviour change and being accepted by the users, also contain a number of potential errors. First of all, the positioning of the ideas in the landscape is difficult, particularly because the position may depend strongly on how the principle is applied, not only on the type of principle. The results of the analysis only indicate that particular types of principles have the potential to result in the desired behaviour or are likely to be accepted by the user. There may also be several other aspects of the design of a product that also affect the success of the design. Never the less, the tool does provide some indication and can provide additional understanding of how the product affects the user, in addition to the exclusion of directly unsuitable ideas.

#### 4.2.4.8. LIMITATIONS

Whenever interviewing someone, there is always the risk of the interviewee adjusting their answers according to what they believe is socially acceptable (social desirability) or what they believe the interviewer wants them to answer (prestige response bias) (Courage and Baxter, 2005). In the study presented in this paper, in particular social desirability may have affected the results of the applied ethnography conducted in the user research phase. In recent years, Norwegian newspapers and magazines have frequently featured articles with descriptions of how one should use modern woodstoves. It is possible that some of the participants adjusted their behaviour because they were embarrassed of not doing it the right way. Even though observations in a lab setting would likely have created even more complications, it is still possible that, during the home visits, the participants behaved differently than normal as they were being observed and the behaviour was recorded, and because they stayed in front of the woodstove during the entire burning process, which most of them normally would not. The purpose of the interview was partly to reduce this effect, as the participants could concentrate on something besides attending the fire. To reduce this bias, the importance of the users behaving their usual way was explained to them before the interview. There is also a risk of a biased population for the user studies, as only 17 studies were conducted and all in the proximity of Oslo. However, due to the time consuming nature of visiting peoples' homes and analysing the rich data from the studies, this risk was unavoidable within the limitations of the project. Small test populations are common in user centred design due to the nature of the research and because of limited resources.

Ensuring the type of academic accuracy in a way that is common in other research areas is therefore often challenging in design research (Aldersey-Williams et al., 1999).

The testing of the prototype has a similar risk of social desirability as the ethnographic studies and the risk of an unrepresentative population, because it was only possible to include 20 participants from the same geographic region. In addition, the behaviour of the participants may have been affected by the unfamiliar nature of the surroundings of the test. There is also a risk of prestige response bias, in particular when participants were asked to comment on the icons on the prototype; they may have understood that these were central in the testing and possibly something the test leader was responsible for. Several of the participants also pointed out that they normally need a few iterations to get to know a woodstove and understand how to use it optimally. The small test population was a consequence of the need for comparable test conditions, which only allowed one test per woodstove per day, and a limitation in the resources, allowing only two weeks of full time access to the test lab facilities and personnel.

The nature of the variations in the measurements of the emissions contains a number of uncertainties, as there were some variables that could not be controlled. Most importantly, the emissions depend on several aspects of the participants' behaviour, such as how many firelighters they use, how tightly they pack the wood, at what time they reduced the air, etc., which could not be controlled as the intention was to investigate how people naturally would interact with the woodstoves. Nevertheless, a few limitations were made to the participants' behaviour, as they were given a controlled amount of wood, firelighters and matches. Several of the participants were used to using large amounts of small wood or paper, but allowing the use of this would dramatically have increased the uncertainties. The variations in other aspects of the participants' behaviour are likely to be the key reason why there is less significant reduction in the emissions from the participants who adjusted the air according to the recommendations.

#### 4.2.4.9. CONCLUSION

This sub-chapter presents a complete user centred, Design for Sustainable Behaviour process, from the initial user research, through the design phase to the building and testing of a prototype. The purpose was to investigate whether an alternative design of a woodstove, informed by principles of behaviour change, will make people interact with it in a way that is more in line with the recommended behaviour, and if this would result in reduced emissions. The initial user research resulted in the creation of four personas, which were used to inform the new design. The most promising and feasible design was selected through a combination of consultation technical personnel at Jøtul and the application of a tool called Principles of Behaviour Change. The resulting design was translated into a prototype, which was tested together with a conventional woodstove, in a lab with regular woodstove users. The reductions in the emissions resulting from the test are relatively large but are all non-significant.

83% of the participants that lighted from the top achieved lower than average particle emissions. The same figures for those who lighted from the bottom or used a small standalone kindling fire are 67% and 55%, respectively, with an average of 57% if we assume that lightning from the bottom and using a standalone kindling fire are two similar conventional approaches. If the measured particle emissions are divided into lower or higher emissions, lightning from the top seems to be clearly better than both lightning from the bottom or using a small standalone kindling fire.

The prototype resulted in behaviours that are more in line with recommended behaviour. The non-significant emission results are likely to be a consequence of the small sample size in the testing, and could benefit from a larger scale testing of the prototype for confirmation or rejection. If such a test should be conducted, it would be interesting to focus on later stages of the burning process, or in other ways remove the variation in how the participants lighted the fire, as this had a large effect and made it difficult to measure the effect of the new design. The description of the design process and the relatively positive results from the testing of the prototype, may contribute to improvement of DfSB processes and attention to the potential environmental benefit from affecting behaviour through product design.

# 5. DISCUSSION

This research project has investigated what type of information can help designers make informed decisions about the type of behaviour changing principles they apply to make people interact with products in the most desirable ways and how this information should be presented to support integration in design projects. The investigation has consisted of a combination of drawing upon existing knowledge, theories and knowledge from literature and both descriptive and explorative empirical studies. This process has resulted in the selection of theoretical framework and behavioural models and factors, the identification of the relevant dimensions of how the design of products affect user, the identification of requirements and development of tools, and an evaluation of the tools. This chapter contains a number of discussions arising from the topics described in this thesis. Firstly, challenges related directly to answering the research questions are discussed, targeting the gathering and analysis of the design dimensions and the development of the DBC. Secondly, more general topics of the research project are discussed, focusing on how ethical challenges are dealt with and the validity and reliability of the results. Finally, a more general discussion is made concerning the challenges of evaluating DfSB projects and the limitations of this project.

## 5.1. DIMENSIONS OF BEHAVIOUR CHANGE

Parts of Chapter 5.1. is adapted from the original text in Daae and Boks, *Dimensions of behaviour change*, JDR, 2013.

The purpose of DBC is to help designers create products that make people use them in a more sustainable way. As previously stated, the intention was to achieve this by helping the designers make informed decisions about which behaviour changing principle they apply in their products. By informed decisions it is meant that the designer uses his or her insight about the user and the context to determine which principles are likely to achieve the desired behaviour change and be accepted by the users. In other words, it is not only assumed that particular characteristics of the user or the context make it more likely that particular design principles will affect the behaviour of the users and be accepted by them, but that it is possible to predict when. Unfortunately, in reality this does not result in a one-to-one matching list, where a given user characteristic can provide you with a definite answer to which design principles you should apply. It is rather that for each user or context characteristic, there are advantages and disadvantages of each type of design principles, with some types possibly being more suitable than others. To complicate it further, it is often just as much a question of how the principle is being applied and presented, as which principles is being used. The DBC tool is an attempt to help designers navigate in this rather complex universe of parameters. The tool does this by presenting 16 different types of design principles and describes them according to one of the 9 dimensions, which the tool suggests that the principles can be adjusted along. The tool also provides a brief introduction to the main behavioural factors that social psychology has identified to affect behaviour, and describes the main effects variations of the dimensions are likely to have on these.

As pointed out earlier, it can be problematic to thoroughly test the successfulness of a DfSB tool and this has not been possible to do within this project either. However, the tools have been tested in a number of evaluations, of which two are capable of providing insight suitable to more than just further product development. In Chapter 4.2.4.5, the behaviour changing, and to a certain degree environmental impact reduction, effect of a product designed using a tool developed in this project is tested. Through a comparative lab study between a conventional woodstove and a high-fidelity prototype, it is found that the application of the principles suggested in the DfSB tool leads to both the desired behaviour change and environmental reduction. Even though the small sample size limits the possibility of drawing definite conclusions, the results of the experiment supports the belief that a DfSB focus on product design, as proposed by the DBC tool, may lead to the desired behaviour change and less environmental impact than a regular design.

The other main evaluation is the Delft study described in Chapter 4.1.2.4, where the results of a DfSB process with and without DBC is compared. Also this study suffers of the previously mentioned challenge of evaluating the actual behaviour changing potential of new designs. Some authors (e.g. Elias, 2011b, Wilson, 2013) solved this problem by building prototypes and testing them in user trials, similar to what was done in the woodstove project.  Unfortunately, it was not feasible within the limitations of this project to apply this approach for the results of the Delft study, as the need for a large population resulted in 108 design concepts that should be compared. Another approach of evaluating the results is to analyse and compare the concepts directly (e.g. Lilley, 2007) or have potential end users evaluate drawings of the concepts (e.g. Tang, 2010). A version of this approach was considered, by having a group of behaviour change experts evaluate the concepts. However, this would require substantial time and efforts from external experts and the interpretation of both the concepts and the target group and context. The chosen approach of identifying and counting the variation in approaches was thus considered the most feasible method to compare the results. This method also enabled a quantification of the results, which simplified the comparison of relatively extensive data. It is of course not given that a larger variation in design approaches considered would automatically result in a better final design, but as one of the requirements for the tool was to "Increase the designers understanding of different aspects of how the product affects the behaviour of the user", this was considered a relevant parameter to measure.

Counting the number of ideas generated is another way to measure the success of a concept development process (Osborn, 1953) and is a commonly used evaluation parameter (e.g. Lockton, 2013). Based on this measurement alone, the results from the workshop indicated a negative contribution of DBC to the design process, as the greatest number of ideas were generated by the teams that did not have access to the tool. The higher number of ideas generated without the tool may be an indication that the tool encumbers the creative process or be a result of the extra time and energy the teams could apply to the idea generation, as they did not have to spend any effort on understanding and applying the tool. However, the amount of ideas on post-it's generated by the teams may be an incorrect measurement of the ideas considered by the teams. Several of the teams reported that they used the examples given on the tools directly when proposing and discussing ideas, without making sketches of them on the post-it's. Thereby, there is a direct error in the measurement of ideas created by the teams with the tool. In addition, more ideas do not automatically mean better ideas. After all, the teams with the tool had a greater variation in the approaches to affect the behaviour. Thus indicating that the number of ideas generated may not be the most appropriate variable to measure in this context. It should also be noted that the teams that did not have the tool in the first session, also in the second session generated more ideas than the other teams did in either session. This may indicated a difference between the creativity level or way of working between the teams.

In addition, several of the students commented that they were tired in the second session and were affected by the heat as the day of the workshop experienced a heat wave in Delft with more than 30 degrees Celsius, which affected both the temperature and air quality, and possibly the motivation of the students. This may have reduced the number of ideas generated in the second session and the concepts they generated. Nevertheless, the number of approaches applied in all the sessions where the teams had access to the tool is very stable. This does indicate that the effect of the tool is fairly similar whether the students use the tool with no introduction, use the tool after introduction or use the tool for the second time. It should however be noted that all the teams that used the tool for the second time actually finished after less than 1,5 hours in the second session, without this affecting the variation of approaches they applied in their concepts. This may indicate that the efficiency of the process increases with previous experience with the tool.

As the concepts designed in this workshop were not developed into high fidelity prototypes and tested, the results do not say anything directly about the actual behaviour changing ability of them. To remedy this, the results may be evaluated according to parameters that are assumed to indicate the desired effect. For instance, the experiment found that the students with the tool, used significantly more unique design approaches to affect the behaviour of the users, than the students who did not have the tool. Even if it is not given that a larger variation in approaches will result in more successful designs, it is not an unreasonable assumption. Similarly the results can be evaluated according to the original list of requirements (Chapter 2.1.3.1) that guided the development of tool 2 (Table 5.1).

Table 5.1. Evaluation of requirement fulfilment of Dimensions of Behaviour Change.

| *Must* | *Evaluation* |
|---|---|
| Help designers to design products that are more likely to be used in the desired way by using the tool, than without the tool. | Unfortunately, this was not possible to measure based on the test, but assuming that a greater variation of design principles does lead to better design, the tool does may indeed increase the chance of the desired behaviour change. The participants also believed that the tool improved the quality of the result. |
| Help designers understand which design principles they should apply to change the behaviour of their target group. | Again, this was not something it was possible to measure directly form the test. There are indications that the tool results in more informed decisions about when to apply which principle both from the survey results and the feedback, although these might not be conclusive. The survey result for the question of whether the tool helped them make decisions about how the design should be, received 3.1, which is barely on the positive side. However, the survey scores a much higher 3.9 to the question of whether to tool helps them understand how design affects behaviour, which is a more positive indication. |
| Increase the designers understanding of different aspects of how the product affects the behaviour of the user | Both the measured increase in variation of the results, and the survey score of 3.9 for the question of whether the tool helped them consider new aspects indicates a clear fulfilment of this requirement. |
| Be easy to use for product designers, fit into designerly ways of working | The feedback and survey states that the tool fits fairly well into the way they normally work and was quite flexible. |
| *Should* | |
| Be possible to understand how to use in 15 minutes | The results don't show whether the tool was understood in 15 minutes, but the survey shows that the tool is fairly easy to understand how to use and both the feedback and the results form the test shows that the students did not have any major problems applying it. |
| Be experienced as inspiring for designers | Both the survey score (3.8) and the feedback states that the students found it inspiring. |
| Be in a format that makes it suitable for discussion and collaboration | It was hard to determine the result of this in the test itself, but the survey score of 3.9 indicates that the students indeed found it to support discussion and collaboration. |
| Should be experienced as suggesting rather than dictating | As the students found it fairly flexible in the survey and this was not brought up as an issue in the discussions after the test, it indicates that this is not an issue. At least it is much better than the Principles of Behaviour change, where this was pointed out as a major issue. |
| Remind the designers of the aspects of a product that affect the way users interact with it | Both the significantly higher variation in the principles considered and the survey result that it helped them consider new aspects indicates that this is fulfilled. |
| *Could* | |
| Be suitable to bring to meetings with clients to help the designers explain their decisions | This was not evaluated specifically, but the format of the tool is likely to fulfil this requirement. |
| Be experienced as primarily visual | Again not investigated specifically, but the fact that it was experienced as inspiring indicates that this requirement also is fulfilled. |
| Be written in a non-scientific language | As the tool was fairly easy to understand, and the students seemed to have a good understanding of the content and purpose of the tool in the discussion, the language is probably sufficiently non-scientific. |

Even though neither of these experiments are able to evaluate if DBC results in more successful behaviour change and reduced environmental impact compared to a DfSB process not using DBC, it may be argued that the two experiments are supplementary and together provide a relatively good indication of the success of the tool. At the very least, the experiments show that the results of a DfSB process with and without a tool provides different results and that a process with the tool can have the desired effect. In this discussion, Principles of Behaviour Change and DBC are considered as the same tool, which is not entirely true, but justifiable as the one builds upon the other, they build upon the same theories and have similar approaches.

Besides the behaviour changing effect of DBC, it may have a number of other positive effects on the design project. It can help the designer consider the way the user interacts with the product from several different perspectives. Some of these might be perspectives that the designer may not be consciously aware of, and even if the designer already is aware of all the perspectives, the tool can provide arguments for why the design is a good solution. The tool can also function as a reminder of the most important behavioural factors and indicates possible consequences of different choices. As the tool contains a multitude of different examples, it can also have a purely inspirational function and be used as a forced function tool in similar ways as DwI (Lockton et al., 2010a).

## 5.2. COMPARISON WITH EXISTING TOOLS

Whenever developing something new, it is relevant to investigate the existing solutions and evaluate the result of the developing process with the most relevant of these. Chapter 2.1.3 contains a description of the existing DfSB tools that can be found in the literature, and brief assessments of how well these tools fulfil the requirements identified in Chapter 2.1.3.1. In the following text, a more elaborate comparison and evaluation is made with the two most relevant of the existing tools; Design with Intent (Lockton et al., 2010a) because this is the DfSB tool that is most mature and has been most widely applied; and the Design Behaviour Intervention Model (Tang & Bhamra, 2012) because this is the tool with the most similar theoretical basis and purpose as the DBC.

### 5.2.1. DESIGN WITH INTENT (DWI)

When comparing DwI and DBC, it immediately becomes clear that the aim of the two tools is slightly different. From its description and the way the effect of the tool was evaluated, DwI aims to help designers generate as many ideas as possible for changing behaviour through their design. DBC, on the other hand, aims to help designers make informed decisions about what ideas to apply in their projects. Although the goal of the tools is similar, the proposed approaches are different. A reason for this difference may be attributed to whether it is believed that the designers primarily needs support to generate more ideas or support to consider the problem from the right perspectives and navigate among the ideas. However, this line of thought should not be drawn too far, as the 1.0 version of DwI was published in April 2010, and thus existed before the work on DBC had started. Therefore, a successful solution for generating ideas already existed and DBC was developed to elaborate further on aspects DwI did not extensively cover. DwI does provide some support in understanding different types of target groups by distinguishing between Thoughtful, Shortcuts and Pinballs, representing the users who wish to understand, chooses the easiest alternatives and follows along mindlessly. This interpretation of the distribution of control (see Chapter 2.1.1) is accompanied by some suggestions to design patterns that are particularly suited to target the different user types. Apart from this, the tool does not provide any information to help the designer consider the appropriateness of the design patterns. The patterns are divided into 8 lenses representing different worldviews; "the way that a designer versed in a particular discipline might approach a brief on influencing behaviour" (Lockton, et al., 2010a, page 386). This differs from the dimensions, which represent the different ways the design principles are applied, and determine how they will affect the behaviour of the user. The differences and similarities between DwI and DBC makes the two tools rather supplementing than competing, and suggests that a project may benefit from applying both for the appropriate purposes, which was also the intention when DBC was developed.

### 5.2.2. THE DESIGN BEHAVIOUR INTERVENTION MODEL (DBIM)

The DBIM was also developed and published prior to this research project (T Tang, 2010). The starting point of DBIM and DBC are similar, as both aim at linking behavioural models and factors identified by behavioural psychology to the choice of design principles. Although DBIM primarily draws upon Triandis' theory of interpersonal behaviour (Triandis, 1977) and DBC upon the CADM (Klöckner & Blöbaum, 2010), these two models are largely overlapping and more or less identify the same behavioural factors. DBIM connects these factors to the distribution of control, which is one of the dimensions for DBC and was the only dimension in the early versions of Principles of Behaviour Change (see chapter 4.1.1), which DBC originates from. All these similarities make it natural to question why Principles of Behaviour Change and DBC were developed. The answer to this question lies in the differences between them. Whereas DBIM makes direct links suggesting appropriate levels of control to affect the various behavioural factors, DBC is based on the understanding that this relation is more relative. The appropriateness and potential success of principles with varying levels of control depend on more than just the type of behavioural factor one is targeting. The DBIM is also presented as a model, prescribing particular connection, but is not developed into a tool that easily supports the practical application in design projects. Finally, as the Principles of Behaviour Change and DBC evolved, it became clear that there was a need for additional dimensions to describe how different types of design principles affect the behaviour of the user, and how and when they should be applied in order to both have the desired behaviour changing effect and be accepted by the user.

## 5.3. ETHICAL IMPLICATION OF UNINTENDED USE OF DFSB RESEARCH

An ethical challenge for any type of DfSB research and in particular for the development of tools aimed at changing behaviour more effectively, is the possibility that the results of the research are being used for other purposes than they were meant to. This might be seen as a potential rebound effect of the research itself, and may theoretically result in a greater increase in environmental impact than the initial targeted reductions. As the basic mechanisms are the same for both sustainable and unsustainable types of behaviour, the same research that aims at making products people use in the most sustainable way, can just as easily be used to make people alter their behaviour in other ways. For instance, a typical example of DfSB projects, is to design washing detergent packaging in a way that makes people only use the optimal amount of detergent. However, the same principles that are used to optimise the detergent use can also be applied to make people use more detergent than they need and thus to buy more detergent than necessary. This can be done by reversing the design principles and for instance make it difficult or unintuitive to use the right amount of detergent, or even by deceiving the users and make it easy to use more detergent than necessary. Although this might be on the edge of lawfulness, it is not an unlikely scenario as most companies aim at growth, which would be achieved by increased consumption of the product or resource the companies are selling. The ethical dilemma for the DfSB researcher would then be whether the initial good intentions of the work justifies it, even if there is no guarantee for achieving environmental benefit in the end. Analysing this, based on the logic of Berdichevsky and Neuenschwander (1999) (chapter 2.1.5, Figure 2.8), the outcome must be considered unintended, reasonably predictable and unethical. Thus, the designer is responsible and at fault. This analysis would be equally valid for a researcher. If so, any research that aims at making designers more effective at making people use their products in particular ways may be considered unethical. This type of logic would naturally undermine almost any DfSB research. However, this argument will by many, and perhaps not unjustly, be dismissed by attributing the unethical behaviour to the company that causes the environmental impact to increase sales, not to the researcher who developed the tool. An interesting approach to overcome this problem could be to develop methods that can only be used to achieve environmentally beneficial behaviour. How this should be done, or if it is possible at all, is uncertain and would need to be investigated further.

## 5.4. VALIDITY AND RELIABILITY OF THE RESULTS

As many of the research activities of this project were qualitative, the assessment of the validity and reliability of the results represents a challenge (see Chapter 3). As can be seen throughout this thesis, efforts were made to make the enquiries as neutral as possible, recruit sufficient and relevant participants, report the most important aspects of the research activities in detail and often triangulating methods. Nevertheless, the results are affected both by the direction and extent of the activities. The results of this project, including the conclusions and answers to the research questions (see Chapter 6.1), are thus to be considered as one possible solution to the initial problem and not as the only solution. However, the choices are the result of informed and conscious deliberations, and thus contribute to strengthening the validity of the results. In several of the studies, depth and granularity of the results were given priority over large sample sizes when choosing the methods. This decision was necessary to collect the required data for the analysis, but reduces the chance of identical results if the studies were to be repeated, and thus also reduces the reliability of the results. On the other hand, this is in the nature of the methods and was unavoidable within the boundaries of the project. Given the way the participants are recruited and the methods applied, it would never the less be surprising if the results of a repeated study should produce fundamentally different conclusions.

The validity and reliability of the quantitative parts of the project, for instance the testing of the woodstoves (Chapter 4.2.4.5), are easier to assess. For this particular test, the validity may be said to be good, as the test was conducted in controlled surroundings with high resources, even though there were a number of non-controlled behaviours. However, the reliability is somewhat compromised by the small test sample. This has direct consequences for the conclusions we can draw from the study and resulted in the insignificance of the reduction in emissions, even though they were reduced by $1/3^{rd}$. The considerations made when the participants were similar to the ones commonly used in qualitative research, where efforts were made to get an appropriate selection of participants to improve the degree of representation. In addition, compared with other design research experiments (see Chapter 2.1.2), the reliability of the results is well within what is normally required to inform a design process.

## 5.5. THE CHALLENGE OF EVALUATING DFSB PROJECTS

There are problems related to conducting experiments that thoroughly measures the successfulness of DfSB, which seems to be commonly experienced among the researchers. If considering the overview of case studies in Chapter 2.1.2, there are shortcomings to all the available studies, although some of them investigate an impressive variety of aspects and levels of detail considering the resources they had available. Whether these shortcomings are important may of course be discussed, as there can be a multitude of opinions regarding what thoroughness and success means. In my opinion, to thoroughly test the value of DfSB, the results of the research would need to be realised in a physical form, either as high fidelity prototypes or as existing products with the desired features, allowing testing in natural surroundings without the test objects being consciously aware of the test. To reduce the chance of the conclusions being the result of happenstance, the new design needs to be tested on a relatively large population. Unless the product in question is one where the users only encounter it very rarely, it would be necessary to measure the long-term effect of the new design and thereby include the new habits that may form in relation to it. With unobtrusive ways to monitor or measure the results, this would also reduce the chance of the participants being consciously aware of being tested and thus avoid biased behaviour. Further, even though the target is to achieve a particular behaviour change, the end goal is to reduce the environmental impact resulting from it. It would thus in most cases be insufficient to measure the behaviour change, but rather the combination of the behaviour change and the environmental consequences of it. Depending on how the results are being measured and how widely the behaviour is being monitored, this could also allow inclusions of rebound effects in the evaluation.

If the goal is to measure the success of a tool to support DfSB, as the case is with this PhD study, it is necessary not only to complete a study as described above for a product developed using the tool, but also for products developed without using the tool, or with alternative tools. Again there should be sufficiently large populations of design teams using the target tool and the alternatives, to make it is unlikely that the results are happenstance or the result of individual differences. A project, such as the one described above, could easily get too complex and resource demanding to be realistic. The natural solution, which is typical for the case studies described in Chapter 2.1.2 and to the studies conducted in this PhD, is to focus on a small aspect of the problem, or to accept a less thorough investigation.

## 5.6. LIMITATIONS

- The majority of the testing and evaluation of the tools during the project have been conducted by design students. The fact that the students are not yet fully trained, have limited experience, are unused to the challenges of design projects in the real world, and that the testing and evaluations have been done in non-commercial projects, can be expected to have an effect on the results. But the need for quick and controlled evaluation of the tools, and the limited resources of the project, made it necessary to accept this limitation. In addition, the immediate availability and access to the students, the possibility of deciding on what and how they should work, and their relatively open minds and the learning context, makes them easy to work with, in particular in the early phases of the tool development, when the tool is less refined.
- As I took part as facilitator in several of the studies, I have also affected the data collected and its reliability. Even if I tried to be as objective and critical as possible, it is possible that some results unconsciously have been affected by the wish to achieve particular goals. However, the resources available for the project did not enable any other approach, and efforts were made to keep the crucial steps of the development as transparent as possible.
- To guide the understanding of how behaviour is determined and can be affected, this thesis has relied on insights from behavioural psychological literature. There are several other fields that target related issues and potentially could have contributed with additional perspectives, such as marketing, behavioural economics and sociology. But as each of these fields contains a substantial literature, it was determined to focus the efforts on the one field that seemed most fruitful. (A comparison of the suitability of behavioural psychology with the other main field discussed in DfSB literature, sociology, can be found in chapter 2.1.6).

# 6. CONCLUSIONS AND FURTHER WORK

In this final chapter of the thesis, the general conclusions from the PhD study are drawn. This is done by first stating how the initial research questions have been answered through the thesis, followed by the general conclusions of the project summarising the main aspects of the conclusions of the individual chapters throughout the thesis; the contribution to knowledge is pointed out; and finally I give recommendations for further work.

## 6.1. ANSWERING THE RESEARCH QUESTIONS

As presented in Chapter 1.2, the main research topic for this PhD project was:

**How can designers be supported in the process of acquiring and translating an understanding of the user and the context into informed decisions about how to design solutions that make people interact with them in the most sustainable way?**

This is a relatively complex topic and has been divided into three research questions to clarify the topics of inquiry and to guide the investigation. Each of these research questions was investigated through sub-questions, which together addressed the main aspects of the research questions. In the following text, the research questions are presented together with their sub questions. Each of these sub-questions is answered and references are given to the papers and chapters addressing the question in more detail. Finally I give an answer to the research question.

### 6.1.1. RQ1. WHICH ATTRIBUTES OF THE DESIGN OF A PRODUCT AFFECT THE WAY USERS INTERACT WITH THE PRODUCT?

As DfSB had been a growing research field for a decade before the initiation of this thesis, it was natural to expect that the literature contained information relevant to answering this question and possibly that the question either directly or indirectly had been investigated. The first sub-question was thus formulated as:

**Which attributes of a product are known in the literature to affect the behaviour of the user?**

The first source of literature investigated, was the literature published more or less directly within the topic of DfSB. This investigation (Chapter 2.1.1 and Paper 5) found that a product was expected to affect the user by the *Direction* (how much the behaviour change is in line with the beliefs and values of the user), *Scale* (whether the changes are made directly in the interaction between the user and the product, the function of the product or in the entire practice), *Empathy* (whether the users focuses on themselves or on others) and *Control* (how much control the user has over the behaviour or how forceful the effect is). Of these, the latter is by far the most dominant in the literature. In addition, a large variety of different design strategies, patterns or principles that may lead to behaviour change were found. A wider search found that the HCI literature included discussion of how the obtrusiveness of a product affects how people interact with it (Chapter 4.1.1.2, Paper 8). In the LCA literature, we also expected to find research related to this topic and insight into how to estimate variations in how people interact with products. However, little attention seemed to have been given to this topic (Chapter 2.2.7, Paper 3). This indicates an additional and potentially valuable, outcome of this research.

Along with the investigation of the different attributes that can affect behaviour, attention was also paid to:

**How can the attributes be organised or structured?**

A few variations were found, but the structuring of the attributes into a dimension, where variation in the attribute could be described according to opposite extremes (Chapter 2.1.1, Paper 5), is the most widely adopted in the DfSB literature. Thus, we identified this as a promising approach. An additional advantage of this structuring is that it enables the combination of two different, mutually exclusive, dimensions into a landscape (Chapter 4.1.1.2, Paper 8). Thus, we get a description with higher granularity.

This investigation uncovered that although the literature contains numerous case studies (Chapter 2.1.2, Paper 3), the identification of the attributes are almost entirely derived theoretically and from the deduction of the researchers. A potential source of additional input would thus be to investigate:

**Which attributes are known implicitly among design practitioners and can contribute to the academic understanding of this issue?**

A series of workshops with design practitioners (Chapter 4.1.2.1, Paper 1) resulted in the identification of a number of dimensions. Some were already known in the literature: Control, Obtrusiveness, Direction, Empathy; some were novel dimensions: Encouragement, Meaning, Importance, Timing and Exposure. The one factor from literature with was not found was Scale, which is unsurprising as it is more related to the level of complexity than the effect on the user, and thus may be less relevant in this context.

RQ1: Which attributes of the design of a product affect the way users interact with the product?

The way a product affects behaviour may be described and adjusted along at least the following nine dimensions:

| | |
|---|---|
| Control: | Shall the user or the product determine the behaviour? |
| Obtrusiveness: | How much attention shall the design demand? |
| Encouragement: | Should the desired behaviour be promoted or the undesired discouraged? |
| Meaning: | Does the design focus on rational or emotional purpose? |
| Direction: | Is the desired behaviour in line or opposing the wishes of the user? |
| Empathy: | Is the user focusing on themselves or others and what others think? |
| Importance: | How important does the users consider the behaviour to be? |
| Timing: | Should the design target the user before, during or after the interaction? |
| Exposure: | How often will the user encounter the design? |

### 6.1.2. RQ2: WHICH CHARACTERISTICS OF THE USER AND THE CONTEXT AFFECT BEHAVIOUR AND HOW CAN THESE SUPPORT THE DESIGN OF BEHAVIOUR CHANGING PRODUCTS?

To address this question, it is first necessary to identify the different factors that make people behave in particular ways. There are several scientific fields concerned with the reasons for people's behaviour and how it may be affected. DfSB research has been dominated by researchers either focusing on behavioural psychology or sociology. In this thesis the focus has been on behavioural psychology, partly due to a personal preference and partly as this seems more suitable to inform how to affect the interaction when a user has encountered a product (Chapter 2.1.6). The investigation was thus guided by the question:

**Which factors does behavioural psychology consider relevant for peoples behaviour?**

A review of behavioural psychology literature uncovered a large variety of behavioural models and factors (Chapter 2.1.8, Paper 1). A combination of comprehensiveness, elegance and easy of use made the Comprehensive Action Determination Model (Klöckner & Blöbaum, 2010) a suitable framework to identify the relevant factors and how they relate to each other. According to this model, behaviour can be affected by:

- Habitual processes consist of schemata, heuristics and associations.
- Intentional processes consist of intentions that are affected by attitudes, which again are affected by beliefs.
- Situational influences consist of subjective and objective constraints. In addition to affecting the behaviour directly, the situational influences also affect the habitual, intentional and the normative processes.
- The normative processes consist of personal norms that are affected by subjective/ social norms and values. These have an indirect effect on the behaviour through affecting the habitual and intentional processes.

However, as it is uncommon for designers to target these factors specifically in their user studies, it was necessary to investigate:

**How can designers gain the necessary insight about relevant factors?**

A review of user research method literature (Chapter 3.1, Paper 4) resulted in an overview of recommendations for the type of knowledge particular methods suitable to investigate. It turned out that the methods could be divided into those that gather information by direct input from the user (interviews, surveys, etc.), and those that do not get direct input from the user (observation, video ethnography, etc.), as well as a few methods combining the two. This property of the methods indicates whether they are suitable to investigate factors that are either internal or external of the user, and either conscious or unconscious to the user. This information was combined with the more specific understanding of the type of information the individual methods was suitable to provide.

**Rq2: Which characteristics of the user and the context affect behaviour and how can these support the design of behaviour changing products?**

Behaviour is affected by a combination of habits, intentions, attitudes, beliefs, subjective constraints, objective constraints, personal norms, social norms and values (Chapter 2.2.1.1, Paper 5). These factors can be investigated by combining user research methods gathering information with and without direct input from the user (Chapter 3.1, Paper 4). These factors will be affected by the choice of design principles and how they are adjusted along the dimensions. The relative importance of the factors can thus inform the design of the products. Some of the key effects are (Chapter 4.1.1.5, Papers 1, 6 & 8):

- The more cognitive workload a user can manage given a product context, the more control the user can be allowed to have over the interaction
- The more a person's beliefs, attitudes and intentions are in line with the intended behaviour, the more control of the behaviour can be given to the user.
- To create or maintain a habit, the experience of using the product, the interaction with the product and the context around the interaction should be as stable as possible. The user should also be given positive reinforcement as often and as closely related to the behaviour as possible.
- To break a habit, make the user aware of the behaviour and make it less desirous to behave so. The user may become aware of the behaviour by changing the experience, making it more difficult or impossible, or through a completely new way of interacting. The behaviour can become less desirous if positive experience from the behaviour is removed, or negative is added.
- The product, interaction, outcome or behaviour should not violate the user's values or norms. The values and norms can determine what the user finds acceptable, for instance how much control a product may have.

More effects can be seen in Figure 4.1.3.

### 6.1.3. RQ3: HOW SHOULD THE SUPPORT BE PRESENTED TO THE DESIGNERS, TO ACCOMMODATE ITS INTEGRATION INTO THE DESIGN PROCESS AND THE WAYS DESIGNERS WORK?

A problem for design research aiming at improving the ways designers work, is to present it in a format that enables and supports the integration of the results in practical design projects. As this is not an unknown challenge, a first step in investigating this was to review:

**Which requirements for how to provide support to designers are known in the literature?**

The literature review uncovered a few studies investigating how eco-design tools should be made to support designers (Chapter 2.1.3.1, Paper 1). These can be summarised as following:

The tool should:

- Be easy to adopt and implement.
- Facilitate designers to fulfil specified requirements.
- Reduce the risk that important elements in the product development phase are forgotten.
- Reduce the total calendar time to solve the task.
- Combine guidance, information and education.
- Contain numerous examples.
- Be as visual as possible and contain a minimum of text. When text is needed, it should be written in a non-scientific language.
- Be referred to when required, and fit into the designers' usual way of working.
- Focus on design.

There may be differences in the requirements for tools with different purposes or topics and none of the literature described tools for DfSB. In addition, the iterations of the tool enabled exposure of early versions of the tools to designers and made it possible to investigate:

**Which preferences do designers have for how support is presented to them?**

The first tool, Principles of Behaviour Change, was developed through 5 iterations (Chapter 4.1.1, Papers 1, 5, 6 & 7) and created the basis for the second tool, Dimensions of Behaviour Change. This tool was developed through 2 iterations (Chapter 4.1.2, Paper 1) and resulted in the final version of the tool (Part III). In each of these iterations the tools were evaluated in practical design projects, in most cases with external designers or design students. Feedback from these experiences shows that the tools fulfil a number of the requirements from the literature. It also provided a basis to evaluate the importance of them, and in addition to formulate a few new requirements (Chapters 4.1.1 & 4.1.2, Papers 1, 2, 6, 7). The most important of these were that the tool should:

- Be inspiring.
- Be in a format that supports collaboration and discussions.
- Be easy to bring to client meetings and help designers justify their decisions.
- Be flexible (suggesting rather than dictating).
- Help the designers consider or remember more perspectives of the design and how it can affect behaviour.

In addition to providing feedback and requirements that informed the development of the tools, the design projects both raised the question and provided input on:

**How can the support be integrated into design projects?**

Early during the development of Principles of Behaviour Change (Chapters 4.1.1.1 – 4.1.1.2, Papers 6 & 7), it became clear that the tool had the potential of providing support both during the idea-generation and evaluation phase of a design project, but that it would be valuable to guide the designers how and when it could be applied. This resulted in the development of a few suggested design processes (Chapter 4.1.1.3, Paper 6, Posters 1 & 2), and finally in the detailed description of the application of the tool in a project redesigning a woodstove (Chapter 4.2.4, Paper 2). In this project the tool was used to analyse the levels of obtrusiveness and control that could be expected to result in the desired behaviour change and at the same time be accepted by four different personas. It was also used to position the ideas in the same landscape. This way, the most and the least promising ideas could be identified.

RQ3: How should the support be presented to the designers, to accommodate its integration into the design process and the ways designers work?

By combining the requirements identified in the literature and the experience from the use of Principles of Behaviour Change in design projects, the following list of recommendations for the design tool was created (Chapter 2.1.3.1, Paper 1):

Must

- Help designers to design products that are more likely to be used in the desired way by using the tool, than without the tool.
- Help designers understand which design principles they should apply to change the behaviour of their target group.

- Increase the designers understanding of different aspects of how the product affects the behaviour of the user
- Be easy to use for product designers, fit into designerly ways of working

Should
- Be possible to understand how to use in 15 minutes
- Be inspiring for designers
- Be in a format that makes it suitable for discussion and collaboration
- Should be experienced as suggesting rather than dictating
- Remind the designers of the aspects of a product that affect the way users interact with it

Could
- Be suitable to bring to meetings with clients to help the designers explain their decisions
- Be experienced as primarily visual
- Be written in a non-scientific language

The application of these requirements resulted in the development of Dimensions of Behaviour Change (Chapter 4.1.2, Paper 1). The final version of this tool can be found in Part III.

## 6.2. MAIN CONCLUSIONS FROM THE PROJECT

As the DfSB research field evolves, the understanding why people behave the way they do and how it might be possible to affect this behaviour increases. However, although the literature contains a growing number of tools and methods, none of them seemed suited to help designers make informed decisions about how they should design products to affect the behaviour of their target group in the desired way. The goal of this PhD project was to try to remedy this and develop an appropriate tool.

The tool development started by exploring the factors, which according to behavioural psychology could affect behaviour and investigate how different types of design principles, could be used to affect these. We found that different types of common user research methods were particularly suited to investigate particular behavioural factors. This insight can enable user centred designers to select the appropriate methods and easier integrate the behavioural aspect in their regular user centred design process. Previously, the design principles were described according to how much control they allowed the user over the interaction, along a sort of dimension, where the user had complete control at one extreme and no control at the other. This was soon expanded by also considering how obtrusive the design principles should be, ranging from designs where the user is unaware to designs that demand the attention of the user. These two mutually exclusive dimensions formed the so-called control-obtrusiveness landscape, which formed the basis for the Principles of Behaviour Change tool. The tool proved potentially valuable through application in a case study on a woodstove. This resulted in a comparative lab testing of a prototype and a regular wood stove. This showed that the prototype based on the tool, made people interact with it in a more correct way and possibly also caused less environmental impact than the conventional woodstove. However, testing of the tool in design workshops and projects with other designers and design students showed that the tool was too dictating and not inspiring enough for the designers. After five iterations, improving the tool in various ways, it was determined to develop a second tool, based on the content and experience from the first tool. Although the second tool builds on the first tool, they may be seen as two separate tools complementing each other, as the way the support is provided is substantially different.

The second tool, Dimensions of Behaviour Change, was meant to help the designer consider the way the design would affect the user from more perspectives and provide more general recommendations, rather than try to help the designers identify the appropriate design principles in detail. To identify the relevant perspectives, a number of workshops were organised with design professionals, investigating the different ways they believed the design of a product affects the behaviour of the user. This resulted in the identification of 9 relevant dimensions, 4 of which were already known from the literature; Control, Obtrusiveness, Direction and Empathy. 5 new dimensions; Encouragement, Meaning, Importance, Timing and Exposure. Through 2 iterations, these 9 dimensions were included in the new tool. This tool consists of 11 cards, where two cards introduces the tool, one card introduces the distribution of control and 16 design principles positioned according to this dimension, and 8 cards each describing the pros and cons of adjusting the design principles along the other 8 dimensions respectively. The backside of these cards provided additional examples and slightly more detailed guidance. An evaluation of this second tool in a design workshop with 46 students at TUDelft, showed that the students who used the tool applied significantly more unique perspectives in their behaviour changing designs, than the students who did not have the tool. The evaluation of the tool by the students also showed that it was fairly well received and accommodated both for the needs of the students and the way the students liked to work. Assuming that the behaviour changing effect found for the first tool also is valid for the second tool, as this tool has the same theoretical basis as the first tool, the Dimensions of Behaviour change may be considered an acceptable contribution to the DfSB literature and help designers make informed decisions about how to design their behaviour changing products.

## 6.3. CONTRIBUTION TO KNOWLEDGE

During the project described in this thesis a variety of research activities have been conducted, and hence created the basis for the development of two design tools. In addition to the development of the tools, the project has resulted in a few contributions to knowledge. Some are direct consequences of answering the research questions and some resulted from the research without being directly related to the research questions. The contributions to knowledge resulting from this PhD project are the following:

- By combining the established distribution of control with the dimension of obtrusiveness, the control-obtrusiveness landscape was created. Although obtrusiveness was well known in the HCI literature, it had not been introduced into DfSB before. The combination with control into the control-obtrusiveness landscape was not only novel but proved useful in the analysis of the types of design principles that could be expected to affect the behaviour of users and be accepted by them. To support this, a contribution was also made to the understanding of how variations of control and obtrusiveness affect the various behavioural factors from social psychology.
- The literature contains a number of dimensions describing variations in behaviour changing design principles, but they are derived from the understanding and intuition of the researchers. An investigation into which dimensions design practitioners consider relevant resulted, not only in the four principles known from literature that target how the user is affected by the design, but also introduced five new dimensions. This result both confirmed the relevance of the existing dimensions and provided new perspectives to consider how people are affected by the design of products, which had

not been previously described in the literature. Through the development of the DBC tool, this insight can also help designers make more informed decisions about how they design products to achieve the desired behaviour.

- The literature contained limited information about what type of insight different user research methods are suitable to investigate and no information specifically targeting behavioural factors from social psychology. By combining the information in the literature and analysing the nature of the user research methods, recommendations could be given for the types of behavioural factors each of the included user research methods should be capable of investigating.
- The project of designing a woodstove to make people use it in a more sustainable way resulted in a few interesting observations. First of all, it showed that making it easier for the user, by having a combined lever for two types of air supply, and providing the user with information about the appropriate positions of the lever, resulted in improved behaviour and possibly also reduced negative environmental impact. In addition, the project resulted in the development of four personas describing the variation of woodstove users. Emission data confirmed reduced PM emissions by igniting the fire from the top instead of the bottom.

## 6.4. FUTURE WORK

This project has successfully answered the research questions and made several contributions to knowledge, but it has also identified a number of aspects that could benefit from further investigations. Some of theses are consequences of the previously acknowledged problem of knowing when a design project is finished. Inherently, the iterative process rarely has a natural and definite point of conclusion, and can thus in theory continue forever. Such processes will in most cases leave room for further improvement and development, almost regardless of how many iterations there have been. The research conducted during the project has also uncovered a number of topics, which either do not directly lead towards answering the research questions or were impossible to pursue adequately, due to limitations in the project. Several of these topics may never the less be of interest and may be worthwhile investigating further.

- This thesis has described a tool development process, first going through 5 iterations for the first tool resulting in the basis for the second tool, DBC, which was developed through two additional iterations. Evaluation of the end result seems promising, but there is still room for further testing and development. Ideally, the tool should be tested in a realistic design process, where several teams are using the tool and several teams are not, or use other tools. The results should be developed into high fidelity prototypes, which should be used by a large number of users over a long period of time in the natural context. This way, the contribution of the tool to the design process, and the behaviour changing and environmental benefit from the tool could be measured. Even though this kind of evaluation may seem unrealistic, the evaluation of the tool could benefit from additional testing, perhaps in particular on longer design projects by design practitioners. The results of the current evaluation could also be used to improve the tool further. The survey after the Delft-study showed that in particular the support for how the tool should be applied and the support in decision-making have a large improvement potential. It could also be interesting to investigate further other formats of the tool, for instance by creating a digital, interactive version of the tool. Although the evaluation of the alternatives concluded by favouring the large-card format, there were several good arguments for a digital tool. Perhaps a promising approach could be to have a combined physical and digital tool, which could be used separately or supplementing each other.

- During the development of DBC, a series of workshops were conducted to investigate which aspects of the design of products, design professionals consider relevant for the behaviour of the users. After the obviously overlapping results had been removed, these workshops resulted in a list of 55 dimensions. To make them clearly distinguishable and relevant, these were divided into 9 dimension categories, which formed the basis of DBC. However, this process opens up for two interesting areas of further research. One could be to investigate if there are other logical ways to analyse the 55 dimensions and see if this results in a different categorization or structuring.. Another direction could be to conduct additional research into the aspects design practitioners consider relevant, either through similar workshops as in this project, or thorough other methods. It is likely that both of these approaches would uncover additional aspects that could contribute to our understanding of how the design of products affect the behaviour of the user.
- The review of DfSB case studies (Chapter 2.1.2, Paper 3) identified a growing base of case studies in the literature, but a large diversity of approaches, methods and ways of reporting, which makes it difficult to draw upon these previous studies. On the other hand, they do provide valuable insight into how people's behaviour is affected by design, how design projects should or should not be tested, which design solutions prove valuable under which conditions, etc. A potentially useful contribution to the DfSB research could thus be to develop a case study database, as previously suggested by Boks in 2011 (Boks, 2011). However, whereas Boks primarily focuses on the potential of using the database to identify the most relevant topics for new case studies, such a database could have a much wider application area. If designed in the right way, the database could contribute to improve future research design; how to measure the results, organise the studies, ensure validity and reliability, etc. It could also enable researchers to draw conclusions about the most favourable ways to affect behaviours, the advantages and disadvantages of particular approaches in particular settings, etc. What the right way to design such a database is, in order to optimise its potential usefulness, will have to be the topic of a separate research project and probably require a number of iterations before the optimal solutions are found. Nevertheless, some initial requirements may be suggested already today, based on an understanding of the existing case studies and the needs in the field:
  - Although the functions and architecture of the database, and integration of the initial studies need to be designed by someone to initialize the process, it is not feasible that the same person should be responsible to add all future studies. It is thus necessary to create the database online, in a wiki-format, enabling researchers to upload their own studies and thus motivating them to report the results according to a more standard framework. A natural location for the database could be on the DfSB web site, suggested by Lilley (2007) and the creation of the structure of the database could for instance be a good way for a future DfSB PhD student to get to know the existing research, and perhaps form the basis of a separate research project.

    - To enable researchers to draw upon this database optimally for their research, it should have a flexible structure, which possibly could be achieved by providing a number of meta-data for each case study. These could then be used to organise the studies in the desired ways, find studies with the desired similarities or characteristics and potentially also contribute to identifying when different types of design principles are more likely to result in the desired behaviour. Even though each individual study only investigates some of the relevant aspects, has some types of bias, has too small sample sizes, etc. a comparison, or even a triangulation with other studies, may make up for some of the shortcomings. Depending on the goal and topic, it could be relevant to inform the interpretation of the results both with studies investigating similar behaviour changing approaches and studies investigating similar products or other products in similar contexts.
    - To make this effective, it would require that the database presents the studies and results in an easily comparable manner, with sufficient level of detail to enable the reader to understand the similarities and differences. Although it might not always be feasible to include, it can also be relevant to consider other phases of the product life cycle than the use phase, to ensure that the environmental benefit achieved from the behaviour change is not overshadowed by increased impact from material choice, production methods, etc.
- As pointed out in the discussion in Chapter 5.3, there is an ethical dilemma for DfSB researchers, as the results of their research in most cases just as easily can be used to achieve unsustainable as sustainable behaviour. It might not be possible, but it would be interesting to investigate whether it is possible to conduct DfSB research, for instance develop a tool to support designers of behaviour changing products, that exclusively can be used to achieve environmental benefit. This would require the investigation of whether there is something fundamentally different between designs that aim to reduce the environmental impact of the behaviour of the user, and designs that do not have this purpose.
- The case study of designing a woodstove to make the users interact with it more in line with the recommended behaviour, concluded with successfully achieved behaviour change and indications of reduced environmental impact. However, due to the lab experiment setting and the small population of the test users, the results do not give any definite answers to the environmental benefit. If the measured effect could be achieved for the entire population, $1/6^{th}$ of the PM emissions in Norway could be avoided. The statistical power test predicts that it is 80% chance that a test with 91 test users on both the prototype and the conventional oven, would result in statistically significant results. In other words, it may be worthwhile to conduct a larger experiment with the existing design, to find out if the results are significant or not. In addition it would be both relevant and interesting to find out what happens to this effect when the user gets accustomed to the design and develops new habits. The results of the testing also indicate that it may be relevant to develop the design of the woodstoves further, perhaps by integrating the thermometer and improved user manual in ways that made the users interact with them, or explore other improvements of the woodstoves.

- As can be seen by the discussion in chapter 2.1.6, there is a division in DfSB research between the researchers who believe it is most beneficial to draw upon the behavioural psychological understanding of how behaviour is formed and affected, and those who prefer a sociological approach. The disagreement between social psychologists and sociologists is neither new nor limited to DfSB and it is not the purpose, or within the scope, of DfSB to unify the two fields. However, there are valuable perspectives and approaches in both disciplines, and there is no reason why DfSB researchers should not be able to draw upon the best of both disciplines. Bringing these two disciplines together will undoubtedly be challenging as they represent fundamentally different worldviews and philosophical perspectives, but there are also several similarities both in the methods they apply and the way they work. If it proves too difficult to create a hybrid approach extracting elements from both disciplines, an alternative solution could be to investigate the strengths and weaknesses of the two disciplines, compared to each other, and develop a way to help designers benefit from the one that is most suited to each particular question. For instance, continuing the current tendency that the sociological approach targets more fundamental changes whereas the psychological approach targets specific interaction with products, it might be possible to apply the first to draw the big lines and the second to adjust the details of the result. However, at the moment this is just speculation and additional analysis is necessary to make qualified decisions about how this should be done.
- As pointed out by Pettersen (2013) there is still need for additional insight into the practical implementation in companies. Although she focuses on practices and not behaviour, her investigations and reflections are likely to be equally relevant for both approaches. Further inquiries, and particularly practical experience of the potential economical consequences, the practical requirements and opportunities, the perspectives of the different stake holders, etc. would be valuable for the practical implementation of the research. The growing interest in behaviour change, not only in the academic context, but also from media, businesses and policymakers, increases the likelihood of results from DfSB research being applied in real world settings. This will both increase the demand for investigation into the practical aspects of DfSB in a commercial setting and provide opportunities to study and analyse how it is applied and the consequences of this. Particularly relevant for this study, and as identified by Pettersen (2013), would be a detailed investigation of the potential of the design tools applied in realistic settings. If the prediction holds true, and behaviour change to a larger extent will be applied in commercial projects, the ethical discussion (Chapter 5.3) of behaviour change, forceful principles and the potential consequences, will also become increasingly relevant and in need of further attention.
- Although DfSB may still be considered to be a young research field, it has matured significantly during the last few years, as is apparent by the number of finalised PhD theses, special issues of journals, dedicated tracks at conferences, etc. Until now, much attention has been dedicated to the exploration and structuring of behaviour changing principles, the understanding of the domain and its benefits and the initial proposals for practical application. For the continuing development of the field, it would be interesting to see larger, more realistic application of the research in projects collaborating with companies, also contributing to the already suggested database. For the evolvement of the research field itself, it would be beneficial with a more uniform

use of vocabulary and methodology, avoiding unnecessary uncertainty and confusion. For instance, terms, principles, strategies and pattern are all used to describe more or less the same aspect of behaviour changing design. Clear definitions and potentially the exclusion of some terms from the common literature, would enable more efficient and precise discussions. The creation and agreement of such a vocabulary could be the topic for a meeting of the DfSB research community, primarily centred around Loughborough, Delft, Chalmers and NTNU, which until now has dominated the development of the field.

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# PART II. THE PUBLICATIONS

# SUMMARY OF THE JOURNAL PAPERS

## PAPER 1.

*Daae, J., & Boks, C. (2013) Dimensions of Behaviour Change, Journal of Design Research (accepted)*

**Purpose**

The purpose of paper 1 is to investigate what design practitioners think is relevant for how the design of products affect the behaviour of the users, translate the result into dimensions the design can be adjusted according to, and finally use this as the basis for the development of a new design tool.

**Method**

The insight from the design practitioners was gathered through a series of workshops, where the designers were challenged draw upon their experience and understanding of products, to describe the aspects of the design of a product they believe affect the way the users interact with it. The results were processed by searching for dimension categories that would remove overlaps, while reducing the loss of detail and nuances as far as possible. The resulting dimensions were investigated to identify the potential consequences they could be expected to have on users with particular characteristics in particular situations. This insight was processed into a tool by attempting to explain and illustrate them as easily and clearly as possible. This was done in an attempt to fulfil a list of requirements that had been generated through literature review and analysis of previous experience. The resulting tool was tested in a design workshop, where 18 groups of students solved design challenges, half the groups with the tool, and half the groups without, followed by all the groups solving different challenges, all using the tool. After the workshop, the students filled in a survey about the experience of using the tool.

**Result**

The workshops with the design practitioners resulted in the identification of 55 dimensions, which were structured into 9 dimension categories: Control, Obtrusiveness, Encouragement, Meaning, Direction, Empathy, Importance, Timing and Exposure. These were translated into a tool, Dimensions of Behaviour Change, where 16 design principles were described according to the dimension of Control, and the 8 other dimensions were described on separate cards. The testing of the tool found that the teams using the tool applied a significantly variation of ways to affect the user's behaviour, than the teams that did not use the tool. The results of the survey showed that the tool was fairly well received by the students and was experienced as a support for them when solving behaviour design challenges.

**Contribution**

The contribution of paper 1 is the identification of how design practitioners believe design affect behaviour, the categorization of this into 9 dimensions, a list of requirements for a tool meant to inform DfSB and the development of a tool that successfully supports DfSB.

PAPER 2.

*Daae, J., Goile, F., Seljeskog, M., & Boks, C., (2013) Burning for Sustainable Behaviour. Journal of Cleaner Production (submitted).*

**Purpose**

The purpose of paper 2 is to investigate how a tool, Principles of Behaviour Change, works in a realistic user centred, DfSB project, and whether the resulting design has the intended effect on the behaviour of the users and leads to lower environmental impact.

**Method**

As the project should follow a user centred design approach, the project started by gathering insight about the users, by conducting 17 ethnographic interviews with woodstove users. Each participant was visited at home, video recording was made of the participant lighting a fire in the woodstove and a semi structured interview was conducted focusing on what, how and why the participant uses the woodstove and more general topics related to firewood, energy consumption and sustainability. The results of the interviews were translated into four personas, representing the different types of woodstove users that had been identified. The tool was then applied to identify the types of design principles that could be expected to change the behaviour, and the principles that were unlikely to be accepted, by each persona and for the entire group. A workshop was then organised with 7 employees at Jøtul, a woodstove producer, to generate ideas for how to make the personas interact with woodstoves more in line with the optimal behaviour. The ideas that could be expected to affect behaviour and be accepted by the users, were identified by comparing the results of the workshop with the results from the analysis by the tool. Among these, the ideas that were most technically feasible to realise were selected and were integrated into a prototype. The prototype was compared with a conventional woodstove, by letting 10 participants use each of the stoves in a lab. The experiment allowed monitoring of what the participants did, and measurements of the emissions of $CO_2$, CO, $O_2$, $NO_x$ and PM.

**Result**

The ethnographic studies resulted in a rich understanding of how and why people interact with their woodstoves the way they do and the identification of a number of undesirable behaviours. The selection of feasible and promising ideas, resulted in a prototype with one single-handle operation for the combustion air, with indications for the suitable positions at different stages of the burning process, a thermometer with indications for when air adjustments are appropriate and a simplified user manual. This was compared with a conventional woodstove with two handles, no indications and a regular user manual. The results for the testing found that only half the participants using the prototype noticed the icons, and none the thermometer and user manual. The participants who noticed the icons behaved much more according to the desired behaviour than the other participants, and emitted 35% less particles than the conventional stove, although this is not a statistically significant reduction.

**Contribution**

Paper 2 demonstrates the application of a DfSB tool in a realistic design project, resulting in successful behaviour change and possibly reduced emissions. It also illustrates the challenge of breaking habitual behaviour in ways accepted by the user.

PAPER 3.

*Daae, J., & Boks, C. (2013) Improving the way LCAs deal with variation in the use phase using design for sustainable behaviour research. The International Journal of Sustainable Engineering, Special Issue on: Design for Sustainable Behaviour (submitted).*

**Purpose**

The purpose of this paper is to investigate how DfSB can contribute to improve the way LCA deals with uncertainty related the variations in the use phase of products.

**Method**

Through studying literature, challenges related to the way LCAs deals with uncertainty related to how products are being used are investigated and analysed. A literature review of DfSB case studies investigates how variations in the way people interact with products are being studies and reported, and how the results are being communicated.

**Result**

LCA studies of products where the use phase represents a significant part of the environmental impact, seem to dedicate less attention to the uncertainty related to how the product is being used, then the relative importance of the impact implies. As precise data of user behaviour often is unavailable due to the resources demanded for gathering the data, it is proposed that LCAs may use small-scale user studies to better inform the way the uncertainty is being dealt with. As DfSB literature contains descriptions and experiences for how this should be done, it might be a valuable source for LCA researchers, by providing information about how this type of studies might best be conducted or by providing information about how products are being used directly. The latter would benefit greatly from a proposed creation of a database of DfSB case studies, where the studies are reported in an easily comparable and navigable manner. The creation of such a database could also contribute to the development and improvement of DfSB research.

**Contribution**

Paper 3 identifies a challenge in LCAs, where uncertainty related to variations in the use phase sometimes receives less attention than the relative impact would deserve. A potential improvement is proposed, by using small-scale case studies to improve the ways the uncertainties are dealt with. A DfSB case study database is proposed, both to support LCAs and to develop DfSB research further.

PAPER 4.

*Daae, J. & Boks, C. (2013) A classification of when to apply different user research methods to support design for sustainable behaviour. Journal of Cleaner Production, special issue from ERSCP EMSU 2013, Istanbul, Turkey, June 4-7. (submitted)*

**Purpose**

The purpose of paper 4 is to create an overview over the types of behavioural factors the user research methods, commonly used in user centred design, are most suitable to investigate.

**Method**

This is investigated by reviewing literature from behavioural psychology to identify the relevant behavioural factors and relevant principle differences between them, which can be used to indicate how they best can be studied. A review of user centred design literature, particularly focusing on collections and descriptions of user research methods, was used to identify relevant methods and provide information about the types of insight each method was reported or expected to be suitable to investigate. In addition, the methods were compared and analysed in quest for fundamental differences, which could be used to identify the value of the methods. The results of applied user research methods in two case studies from the DfSB literature were analysed and compared with the types of information the overview predicted they should be suitable to investigate.

**Result**

The result of the review of behavioural factors, found that they can be categorised as Internal – Conscious: intentions, attitudes, beliefs, subjective constraints, personal norms and values; Internal – Unconscious: habits; External – Conscious: social norms; and External – Unconscious: objective constraints. The review of the user research methods, found that they either are useful for investigating conscious factors, by gather information with direct input from the users: interview, focus group, survey, verbal protocol, conjoint technique, wants and needs analysis, card sorting, group task analysis and probes. Alternatively they are useful for investigating external factors, by gathering data without direct input from the users: observation, studying documentation, video ethnography, shadowing, user testing, empathic design and culturally focused research. To investigate habits, which are Internal – Unconscious, you either need to triangulate different types of methods, or use applied ethnography or contextual inquiry, which already combine several methods. In addition, a number of indications for particular types of insight the methods are useful to investigate were collected. The comparison with the case studies found that the results they provided in the studies were in line with the analysis, and that experienced researchers have a good understanding of the expected outcome of the applied methods.

**Contribution**

The contribution of paper 4 is an overview of the types of behavioural factors, which commonly used research methods, can be expected to be suitable to investigate. Although this might be implicitly known among experienced user researchers, this type of overview has not been created before and may thus be useful both for students or inexperienced user researchers and as support or confirmation for experienced researchers.

PAPER 5.

*Zachrisson, J., & Boks, C. (2012) Exploring behavioural psychology to support design for sustainable behaviour research. Journal of Design Research vol. 10 (1/2), pp 50-66*

**Purpose**

The purpose of paper 5 is to develop initial support for designers in making informed decisions about how they design behaviour changing products. The approach is based on the assumption that the behavioural factors that may affect behaviour can be affected by particular properties of the design. If so, this would enable informed decisions about how a product should be designed to affect the behaviour of a target group, for which the dominating behavioural factors are know.

**Method**

First of all, it was necessary to find a way to compare and distinguish different types of design principles for behaviour change through design, which was done by reviewing DfSB literature. Secondly, it was necessary to identify the behavioural factors that may affect behaviour. This was done by reviewing behavioural psychological literature and identifying promising behavioural models. Further review of this literature, investigated how variations in the design principles could be expected the affect the behavioural factors.

**Result**

The results of the review of DfSB literature, identified that differences between behaviour changing design principles often was described by how much control the user have over the interaction. This may vary from one end of a scale, where the principle allows the user to be in complete control, to the other end, where the user has no control. By analysing the results of the literature review, the type of principles leading to the decreasing degree of control along this scale can be described as: Information, Feedback, Enabling, Encouraging, Guiding, Steering, Forcing and Automatic. The review of the behavioural psychological literature identified the Comprehensive Action Determination Model (CADM) by Klöckner and Blöbaum as a promising framework, which identified that behaviour can be affected directly by Habitual- and Intentional factors, and Situational influences, and indirectly by Normative factors. The further investigations found that it is likely that variations in control may affect these, which resulted in the formulation of a number of guidelines.

**Contribution**

Paper 5 contributes with the formulation of a series of words describing the variation in design principles according to how much control they give the user over the interaction, the identification of the CADM as a promising model to inform DfSB, and the formulation of a number of guidelines for how different types of design principles can be expected to affect the behavioural factors identified by the CADM.

# SUMMARY OF THE CONFERENCE PAPERS

PAPER 6.

*Daae, J. & Boks, C. (2013) From teaching sustainable product design to teaching sustainable behaviour design. Proceedings of Cumulus 2013, The 2nd International Conference for Design Education Researchers, Oslo, May 14th – 17th.*

**Purpose**

The purpose of paper 6 is to report on the development of DfSB focus in the Eco-design subject at the Institute of Product Design at NTNU. The paper also presents a DfSB tool and proposed design process described in a booklet, Principles of Behaviour Change, and the experience of letting design students work with this tool in their projects.

**Method**

35 students, half from product design and half from industrial ecology or exchange students, were divided into 8 groups and worked on a design project for a full semester in a 7,5 ECTS Eco-design subject. The goal was for the groups to apply a user centred design process to design a solution that would make people's behaviour related to a chosen product, more sustainable. The topics the student chose to work on were: dishwashing, laundry, disposal of special waste in homes, food waste and energy consumption while sleeping. The booklet suggested that the students started by studying and measuring the baseline practice, identified which behaviour to change, identified how to affect the behaviour, selected the types of design principles to use, generated ideas, evaluated and selected ideas and finally refined the results. For each of these steps, the booklet suggested tools or methods the students could apply.

**Result**

The result was that the students managed to maintain a behavioural focus throughout the project. The resulting designs targeted the intended behaviours and almost all the groups had good arguments for why they expected the design to affect the behaviour of the target group the desired way.

**Contribution**

The contribution of paper 6 is the description of the tool, Principles of Behaviour Change, and reporting on how this was applied in student DfSB projects.

PAPER 7.

*Zachrisson, J. and Boks, C. (2011) Using a guide to select design strategies for behaviour change; Theory vs. Practice. Proceedings of EcoDesign 2011, Kyoto, Japan, November 30th – December 2nd.*

**Purpose**

The purpose of paper 7 is to report the experience from applying a DfSB tool in a graduation project, aiming at making behaviour related to oral health care more sustainable, and using this to evaluate the tool.

**Method**

In this project the oral health care practices of a target group of Norwegian or Dutch citizens were investigated by using a combination of several user-centred-design research methods: interview, overt observation, covert observation (video recording), cultural probing, survey, generative sessions and a blog analysis. To support the analysis of the data and translate it into design solutions, a DfSB tool was applied, which consists of a set of guidelines suggesting how much control the user should have and how obtrusive the design should be, to affect particular behavioural factors identified in the target group.

**Result**

The result was the identification of a number of improvements for the tool, including: a clear guidance for how the tool should be included in the design process, if the tool should be applied when generating or evaluating ideas, the behavioural factors should be explained in an easier way, the language should be made easier and the presentation of the guidelines should be improved.

**Contribution**

The contribution of paper 7 is the presentation of how the tool can be applied in a project and the challenges related to this, leading to improvements in the tool.

PAPER 8.

*Zachrisson, J. and Boks, C. (2011) Obtrusiveness and design for sustainable behaviour, Presented at Consumer 11, Bonn, Germany, July 18th – 20th.*

**Purpose**

The purpose of paper 8 is to introduce Obtrusiveness as a way to distinguish between different types of behaviour changing design principles and combining it with the distribution of control to create the Control-Obtrusiveness landscape to describe principles with a higher granularity. Further, the paper suggests effect different levels of obtrusiveness may have on behavioural factors and thus indicating how particular types of design principles may be suitable to affect the behaviour of target groups with particular dominating behavioural factors.

**Method**

A literature review was conducted to investigate how the obtrusiveness of design had been described in the literature and a review of behavioural psychological literature investigated how behavioural factors may be affected by different levels of obtrusiveness.

**Result**

The literature review identified that obtrusiveness had received some attention in the literature, and in particular in HCI. Similar to how the distribution of control can be described as a dimension between design solutions that allows the user to be in complete control over the interaction with the product and solutions that gives the user no control, the obtrusiveness can also be described as a dimension between two extremes. From the most to the least obtrusive solutions, they can be described as: Demand action, Interrupt, Make aware, Change blind and Ignore. This dimension may be considered mutually exclusive to the distribution of control, enabling the creation of a landscape, with the distribution of control as one axis and obtrusiveness as the other. Theoretically, every design solution can be positioned within this landscape according to how much control it gives the user and how strongly it demands the attention of the user. Through a set of guidelines identifying how designs with different levels of control and obtrusiveness affect behavioural factors, it should be possible to identify the types of design principles that can be expected to affect a target group, when the dominating behavioural factors for the group are known.

**Contribution**

Paper 8 introduces obtrusiveness as a way to describe differences between behaviour changing design principles, which can be combined with the distribution of control in a control-obtrusiveness landscape. Guidelines related to how variations of obtrusiveness can be expected to affect different behavioural factors are also suggested.

# THE JOURNAL PAPERS

PAPER 1. DAAE, J., & BOKS, C. (2013) *DIMENSIONS OF BEHAVIOUR CHANGE*, JOURNAL OF DESIGN RESEARCH (ACCEPTED)

*J. Design Research, Vol. X, No. Y, xxxx* 1

# Dimensions of behaviour change

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**Abstract:** There is a significant potential for obtaining environmental benefit from designing products in a way that makes people use them optimally. Recent literature has proposed a number of dimensions to be considered in the process of designing such products. However, the selection of these dimensions appears to be based mostly on the intuition of the researchers, with no documented empirical investigations. The study described in this paper investigated this potential, through five workshops with designer practitioners. This resulted in the identification of 55 variations of how to affect behaviour, which are categorised into nine dimensions. These cover both the dimensions already known from literature and suggest new dimensions, and contribute as such with new perspectives for understanding how design for sustainable behaviour can be successful. These dimensions have formed the basis for the development of a tool, *Dimensions of Behaviour Change*, which was prototyped and tested in a design workshop. The results from the testing suggest that the tool helps designers consider more aspects of how to affect behaviour through design.

**Keywords:** environmental design; design for sustainable behaviour; design tools; design research; design dimensions; design tool development; product design; classification of design principles; behaviour changing design; persuasive technology; behaviour change.

**Reference** to this paper should be made as follows: Daae, J.Z. and Boks, C. (xxxx) 'Dimensions of behaviour change', *J. Design Research*, Vol. X, No. Y, pp.000–000.

**Biographical notes:** Johannes Zachrisson Daae is currently PhD student at Department of Product Design at the Norwegian University of Science and Technology (NTNU), within the topic of 'Design for sustainable behaviour'. His research focus is on how to enable designers to include design for sustainable behaviour in their design projects. He holds a Master of Design for Interaction degree from Delft University of Technology in The Netherlands, and has also studied product design at NTNU.

Casper Boks has been a Professor in Sustainable Product Design at the Department of Product Design, Faculty of Engineering Science and Technology, Norwegian University of Science and Technology (NTNU) since 2007. Previously, he was an Assistant Professor in the Faculty of Industrial Design Engineering at the Delft University of Technology (PhD in 2002). He holds a Master degree in Applied Econometrics at the Erasmus University Rotterdam in 1995. His research interests include sustainable product innovation and education in general, and currently focus on design for sustainable behaviour, sustainable design for non-western cultural contexts, and organisational, managerial and stakeholder conditions for successful implementation of sustainable product innovation.

## 1 Introduction

A significant share of the environmental impact from many consumer products happens during the use phase (Brezet and van Hemel, 1997). For instance, 80 to 90% of the energy demand of cold appliances (Rüdenauer and Gensch, 2007), 76% of the carbon emissions of a washing machine (Electrolux, 2011) and 60% of the environmental impact from wood stoves (Solli et al., 2009). Hanssen (1998) found that among the 18 products he investigated, the products that transform chemically in their application or consume energy when being used, the largest environmental impact is caused during the use phase. Often, the environmental impact caused during the use phase of a product will vary, depending on how the product is being used (Gill et al., 2010). Therefore, there is a significant potential environmental benefit from designing the products in a way that makes people use them optimally. For instance, in a test of the Eco Kettle (http://www.ecokettle.com), Defra (2008) found that on average consumers could save 30% of the energy compared to using regular kettles because the design of the kettle changes the way people use them.

Understanding and affecting how end users interact with products is one of the goals of design research (Kannengiesser and Gero, 2012). There are several potential benefits from such insight, such as users' efficiency, safety, satisfaction and the aesthetic of interaction itself (Crilly, 2011). The last decade, the environmental potential of controlling this interaction has resulted in a growing field within design research, investigating how products should be designed to achieve the desired, sustainable, behaviour change (Elias, 2011; Lilley, 2007, 2009; Pettersen and Boks, 2008; Scott et al., 2012; Wever et al., 2008). A result of this research has been the identification of a number of strategies or principles for how behaviour change could be achieved through product design (Elias et al., 2007; Lidman and Renström, 2011; Lilley, 2007; Lockton et al., 2010; Rodriguez and Boks, 2005; Tang and Bhamra, 2012; Zachrisson and Boks, 2012). To distinguish between the different principles and understand how they affect user behaviour, a few properties of the principles have been identified. One way to understand the properties, is as a dimension with two extremes where principles can be positioned somewhere between these two extremes. However, only few dimensions have been suggested in literature, nor has there been much discussion about whether these dimensions cover the full spectrum of design strategies that can be employed to support sustainable behaviour. As none of the dimensions were reported to be proposed based on the experience of active design professionals, it has been assumed that there is a potential for uncovering additional dimensions from investigating how experienced design professionals believe products affect behaviour. In order to obtain a more comprehensive understanding of this spectrum of principles, the purpose of this study is to try to answer the following research questions:

1 Which dimensions do design professionals consider relevant for classifying different ways to alter behaviour through product design and enable more informed decisions about when the principles should be used?

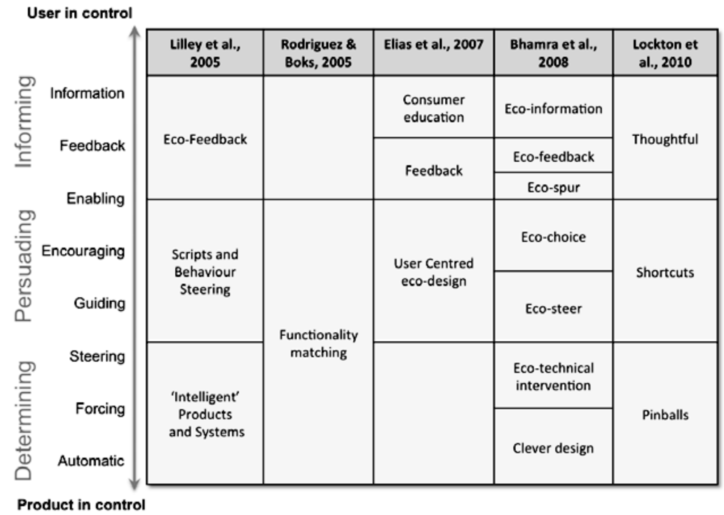
2 How should the dimensions be presented to provide useful support when designing products that are likely to be used in the most sustainable way?

## 2 Background for RQ1: the dimensions identified in the literature

One of the first contributions to understanding how the design of products affects behaviour were Jelsma's three dimensions of scripts, that describe factors that influence the struggle between the force exerted by scripts and the behaviour of the user (Jelsma, 1997). The first dimension is the *direction of the change*, describing how much the behaviour change is in line with the beliefs and values of the user. The second dimension is the *force* of the script, describing how difficult the script makes it for the user to act differently than what is intended. The third dimension is the *scale*, distinguishing between changes that are made directly in the interaction between the user and the product, the function of the product and changes in the entire practice. In 2006, he elaborated further on these dimensions to make scripts methodologically usable for linking design and use (Jelsma, 2006). The dimensions are essentially an elaboration of the three notions derived from the concept of script proposed by Akrich and Latour; *in-scription, prescription* and *de-scription* (Akrich, 1992). *De-scription* is the purpose (for instance; do not forget to bring the hotel key back to the front desk), *in-scription* is the translation of the *de-scription* into the product (for instance, heavy weight on the key reminds guests to return the key) and *prescription* is what a devise allows or forbids the actor to do (for instance, forget to return the key to the front desk or not). Jelsma proposed that the script concept can be elaborated by the three dimensions he previously suggested, and added the dimension of *distribution*, referring to how much control the user has over the behaviour. As both *Force* and *Distribution* are described by how much the product allows the user to behave in unintended ways, it is a bit unclear what the practical difference between the two is. Different ways of achieving or preventing this behaviour have been widely discussed in literature, as previously summarised by the (Zachrisson and Boks, 2012) in Figure 1, and this dimension of a designer's solution space is commonly referred to as the distribution of *control*.

This brief overview illustrates that significant attention has been given to understanding how design may affect behaviour. However, there has been only limited discussion about when different strategies are most appropriate to apply. Some recent publications (Bhamra et al., 2008; Tromp et al., 2011; Zachrisson and Boks, 2012) have suggested that choosing the appropriate principle for a particular design task depends on who the user is and which situation the product will be used in. Thus, there may be a potential for using the designers understanding of the user and context to make informed decisions about which principle is more likely to be accepted by the user and lead to the desired behaviour change. The challenge, which is also the goal of this research, is to support this translation and the identification of the most promising principles.

**Figure 1** The distribution of control in literature




*Source:* Bhamra et al. (2008), Elias et al. (2007), Lilley et al. (2005), Lockton et al. (2010), and Rodriguez and Boks (2005)

In Bhamra et al. (2008), proposed a connection between different levels *control* and particular parts of behavioural models from social psychology (Bhamra et al., 2008). This connection was further elaborated by the Zachrisson and Boks (2011, 2012) leading to the suggestion of using the dimension of *Obtrusiveness* as a potential supplement to the dimension of *control*. The dimension of *obtrusiveness* refers to how much attention the product demands from the user. In Tromp et al. (2011), proposed *Salience*, referring to how implicit or explicit the strategy, and *Force*, referring to how strongly the behaviour of the user is influenced (Tromp et al., 2011). The way these dimensions are described, it is apparent that the dimension of *Salience* is closely related to *Obtrusiveness*, and *Force* is closely related to *Control* as they to a large degree describe the same relation between the product and the user.

These studies suggest that dimensions might have a value in supporting design of behaviour change, but they do not contain any evidence that the list of dimensions discussed in literature is exhaustive. In order to investigate if design practitioners identify the same dimensions as the literature, a study was conducted and is described in detail in the Method section.

## 3 Background for RQ2: how to design design-tools for designers?

To determine how the dimensions should be presented to designers to provide the optimal support for selecting design strategies, it is necessary to understand how designer work and how methods or tools should be designed to support their work. This will be done partly by gathering the opinions of design practitioners, partly by evaluating the experience and feedback the authors have gathered from projects where an earlier version of a behaviour changing design tool was applied, and partly by investigating the recommendations that can be found in the literature.

In Jones (1992, p.28), observed that the literature on the process of creative thinking is "extensive, but none too helpful". Since this observation was made, the literature has continued to expand not only in quantity, but also in the variation of perspectives and directions. In Cross (2008), pointed out that there has been a substantial growth in new, unconventional methods, which attempt to bring rational procedures into the design process. Although not embraced by everyone, the need for new methods is growing with the increase in complexity for many modern design projects (Cross, 2008). According to Cross, the new methods tend to formalise certain procedures and externalising design thinking. The formalisation of procedures may reduce the occurrence of oversight and widen the solution space, whereas the externalisation of design thinking frees your mind to think creatively and aids all the members of the design team to understand what is going on. He distinguishes between 'Creative Methods', which are intended to increase the solution space and remove mental blocks, and 'Rational Methods', which are intended to improve the quality of design decisions. The contribution of these methods are in line with Jones observation that the "enemies of originality are mental rigidity and wishful thinking" [Jones, (1992), p.29].

However, even though there has been a substantial increase in both the quantity and usefulness of this literature, there is still a lack of methodological support for identifying the most suitable design methods (Ernzer and Birkhofer, 2002). When reviewing the literature presenting development of new design methods and tools, there seems to be limited discussion about how the methods or tools should be designed to support the way designers work and the translation of this into requirements for how the tool should be designed (Brandt and Messeter, 2004; Buur and Soendergaard, 2000; Desmet, 2002; Elias, 2011; Halskov and Dalsgaard, 2007; Lockton et al., 2009; Lucero and Arrasvuori, 2013). There is nevertheless literature that does move in this direction. A few publications seem particularly relevant for understanding how designers use tools, what makes certain tools particularly valuable and the reasons why other tools are not applies. An extensive contribution is the doctoral thesis by Lindahl (2005) on "Engineering Designers Requirements on Design for Environment Methods and Tools". Even though this research focuses on engineering designers and not product designers, it is still likely to be relevant in the context of Design for Sustainable Behaviour as both groups thinks creatively about the design of products and many of the tools Lindahl investigates also are used by product designers. However, there are also differences between the type of work the two types of designers do and how they do it, which may affect their requirements for methods and tools. This should be taken into consideration when considering the applicability of Lindahls conclusions.

In his research he investigated which methods and tools designers' use, obstacles they experience with using particular methods and tools, and the requirements they have for the methods and tools they use. His main focus was to find out how Design for Environment methods and tools should be designed to become more commonly used, but in the research, he also investigated the use of several other types of design methods and tools. His reason for this was the assumption that "the basic requirements for a method or tool to become utilized are the same" (Lindahl, 2006) and it strongly increased the basis from which he could extract data.

In his thesis (2005), he presents a list of 32 requirements ranked according to their importance for a tool to be utilised. He concludes that all these requirements can be summarised into four major requirements. A method or tool must be:

1 easy to adopt and implement

2 facilitate designers to fulfil specified requirements

3 reduce the risk that important elements in the product development phase are forgotten

4 must reduce the total calendar time to solve the task.

He points out that if "a method or tool helps designers to fulfil the specified requirements, it will also most likely help them to reduce the calendar time as well as the number of working hours needed to accomplish the product development". In addition, he also identified the three main purposes designers have to utilise methods and tools. The methods or tools "(1) facilitate various kinds of communication within the product development process, (2) integrate knowledge and experience into the methods and tools as a know-how backup and (3) contribute with structure in the product development".

The importance of ease of adoption and implementation was confirmed by a study by Knight and Jenkins (2009). They examined the eco-design tools designers' use in their practice and found that the tools should be clear and visible, and should be both useable and useful for the design community. Through their study they also found that the tools can be classified into three categories: 'Guidelines', providing broad support but little detail, 'Checklists', providing in-depth but narrow application at selected stages in the process, or 'Analytical tools', providing detailed and/or systematic analysis at specific stages of the process. All three types of tools were considered to be useful, but when asked to rank the tools, 'Checklists' were considered to be most applicable in their companies, followed by 'Guidelines'.

Another thorough investigation into how eco-design tools should be designed to support the needs of designers was presented by Lofthouse (2006). She found that designers tend to look for tools that combine guidance, information and education. The tools should contain numerous examples, be as visual as possible and contain a minimum of text. When text is needed, it should be written in a non-scientific language. The tool should be possible to use without spending too much time, be referred to when required and fit into the designers' usual way of working. It is also crucial that the tool focuses on design and not on strategic management or retrospective analysis of existing products. Although Lofthouse's investigation focuses more on traditional eco-design issues, such as information about environmental impact of materials and processes, many of the requirements may be relevant for the context of behaviour change too.

In addition to draw upon the understanding presented in the literature to determine how the dimensions should be presented to the designers, the authors can also draw upon the experience and feedback they gathered through previous projects applying another tool to help designers design behaviour changing products. This tool, *Principles of Behaviour Change*, is in the form of a guide to help designers analyse the level of obtrusiveness and control they should apply according to their target group and was first presented in 2010 (Zachrisson and Boks, 2010). The essence of the tool consists of an illustration of the landscape of obtrusiveness and control in line with how these dimensions are described in the literature (Figure 2) and a set of guidelines. The guidelines draw extensively upon behavioural psychology literature and point out when particular situations or aspects of the users make it more or less likely that certain levels of obtrusiveness and control will be accepted, and will lead to the desired behaviour change.

**Figure 2** The landscape of obtrusiveness and control


The tool was applied in a number of projects by design students at the authors' home university. The first project where the tool was applied was a master project in 2011 and the experience from the application of the tool in the project was presented later the same year (Zachrisson et al., 2011). The conclusion from this project was that the tool was valuable to guide design decisions and as a checklist to make sure all the most important aspects were included. However, it was also obvious that it was unclear how and when the tool was to be applied, the theoretical background information the tool built upon was too complex to be easily understood by designers and the results of the analysis was not sufficiently easy to understand. It was understood that for any future version of the tool it should be clearer how the tool should be applied, using clear illustrations and examples.

A class of (mainly) last year bachelor students applied a new version of the tool in eight parallel group projects in a semester-long design course at the authors' home university, in the spring of 2012. The experience from these projects partly supported the results from the previous application of the tool, but also pointed out some other considerations that should be taken into account (Daae and Boks, 2013). These included that the tool should be more dynamic and accommodate designers that wish to use their intuition and apply the parts of the tool they believe are most relevant for their particular project. In addition it was clear that the students prefer tools they experience as inspirational rather than strictly guiding.

These experiences and recommendations from the literature form a strong basis for understanding the most important aspects to take into consideration when designing a new tool for designers. However, as the experience was gathered from student projects and not from design practitioners and the insight from the literature about design methods and tools in general and not necessarily from a product design perspective, it was decided to focus the last part of the study on the design practitioners thoughts on how the dimensions should be presented.

## 4 Method

According to the information provided in the literature, the proposed dimensions are motivated by the understanding and intuition of the researchers. To inform a more elaborate discussion on the identification and relevance of dimensions and how to utilise them, we have chosen a combination of creative workshops and expert interviews to gather empirical material. Expert interviews are frequently applied in empirical research and can contribute to theoretical reflection and practical aid (e.g., Bogner et al., 2009). The purpose of combining this with the setting of a creative workshop was to let the participants think more freely and creatively around the topic. This was believed to be relevant as it was assumed that the participants might not have thought explicitly about topic before, even if they were assumed to have substantial understanding of it. As experts, we chose design practitioners, professionally employed at different design agencies and companies located in Oslo and Trondheim. Our empirical data was collected during five workshops at these companies, in workshop session that lasted for about two hours and had between two and six participants. All participants hold a master's degree in industrial design and work with product and interface design on a daily basis.

This method allowed us to investigate which dimensions design practitioners themselves consider relevant. Although most designers may not explicitly have considered the question before in the context of designing for sustainable behaviour, experienced designers can be expected to have an extensive, implicit understanding of how to affect user behaviour as they design user interfaces. By comparing the dimensions identified through this approach with the ones found in literature, a broader understanding of the problem can be achieved. Similarities between the two sets may be understood as a support for the validity of the sets, whereas differences may raise questions about the validity and the reasons for the differences.

The primary purpose of the workshops was to investigate which dimensions the design practitioners considered relevant to understand how a design affects the behaviour of its users. In other words, it was our aim to uncover as many dimensions as possible along which a designer can manoeuvre when designing a product aimed at changing behaviour. It was not our intention to research which dimensions would be useful more often than others, as that is considered to be depending on the context of the design problem. It was assumed that designers often implicitly or explicitly use product semantics or inscribe scripts in their designs, to make people use them in a particular way; however, designers might not include this explicitly in their design processes. The challenge would therefore be to make the designers reflect upon their understanding from a common starting point without providing too much information that might bias the results. At the same time, the pilot test (workshop 1) made clear that it was necessary to provide the designers with considerable guidance to understand the challenge and get them started and provide meaningful reflections.

To give the participants an introduction into the topic and a common starting point, each workshop started off with a presentation, consisting of the following steps:

1 Introduction of the potential for environmental benefit from alteration of how people interact with products.

2 Presentation of a large number of pictures of products that can affect the behaviour of their users was presented, with an explanation of how these could represent different principles for affecting behaviour.

3 An explanation of the need to distinguish between principles, and to facilitate the process of matching the choice of principle with the intended behaviour change.

4 A suggestion that one way of distinguishing between different principles is to consider how they affect the user, for example according to how much they allow the user to determine their behaviour themselves. We used a large number of illustrations to clarify this to the workshop participants (see example in Figure 3).

5 The designers were challenged to suggest which other dimensions, according to their own experience, could be identified to distinguish (i.e., understand the difference) between principles that can be expected to lead to behaviour change. They were asked to individually write the suggestions on post-its and try to formulate them as word-pairs on opposite sides of a scale. We chose to let the participants consider the principles in terms of dimensions with opposite extremes, to keep the results in a similar structure compared to the previous proposals in the literature. To support the process, a number of picture pairs were shown and it was suggested that they could compare them, as exemplified before, to get started. When the initial rate of writing on the post-its declined, the picture pairs were replaced by a collection of 63 different pictures of products that might affect the behaviour of the users in order to provide additional examples and provide new inspiration (see Figure 3).

6 When the designers felt that they had exhausted the most obvious dimensions, after 15 to 30 minutes, the post-it writing process was stopped. The designers were then asked to explain their suggested dimensions to the rest of the group and the facilitator posted the post-its on a wall. During this process, the overlapping dimensions were clustered and the overall variation of dimensions was discussed. Each designer was then given five stickers, and was asked to attach them to the dimensions they thought were the most intuitive and important to determine when different principles could be expected to change behaviour or be accepted.

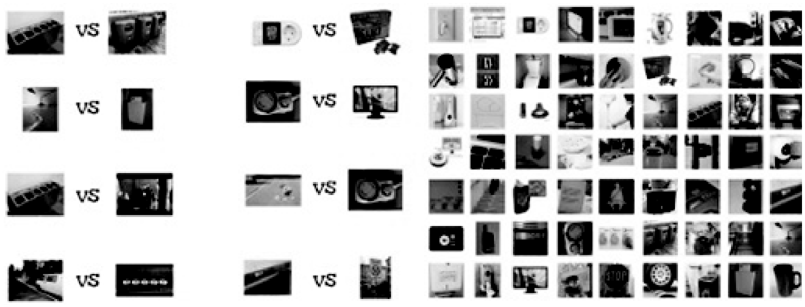
7 The last part of the workshop consisted of a discussion about how the understanding of behaviour change through design, how the dimensions should be presented to support designers in their work and how much guidance they should be given to understand the implications different principles. One central topic in this discussion was the number of dimensions to include. More dimensions could potentially improve the understanding of when different principles should be used but will also require more effort. To help the designers consider alternative ways in which the

information could be presented, they were shown five alternative ways of guiding the selection of principles according to the distribution of control, and the obtrusiveness of the principles, the same landscape as can be seen in Figure 2.

One alternative consists of simple statements and indication of the recommended area of the dimensions, one presented information about expected consequences of principles from different parts of the landscape in the corresponding areas, one presented a flow diagram, where the reader is guided to recommendations by answering questions about the user and the context, one asked simple questions about the user and the situation, and provides recommendations directly according to the answers and one presented bullet-points of the expected consequences of principles along the two dimensions.

**Figure 3** Illustrations used during the workshops


**Figure 4** Word pairs and additional examples




## 4.1 Method: structuring of the dimensions

After conducting the workshops, it was obvious that the dimensions suggested during the workshops were on several different levels and partly overlapping. Keeping in mind the goal of developing support for aiding designers' understanding of dimensions of behavioural change and how this may aid the selection of suitable design principles, the dimensions needed to be structured in a clear and logic way. This was done by the authors in several iterations, striving to achieve as meaningful categorisation as possible. A number of challenges were encountered. First of all, no obvious theoretical framework to guide the structuring process was available, leaving room for several approaches, depending on which logic is used to interpret and distinguish between the proposed dimensions. Secondly, one will always run the risk of loosing information or nuances in the process of categorising or structuring. The larger the categories, the more likely it is that important nuances are lost as common elements of multiple dimensions are combined. Finally, proposing the concept of dimensions as a suitable way to present the different ways a product might affect the behaviour of the user posed some challenges in itself. Some of the dimensions allowed for a continuous description along a scale, whereas others may be more suitable for a more discrete description, or even represent different logical concepts that are not necessarily opposing. However, the concept of dimensions along a scale between opposing mechanisms was maintained to explore its potential, partly in search of uniformity with dimensions that have become more or less established already (control and obtrusiveness). Efforts were made to maintain the essence of all the dimensions and reduce loss of information as far as possible. The resulting dimensions where then developed into a design tool, guided by the requirements identified in the literature and previous experience (see Table 1).

**Table 1** Requirements for the tool

| | |
|---|---|
| | *Must* |
| Nr. 1 | Help designers to design products that are more likely to be used in the desired way by using the tool, than without the tool. |
| Nr. 2 | Help designers understand which design principles they should apply to change the behaviour of their target group. |
| Nr. 3 | Increase the designers understanding of different aspects of how the product affects the behaviour of the user |
| Nr. 4 | Be easy to use for product designers, fit into designedly ways of working |
| | *Should* |
| Nr. 5 | Be possible to understand how to use in 15 minutes |
| Nr. 6 | Be experienced as inspiring for designers |
| Nr. 7 | Be in a format that makes it suitable for discussion and collaboration |
| Nr. 8 | Should be experienced as suggesting rather than dictating |
| Nr. 9 | Remind the designers of the aspects of a product that affect the way users interact with it |
| | *Could* |
| Nr. 10 | Be suitable to bring to meetings with clients to help the designers explain their decisions |
| Nr. 11 | Be experienced as primarily visual |
| Nr. 12 | Be written in a non-scientific language |

### *4.2 Method: testing of the tool*

In order to evaluate how well the new tool fulfilled the requirements, a comparative study was done by testing the tool on design cases. An initial plan for testing and evaluating the tool was developed and tested in a pilot study to be refined before the actual testing. This pilot study also served to gather some additional feedback on the design of the tool and allow an extra iteration before the testing.

The pilot study was conducted at Stanford University in April 2013. Twelve participants were recruited, with varying degrees of design experience, ranging from students who only had a few design courses to experienced design professionals. First, the participants were given a brief presentation, introducing the importance of behaviour change and some examples of behaviour changing products. At the end of the presentation, they were shown three short videos of people using a water kettle to boil water for a cup of tea and brief interviews on what they had done and why. After the videos the participants were divided into 6 pairs matching one experienced with one less experienced designer. They were told they should spend the next five hours generating ideas and developing three concepts for how to avoid the people in the videos boiling more water in the kettles than they needed. Each pair got a separate cubicle, a bunch of post-its and markers and three sheets to draw the concepts on and explain why and how it would affect the behaviour of the target group. In addition, two of the pairs received the above described *Principles of Behaviour Change* tool, two pairs received the new tool, *Dimensions of Behaviour Change*, and the last two pairs received a 'base-line' tool consisting of design examples. After they had finished the design challenge, all participants filled out a survey about the experience of the tool they had worked with.

The experience from the pilot study indicated a number of adjustments of the testing protocol to enhance the evaluation of the tool. First and foremost, the number of teams working in each condition should be increased, to reduce the effect of individual variation among the participants. To achieve this, the number of participants should be increased and a more homogenous group of participants should be recruited. In addition, rather than trying to compare and evaluate several tools simultaneously, the new tool should be isolated and compared to teams working without a tool at all. Feedback from the participants also indicated that including design for a specific target group complicated the design task without necessarily providing too much benefit. Removing this condition simplified the task and could allow less time for the design challenge. It also indicated that it could be relevant to investigate the effect of repeated use of the tool, as time and effort was spent on understanding the tool in the beginning of the session. To reduce the risk of particular properties of the design challenge affecting the results, more than one design challenge should be included in the study. Finally, the feedback from the two pairs that had worked with *Dimensions of Behaviour Change*, enables some minor adjustments, improving the usability of the tool.

Based on these experiences, a new study was designed. This time the workshop was arranged at Delft University of Technology. Forty six students, all in the last year of the Bachelor study, half from industrial design and half from aerospace engineering, participated in the workshop. The students were randomly divided into 18 teams with at least one design student in each team, and split into two rooms with 9 teams in each. The teams were given one of three design challenges, a bunch of post-its and markers, and two hours to generate ideas and select the three best ideas. These ideas should be presented with a drawing and an explanation why and how it should result in the desired behaviour. In the first session, half the teams got the *Dimensions of Behaviour Change* tool. In the second session all the teams got the tool (see Table 2).

**Table 2** Set up of workshop to test *Dimensions of Behaviour Change*

| | | Design a solution that makes people unplug their cell phone chargers when it is not being used for charging the phone. | Design a solution that makes people only boil the amount of water they need in a water kettle. | Design a solution to avoid the heating being turned on and a window being open at the same time, in the same room. |
|---|---|---|---|---|
| Introductory lecture about why behaviour change is important | | | | |
| Session 1 (2 hours) | Teams get the tool but no introduction (room 1) | Team 1, 2, 3 | Team 4, 5, 6 | Team 7, 8, 9 |
| | Teams get no tool (room 2) | Team 10, 11, 12 | Team 13, 14, 15 | Team 16, 17, 18 |
| Lunch | | | | |
| Lecture with introduction to the tool | | | | |
| Session 2 (2 hours) | Teams have experience and uses tool for second time (room 1) | Team 7, 8, 9 | Team 1, 2, 3 | Team 4, 5, 6 |
| | Teams have experience and uses tool for the first time (room 2) | Team 16, 17, 18 | Team 10, 11, 12 | Team 13, 14, 15 |
| Students fill out survey | | | | |
| Presentations and discussion | | | | |

After another two hours, the students filled in a survey where they were asked to evaluate a number of statements about the tool on a scale from 1 to 5, where 1 signified ‘strongly disagree’, 2 ‘disagree’, 3 ‘neither agree nor disagree’, 4 ‘agree’ and 5 ‘strongly agree’.

In addition to counting the number of ideas generated by the teams, the presented ideas were analysed to identify the type and number of behaviour changing approaches applied. This allowed for an evaluation whether the tool helps the students consider a greater variation of ways to affect behaviour. In doing so, not only the total number of approaches among the three concepts developed by each team for a problem was counted, but also the number of unique approaches. As it could be expected that the teams would apply the same approach to more than one of the concepts for a challenge, it was interesting to know how many different approaches they applied. The number of unique approaches is thus to be understood as the number of different approaches applied, not double counting if an approach has been applied more than once by a team for the same challenge. This may be the most interesting measurement of success, as it represents the actual variation in how the students try to affect behaviour.

## 5 Results

As pointed out earlier, the pilot study showed that the designers needed some guidance to really understand the task at hand and start generating ideas. This might be due to the theoretical nature of the task, something which most of the participants, according to themselves, are rarely were confronted with, but also the novel way of thinking. The latter is apparent from the feedback received from the participants after the workshop, where all groups claimed to have enjoyed the different perspectives the topic provided on how users are affected by product design. However, once the participants understood the way of thinking, all the groups generated multiple suggestions to relevant dimensions.

There seems to be a relation between the number of participants in the workshops and the number of dimensions they proposed, as the two workshops with the most participants proposed about twice as many dimensions as the three smaller groups. However, this difference may also be explained by factors such as group dynamics, individual qualities, differences in how they normally work, etc. In all the workshops several dimensions were suggested multiple times by different participants, and could therefore be reduced to a single dimension that did not overlap any other dimensions. Table 3 shows the number of participants in each workshop and the number of independent dimensions suggested in each workshop.

**Table 3** Workshop results

| | *Workshop 1* | *Workshop 2* | *Workshop 3* | *Workshop 4* | *Workshop 5* |
|---|---|---|---|---|---|
| Number of participants | 6 | 3 | 4 | 2 | 5 |
| Number of dimensions | 41 | 20 | 19 | 19 | 37 |

Between the different workshops several dimensions were overlapping. After removing the identical ones, the combined outcome of all the workshops was a list of 55 independent dimensions, which may be seen in Table 4.

**Table 4** All 55 dimensions

| *No.* | *Dimension* | *No.* | *Dimension* |
|---|---|---|---|
| 1 | User in control vs. product in control | 29 | Trendy vs. not trendy |
| 2 | Encourage vs. impose | 30 | I know I do something vs. the worlds knows it |
| 3 | Passive user vs. active user | 31 | Environmentally concerned vs. not environmentally concerned |
| 4 | Users responsibility vs. others responsibility | 32 | Competition vs. no competition |
| 5 | Helpful vs. annoying | 33 | Fulfilment of dreams vs. survival |
| 6 | Obvious vs. hidden | 34 | Much info/output vs. little info/output |
| 7 | Information vs. simplify | 35 | Opposing information |
| 8 | Consequences for me vs. for others | 36 | Meaningless vs. meaningful |
| 9 | Simple vs. complicated | 37 | Polite vs. impolite |
| 10 | Emotional vs. rational | 38 | Neutral sender vs. non-neutral sender |

**Table 4** All 55 dimensions (continued)

| *No.* | *Dimension* | *No.* | *Dimension* |
|---|---|---|---|
| 11 | Instructions vs. feedback | 39 | Aesthetics vs. usability |
| 12 | Fun vs. meaningful | 40 | On my way vs. far away |
| 13 | Force vs. guide | 41 | Opt in vs. opt out |
| 14 | Wish vs. should | 42 | Correct vs. incorrect mental model |
| 15 | Invite vs. deter | 43 | Force controlled usage vs. punishment |
| 16 | Large consequence vs. small consequence | 44 | Open and inviting vs. secretive and mysterious |
| 17 | Primary function vs. disconnected | 45 | Preventing vs. reducing consequences |
| 18 | Rarely vs. frequent usage | 46 | Stigmatising vs. elevating |
| 19 | Always vs. particular situations | 47 | Reduce usage vs. increase usage |
| 20 | Information vs. overruling | 48 | Perfect vs. improved |
| 21 | Choice vs. no choice | 49 | One culture vs. another |
| 22 | Long term vs. short term consequences | 50 | Social norms vs. individual norms |
| 23 | Convince vs. demand | 51 | Individual freedom vs. greater good |
| 24 | Good vs. bad conscience | 52 | Engineering spec. vs. usability spec. |
| 25 | Physical vs. intellectual consequence | 53 | Dosage vs. continuous |
| 26 | User agree vs. do not agree | 54 | Central function vs. additional function |
| 27 | Reward vs. do not reward | 55 | New product vs. adjust old product |
| 28 | Easy vs. overkill | | |

As is apparent from the number of dimensions identified, the participants were able to consider numerous perspectives on how behaviour may be affected by design. However, identifying the most important ones turned out to be more challenging for the workshop participants. Thus, they felt the importance of the dimensions depended too much on the designer's preferences and the type of product that should be designed, and that it thus was almost impossible to prioritise them from a general perspective. The general response was that it would be good to have a rather wide selection of dimensions and let the designers choose the once they felt were most suitable for their project.

The results of the question regarding how the dimensions should be presented, confirmed the results of the literature review and experiences from the earlier tool. The tool should be easy and quick to understand and implement, support collaboration, be experienced as inspiring, and be flexible and allow the designers to feel that they are in control and apply parts of the tool without having to apply the rest. Several of the designers also mentioned that it would be very valuable if the tool could support the designers not only to design products that are likely to lead to the desired behaviour change, but also support the designers in convincing their clients to accept the proposed design solutions.

## *5.1 Result: categorisation of the dimensions*

Table 5 presents a proposal for how the results of the workshops may be tabulated and structured. In this proposal, the dimensions from the workshops are first categorised according to their topic. By considering the effect these different categories may have on the user, all the categories are translated to a comparable format and a set of nine distinguishable dimensions are proposed. For each of the dimensions, a number of design strategies, represented as mechanisms, are proposed, based on the data from the workshop.

**Table 5** Categorisation of the empirical data: from 55 dimensions to nine main dimension categories

| *Dimensions from the workshops* | *Description of the dimensions* | *Proposed dimensions* |
|---|---|---|
| Choice vs. no choice<br>User in control vs. product in control<br>Convince vs. demand<br>Encourage vs. impose<br>Information vs. overruling<br>Force vs. guide<br>Individual freedom vs. greater good<br>Opt in vs. opt out<br>On my way vs. far away<br>Simple vs. complicated<br>Information vs. simplify<br>Forced usage vs. punishment | Shall the user or the product determine the behaviour?<br>Allow the user freedom of choice of action vs. Forcing the user by giving product control | Control [known from literature, e.g., Jelsma (1997), Lilley et al. (2005), and Elias et al. (2007)] |
| Passive user vs. active user<br>Obvious vs. hidden<br>Open and inviting vs. secretive and mysterious | How much attention shall the design demand?<br>Demand attention or action from the user vs. Use a subtle or obvious approach to reach a goal | Obtrusiveness [known from literature; Zachrisson and Boks (2011), Tromp et al. (2011)] |
| Helpful vs. annoying<br>Invite vs. deter<br>Polite vs. impolite<br>Stigmatising vs. elevating<br>Reduce usage vs. increase usage<br>Reward vs. do not reward<br>Good vs. bad conscience<br>Much info/output vs. little info/output | Should the desired behaviour be promoted or the undesired discouraged?<br>The design leads the user towards the desired behaviour<br>vs.<br>The design leads the user away from the undesired behaviour (discrete scale) | Encouragement (novel) |
| Fun vs. meaningful<br>Emotional vs. rational<br>Competition vs. no competition<br>Wish vs. should | Does the design focus on rational or emotional purpose?<br>Motivate the user through fun (hedonic)<br>vs.<br>Motivate the user through meaning (rational) | Meaning (novel) |

**Table 5** Categorisation of the empirical data: from 55 dimensions to nine main dimension categories (continued)

| *Dimensions from the workshops* | *Description of the dimensions* | *Proposed dimensions* |
|---|---|---|
| User agree vs. do not agree<br>Meaningless vs. meaningful<br>Primary function vs. disconnected<br>Central function vs. additional function<br>Trendy vs. not trendy<br>Environmentally concerned vs. not concerned | Is the desired behaviour in line or opposing the wishes of the user?<br>The user is motivated to perform the behaviour vs. The user is not motivated to perform the behaviour | Direction [known from literature; Jelsma (1997)] |
| I know I do something vs. the worlds knows it<br>Social norms vs. individual norms<br>Consequences for me vs. for others<br>Users responsibility vs. others responsibility | Is the user focusing on themselves or others and what others think?<br>Play on the user's concerns about himself vs. the user's concerns about others | Empathy (known from literature; mentioned by Tromp et al., 2011) |
| Physical vs. intellectual consequence<br>Fulfilment of dreams vs. survival<br>Large consequence vs. small consequence<br>Neutral sender vs. non-neutral sender | How important does the user consider the behaviour to be?<br>Make the user feels strong pressure vs. Use weak pressure | Importance (novel) |
| Instructions vs. feedback<br>Long term vs. short term consequences<br>Preventing vs. reducing consequences | Should the design target the user before, during or after the interaction?<br>The user experiences it now vs. The user experiences it later | Timing (novel) |
| Always vs. particular situations<br>Rarely vs. frequent usage<br>Dosage vs. continuous | How often will the user encounter the design?<br>The user is always affected vs. The user is sometimes affected | Exposure (novel) |
| Easy vs. overkill<br>Perfect vs. improved<br>One culture vs. another<br>Opposing information<br>Engineering spec. vs. usability spec.<br>New product vs. adjust old product<br>Aesthetics vs. usability | Not usable? | |

In this process, seven of the 55 originally proposed dimensions were not included in the structuring. These dimensions were excluded because it is unclear how they were meant to affect the behaviour of the user. Four of the dimension categories are to some extent known from existing literature.

The dimension category *Control* (corresponds with *Force*, *Distribution* and *Control), Obtrusiveness (corresponding with Salience) and Direction* are reasonably well known from literature, whilst empathy has been touched upon by Tromp et al. (2011) who refer to the consideration of collective versus individual concerns. These three dimension categories represent 20 of the 55 dimensions identified from the workshops. The rest of the dimensions have been categorised in five dimension categories novel to design research, at least in the context of sustainable behaviour change: *Encouragement, Meaning, Importance, Timing and Exposure.* It should be noted that the categorisation of dimensions is an exercise in progress; further research will be needed to determine if this categorisation is both correct and meaningful.

Interestingly, the dimension *Scale,* known from literature, cannot be satisfactorily identified from the 55 dimensions derived from the workshops. This may be seen as an indication that the nine proposed dimension categories do not provide an exhaustive picture of all relevant dimensions. However, considering that *Scale* is described as the level of complexity and does not directly say anything about how the behaviour of the user is affected, its lack of a corresponding dimension may be a natural consequence of what was the principle quest of the workshops: to identify how a product can affect the behaviour of the user, and not to what extent.

As it was at this stage not our goal (nor is it likely possible) to arrive at a set of mutually exclusive categories of dimensions, both the number and naming of the proposed dimensions is ambiguous to a certain extent, and overlap may be assumed to exist between the categories proposed here. For example, one can argue that encouragement, as in 'designing in' an architectural element or consequence that encourages a user to use a product in a certain way, is a strategy that belongs on the well-known control spectrum. We have however also chosen to name Encouragement as a separate, novel dimension, as it does not affect how much control the user has over the behaviour, but affects the users motivation to perform it. Encouragement is about motivations, whereas control is about affordances or usability. Similarly, providing Meaning, or playing on Empathy, can also be regarded as ways to encourage users towards a behaviour, but are proposed as separate categories because they represent different perspectives. Whereas Encouragement represents the variations between strongly discouraging and strongly encouraging, Meaning represents the variation between motivating rationally by making the user feel it is the right thing to do and emotionally by making the desired behaviour pleasurable. Empathy represents a scale of solutions to influence behaviour ranging from making the user aware of, or consider, others, to allow for a purely egocentric perspective.

As such, the distinction between the nine different dimensions was the result of an attempt to find a meaningful balance between granularity and level of aggregation. If the number of dimensions had been reduced further, important distinctions and nuances had been lost, as categories would have to be combined. If the number of dimensions had been increased, clear enough distinctions between the categories may have become difficult.

It should however be noted that the results achieved through the study described in this paper, may have been affected by the way the topic was presented in the workshops. As the designers needed some guidance to understand the question at hand, it was impossible to avoid giving examples and descriptions that may have affected their way of thinking. However, an effort was made to reduce this as much as possible. The designers' experience of the novelty of the approach and the time limitation of the workshops makes it unlikely that there is no further potential for finding additional dimensions. Nevertheless, the amount and variety of the proposed dimensions provides reassurance that the most significant dimensions were identified.

### *5.2 Result: proposal for a design tool*

To enable designers to draw upon the results of this research and, potentially, design products that are more likely to be used in the most sustainable way, the results of the research need to be translated in a format that is usable for designers. The literature review on how to design design-tools for designers, the experience from the previous projects and the information gathered through the workshops contains substantial information about how a tool should be designed to support designers. This information can be summarised into the following list of requirements.

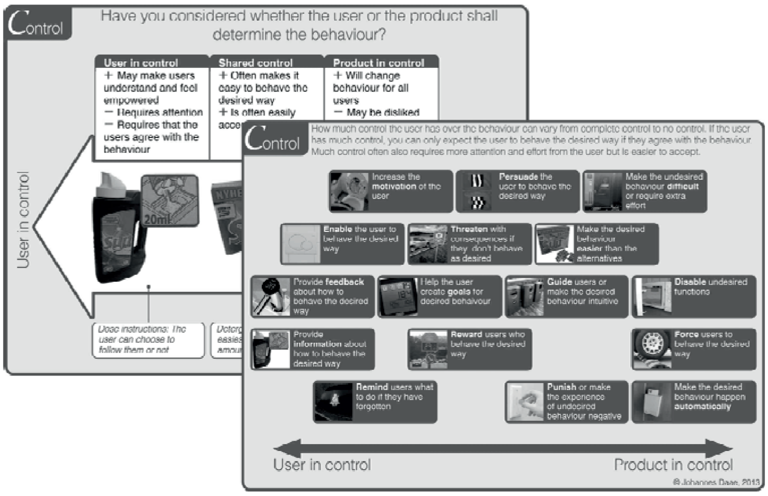
There are two aspects of the design of the tool that affect whether the tool is suitable to fulfil its purpose or not; the content and the format. In the literature there are numerous design tools available, covering a great variety of formats. A few of the requirements describe aspects that are directly related to the format, which may support the selection of an appropriate format. However, it should be noted that this only to a limited degree can support the choice of format as it often is more a question of how it is applied to the format than which format it is applied to.

The first choice to make is whether the tool primarily should be physical or digital. A clear advantage by the digital format, which was pointed out by some of the workshop participants, is the opportunity of interacting with the tool, providing input to customising the tool and navigating in the information, such as Fogg's (2013) behaviour wizard. However, some workshop participants commented on the collaborative and inspirational advantage of a physical tool. Even though it might be argued that these challenges can be overcome also in a digital format, it was decided to create a physical tool.

Also within the physical format, there are numerous alternatives. A version of the previous tool had been developed into a booklet. However, feedback from students working with this tool indicated challenges regarding the ease of integration in their regular way or working and that they found the booklet format not so inspiring (Daae and Boks, 2013). An interactive, physical tool, such as the Behaviour Change Wheel (Michie et al., 2011) is a format with great potential due to its dynamic format, but was considered to complicated due to the complexity and amount of information the tool needed to contain. Another alternative could be a poster, such as the Cradle to Cradle Map (De Argumentenfabriek, 2010), but a card format was prefered due to its discrete nature and dynamic potential for use in workshops (Lockton, 2013). However, as Lockton points out, a small card format only facilitates one person reading it at a time. To support collaboration, and enable presentation of the relatively substantial amount of information needed for each card, it was decided to make relatively large cards (A5 format in landscape).

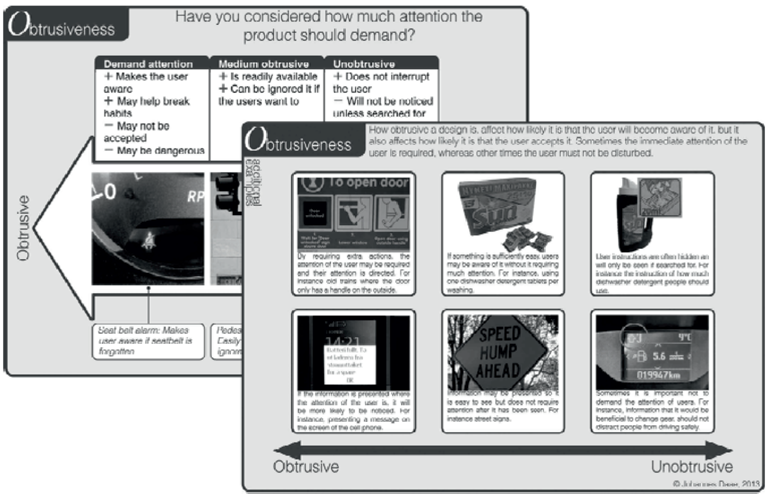
Designing the tool in a card format, making it easy to understand, and creating an inspiring and primarily visual experience, all suggest that the content should have as little text as possible. At the same time, it must contain sufficient information to provide the designers with the necessary support. As the tool is meant to support product designers in general, it cannot be required that they have explicit experience with behaviour change. Thus, the tool needs to present an overview over design principles in addition to the dimensions. As the dimension of control is relevant for all design principles and experience has shown that designers tend to find it intuitive, it was decided to use this dimension as a way of explaining the design principles. The other dimensions can then be used to adjust how the principles are experienced by the user.

**Figure 5** The dimension of control and 16 design principles




Note: Front and back side.

**Figure 6** An example of a dimension card




Note: Front and back side.

The tool, *Dimensions of Behaviour Change*, consists of one card presenting the distribution of control and 16 different design principles relative to how much control they allow the user during the interaction (Figure 5), eight cards presenting the other dimensions separately (Figure 6) and two cards presenting the tool and how it should be used.

Each dimension is presented as a line spanning between two extremes. An example is given for each extreme and for the area between. Each example is illustrated both by a photo of a product, that may affect the user by that specific state of the dimension, and a brief explanation of how the product on the photo may affect a user's behaviour. To help the designers understand the potential consequences of the different parts of the dimension, a number of likely advantages and disadvantages are briefly stated for each extreme, and in some cases also for the central part of the dimension.

The goal of this research has been to support the design of products resulting in more sustainable behaviour. However, as much of the literature and the topic of the workshops considered behaviour change in general, there is every reason to believe that the tool would be equally suitable to support other types of behaviour changes as well.

## 5.3 Result: evaluating the effect of the tool

As each team generated ideas and developed the three ideas they believed would be most successful into concepts, the data from the workshop contains nine concepts from each of the three design challenges for each of the four conditions, in addition to the ideas on post-its survey results.

To compare the results, each concept was analysed and the approaches applied to affect the behaviour of the user were identified. This included both the approaches that were obvious from the design and the once targeted in the descriptions. In this process, efforts were made to avoid awareness of the condition it was generated under and thereby reduce the risk of bias. For each team, in each condition, the total number of approaches either directly applied in the design or described to be targeted in the text, was counted and provided the total number of approaches. The overlapping approaches were removed, resulting in the number of unique approaches.

In addition, the number of ideas generated by each team, in each condition was counted. This was done by counting the number of post-its and removing the once that obviously did not contain an idea, but had been used for categorisation, testing markers, etc.

When testing the equality of means of two independent, continuous, non-normal, distributions, the Wilcoxon rank-sum test is appropriate (Walpole et al., 2002). The result was that teams that did not have the tool in the first session on average generated 56% more ideas than the teams that had the tool in the first session, and the Wilcoxon rank-sum test gave rank sum of $w = 171$, a unit of normal distribution of $z = 2.211$ and significance level of $p = 0.027$, making it a significant result. In the second session, the teams that used the tool for the first time generated 63% more post-its than the teams that used the tool for the second time, and rank sum $w = 136$, unit of normal distribution of $z = 1.903$ and a significance level of $p = 0{,}057$, making it non-significant (see Figure 7 for details).

**Figure 7** Ideas generated on average per team

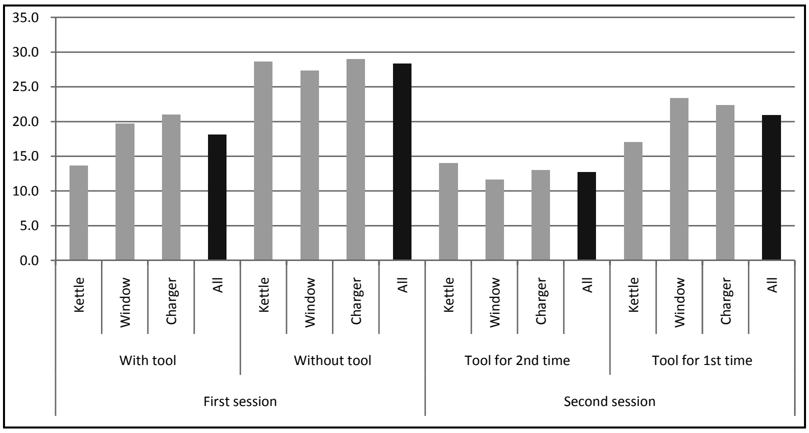
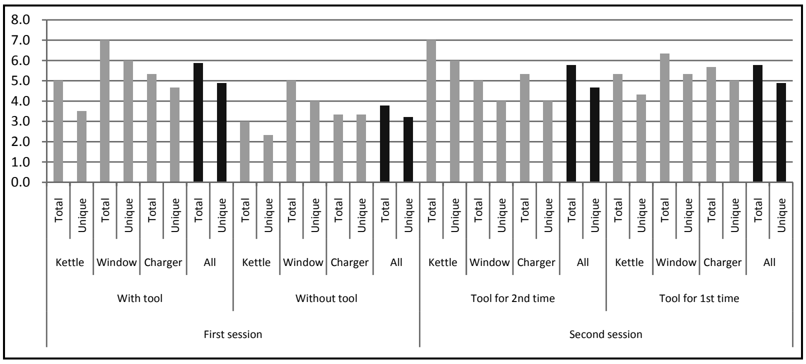



**Table 6** The number of approaches used per group

| | | Teams with tool both sessions | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *1* | *2* | *3* | *4* | *5* | *6* | *7* | *8* | *9* | *Avg.* | *St. dev.* |
| Session 1 | Total | 4 | - | 7 | 4 | 5 | 8 | 2 | 9 | 8 | 5.9 | 2.47 |
| | Unique | 4 | - | 6 | 4 | 4 | 5 | 2 | 8 | 6 | 4.9 | 1.81 |
| Session 2 | Total | 4 | 5 | 5 | 7 | 6 | 4 | 6 | 5 | 10 | 5.8 | 1.86 |
| | Unique | 3 | 5 | 4 | 6 | 5 | 3 | 4 | 3 | 9 | 4.7 | 1.94 |
| | | *Teams with tool only second session* | | | | | | | | | | |
| | | *10* | *11* | *12* | *13* | *14* | *15* | *16* | *17* | *18* | *Avg.* | *St. dev.* |
| Session 1 | Total | 4 | 5 | 5 | 5 | 3 | 4 | 3 | 3 | 2 | 3.8 | 1.09 |
| | Unique | 3 | 3 | 5 | 4 | 3 | 4 | 3 | 2 | 2 | 3.2 | 0.97 |
| Session 2 | Total | 6 | 6 | 6 | 5 | 5 | 6 | 5 | 6 | 7 | 5.8 | 0.67 |
| | Unique | 5 | 6 | 5 | 4 | 3 | 6 | 4 | 5 | 6 | 4.9 | 1.05 |

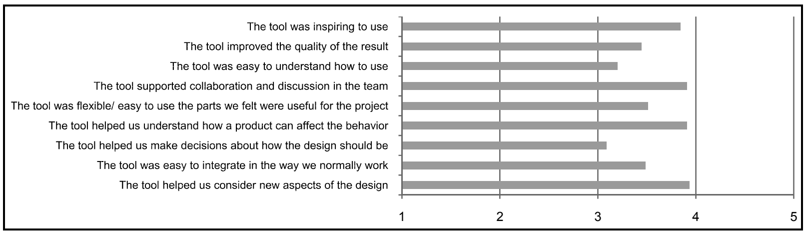
However, even though the teams that did not have the tool generated the most ideas, they had the smallest variation both of total and unique approaches. In all the three conditions where the teams used the tool they had on average between 5.8 to 5.9 approaches in total and 4.7 to 4.9 unique approaches. The teams that did not have the tool used on average 3.8 approaches in total and 3.2 unique (see Table 6/Figure 8). Thus, the teams that used the tools in the first round applied 55% ($w = 153$, $z = -1.76$, $p = 0.0784$) more approaches in total, which is not a significant result. But they applied significantly (53%, $w = 153$, $z = -2.116$, $p = 0.0343$) more unique approaches that the teams that did not have the tool (see graph 2). In the second session, both the teams that used the tool for the first and second time applied 5.8 approaches in total ($w = 153$, $z = 0.86$, $P = 0.3898$) and the teams that used the tool for the first time applied 4% ($w = 153$, $z = 1.237$, $p = 0.2162$) more unique approaches than those that used it for the second time, giving non-significant results.

**Figure 8** The number of approaches used per group and challenge on average




The results of the survey indicated that the students in general were positive to the tool and felt it supported them in the design challenges (see Figure 9). For every question the answers ranged from 2 and 5, which not surprisingly, indicates that the tool worked better for some students than for others. However, as all categories are above 3 and many of them are close to 4, the majority of the students thought the tool had a positive effect on their work. For the questions regarding how inspiring the tool was, how well it supported the collaboration and discussion in the team, how well it helped them understand how a product can affect behaviour and how well it helped them consider new aspects of the design, the score is almost 4 on average and was supported by the finding that the teams with the tool used a greater variation of approaches to affect behaviour. This was also supported by several of the students who commented that the tool helped them understand and consider the perspectives that could help them design better solutions. On the other hand, the question regarding the ease of use and how well the tool supported the decisions of how the design should be, scored just above 3. The former of these indicates that the usability of the tool could be improved further. The latter may indicate that the tool does not support this process well enough, but can also be a consequence of the limited time the students had, and thereby the superficial way which they applied the tool.

**Figure 9** The evaluation of the tool by all the students



## 6 Discussion

The challenge of evaluating the actual behaviour changing potential of new designs is a well-known problem in the DfSB literature. Some authors (e.g., Elias, 2011; Wilson, 2013) solved this problem by building prototypes and testing them in user trials. Unfortunately, it was not feasible within the limitations of this project to apply this approach, as there were 108 design concepts that should be compared. Another approach of evaluating the results is to analyse and compare the concepts directly (e.g., Lilley, 2007) or have potential end users evaluate drawings of the concepts (e.g., Tang, 2010). A version of this approach was considered, by having a group of behaviour change experts evaluate the concepts. However, this would require substantial time and efforts from external experts and would still be heavily subject to the personal preferences of the expert, and the interpretation of both the concepts and the target group and context. The chosen approach of identifying and counting the variation in approaches was thus considered the most objective and feasible method to compare the results. This method also enabled a quantification of the results, which simplified the comparison of relatively extensive data. It is of course not given that a larger variation in design approaches considered would automatically result in a better final design, but as one of the requirements for the tool was to "Increase the designers understanding of different aspects of how the product affects the behaviour of the user", this was considered a relevant parameter to measure.

Counting the number of ideas generated is one way to measure the success of a concept development process (Osborn, 1953) and is a commonly used evaluation parameter (e.g., Lockton, 2013). Based on this measurement alone, the results from the workshop indicated a negative contribution of the *Dimensions of Behaviour Change* tool to the design process, as the greatest numbers of ideas were generated by the teams that did not have access to the tool. The higher number of ideas generated without the tool may be an indication that the tool encumbers the creative process or be a result of the extra time and energy the teams could apply to the idea generation, as they did not have to spend any effort on understanding and applying the tool. However, the amount of ideas on post-its generated by the teams may be an incorrect measurement of the ideas considered by the teams. Several of the teams reported that they used the examples given on the tools directly when proposing and discussing ideas, without making sketches of them on the post-its. Thereby, there is a direct error in the measurement of ideas created by the teams with the tool. In addition, more ideas do not automatically mean better ideas. After all, the teams with the tool had a greater variation in the approaches to affect the behaviour. Thus indicating that the number of ideas generated may not be the most appropriate variable to measure in this context. It should also be noted that the teams that did not have the tool in the first session, also in the second session generated more ideas than the other teams did in either session. This may indicated a difference between the creativity level or way of working between the teams.

In addition, several of the students commented that they were tired in the second session and were affected by the heat as the day of the workshop experienced a heat wave in Delft with more than 30 degrees Celsius, which affected both the temperature and air quality, and possibly the motivation of the students. This may have affected the number of ideas generated in the second session and the concepts they generated. Nevertheless, the number of approaches applied by in all the sessions where the teams had access to the tool is very stable. This does indicate that the effect of the tool is fairly similar whether the students use the tool with no introduction, use the tool after introduction or use the tool for the second time. It should however be noted that all the teams that used the tool for the second time actually finished after less than 1.5 hours in the second session, without this affecting the variation of approaches they applied in their concepts. This may indicate that the efficiency of the process increases with previous experience with the tool.

## 7 Conclusions

This paper has aimed to provide a better understanding of which dimensions may be relevant to classify design for sustainable behaviour principles and enable more informed decisions about when the principles should be used. A comparison between dimensions proposed by the design professionals during workshops and dimensions proposed by researchers in the literature, reveals that using their expert knowledge and experience, the designers came up with several dimensions that had not been previously considered to structure design principles, and which have not been discussed in design (for sustainable behaviour) literature before. This may therefore significantly contribute to our understanding of behaviour change through design. Although future research may be necessary to fine tune the dimensions, it is likely that insights like these may considerable extend the solution space as well as stimulate inspiration and creativity to pick the right solutions from that space.

The testing and evaluation of the tool indicated that the tool did help the students consider a significantly greater variation of unique approaches in their concepts and was generally experienced as a positive contribution. However, the larger quantity of ideas generated by the teams that did not have the tool indicates that it may be beneficial to conduct parts of the idea generation process before introducing the tool. The feedback from the students also indicates that the communication of how the tool should be used could be improved.

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PAPER 4. DAAE, J. & BOKS, C. (2013) *A CLASSIFICATION OF WHEN TO APPLY DIFFERENT USER RESEARCH METHODS TO SUPPORT DESIGN FOR SUSTAINABLE BEHAVIOUR*. JOURNAL OF CLEANER PRODUCTION (SUBMITTED)

**Abstract.**

When designing products to create behaviour change, it is crucial to have insight about the users and their context. The discipline of user centred design has developed numerous methods to provide this type of insight, but there is little information in literature about what insight the various methods may provide. This paper presents a review of user research methods, and assesses their potential for acquiring specific insight. The review focuses on investigation of the factors affecting behaviour, identified by social psychology. The result is a table matching the methods with the factors they are most suitable to investigate and the conclusion that the factors that are relevant to investigate may be either internal or external, and conscious or unconscious. This result is compared with the description of two case studies from literature, for validation.

**Keywords.**

User Centred Design, User Research Methods, Eco-Design, Sustainable Behaviour, Behavioural Psychology

## 1. Introduction.

In recent research there is consensus about the large potential for environmental benefits from altering users' behaviour and the way they interact with products (Elias, 2011; Jackson, 2005; Jelsma and Knot, 2002; Lilley, 2007; House of Lords2011; Rodriguez and Boks, 2005). User centred design and interaction design have been found to be promising approaches to address this challenge (Wever et al., 2008). A number of strategies for how products can be designed to affect behaviour has been identified (Bhamra et al., 2008; Lidman and Renström, 2011; Lilley et al., 2005; Lockton et al., 2010; Rodriguez and Boks, 2005), and in some cases applied in projects (Bhamra et al., 2008; Daae and Boks, 2013; Elias, 2009). These projects apply user centred methods to gain insight about the user and the context of the behaviour to be studied. However there has been little discussion about which methods are to be applied for the user research and why.

The discipline of user centred design had its origin in the 1980s (Vredenburg et al., 2002). It had become apparent that much insight could be gained by studying users and their interaction with computers, when developing new products (Norman and Draper, 1986). Since then, user centred design has become one of the most influential directions within product design. A large number of methods have been developed throughout the years, aiming at providing new types of insight and perspectives. Many user centred research methods are adopted from other disciplines, but are simplified to make them more suitable for commercial needs. This is done because it is more important to get results fast rather than ensuring academic accuracy in the design field (Aldersey-Williams et al., 1999).

Studies of how users interact with products, can aid researchers and designers in finding the specific information they are looking for, but it also creates a challenge for them. Due to the amount and variation in methods, it can be difficult to obtain an overview over the methods and to understand when the different methods would be most valuable to apply. In an attempt to remedy this, several reviews have been made, presenting selected methods or approaches (see for example: Aldersey-Williams et al., 1999; Blomberg et al., 1993; Courage and Baxter, 2005; Kujala, 2003; Maguire, 2001; Muller and Kuhn, 1993; Preece et al., 2002; Sanders, 2006; Steen, 2008). These reviews present descriptions of how and at what stage in the process different methods should be applied. Several of them also have illustrations, or highlight certain aspects of the methods in tables, to ease comparison.

Preece et al. (2002) states that there are five basic methods for gathering data, namely questionnaires, interviews, focus groups and workshops, naturalistic observation and studying documentation. It can be argued that some methods, for example probes or empathic design, are not really combinations of any of these. However, such a simplification may aid the understanding of how different methods are related to each other.

Even though there is extensive literature on user-centred methods, little information is presented of what they actually can tell us about the user, the situation or the context. By reviewing a number of the most common user research methods and structuring them according to what type of insight they are most suitable to investigate, this review aims to give insight on what type of information they may provide. To structure such a review, it is necessary to have a common framework of possible insight the various methods can provide. In order to accommodate the goal of behavioural change, behavioural models from social psychology are chosen as source of such a framework.

The structure of this paper is therefore as following. Firstly, a brief introduction to behaviour models from social psychology, resulting in a selection of one model. Secondly, a review of user research methods according to their strengths in investigating the factors identified by the selected model. By comparing the description of the user research methods with properties of the factors identified by the behavioural model, a table matching methods with the factors they may investigate is generated. Finally, an analysis of two studies from literature is presented, comparing the choice of user research methods and insight gained from them with the results from the review.

## 2. Factors affecting behaviour.

Psychology is a discipline that has done a great effort to identify the factors affecting human behaviour (Klöckner and Blöbaum, 2010). Throughout the years, numerous theories and models have been developed and presented, contributing to unravel the complexity of behaviour determination and prediction. In 2005, Tim Jackson presented a review of models describing behaviour and behavioural change. He points out that many of the models are missing key causal influences, often by focusing either on internal (attitudes, values, habits and personal norms) or on external aspects of behaviour (incentives, institutional constraints and social norms). This makes them less suitable as heuristics for exploring specific behaviour, or identifying the factors that may influence behaviour (Jackson, 2005). As pointed out by Paul Stern: "environmentally relevant behaviour lies at the end of a long causal chain involving a variety of personal and contextual factors" (Stern, 2000). Some models attempt to include all the possible variables that might affect behaviour. However, these models tend to be too complex, making it difficult to test them empirically to obtain quantitative evidence of behaviour (Jackson, 2005).

In 2010, Christian Klöckner and Anke Blöbaum presented a first version of a Comprehensive Action Determination Model (CADM – see figure 1). This model is based on four theories that have been acknowledged for their strength of explaining behaviour, but they are also criticized for not integrating all the factors that may influence behaviour. These four theories are the Theory of Planned Behaviour (TPB), the Norm-Activation Model (NAM), the theoretical concept of habit and the Ipsative Theory of Behaviour. By combining the theories, Klöckner and Blöbaum aim at removing the limitations of each theory and creating a model encompassing both the internal and external factors. They tested the model in an empirical study against with the NAM and the TPB. In addition to a combination of the two, which had been introduced earlier in an attempt to explain behaviour through a larger variety of factors. The conclusion was that the CADM explained the variation significantly better than the other models (Klöckner and Blöbaum, 2010). This could suggest that the CADM both identifies the variables that might affect behaviour and is suitable for empirical testing, as requested by Tim Jackson.

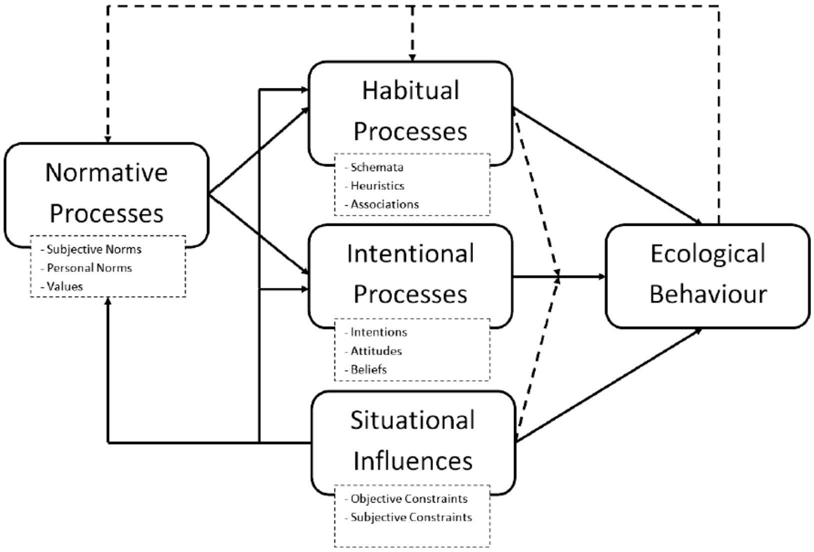


Figure 1: The comprehensive action determination model (CADM) (Klöckner & Blöbaum, 2010)

The CADM explains that individual behaviour is directly determined by influences from three possible sources: *Habitual, Intentional* and *Situational*.

The *Habitual* processes consist of *schemata, heuristics* and *associations* (Klöckner and Blöbaum, 2010). The difference between the three lies in the explanation of how the automated process is created (See table 1 for details). However, the automated effect this has on the behaviour is the same, and there are reasons to believe that the formation of all of them have to go through the steps to successfully perform the behaviour (Klöckner and Matthies, 2011). In addition there is a tendency that strategies for changing behaviour does not seem to distinguish between them (Jackson, 2005; Jager, 2003; Robertson, 1967; Verplanken and Wood, 2006). This simplification will be applied in the following analysis, as the distinction creates more complexity without contributing with any obvious identification or explanation power. Thus is simply the term *habit* included in this study.

The *Intentional processes* consist of *intentions, attitudes* and *beliefs*. These are connected in a hierarchical structure where *intentions* are affected by *attitudes*, which again are affected by *beliefs* (Klöckner, 2010).

The *situational influences* consist of *objective constraints*, which enable or limit the behaviour directly, and *subjective*, or *ipsative*, constraints, which are the factors the user perceives to be relevant for their behaviour (Frey, 1988). The *objective constraints* form the basis for what the user perceives, but *subjective constraints* can also include factors that are not objective (Frey, 1988; Klöckner and Blöbaum, 2010).

In addition to affecting the behaviour directly, *situational influences* also affect the *habitual*, *intentional* and the *normative processes*.

The *normative processes* have an indirect effect on the behaviour through affecting the *habitual* and *intentional processes*, and consists of *personal norms* that are affected by *subjective/ social norms* and *values* (Klöckner and Matthies, 2011).

The CADM provides an overview of the factors affecting ecological behaviour. Due to its aim at being a comprehensive model, it has the potential to provide the input necessary to understand what can be studied with various user centred research methods. By identifying what insight the different methods may provide, this can be used as a framework for selecting appropriate user centred design methods. However, in order to be able to do this matching it is necessary to understand what the factors from the CADM really mean. An attempt to provide this understanding is presented in Table 1.

Table 1: Definitions of the factors

| Name of factor | Explanation |
| --- | --- |
| **Habitual Processes** | Habits are automated processes. They can both be conscious and unconscious to the user. (Verplanken and Wood, 2006) |
| **Schemata/ Scripts** | "The schema or script approach treats habits basically as knowledge structures that provide people with a blueprint of expectable or appropriate behaviour sequences in certain situations even if the complete set of situational information is not processed." (Klöckner and Matthies, 2011) |
| **Heuristics** | "Understanding habits as heuristics means that habits are nothing but extremely simple and efficient decision rules that allow people to make comparatively good decisions with comparatively little effort in information processing." (Klöckner and Matthies, 2011) |
| **Associations** | "… habits are cognitively represented by strengthened connections (neuronal pathways) between parts of the neuronal network activated by situational cues and other parts activating behavioural patterns. The more often the parts of the network responsible for processing specific situational cues are activated simultaneously with the parts responsible for activating specific behavioural patterns the stronger their neuronal connection gets." (Klöckner and Matthies, 2011) |
| **Intentional Processes** | |
| **Intention** | "A determination to act in a certain way" (Webster) |
| **Attitudes** | "A mental position with regard to a fact or state" (Webster) |
| **Belief** | "Conviction of the truth of some statement or the reality of some being or phenomenon especially when based on examination of evidence" (Webster) |
| **Situational Influences** | |
| **Objective Constraints** | "… preclude or inhibit people's ability to participate in particular activities and that they exist independently of individual's perception" (Tanner, 1999) |
| **Subjective Constraints** | Conditions that the user perceives to be constraining or enabling behaviour (Klöckner and Blöbaum, 2010). |
| **Normative Processes** | |

| | |
|---|---|
| **Subjective/ Social Norms** | "… the perceived expectations of relevant other people" (Klöckner, 2010) |
| **Personal Norms** | "… domain specific feelings of moral obligation to act" (Klöckner, 2010) |
| **Values** | "… the most basic and abstract assumptions about what should be done, what is good, and what is bad" (Klöckner, 2010) |

### 3. The User Research Method Comparison.

The collection of user research methods was gathered by reviewing relevant literature with overviews and descriptions of user centred design methods. As the focus is to create an overview over methods that provide insight about the user, only the methods that aim at gathering information about the user or context were included. Methods that are meant to communicate the results of the research or translate the results into design solutions were not included. The focus is on identifying the factors that are affecting the behaviour, not on investigating the behaviour itself.

Two effects that some of the descriptions refer to, which may influence the truthfulness of the information provided by participants, are social desirability and prestige response bias. Social desirability occurs if the participant prefers to answer what he thinks is most socially acceptable rather than the truth. If the participant answers what he thinks the researcher wants to hear, it is called prestige response bias (Courage and Baxter, 2005). Courage and Baxter (2005) discusses these factors in relation to interviews and questionnaires, and claim that the risk for them can be avoided if the researcher is aware of them, and is careful in the way the question is formulated. It is however reasonable to believe that they can affect all types of research where a user is involved, although Blomberg et al. (1993) points out that lack thereof is one of the advantages of observations compared to techniques where the user talks about the behaviour.

There are two properties of behavioural factors identified by the CADM, which may be significant for how they could be investigated. One of these was pointed out by Jackson (2005) when he identified that the factors can either be internal or external. The internal factors are embedded within the user and include factors such as attitudes, values, habits and personal norms. The external factors are embedded outside the user, and include institutional constraints and social norms. As the internal factors are embedded within the user, is it necessary to gain information from the user to investigate these. The external factors however, can be investigated without direct input provided by the user. But this does not necessarily exclude the possibility of investigating the external factors through input provided by the user.

The other property concerns whether the factor is conscious or unconscious to the user. Klöckner et al. stated that habits should be considered unconscious, as they are conducted without deliberate thinking. Thus are people most likely unable to provide information about this (Klöckner et al., 2003). Similarly, Frey (1988) points out that there can be unconscious reasons why the subjective possibility set overextend or underextend the objective possibility set. Thus can objective constraints also be considered to be unconscious for the user and something the user cannot provide information about. It should be noted that in the field of psychology, the term unconscious is used about something the subject is not consciously aware of.

Based on these properties, it is possible to deduce two basic assumptions for how the different factors can be investigated:

Only the factors the user is conscious about can be investigated through information provided by the user.

Only external factors can be investigated without direct information provided by the user.

By dividing the factors according to the properties and highlighting the two assumptions, a matrix indicating how the assumptions affect the investigation of the factors can be organised as done in Figure 2. The included factors are the ones identified by the CADM (Figure 1) model and are categorised according to their explanations (Table 1).

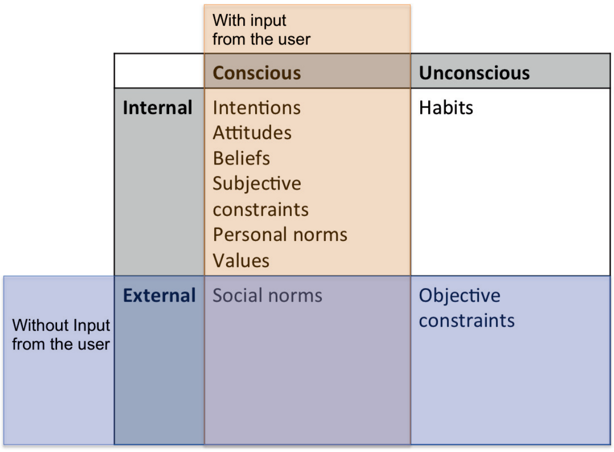


Figure 2: Factor matrix

### 3.1 The Review of the User Research Methods.

The methods that have been included in this review are listed in Table 2.

Table 2: Methods included in the review

| 4.1: Techniques for communicating with the users. | 4.2: Methods for gathering information without input from the user: | 4.3: Methods for combining information with and without input from the user: |
|---|---|---|
| **Interview** | Observation | Applied ethnography |
| **Focus group** | Studying documentation | Contextual enquiry |
| **Survey** | Video Ethnography | |
| **Verbal protocol** | Shadowing | |
| **Conjoint technique** | User testing | |
| **Wants and needs analysis** | Empathic design | |

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|---|---|
| **Card sorting**<br><br>**Group task analysis**<br><br>**Probes** | Culture-focused research |

The methods are divided into three categories, according to how they gather information. Each method is presented with a description and a summary of what the literature describes as its purpose. After all the methods in a category are presented, there is a discussion of the potential for the individual method for investigating the factors identified by the factor matrix (Figure 2). This discussion is based on the identification of aspects in the description or purpose that qualifies or disqualifies the method for investigation of certain factors.

### 3.2 Techniques for communicating with the users.

These methods are based on information provided by the user, which gives access to internal factors. But as the information only is provided by the user, is it necessary to be aware that the information is subjective and may be affected by factors such as social desirability and prestige response bias. These techniques are also not suitable to provide information about factors that the user is not consciously aware of.

Table 3: Techniques for communicating with the users.

| Description of the method | Purpose described in literature |
|---|---|
| **An Interview is a dialogue between a researcher and one or more respondents. (Aldersey-Williams et al., 1999, Courage and Baxter, 2005, Preece et al., 2002)** | Interviews are suitable to provide information about individual actions, motivations, reconstruction of decision-making processes (Aldersey-Williams et al., 1999), needs, thoughts, experiences (Courage and Baxter, 2005), attitudes and beliefs (http://www.Usability-first.com). They can provide rich, detailed data, and give a holistic view of the system (Courage and Baxter, 2005). Individual interviews are more suitable to investigate sensitive topics than methods involving more people (Aldersey-Williams et al., 1999). |
| **A Focus Group is a group discussion about a product or a topic (Aldersey-Williams et al., 1999, Courage and Baxter, 2005, Gibbs, 1997, Preece et al., 2002).** | Focus groups can provide information about both explicit and implicit needs and reactions (Aldersey-Williams et al., 1999). It is useful to gain consensus or highlight areas of disagreements within the group (Preece et al., 2002), generate ideas or discover problems, challenges, frustrations, likes, dislikes, opinions, attitudes, preferences, initial reactions and priorities (Courage and Baxter, 2005). |
| **Surveys or Questionnaires are series of questions requiring direct responses, often multiple-choice or rating on a scale (Preece et al., 2002, Courage and Baxter, 2005, Maguire, 2001).** | Because the possibility to distribute the questionnaire, it is useful to get input from a large group of people (Preece et al., 2002). As surveys can be completely anonymous, they may be more suitable than interviews to investigate sensitive information. The questionnaire can provide information about what users want or need, the population and their characteristics, what they like or dislike, (Courage and Baxter, 2005) and |

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|---|---|
| | current work practices and attitudes (Maguire, 2001). |
| **In Verbal Protocols the subject explains what he or she is thinking, either by talking aloud while they are performing a task, or explaining what and why he or she was doing afterwards (Love, 2005).** | This technique is used in combination with observation and can give information about what a subject was thinking about, reasons for the way he or she behaved a certain way, or about particular feelings about a certain task (Love, 2005). |
| **Conjoint Techniques are based on presenting multiple design features to subjects simultaneously, and subsequently asking them to rate combinations of features (Aldersey-Williams et al., 1999).** | Because subjects rate combinations of features, this method can give information about how much subjects value individual features (Aldersey-Williams et al., 1999). |
| **Wants and Needs Analysis is done by asking a group of subjects to brainstorm about what they want or need in a product they are familiar with (Courage and Baxter, 2005).** | The result of this can be a prioritized list of the type of features and characteristics a subject wants or needs in a product (Courage and Baxter, 2005). |
| **Card Sorting is conducted by writing features of the product or system on cards and asking subjects to organise them or sort them into meaningful groups (Courage and Baxter, 2005).** | Through this technique it is possible to gain insight about how a subject believes a product functions and thereby the conceptual model the user has of the product or system (Courage and Baxter, 2005). |
| **Group Task Analysis is a technique where a small group of users figures out the steps involved in a performing a particular task (Baber et al., 2008, Crystal and Ellington, 2004, Courage and Baxter, 2005).** | The task analysis aims at explaining about the steps and the sequence a task consists of, the users' goal, the information needed, problems they encounter, preferences (Courage and Baxter, 2005), description of observable behaviour (Baber et al., 2008), and/or constraints imposed by nature and what the user knows (Crystal and Ellington, 2004). |
| **In Probes or Diary Studies, participants are given packages containing different tools to document their lives and experiences, such as a camera, a questionnaire, diaries, etc. (Love, 2005, Lucero et al., 2007, Maguire, 2001, Steen, 2008).** | By giving participants probes, they are enabled to provide a personal record of (Love, 2005), and report on their daily lives and experiences (Steen, 2008). |

### 3.2.1. Discussion about the techniques for communicating with the users.

According to the factor matrix, the methods described in table 2 may have the potential to investigate all the internal, conscious factors: *Beliefs, attitudes, intentions, personal norms, subjective constraints* and *values*. Based on their descriptions, this can be true for a number of the methods. *Interviews, focus groups, surveys, verbal protocols* and *probes* are all described as general techniques for acquiring input from the user, without any limitations to what the focus of the investigation is. Although some methods may be more suitable than others depending on the purpose and situation. For instance, group techniques will be less suitable for investigating sensitive topics than techniques that address only one user at the time.

On the other hand, some of the methods aim at acquiring specific information from the user. *Conjoint techniques* focus on investigating the relative importance of product features according to users. This may provide insight about the attitude, personal norms and values, as these all are related to the user preferences. The Insight will however be very specifically connected to the features of the product in focus.

*Want and need analysis* is a similar method, but focuses on the users inventing new features, rather than evaluating existing ones. It is not obvious if this will reveal other factors or address factors more deeply, although the user has more freedom using this method. Nevertheless, this technique will also focus on factors strongly connected to the product features.

*Card sorting* aims at revealing how the user believes that a product functions. This technique aims specifically at the beliefs of the user, but is also limited to the beliefs concerning the product and how this functions.

*Group task analysis* is similar to card sorting, but focuses on a group figuring out the steps involved in a task, instead of organizing already defined steps. Similarly to the difference between *conjoint techniques* and *want and need analysis*, it is not clear what effect the involvement of imagination will have for the investigation. Also this technique investigates believes only about the specific task.

As the insight provided by the four last techniques are so specifically related to the product or task in question, their usefulness might be limited in projects where more general insight is needed.

### 3.3. Techniques for investigating what the users do.

These methods gather information about the user or the context indirectly, either through observing behaviour or studying other relevant information. This allows access to information that the user may be unaware of, but cannot investigate factors that are embedded in the mind of the user.

Table 4: Techniques for investigating what the users do.

| Description of the method | Purpose described in literature |
|---|---|
| **Observations consist of watching and recording users' behaviour, either in the natural context or in a lab setting. (Aldersey-Williams et al., 1999, Blomberg et al., 1993, Preece et al., 2002, Love, 2005).** | The method can identify illogical behaviour, measure performance time, insight about difficulties of tasks (Aldersey-Williams et al., 1999), the natural occurring behaviour (Love, 2005) and behaviour that can be hard for the user to describe or explain (Preece et al., 2002). "What people say they do and what they actually do may be different (Courage and Baxter, 2005). |
| **Studying Documentation consists of reading about formal or informal rules, regulations and standards (Preece et al., 2002).** | This may provide information about formal constraints in the context of the usage, and prescribed procedures (Preece et al., 2002). This can help understanding norms or values in a group. |
| **Video Ethnography is a type of observation where the behaviour of the user in the natural context, is recorded** | It is useful to identify and analyse work related activities (Aldersey-Williams et al., 1999), user-based technological requirements, common comprehension in the development team of the |

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|---|---|
| **on video. (Aldersey-Williams et al., 1999, Brun-Cottan and Wall, 1995, Kujala, 2003, Kumar and Whitney, 2003).** | users' perspectives (Brun-Cottan and Wall, 1995), making comments about the activities and recognizing patterns in the behaviour (Kumar and Whitney, 2003). |
| **Shadowing is a technique where the researcher is following users in their daily activities over a long period of time, and documenting their behaviour by video recording or note taking (Aldersey-Williams et al., 1999, Brun-Cottan and Wall, 1995).** | The technique can provide insight about what people really do (Aldersey-Williams et al., 1999) and it can verify and correct an evolving understanding of their behaviour (Brun-Cottan and Wall, 1995). |
| **User Testing are tests where users perform predefined tasks while being observed and recorded (Aldersey-Williams et al., 1999, Preece et al., 2002, Sanders, 2006).** | The user test is meant to provide information about performance time, errors and aspects the user finds difficult, but it can also help explain why users behaved the way they did (Preece et al., 2002). |
| **Empathic Design is a technique using observation, role-playing, playing with prototypes, or other techniques to gain empathy for the user and try out the behaviour in a certain context (Aldersey-Williams et al., 1999, Steen, 2008).** | Through this technique, the researcher can get input about users' experiences and emotions towards the surroundings, in different or future physical, social or cultural contexts (Steen, 2008). |
| **Culture-Focused Research uses measures like census-taking and demographic data to look at general patterns of daily life, for instance value systems or social structures and relationships (Kumar and Whitney, 2003).** | This cannot only provide demographic information, but also insight about behaviour, beliefs and goals (Kumar and Whitney, 2003). |

### 3.3.1. Discussion about the techniques for investigating what the users do.

Based on the factor matrix, these techniques may be suitable for investigating the external factors, *social norms* and *objective constraints.* There are differences between these two factors, which affects how they can be investigated. *Social norms* are conscious to the user whereas *objective constraints* are defined to be unconscious to the user. The conscious aspects of the *objective constraints* are included in the *subjective constraints.* In addition, the *objective constraints* are found in the physical world around the behaviour, whereas the *social norms* are found in the society around the user. As the *social norms* are a non-physical factor, this cannot be directly observed. Thus will techniques based purely on observation, such as *observation, video ethnography, shadowing, user testing* and *empathic design*, primarily be suitable to investigate objective constraints. The understanding of the behaviour that these methods create, can give the researcher hints about other factors as well. However, not all *objective constraints* can be observed either. Rules or regulations for instance would be hard to observe, but could rather be investigated through *studying documentation or culture focused research.* But these would only affect the behaviour if the user were aware of them, and would thus be included in the *subjective constraints* too. The two latter methods could also uncover information about *social norms* when this is included in the documentation.

### 3.4. Techniques investigating both what the users do and communicating with the users.

As these methods combine observation with information provided by the user, the factor matrix predicts that they should be suitable to investigate all the factors that are external or conscious to the user.

Table 5: Techniques investigating both what the users do and communicating with the users.

| Description of the method | Purpose described in literature |
|---|---|
| **Applied Ethnography or Field Study is a technique where the researcher observes usage of products in its natural setting, and tries to understand why the user behaves the way he does in the given situation. The technique includes observation, interview and video analysis (Blomberg et al., 1993, Steen, 2008, Steen et al., 2007, Sanders, 2006).** | The purpose is to understanding how people use products (Steen, 2008) with focus on observing the behaviour in the natural situation, understanding it in the social and cultural context, how the user creates meaning (Blomberg et al., 1993), and understanding the users implicit or non-verbal needs (Kujala, 2003). |
| **Contextual Inquiry or Contextual Design is a technique where the researcher joins the user in his work as his apprentice, in the natural context. (Beyer and Holtzblatt, 1999, Courage and Baxter, 2005, Holtzblatt and Jones, 1993, Kujala, 2003, Steen, 2008).** | This technique can provide details and motivations that are implicit to peoples' work because they have become habitual, who the user really are, how they work (Beyer and Holtzblatt, 1999) and insight into the context of the usage situation (Courage and Baxter, 2005). |

#### 3.4.1. Discussion about the techniques investigating both what the users do and communicating with the users.

As both methods in Table 5 are described as general investigations of the user and the context, there is no indication that either of them have limitations to investigating the factors identified by the factor matrix. On the contrary, the combination of observation and dialogue may improve the level of detail and nuances that can be investigated through the methods.

There may also be an additional benefit of this combination. According to the factor matrix, habits are a problematic factor to investigate. Klöckner et al. (2003) also acknowledged this problem. Habits are both internal and unconscious, and none of the assumptions cover this combination. However, Beyer and Holzblatt (1999) identify that *contextual inquiry* has the potential to uncover habits because it may gain insight into factors that are implicit to the user. The combination of observing the behaviour may indeed make it possible to identify which behaviours are habitual or not. If this is so, *applied ethnography* should also have a similar ability to investigate habits. The same might be true if other methods with different focuses are combined. This is known as triangulation (Love, 2005).

Another way to investigate habitual behaviour is through longitudinal analysis. This is a technique where the researcher conducts repeated assessment of the same people over a period of time to monitor change or development. The assessment techniques can be anything from video interviews to physical measurements (Aldersey-Williams et al., 1999; Love, 2005). It can provide information about changes in mental or physical functioning or capabilities (Aldersey-Williams et al., 1999), development of habits or changes in attitudes (Love, 2005).

### 3.5. Results of the review.

Table 6 aims to summarise the conclusions from the review by matching the methods with the factors discussed in the previous sections. As pointed out in the review, some of these methods are general whereas others can only investigate the aspects of the factors that are closely related to the topic of the investigation. Triangulation of methods may result in the possibility to investigate more factors than just the sum of the factors the methods initially could investigate.

Table 6: Matching methods with factors

| ■ = Recommended | Habits | Beliefs | Attitude | Intention | Objective constraints | Subjective constraints | Social norms | Personal norms | Values |
|---|---|---|---|---|---|---|---|---|---|
| Interview | | ■ | ■ | ■ | | ■ | ■ | ■ | ■ |
| Focus group | | ■ | ■ | ■ | | ■ | ■ | ■ | ■ |
| Survey | | ■ | ■ | ■ | | ■ | ■ | ■ | ■ |
| Verbal protocol | | ■ | ■ | ■ | | ■ | ■ | ■ | ■ |
| Conjoint technique | | | ■ | | | | | ■ | ■ |
| Wants and needs analysis | | | ■ | | | | | ■ | ■ |
| Card sorting | | ■ | | | | | | | |
| Group task analysis | | ■ | | | | | | | |
| Probes | | ■ | ■ | ■ | | ■ | ■ | ■ | ■ |
| | | | | | | | | | |
| Observation | | | | | ■ | | | | |
| Studying documentation | | | | | | | ■ | | |
| Video ethnography | | | | | ■ | | | | |
| Shadowing | | | | | ■ | | | | |
| User testing | | | | | ■ | | | | |
| Empathic design | | | | | ■ | | | | |
| Cultural focused research | | | | | | | ■ | | |
| | | | | | | | | | |
| Applied ethnography | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Contextual enquiry | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |

### 4. Comparing the review with user research studies.

As a first step in connecting the review of user-centred design methods to the reality of user research and design projects, and to verify the findings, two user research studies described in literature are analysed. The focus in the analysis is to see how the choice of methods, the intended output and the resulting knowledge match with the description and conclusion in the method review. Both studies are focusing on reducing the environmental impact caused by refrigerator usage, based on input gathered from user research.

**4.1. Comparison 1.**

In 2009, Edward Elias presented a report describing a project with user research as input to a design process (Elias, 2009). The purpose of the research is stated to be that “the behaviour in question must first be identified, observed and recorded”. More specifically, the aim was to figure out how users were interacting with a refrigerator and identify the behaviours that caused the main environmental impacts. This was done by installing a video camera in two different kitchens, one for 9 and the other for 18 days. It was stated that the environmental impact of a refrigerator is largely determined by how long and how often the refrigerator door is opened. The result of the study was 1) a list of actions that the user performs while keeping the refrigerator door open, 2) the frequency of these actions, and 3) the time the door was open for each action. Based on this it was calculated how much time the refrigerator door was open unnecessarily for each action. Thereby behaviours were identified that would be the most beneficial to change. The relevant behaviours were analysed, and assumptions were made about why the door was left open longer than what was deemed necessary. These assumptions were translated into suggestions for product improvements and used as input to an idea generation process for improving refrigerator designs.

The user research method used, is what the above review refers to as video ethnography. According to the analysis in the review, video ethnography is most suited to uncover objective constraints. Uncovering objective constraints is clearly one of the main focuses of the study, as the aim was to identify which aspects of the refrigerator design that causes undesired behaviour. The duration of the study might have lead to uncovering of habitual behaviour, as described in the section about longitudinal analysis above. However, habits are not discussed in the report, even though interaction with a refrigerator is likely to become habitual due to the frequency of the behaviour, the simplicity in the action and relative stability of the context. The analysis does look for patterns in the behaviour, but seems to try to explain these entirely by intentional processes such as “searching content” or “moving things to get it out”. Automated processes are not considered, although they do include lack of attention with the user for what he or she is doing, as one of the possible causes for undesired behaviour. Identification of habits might have influenced the generation or evaluation of design solutions. As a conclusion to the comparison, there seems to be a fairly good coherence between the insight they gained from the method, and what the review identified.

The choice of method is discussed in the concluding remarks of the report. It is justified by the chosen methods’ ability to investigate behaviour over a long period of time and avoiding social desirability and prestige response bias. This is argued to make the method more suitable than applied ethnography, which is stated to be the alternative. The conclusion in the report states that a combination of the two possibly would be the best if the resources permitted it. This request for triangulation is in line with what was recommended earlier in this paper. Such a combination of methods could not only have brought insight that could limit the need for assumptions about the reasons for undesired behaviour. It could also have provided insight about other reasons for the behaviour, such as false beliefs about which goods that need to be stored in a refrigerator, the enjoyment of having a clean refrigerator, the norm that one should eat the oldest food first and thereby store it in the front of the refrigerator, and so on. But as the report points out, the choice of method is constrained by the time and resources available.

### 4.2. Comparison 2.

Another investigation of refrigerator usage through user research methods, was presented by Bhamra et al. in 2008 (Bhamra et al., 2008). In this study they aim "to solve environmental problems of use behaviour and activities around the refrigerator and freezer". First they conducted a survey and a semi-structured interview "to investigate what consumers thought about their refrigerator and freezer and the environmental impact of their use". Based on this they identified three groups of activities around the refrigerator and freezer: Condition and environment of product in use, food shopping and food preparation".

The two latter groups were further investigated using a survey and observations. To gain explanation of the observed behaviour from the participants, an interview and another survey was conducted. In addition to this, they also conducted a 24-hour recording of refrigerator and freezer use, followed by a survey investigating "factors influencing decision making and behavioural change".

Based on the observations, a number of behavioural patterns related to where different items were positioned in the refrigerator were observed. From analysis of the interviews they found information about the participants' beliefs, values and attitudes, such as their belief that the way they used the refrigerator has little impact on the households' energy consumption and the priority to ensure the conservation of the food rather than saving energy.

In summary, the methods they applied in this study are as follows: First they used interview and survey. Then they conducted an observation and an interview about the observation, making it a version of contextual inquiry, and another survey. The 24-hour observation is a video ethnography, followed by yet another survey.

If comparing the motivation for using these methods described in the paper, with the factors from the CADM, there are clear similarities. In the paper they describe that they wanted to "collect information about the "actual" and "assumed" needs", which sound like a combination of beliefs and constraints, "the diversity in use context", being constraints, "the unsustainable and sustainable use patterns", being habits, and "the hidden factors behind the usage", which is likely to be a combination of intentional and normative factors. In addition, the "actual use behaviours and habits and their problems and difficulties in operating products", probably refer to habits and objective constraints.

The description of what they found through the methods is also in line with what was identified in the review. The behavioural patterns found through the observations and the post-observation interviews, consist of a combination of habits and objective constraints. This supports the notion that triangulation of methods can be used to investigate habits, even if none of the methods individually could be expected to do so. Based on this insight, a number of design solutions were suggested, such as using a flexible interior in refrigerators or new internal structures, which would be a change of the constraints. Another suggestion was to encourage users to become conscious of their behaviour due to options in the product, which would be a way of breaking habits. From the interviews they found information that confirmed the presence of values, beliefs and attitudes, which are three of the factors identified in the review. Based on this, interventions were suggested to inform the user about how to use the refrigerator effectively. This solution focuses on changing the intentions of the user, which fits well with the insight about the intentional processes.

**5. Discussion.**

The study described in this paper was motivated by the lack of information about what different user research methods are suitable to investigate. The literature reviewed for the study confirms this need as the information that was found was limited and not presented in a comprehensive, easily comparable manner. However, the use of behaviour models from social psychology as a framework for identifying the factors that should be investigated can be a topic for discussion. No earlier examples of application of such models within this field were found in the literature reviewed for this study. The selection of behavioural model was based on the quest for the model that gave the most comprehensive description of behaviour. But when considering the result of the study presented in Table 6, is it can be questioned if the level of detail is adequate for this purpose.

With a few exceptions, there is a strong consistency of factors that can be investigated by using the same method. *Personal norms* and *values* can always be investigated through the same method. The same is true for *beliefs, attitude* and *intentions*, except the methods that are specifically designed to investigate the users priority of design elements or understanding of how a product functions. A possible simplification of the model could therefore be to use the term *intentional processes* as presented in the CADM model, and a modified *personal normative processes*. This would reduce the number of factors from nine to six and, possibly simplify the application of the model as the designer/ research could avoid distinguishing between factors that have a similar effect on the behaviour.

However, this logic of simplification can only be applied to factors that are interconnected and concern the same aspects of the behaviour. *Beliefs, attitude* and *intention* all shape what the user rationally would intend to do, *values* and *personal norms* shape what the user considers to be right or wrong. Their effect on the behaviour is thus significantly different, and the investigation would lose important nuances if they were treated as the same factor.

The notion from Preece et al. (2002), that there are five basic techniques, seems appropriate also when investigating the purpose of the methods. However, there may be a difference in what the five basic methods are. Preece et al. identify: Questionnaires, interviews, focus groups and workshops, naturalistic observation and studying documentation. When considering the conclusion of the analysis above, a similar set could be: Dialogue with the user, the users' prioritising of features, the users' understanding of functionality, observing the user and studying information. The main difference between these two sets of basic methods seems to be whether the focus is on how the information is gathered, or on what insight the method provides. However, even if the methods can be simplified into five groups based on the types of factors they can investigate, there are other differences between them. When selecting which methods to apply, it is crucial to not only select methods that are suitable for the purpose of the investigation, but also to select methods that are possible to apply within the limitations of the specific situation. There might be constraints related to time, possible involvement of the user, number of users, etc., which can qualify or disqualify certain methods. This review is only meant to aid in the understanding of what the methods are suitable to investigate. Thorough understanding of the methods themselves and consultation with other method reviews is necessary to make appropriate selection of methods.

The comparison between the two studies identified some interesting points. First of all, the studies confirm the assumption that different user research methods may provide different types of insight. Furthermore, there were clear similarities between what the studies reported to have found by using the chosen methods and what the review concluded that the methods are most suitable to investigate. This supports the validity of the review, although more studies including more of the methods must be conducted and analysed to ensure further validation.

**6. Conclusion**

The aim of this study was to investigate what type of insight designers and researchers can expect to gain by applying different user research methods. To do so, the study conducted an investigation of what the different research methods commonly used in user centred design, are most suitable to investigate. To structure the investigation and improve the chances that all the factors affecting behaviour are covered, behavioural models from social psychology were introduced. The comprehensive action determination model (CADM), presented by Klöckner and Blöbaum in 2010, was identified as a potential framework of factors affecting behaviour. This was primarily due to its inclusion of both internal and external factors, and its ability to predict behaviour when tested. This study identifies which research method may be used when investigating the factors from the CADM .

The identification of which factors can be investigated using the different methods was based on the identification of two property pairs of the factors: Conscious/unconscious and internal/external. Each of the factors has one property of each of the pairs. Based on the description of the methods found in the literature, assumptions could be made of how these properties affected the potential of investigating the different factors with each of the methods. This division was further specified according to strengths or limitations of the methods described in the literature. The result is a table (see Table 6) that can help designers and researcher make informed decisions about the choice of research methods.

Comparison between the results of the analysis and two case studies shows the value of user research in identifying and investigating (possible reasons for) unsustainable behaviour. The diversity of the solutions in the studies can be traced back to different types of behavioural factors. This supports the value of knowledge about the various factors that influence behaviour and informed decisions about how different factors should be investigated. However, the analysis is heavily based on interpretation of the methods. Therefore, the review presented in this paper should be further tested and developed through case studies before it can be used as valid guidelines for selecting user research methods in studying design for sustainable behaviour.

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# Exploring behavioural psychology to support design for sustainable behaviour research

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**Abstract:** Increased focus in research on the environmental consequences of behaviour and product use in the last decade has resulted in a number of proposed different design strategies that may stimulate desired behavioural patterns or help avoiding undesired ones. Although this provides understanding of how behaviour may be changed, there has been limited discussion about how to choose and apply the different strategies depending on the context. This paper aims to investigate how behavioural models and theories from social psychology can contribute to this discussion. The analysis is based on an identification of different factors that affect behaviour and a distribution of design strategies according to how they divide control between the user and the product. By investigating how variation in the division of control may be related to the factors affecting behaviour, a number of principles for selecting strategies may be derived.

**Keywords:** sustainability; behaviour; social psychology; design research; environmental consequences; product use; design strategies; desired behavioural patterns; context; factors affecting behaviour; design strategy distribution; user control; selecting strategy principles.

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## 1 Introduction

Recent research suggests a large potential for achieving environmental benefits from altering users' behaviour and the way they interact with products (Lilley, 2007; Jelsma and Knot, 2002; Jackson, 2005; Rodriguez and Boks, 2005; Elias, 2009; Wever et al., 2008). Some authors have proposed strategies for affecting user behaviour, sometimes but not always accompanied by case studies (Lilley et al., 2005; Jelsma, 2006; Bhamra et al., 2008; Elias, 2009; Lilley, 2009; Lockton et al., 2010). This research has suggested the potential of design for sustainable behaviour and identified promising design strategies, but there has been limited discussion in literature about when and in which context the different strategies are most likely to be effective (Pettersen and Boks, 2008b).

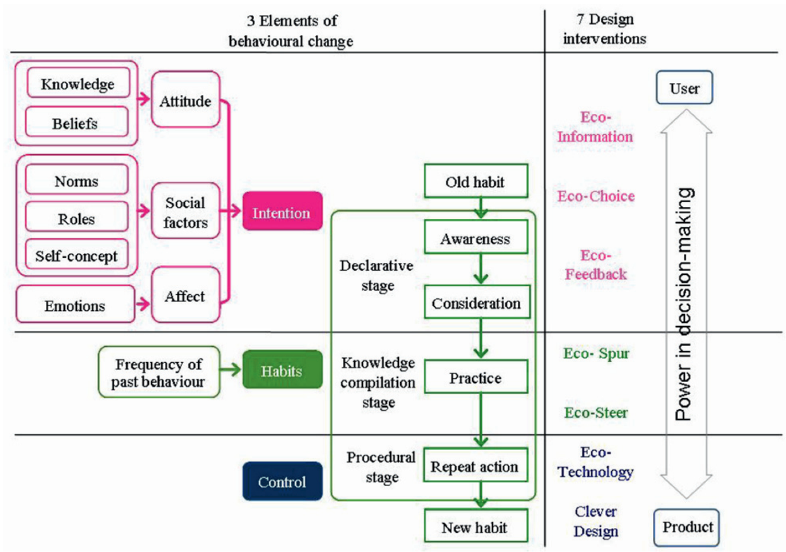
This paper assumes that better understanding user behaviour (and the drivers behind it) is essential for taking this discussion one step further. Understanding reasons for behaviour has been the topic of extensive research across multiple disciplines, such as psychology, sociology, anthropology, marketing and political science, but the level of applying this body of knowledge in a design for sustainable behaviour context is so far limited. One reason may be that it is regarded by designers as a "comprehensive and rather unmanageable range of literature" (Pettersen and Boks, 2008b). This paper provides a more extensive discussion of how psychology research may contribute to design for sustainable behaviour, as "understanding, explaining and changing human behaviour are the main objectives of psychology in general" (Klöckner and Blöbaum, 2010). Studies of the relation between attitude and behaviour have been published as early as the 1930s (Ajzen and Fishbein, 1977). Throughout the years, numerous theories and models have been developed and presented, contributing to unravelling the complexity of behaviour determination and prediction, and identifying multiple factors affecting behaviour.

The approach of trying to use social psychology to support the selection of design strategies is not entirely novel. Bhamra et al. (2008) present two theories from social psychology: Triandis' (1977) theory of interpersonal behaviour and Anderson's (1982) theory of development of cognitive skills. Bhamra et al. use the theories to identify when different design interventions should be applied in order to create new habits (see Figure 1). Triandis' theory identifies a number of different factors that may affect behaviour. However, the main structure is based on Anderson's theory, which identifies three stages in development of cognitive skills. Firstly, the declarative stage, in which facts about the skill domain are interpreted. Secondly, the knowledge compilation stage, where knowledge is converted into a procedural form and can be directly applied without further interpretation, and finally the procedural stage, where knowledge can be applied more appropriately and the process can be speeded up (Anderson, 1982).

This approach of comparing the behavioural theory, not only with the stages in formation of cognitive skills, but also with design strategies according to their division of control, points out the potential of combining these types of research.

The focus of the research by Bhamra et al. appears to be on the transformation of habits. This is an important topic, but as Triandis' theory and several other theories in social psychology point out, habits are only one of several factors affecting behaviour. "Environmentally relevant behaviour lies at the end of a long causal chain involving a variety of personal and contextual factors" (Stern, 2000a). The model suggested by Bhamra et al. makes a connection between design strategies and Triandis' theory, but this is not further discussed in the paper. The reasons for the indicated connections are based on "the understanding of the behaviour disintegration and formation and relationship between antecedents of change in behaviour/habit and different levels of design intervention" (Bhamra et al., 2008).

**Figure 1** Model for selecting power in decision-making (see online version for colours)




*Source:* Bhamra et al. (2008)

A thorough investigation of what different factors that affect behaviour can tell us about the potential usefulness of design strategies is therefore essential. In order to conduct such an investigation, there are a few topics that need to be addressed. These include:

1 A structuring of design strategies proposed in literature, enabling comparison and discussion about their applicability. A solution to this is suggested by comparing the various proposed strategies.

2 A framework for understanding the factors that are affecting behaviour. A suitable framework is proposed, inspired by Bhamra's introduction of social psychology models for this purpose.

Finally, these two sources of insight are brought together, to explore how they can be of help in making informed decisions about when different strategies for how products can be designed to achieve sustainable behaviour, are likely to be effective. This connection is presented in the form of a set of preliminary principles.

## 2 Structuring the design strategies

During the last decade, there has been an increasing focus in product design research on how the design of products can influence and alter the behaviour of users as this could reduce the negative environmental impact of activities associated with the behaviour. A number of strategies for how behaviour can be altered have been identified, but even though many of the strategies appear similar, there are differences in the way they are presented. An investigation and recommendation of when different strategies are most likely to be effective, requires a structured comparison of the strategies.

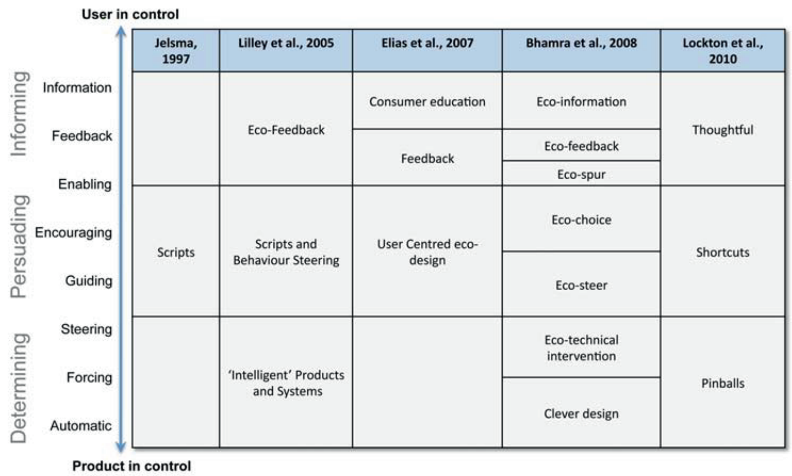
In 1997, Jelsma connected Akrich's (1992) concept of 'script' to the goal of reducing environmental impact through the way users interact with products. He described a script as a means for altering the way products are used and thereby limiting the environmental impact. The idea behind a script is "a kind of user manual inscribed into an artefact" where the design of the product guides the way it is being used (Jelsma, 1997). Jelsma has also suggested four different properties of scripts: force (how strongly the script prescribes the behaviour), scale (the level of complexity), direction (in which direction the behaviour is being steered), and distribution (how much responsibility and power the user is given) (Jelsma, 2006).

The dimension of distribution is the property used by Lilley et al. (2005) their proposed extension of this structure of strategies in 2005. In this structure, the concept of scripts covers the middle part of a spectrum, but at the respective ends of this spectrum eco-feedback and 'intelligent' products and systems are added. Whereas scripts persuade or guide product use through the way it is designed, the idea behind eco-feedback is to influence the behaviour through providing information or feedback, thus leaving full control with the user. The latter category, 'intelligent' products and systems, takes control of the behaviour away from the user and forces desired behaviour or blocks inappropriate behaviour. To illustrate this with an example of washing detergents, the eco-feedback could be achieved through a written instruction on the packaging of how much detergent one should use in an average washing machine. The script approach could be 'tablets' containing the appropriate amount of detergent and the 'intelligent' product and system approach could be a machine that automatically adds detergent from a reservoir. According to Jelsma and Knot (2002), the concept of scripts "can be more or less compelling, but it will never totally determine user actions". Bhamra et al. (2008) elaborate the distribution by Lilley et al. even further by splitting it up into seven parts; 'eco-information' is information provided to the user, 'eco-choice' is providing options for the interaction, 'eco-feedback' informs the user about the consequences of his/her behaviour, 'eco-spur' is inspiring the intended behaviour through rewards or penalties, 'eco-steer' aims to make intended behaviour easier or unintended behaviour more difficult, 'eco-technical' intervention aims to make intended behaviour automatic through advanced technology and 'clever design' aims to do the same by other than mere technological solutions, such as by focusing on shape, colour and ergonomics.

A similar structure was presented in 2007 by Elias et al. (2007) consisting of consumer education, feedback and user centred eco-design. The user-centred eco-design is defined as "creating products where the most intuitive and comfortable way of using and interacting with a product or system is also the most environmentally friendly".

This research points out that the structuring of design strategies based on the distribution of control between the user and the product is widely used, as already recognised by Pettersen and Boks (2008a). As the structuring also has a foundation in the way the user interacts with the product and the amount of attention and reasoning demanded by the user, it is appropriate to discuss a framework that compares this with knowledge about reasons for behaviour.

**Figure 2** Comparison of strategies from literature (see online version for colours)

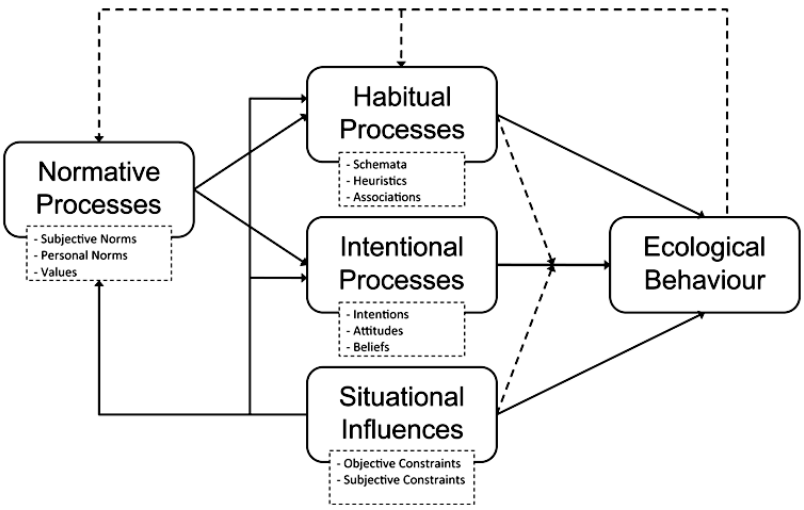



In this paper, the distribution of control will be treated as a spectrum where the user is in control on one end, and the product is in control on the other. At the end where the user is in control, the design strategies aim to provide the user with information or feedback. This input will in most cases have to be registered, interpreted, understood and reasoned upon before a behaviour change can be expected. At the other end of the spectrum are design strategies that either force the user to behave in a certain way or eliminate the users behaviour by acting automatically. As the user does not have any influence, these strategies will, in principle, require limited or no attention from the user to change the behaviour. The variation in cognitive load that different strategies may require from the user was also recognised by Lockton et al. (2010). They created a spectrum similar to the one introduced by Lilley et al. (2005), but based on variations in cognitive load. The categories in this spectrum are called 'thoughtful', 'shortcuts' and 'pinballs'. Between the two extremes there are strategies with a varying degree of division of control. Solutions can range from simply enabling a certain type of behaviour, to guiding or steering the behaviour in the intended direction. In Figure 2, the distributions as proposed by various authors are compared based on the description of how the strategies will affect the behaviour of the user. The comparison should be seen as a means of understanding how the different distributions relate to each other, rather than as a strict categorisation. As there can be variations in how forceful a specific type of strategy is when implemented in a design, it is not straightforward to make strict levels of distribution. The spectrum should rather be seen as a continuous distribution. To clarify the spectrum, a number of words are suggested for the different levels along the spectrum.

## 3 Social psychology models

In 2005, Tim Jackson presented a review of social psychology models describing behaviour and behaviour change. He pointed out that many of the models are missing key causal influences, often because the focus is either on internal (attitudes, values, habits and personal norms) or external aspects of behaviour (incentives, institutional constraints and social norms). This makes these models less suitable as heuristics for exploring specific behaviour or for identifying the factors that may influence the behaviour. Although some models attempt to include all possible variables that might affect behaviour, these tend to become too complex for empirical testing and obtaining quantitative evidence of behaviour (Jackson, 2005). According to Jackson's evaluation, Triandis' theory, applied by Bhamra et al. (2008), is one of the most promising models, though not as commonly used as several other theories, probably due to its complexity or lack of parsimony.

**Figure 3** The CADM




*Source:* Klöckner and Blöbaum (2010)

In search for an alternative model, complete yet useful for testing purposing, the comprehensive action determination model (CADM – see Figure 3) by Klöckner and

Blöbaum (2010) is considered in the present paper. This model is based on four theories that have been acknowledged for their strengths in explaining behaviour, but which have also been criticised individually for not integrating all the factors that may influence the behaviour. The theories included in the CADM are the theory of planned behaviour (TPB), the norm-activation model (NAM), the theoretical concept of habit and the ipsative theory of behaviour. By combining these theories, Klöckner and Blöbaum aim to create a model encompassing both the internal and external factors. They tested the CADM model in an empirical study together with TPB and NAM, and a combination of the two, which had been introduced earlier in an attempt to explain more factors. The conclusion was that the CADM explained the variation significantly higher than the other models (Klöckner and Blöbaum, 2010). This indication of validity, together with the fact that it includes both internal and external factors, suggests that the CADM may provide an interesting alternative to Triandis' theory.

The CADM suggests that individual, sustainable behaviour is directly determined by three types of influences: habitual, intentional and situational. Habitual processes consist of schemata, heuristics and associations (Klöckner and Blöbaum, 2010). The difference between the three is in the explanation of how automated behaviour is created. Schemata are based on the idea of a 'blueprint' of behaviour for certain situations. Heuristics are seen as simple decision rules and associations are strengthened neural connections in the brain between parts that are often activated together (Klöckner and Matthies, 2011).

Intentional processes consist of intentions, attitudes and beliefs. These are connected in a hierarchical structure where intentions are affected by attitudes, which again are affected by beliefs (Klöckner, 2010). Objective constraints enable or limit the behaviour directly, whereas the subjective or ipsative constraints are the factors the user considers to be relevant for their behaviour (Frey, 1988; Klöckner and Blöbaum, 2010). The objective constraints form the basis for what the user perceives, but subjective constraints can also include factors that are not objective (Frey, 1988). In addition to affecting the behaviour directly, situational influences also affect habitual, intentional and the normative processes. Normative processes have an indirect effect on the behaviour through affecting habitual and intentional processes, and consists of personal norms that are affected by subjective/social norms and values (Klöckner and Matthies, 2011).

Although the CADM does not incorporate every single factor affecting sustainable behaviour (for instance affect, which is included in Triandis theory, has been left out of the CADM), it may provide the most promising framework available so far. The combination of its relative complexity and ability to predict behaviour in empirical studies makes it a promising framework for further study and application in the current context.

## 4 When to apply design strategies

Insights from the above discussed frameworks for design for sustainable behaviour strategies (Figure 2) and factors influencing sustainable behaviour (Figure 3) can provide a foundation for informing designers in choosing appropriate strategies for designing sustainable behaviour. In order to do so, the subsequent section of the paper aims to analyse the factors identified by the CADM in how they affect expected effectiveness of design strategies according to the division of control between the user and the product.

## *4.1 Situational influences*

The first factor to investigate is situational influences, which are constraints and possibilities created by the context or a product itself. The way a product is designed, or the way the context affects the interaction with it, determines the constraints and/or possibilities the user experiences when using the product. It also affects the user's perceived behavioural control. Are there limitations or possibilities among the capabilities of the user? Are there aspects in the usage situation or the context of the usage that enable or limit certain types of behaviour? This is already a topic of user centred design literature (see for example, Preece et al., 2002) and is commonly integrated in design processes (see for example, Maguire, 2001); understanding the context can predict the effectiveness of design strategies.

According to the CADM, situational influences consist of objective and subjective constraints. Objective constraints refer to constraints that are actually present whereas subjective constraints are only perceived to be constraining. No matter if the constraints are real or only perceived, they can strongly affect a user's behaviour, including the amount of attention the user is able or willing to give the interaction with a product. For instance, if a product is designed to be used while the user is driving a car, it is crucial that it is possible to operate the product with only one hand and suddenly can be left alone without this causing any problems. It is also important that the interaction with the product does not require much attention or reasoning from the user, as he/she should focus on driving. Both these concerns are already identified and included in standard design processes and will directly say something about the applicability of different strategies. However, as earlier described, there seems to be a tendency that the more control the user has, the more cognitive load the interaction requires. Based on this assumption, the understanding of how much attention the interaction with a product requires may be a strong indicator of how much control the user should have.

## *4.2 Intentional processes*

In 2000, Stern (2000b) presented the attitude-behaviour-context theory (ABC theory) discussing how contextual factors affect the influence attitudes have on behaviour. The contextual factors consist of external factors, such as laws and regulations, community expectations and global variations (e.g., interest rate and oil prices), but also of the capabilities and constraints provided by the technology and built environment (Stern, 2000b). This is similar to what Klöckner and Blöbaum (2010) call situational influences. Stern implies that when the context affects the behaviour strongly, positive or negative, the attitude has little influence on the behaviour. But when the context effect is small or neutral, the attitude of the user plays a significant role for the behaviour. He describes this as an inverted U-shaped function.

In other words: if the external factors or the design of the product make it very easy to behave in a certain way, or sufficiently difficult to prevent behaving that way, users will behave this way no matter what their attitude is towards the behaviour. The opposite is the case when the context makes the behaviour difficult. If something is impossible to do, users will not do it, no matter how much they want to. To illustrate this with an example, imagine a situation where a person might or might not travel to work by bus. If there are no bus routes available, one cannot travel by bus even if a strong wish to do so exists. Alternatively, if one does not have any other means of transportation, one needs to take the bus even if one resents doing so. However, if both bus and car are equally available and convenient, one's preference may determine the choice of travel.

As already pointed out, the intentional factors in the CADM are interconnected in a hierarchical structure. "The intentional processes capture all aspects of deliberate decision making based on knowledge and beliefs about product characteristics, the resulting attitudes about it, and forming an intention to buy a certain product" (Klöckner, 2010). This relation between the factors also seems apparent if the logic reasoning in the ABC theory should be applied on intentions or belief. Based on this, it can be assumed that the ABC theory really discusses how the strength of the context affects deliberate behaviour decisions.

This points out an interesting aspect of the division of control discussed in Section 2. As the strategies leave varying degrees of control to the user, it is reasonable to assume that it will be beneficial to use strategies where the degree of control for the user is corresponding with how much the user's intentions, attitudes or beliefs are in line with the intended behaviour.

The following section aims at investigating what the ABC theory implies, described from the viewpoint of design for sustainable behaviour. From this perspective, the strength of the contextual factors can be seen as how strong it forces the user to behave a certain way. This division of control is represented by three different ways in which the strategies try to change the behaviour, as proposed in Figure 2: informing, persuading and determining.

At the informing end of the spectrum, the user is completely in control but receives information or feedback about the behaviour or the consequences of it. For this to be effective the user has to take in the information, and be willing to change the behaviour. This implies that the user should have a positive attitude or be motivated to perform the intended behaviour. This is supported by the finding that feedback is only effective if the user has a goal that the feedback helps to achieve (McCalley and Midden, 2002). It is of course possible to try to change the beliefs of the user, and thereby the attitude and intentions, by providing the user with information. How likely this is, will depend on how strong the beliefs of the user are and whether the user is open for changing beliefs or not (Verplanken and Wood, 2006).

At the persuasive part of the spectrum, the user is still in charge, but the product takes more control by making the desired behaviour easiest or most intuitive. These strategies can be assumed not only to be effective on users with a positive attitude but also on users who do not have a particular attitude. As the desired behaviour is easiest, this is what the user can be expected to do, as long as no effort is made to behave in another way. If someone chooses to make such an effort, it can be assumed that a negative attitude exists towards the intended behaviour. This could either be because of a belief that the intended behaviour is wrong, or simply because a positive attitude exists towards an opposing behaviour. This effect was also identified by Stern (2000b), who suggests that "environmental significant behaviour can also be affected by non-environmental attitudes".

The determining strategies take the control away from the user by restraining certain behaviour or automatically performing actions. This can either be apparent to the user or be done without the user being aware of it. Because the behaviour is not the result of the user's attitude, it can be assumed that this strategy can be effective for all the above-mentioned attitudes. There are however a number of potentially negative consequences of taking the entire control away from the user. As pointed out by Jelsma (1997), users may feel manipulated and forced, which may result in resistance to, or alteration of the product. Other consequences may be related to the users' awareness of the consequences or feeling of responsibility, and ethical and moral implications [for elaborate discussions on this topic, see Verbeek (2006) or Pettersen and Boks (2008a)]. These potential rebound effects and ethical implications should be taken into consideration if applying strategies from the determining end of the spectrum. Some authors (see for example, Berdichevsky and Neuenschwnder, 1999) have attempted to make rules or guidelines to answer this question. However, "there does not appear to be any hard and fast answers to the underlying moral concerns of influencing behaviour through design" (Lilley, 2007).

Summarising the three attitudes identified above:

- Positive users are users that are willing to make an effort to behave sustainably.

  Example: Hotel guests will make sure that towels are hung appropriately to avoid that they will be changed, even if they are wet or slightly dirty.

- Neutral users are not willing to make an effort, but don't mind if their behaviour is sustainable.

  Example: Hotel guests will hang towels they do not mind using again if they remember to do so, but they do not really mind if they forget.

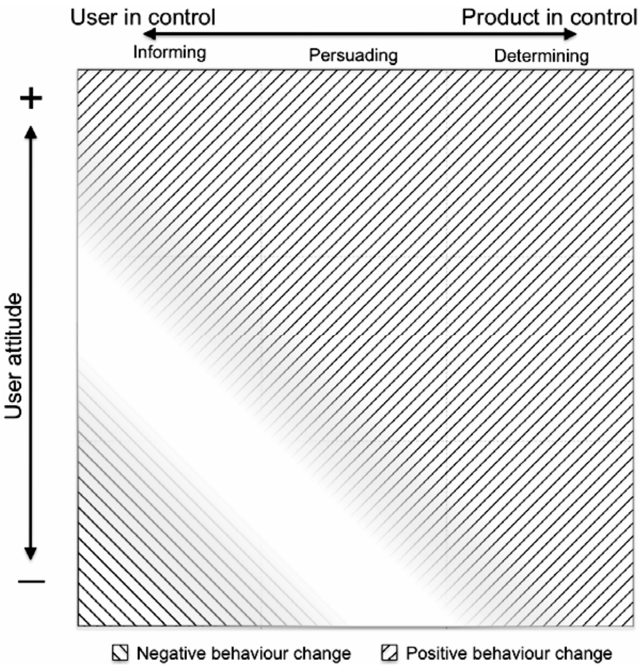
- Negative users have beliefs or attitudes that make them negative towards the intended behaviour. This can either be directly towards the goal (in this case sustainability), they want to act un-sustainably as a principle, or they might just have other priorities such as comfort or economy.

  Example: Hotel guests will always leave towels on the floor to have them changed, in order to get the maximum out of the money they have paid to the hotel.

However, it is an oversimplification to categorise a person's attitude simply as either positive, neutral or negative. In reality, unlimited variations exist of how positive or negative a person's attitude is towards a given behaviour. The above analysis is in other words only a logic construct to help investigate how likely the effectiveness of a strategy is, depending on its division of control. The resulting hypothesis of the relation between user attitudes and the division of control can be simplified as done in the following model (Figure 4).

This model is based on the viewpoint that "if the investigator chooses to observe a single action with respect to a given target in a given context in order to obtain correspondence, the attitude also has to be very specific" (Ajzen and Fishbein, 1977). In other words, it is important to identify the attitude of the user towards the specific behaviour of interest, and not the general value of the user. This may result in varying attitudes from the same user depending on the behaviour in focus. Therefore, if this should be used as input for selection of design strategies, it is important to investigate attitudes towards the specific, intended behaviour.

**Figure 4** Relation of user attitude and division of control (see online version for colours)




## *4.3 Habitual processes*

For the purpose of this analysis it is assumed that all three habitual processes can be treated the same way and considered as simply being habits. There are several reasons for this. First of all, the literature describing strategies for breaking habits (Verplanken and Wood, 2006; Jackson, 2005; Jager, 2003; Robertson, 1967) does not make a distinction between the different habitual processes. As this literature is the primary source for the analysis, it is a challenge to make such a distinction. In addition, the automated effect the habitual processes have on the behaviour is the same and it is suggested that the formation of all of them have to go through the step of successfully performing the behaviour (Klöckner and Matthies, 2011). If future research uncovers properties of the different habitual processes that are crucial for the selection of design strategies, another analysis should be conducted including this distinction.

Before analysing habits, is it important to be aware of an aspect pointed out by Jager. "The habitual behaviour in question has been performed for the first time at a given moment" (Jager, 2003). In other words, before the behaviour has become habitual, it is affected by the same factors as any other behaviour and is subject to the situational and intentional processes. This will also be the case if the habit is broken and the behaviour no longer is habitual (Jager, 2003). Accordingly, habits should be addressed in two different manners. In the cases of 'bad' habits, it can be relevant to break the habits and make the behaviour subject to situational and intentional processes. In case of 'good' behaviour, it can be relevant to ensure repetition by making it habitual. Or as Verplanken and Wood (2006) point out, interventions can disrupt old habits and establish new ones.

The creation of habits is assumed to go through stages, such as those previously described by Anderson (1982). Both Klöckner and Matthies (2011) and Jager (2003) identify that repetition is crucial in the formation of the habit. Jager also points out that the context around the behaviour should be similar from one time to another and the direct outcome of the behaviour should be satisfying for the user. "The closer the reinforcement follows after performing the behaviour, and the more often a reinforcement follows after performing behaviour, the stronger the stimulus-response relation or script gets" (Jager, 2003). Even though the design of the product can support the formation of circumstances that might trigger the script, this is a complex matter as the context of the behaviour is often hard to control. The positive reinforcement is however something that could be created by the product and therefore is a factor to look for in the choice of design strategies. This type of strategy is referred to by Bhamra et al. (2008) as eco-spur, or by Lockton et al. (2010) as rewards.

Several different strategies and approaches exist for breaking habits. Verplanken and Wood present three interventions for policy makers to change habits: downstream, downstream-plus-context-change and upstream. Downstream interventions are information campaigns, and are argued to have limited ability to change behaviour. If the information is presented at the moment when the circumstances that trigger the habit are being changed, they are much more likely to be effective. These are referred to as downstream-plus-context-change interventions. The most effective interventions however are upstream interventions, where something in the performance environment is being changed (Verplanken and Wood, 2006). The latter one is also recognised by Jager, who points out that removal of a stimulus might stop the 'script' from being activated. He also identifies that change in the experienced outcome of the behaviour or making the behaviour impossible will break the habit (Jager, 2003). The idea of making the behaviour impossible is one possible consequence of the type of strategies where the product is in control. Jager's notion of practical and ethical problems connected to such strong interference is also matched in the design literature by for instance Pettersen and Boks (2008a) or Lilley et al. (2005).

Robertson (1967) identified another aspect of how the design of products can break habits. He classified innovation according to its effect on established patterns, and proposed that innovations can be classified as continuous, dynamically continuous or discontinuous.

- Continuous innovations are minor alterations of products, such as fluoride toothpaste, and have the least disrupting influence on established patterns.
- Dynamically continuous innovations are the creation of a new product or the alteration of an existing, such as an electrical toothbrush, and have a more disruptive effect.
- Discontinuous innovations are establishments of totally new product types, such as the introduction of a new chewing gum, which makes brushing of teeth unnecessary. This will establish totally new habits.

From an interaction design point of view, this classification points out what might already be implicitly understood. The more innovative, or different from the previous, the interaction with a product is, the stronger is its ability to break a habit involving the product. This idea of removing the triggers for the habit is the same as Jager, and Verplanken and Wood identified above. The product, or the way to interact with it, can be among the factors that trigger a habitual behaviour and, because the product is often in the focus of the user, it can in fact be considered as one of the most important factors. In other words, the new product's ability to break old habits will be related to the novelty of the interaction with the product. The opposite should also be true. If the aim is to maintain a habit, a new product should avoid novelty in the interaction.

### *4.4 Normative processes*

According to the CADM, the normative processes do not affect the behaviour directly, but are affecting both 'intentional processes' and 'habitual processes' (Klöckner and Blöbaum, 2010). Personal norms are stable over time and are representations of one's value system and mediated by social norms (Klöckner and Matthies, 2011). Schwartz (1977) states that norms affect attitudes as "evaluations of acts in terms of their moral worth to the self". In other words, norms will affect the choice of design strategies by being the criteria the user applies to evaluate whether a given solution is acceptable or not. This can disqualify the strategy, even if it otherwise would be likely to have the desired effect, if it for instance violates the user's value of freedom by forcing certain behaviour. It can also be experienced as a positive reinforcement of a habit, if the user experiences that the behaviour or the outcome of it supports his/her values or norms.

## 5 Discussion

This research suggests a potential for using knowledge about how behaviour is determined, to understand when different behaviour changing strategies are likely to be effective. The analysis investigated how the division of power could be distributed for different relevant user or context characteristics, as identified by behavioural psychology. The results of the analysis may be summarised as a set of principles for when positive behaviour change can be expected. Some of the principles might be understood intuitively and may in some cases already be included in design processes. However, by stating them explicitly, unravelling their theoretical backgrounds and presenting them in connection with other, less intuitive principles, their usefulness as analytical tools may be improved. Not only for inexperienced designers who do not intuitively follow them, but also for experienced designers who can better understand their implications and how they relate to their projects. Also, creating an overview and connecting the principles to the various factors described by the CADM may facilitate the consideration of every relevant aspect.

**Table 1** Summary of the principles

| *Principle* | *Rationale* | *Example* |
|---|---|---|
| | *Situational influence and intentional processes* | |
| The more cognitive workload a user can manage given a product context, the more control the user can be allowed to have over the interaction | Strategies where the user is in control often require more attention because the user has to consciously understand and interpret more. | When designing a car stereo, it may be a good idea to avoid providing the user with too much information or feedback from the system, as the attention should be focused on the driving. |
| The more a person's beliefs, attitudes and intentions are in line with the intended behaviour, the more control of the behaviour can be given to the user. | A user can only be expected to make an effort to do something, if he/she is motivated to do so. | You can only expect a person to buy ecological eggs because of information about animal welfare, if the person thinks animal welfare is important. |
| | *Habitual processes* | |
| To create or maintain a habit, the experience of using the product, the interaction with the product and the context around the interaction should be as stable as possible. The user should also be given positive reinforcement as often and as closely related to the behaviour as possible. | If a user gets a positive experience by doing something, and repeats it multiple times under similar conditions, it may become automatic and a habit is created. | If a room is to be refurbished, but it is desirous to maintain that the users unconsciously turns off the light when leaving a room, the experience of turning off the light should be maintained by choosing the same or similar type and position of the light switch. |
| To break a habit, make the user aware of the behaviour and make it less desirous to behave so. The user may become aware of the behaviour by changing the experience, making it more difficult or impossible, or through a completely new way of interacting. The behaviour can become less desirous if positive experience from the behaviour is removed, or negative is added. | To break a habit, the user should be made aware of what he/she is doing and be motivated to change it. | To prevent car use during commuting, free parking at work can be removed, and information can be provided about how much money, time, and/or environment that can be saved by using bikes or busses instead. By removing the free parking, the commuter is made aware of the behaviour. Providing motivation for finding alternative ways of commuting may then change the former habit. |
| | *Normative processes* | |
| The product, interaction, outcome or behaviour should not violate the user's values or norms. The values and norms can determine what the user finds acceptable, for instance how much control a product may have. | The values and norms determine what a user thinks is right or wrong. If these are violated, the user will probably not accept the design. | A person, who considers it to be a personal right to choose to use a seat belt or not, may not be willing to have a car that forces the driver and all the passengers to use it. Instead of successfully changing the customer's behaviour, he or she will choose another car. |

The analysis and principles suggest that further elaboration of this investigation is necessary. It shows that the distribution of control is a relevant dimension for the purpose, but it is not sufficient by itself. Other properties of design strategies for behavioural change may exist that can be used to compare or structure them. Jelsma described the script concept with three additional dimensions and Lockton et al. (2010) have developed a framework based on the function of the strategies, in addition to the previously mentioned variation of cognitive load. Inclusion of these dimensions could contribute with further insight or other results than just the division of power. The principles identified by this study, and possible future studies with more dimensions, should be connected to the real world through empirical studies. This will not only be a way of testing the theoretical work, but can also result in further elaboration and deeper insight.

## 6 Conclusions

In this paper the potential for supporting the selection of design strategies for behavioural change, by addressing behavioural theories from social psychology, has been investigated. In the investigation, the design strategies were structured according to the division of control between the user and the product. The analysis of strategies proposed by a number of other authors suggests that there are numerous overlaps between the various distributions, and that they all may be covered by the same distribution, which would considerably simplify the connection between the investigations performed by multiple researchers.

A behavioural model (the CADM) was proposed to allow for the identification and a much-needed comprehensive overview of factors that may affect the behaviour. By studying theories and models related to the various factors, a number of potential effects that variations in the distribution of control may have on the different factors have been identified and made explicit. The preliminary results of this insight are summarised as a set of principles, presented in the discussion section. This supports the notion that social psychology may contribute to the selection of design strategies and could function as a starting point for the requested toolbox.

This research will continue with case studies to empirically validate the theoretical deduction of the principles; several projects have been initiated to that end, focusing on practices including oral healthcare and woodstove firing. In these projects, attention is also paid to how to communicate the principles (Zachrisson et al., 2011).

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# From teaching sustainable product design to teaching sustainable behaviour design

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***Abstract:*** *Traditionally, sustainable product design research and education has been focused on manufacturing and end-of-life aspects With a new found focus on the use stage, as in the research area of Design for Sustainable Behaviour (DfSB), a better understanding of how a focus on behavioural aspects can reduce life cycle impacts has emerged. Preliminary findings from on-going DfSB research were used as basis for the development of a method to guide designers in selecting promising design principles that can contribute to change user behaviour into more environmentally friendly patterns. This method is presented, and experiences with using the booklet in a sustainable product design course are shared. The paper reflects on how students cope with this research-based approach, and how research has benefited from this course.*

***Keywords****: Design for sustainable behaviour, sustainable product design education.*

# Introduction

In recent years sustainable product design research and education has seen an evolution from applying ecodesign guidelines targeted mostly at redesigning products, to more sophisticated levels of incorporating sustainability principles in product design. This has been fuelled by progressing insights on the complexity of the ever broadening topic, as the field has expanded in scope from a product to a systems perspective, from an environmental to a sustainability context, and from a concept development to technology transfer and commercialization perspective (Boks and McAloone, 2009). Research focusing on the use phase of products has throughout these transitions mostly focused on technological solutions to achieve resource use (mostly energy use) efficiency. But more recently research has suggested that through better understanding user behaviour, and applying that knowledge in design solutions that may make users behave in environmentally preferred ways, significant additional energy consumption reduction may be achieved. Design researchers increasingly understand their role in investigating such opportunities to influence users to alter their behaviour into more sustainable behaviour and consumption patterns (Tromp et al., 2011). As a result, we can now observe a young area of research emerging, referred to as Design for Sustainable Behaviour (DfSB) aiming at exploring design strategies for reducing behaviour-related environmental impacts of product and systems as well as more general applications to persuade users into more socially desirable behavioural patterns (Lockton et al., 2010). DfSB research incorporates insights from scientific fields including social psychology, persuasive technology, sustainable consumption, stakeholder analysis and interaction design. The current state of the art is one of exploring case studies, identifying design principles and developing guidelines to choose appropriate principles for specific design challenges.

The authors are part of a research group that has adopted Design for Sustainable Behaviour as a key research area. One of the on-going PhD projects aims at providing designers with a means to make informed decisions about which design principles to apply. In the first stages of this project, preliminary guidelines for selecting principles have been proposed (Zachrisson and Boks, 2012). These guidelines propose a way of translating information about human behaviour and insight from social psychology literature to recommendations for design principles. However, these preliminary guidelines have been derived from literature and theory, and have not yet extensively been tested in practical design projects.

## *Embedding Design for Sustainable Behaviour in education*

Although education in sustainable product design has been done in many ways, most approaches found in design or engineering design curricula worldwide have a number of commonalities. From a traditionally very material and end-of-life focused teaching subject, the subject is, at least in literature, increasingly understood to relate to all aspects of regular product design and development. This includes the additional integration of sustainability criteria, with the aim of teaching students how to balance between possibly conflicting economic, environmental and social/ethical criteria, and how to exploit potential synergies. In practice, the integration of sustainability concerns in design and engineering education has been characterised as little and slow (Lozano, 2010, Quist et al., 2006, Velazquez et al., 2005, Boks and Diehl, 2006) a symptom of which may be the observation that the subject can be characterised as imprinted by a rather material and engineering focus. Although this may be improving, teaching sustainable design with a focus on the use phase, including behavioural issues, have only received limited attention in literature so far. Loughborough University, one of the leading universities researching this topic, reported on the development of the website design-behaviour.co.uk as an inspiration tool for design students and designers (Lilley and Lofthouse, 2009). These authors have also reported on a pilot to develop teaching material for ethical thinking to support design for sustainable behaviour (Lilley and Lofthouse, 2010). They report mainly on how to include ethics, and pointing out challenges for educators in terms of providing students to use arguments and reasoning in the many cases where metrics and absolute answers are not available. They suggest using a checklist for students to evaluate design consequences, but do not discuss experiences with teaching a design methodology targeted at finding behaviour-changing solutions.

As DFSB is a focal research area at NTNU's Department of Product Design (IPD), and the focus of three doctoral research projects since 2008, the sustainable product design course taught in the spring semesters of 2011 and 2012 has endeavoured just this: choosing DFSB as the main coat hanger for structuring these courses. In semester-long assignments, students were challenged to identify potentially unsustainable practices and behaviour and use these as a point of departure for analysing attitudes, norms, habits and situational context related to (unsustainable) user practices such as (dish)washing, food wasting, temperature control, et cetera. As (re)designing behaviour instead of (just) (re)designing products requires a much broader perspective, the course has focused on analysis, and linking this to conceptualisation, rather than on detailed design. This meant that students needed to be newly introduced to not only research methods, but to a research and analysis attitude as well.

This paper aims to report on our experiences in doing so, by introducing our teaching methods and the guide used in our course. It is attempted to uncover advantages and disadvantages of the chosen teaching strategy. In order to do so, the paper is structured as follows. First a brief introduction in the underlying teaching philosophy is provided, i.e. the teachers' conviction of how sustainable product design in general should be addressed in an educational context, regardless of the choice of teaching format. This section also introduces how sustainable product design has been taught at IPD before the introduction of DfSB in education to facilitate reflection. These two introductions are then used to explain how DFSB has gradually gained a more important focus in our teaching, up until the 2012 spring semester where it has become the main focus. A discussion about our experiences from both a research-based education, and an education-based research perspective follows, before we highlight our most important conclusions.

## Teaching philosophy

Instead of teaching students that sustainable product design is a morally superior trade of design, using pictures of retreating glaciers and lone ice bears on miniature ice growlers, sustainable product can also be taught as being really not that different from regular product design. Essentially, it considers all factors that are relevant for the conceptualization and development of products and services. It addresses hereby the complete life cycle and all relevant stakeholders that will, during the life cycle, interact with the product or service. Of course, individuals may have, and contexts may dictate different ideas about what is relevant. Within the context of sustainable product design, relevant aspects are generally understood to be of a functional, economic, environmental, social and/or ethical nature. Sustainable product design education should therefore be taught holistically rather than 'merely' developing concepts for environmentally superior products. Such a holistic perspective can be achieved by challenging students to genuinely consider all relevant design parameters on an equal basis, including aspects of an economical, aesthetical, ergonomic, convenience, and sustainable nature. Doing so allows the identification of design dilemmas when searching for opportunities to avoid avoidable impacts on the environment, and an understanding of how environmentally preferred design solutions affect other relevant design parameters, allowing realistic solutions. In practice, this approach boils down to students becoming able to reason like *"Is it worth to sacrifice aesthetics for environmental impact if that means to abandon a 'nice looking' coating? But what if a nicer look will increase the products' life time, reducing the need for replacement? But would a company be interested in selling a product with longer life time and thus lowering sales? Or would that improve the company's image with increased sales as a result?"*

To become able to make such dilemmas as explicit and solvable as possible requires that students can use appropriate methods for quantitatively and qualitatively measuring and assessing individual design parameters, as well as evaluation methods that can make trade-offs visible (and thus decisions possible) between parameters that are usually measured in completely different dimensions such as exemplified above. This often means that students need to develop their own methods as these are not readily available, which requires the very holistic perspective that students are to acquire.

This teaching philosophy has been the basis for a series of sustainable product courses which have been taught at IPD since the 2007 spring semester, though with an increasing role for the use phase. These courses take place in the 6th semester of the 5 year Masters programme in Industrial Design. These courses typically host 25 IPD design students and 15 other students, mostly from NTNU's Industrial Ecology international master program or exchange students with various backgrounds. The course formats are briefly elaborated on the in the next subparagraph.

## *Course formats in teaching Sustainable Product Design at IPD (2007-2010)*

Over the years, the course has experimented with different course set-ups and focal perspectives. Earlier on, courses were mainly inspired by more traditional ecodesign approaches, based on product comparison and redesign. In 2009 and 2010, partly inspired by how sustainable design had been taught at the Technical University Denmark, the main course deliverables included a product analysis report and a playable board game inspired by eco-design methodology. The purpose of the game was to educate a chosen audience, for example a group of product developers in a company; on aspects of sustainability, on a general level or in the context of a certain product (Boks and McAloone, 2009b). Compared to a standard report assignment based on evaluating existing and redesigning new solutions with environmentally superior characteristics, it was found that for the best students, the eco-game exercise strengthened a vital competence of being able to mediate and communicate about the topic at hand, and that the format supported the aim of taking a beyond-product perspective. The game exercise was very effective in exposing students' lack of knowledge and understanding, but a negative aspect was that the exercise invited for a focus on aesthetic appeal and game experience rather than a focus on the core of the exercise (i.e. being able to absorb and communicate knowledge about the life-cycle perspective of products in their product system).

Since 2007, student assignments have become gradually more extensive and have been showing a greater variety of tools and methods used. Earlier assignments were principally based on straightforward benchmarking of products, identifying stages in the life cycle and components in the product with potential for improvement, combining good solutions in the product analysed, and using creativity to develop alternative product concepts with superior environmental improvement. In the 2009 and 2010 courses, more attention was given to the additional evaluation of non-technical/physical aspects. Groups mostly used their own 'expert evaluation', giving their own opinion on aspects such as aesthetics, functionality, cost of ownership and user friendliness (instead of attempting to measure these in some way, apart from environmental impact, which was mostly done with Eco-it software). Commonly, groups used 1-5 scales to grade the various aspects, and used a similar weighting scheme to arrive at final scores for each product analysed.

Though insightful for students in terms of understanding the broad spectrum of variables to be considered in good product design, students seldom showed initiative to exploit such matrices to formulate explicit design dilemmas. Experience tells that they need to be explicitly challenged to identify the single or combined product features or design solutions that cause a product to score well on one aspect, and worse on another, and to formulate this as a dilemma to be solved. And even then, most groups did not succeed in doing this. That said, many did arrive at interesting redesigned or sometimes even novel product concepts, opening up for a discussion to what extent creativity and gut feeling can replace prior analysis. However, the teaching philosophy for this course has remained with the assumption that both gut feeling and analysis work synergistically, and that students are served with gaining experience of context and user analysis before entering ideation phases; partly also because the focus in many courses is in fact on ideation rather than analysis.

## Embedding Design for Sustainable Behaviour in education

The 2011 edition of the course embraced "design for sustainable behaviour" as an additional explicit component of the course. This provided us with an opportunity to use student assignments as a way to test preliminary research results in practical projects covering several different practices, providing the opportunity to do both research-based education and education-based research. Students were challenged to identify potentially unsustainable practices and behaviour and use these as a point of departure in their projects. To give the students an understanding of the reasons for why behaviour change can be relevant form an environmental perspective and an overview over the insight that the research had brought forward, a number of lectures on DfSB were given in the beginning of the course.

As a result of this substantial focus on user behaviour, in the 2011 course all groups did investigate the behaviour of the users and some of the groups even applied a well justified triangulation of different methods. However, analysing the reports from the project it became apparent that most of the groups ended up with a more traditional redesign project and not particularly focused on behaviour change. Even though some groups did identify behavioural problems, their process and solutions focused on reducing environmental impact from a technical point of view rather than making users behave more sustainably. Moreover, whenever students did try to affect user behaviour, their choices of behaviour changing design principles did not always appear to result from conscious deliberation and evaluation.

## *Course format additions for 2012*

Based on 2011 experiences and the increased focus on DfSB research at IPD, it was decided to increase focus on behaviour change even further in the 2012 course. Several of the lectures during the first weeks centred on what DfSB is, and on choosing and using user-centred methods such as surveys, interviews, probes, observations and focus groups in design projects, as previous experience told that students are relatively unfamiliar with using these methods appropriately. Also, the use of personas as a way to integrate and communicate research data was focused on. It was decided to develop and print a first version of the mentioned booklet guide and recommend the students to use it, in order to strengthen the DfSB focus in the course and help the students to structure their behaviour changing design projects. The structure of the assignments was aligned with the approach in the booklet to facilitate the students understanding and progress.

Figure 1 shows the development in the course format, showing the main deliverables required and the main methods applied, over time.

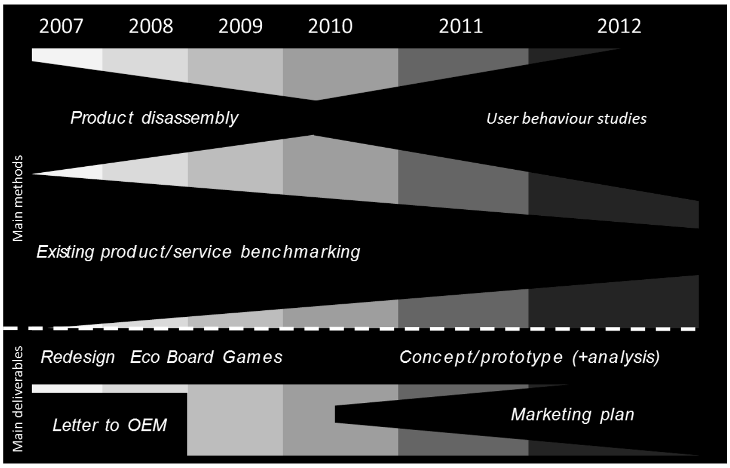


***Figure 1**. Course overview 2007-2012 with main methods and deliverables*

## *Booklet: Principles of Design for Sustainable Behaviour*

The booklet (Figure 2) is based on a PhD project at IPD which aims at developing a guide to help design practitioners identify the most promising design principles to people use their products in a way resulting in the least environmental impact. The theoretical basis for the guide is built upon a combination of insight from social psychology regarding the main factors affecting our behaviour, and strategies for behaviour changing design, from design research. The booklet is meant to communicate the results of this research in a form that is suitable for use in a design project. A major emphasis is put on helping designers to translate their understanding of the user and the context into an appropriate selection of design principles.

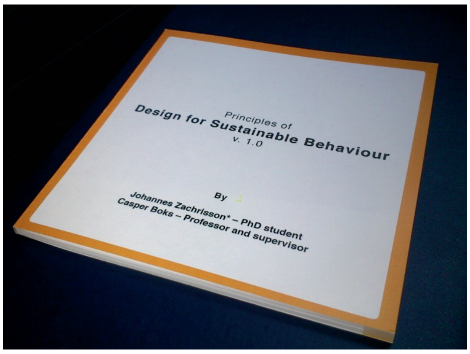


***Figure 2**. Booklet on Principles of Design for Sustainable Behaviour*

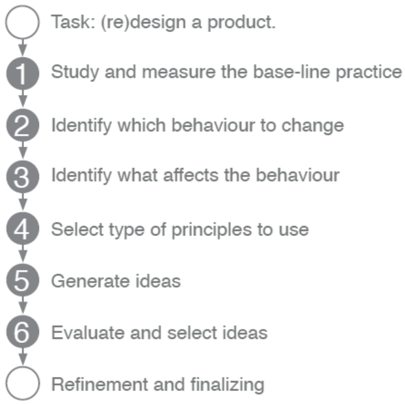


***Figure 3**.Design process as suggested in the booklet*

The structure of the booklet is built around a suggested design process (Figure 3), with descriptions of the purpose and activities for each step, and with the help of appropriate examples. Although the figure illustrates a linear process, the sequence, number of iterations, or even in- or exclusion of steps may depend on the project and the preferences of the designer. The steps proposed in the booklet are as follows:

STEP 1: STUDY AND MEASURE THE BASE-LINE PRACTICE

This step explains how to choose the right methods to gather the most relevant information for a specific project, and why that is an important decision. There are numerous different methods and tools to gather information about the user and the usage situation, and which tools are most suitable for a particular project depends on a number of factors, such as the time and resources available, the competence available in the team, the accessibility of the target group, the goal of the research, etc. Although methods useful for a DFSB oriented project are similar to those commonly used in 'regular' user-centred design projects, the methods described in the booklet require some specific information about what goes on in the mind of the user, what goes on around the user and what the user actually does, which is described in more detail in steps 2 and 3. There may also be things the user does or that affect behaviour, which the user is unaware of. To investigate this it is necessary to combine methods or use methods that investigate both aspects, such as applied ethnography or contextual enquiry. This step also highlights the importance of researching previous, similar studies, as user research can be expensive and time consuming, and provides some resources to assist in this process.

STEP 2: IDENTIFY WHICH BEHAVIOUR IS TO BE CHANGED

Once the information about the user and the context has been gathered, one needs to determine which behaviours to change or maintain. As the goal is to use design to reduce avoidable environmental consequences related to behaviour, it is valuable to identify those behaviours that both cause significant environmental impact and are possible to affect through design. The larger the potential impact reduction and the easier it is to affect it through design, the easier it will be to achieve environmental benefit. A natural starting point can be to identify the behaviours that have the largest total impact on the environment. Ideally this should be quantified, for instance through multiplying the energy consumption caused by the behaviour with the duration of the consumption. If quantification is problematic, it may be possible to consider the effects relative to each other more qualitatively. The interesting element is to identify how much energy could be saved with a different behavioural while still achieving the goal. It is important to consider the entire practice, as there might be low hanging fruit also outside the core behaviour. If it has been possible to calculate the actual impact of the behaviours, this information can be used after the project to estimate the achieved improvements and thereby the successfulness of the behaviour changes.

STEP 3: IDENTIFY WHAT AFFECTS THE BEHAVIOUR

When trying to change the behaviour of people and how they use products, it is necessary to realize that behaviour can be affected by a number of different factors and often a combination of several. The information gathered during the user studies can be analysed to identify the most important factors for your target group, by identifying the main reasons for why they behave the way they do. One way of understanding and structuring the factors is by dividing them into four different groups:

- What the user wants: What does the user intend to do? What does the user believe are the consequences of the behaviour? What is the attitude of the user towards these consequences? For instance the environmental impact, the effect is has on other people, the cost, etc.
- The influence of the surroundings: Which constraints are caused by the context around the use of the product? Do the surroundings make certain behaviour easier or more difficult to do? Does the product itself direct the user towards certain behaviour? Are there elements in the surroundings that affect the behaviour of the user and the interaction with the product?
- The habits: Are there things the user does without necessarily being aware of it? These can either be simple, stand-alone actions or routines consisting of sequences of several actions.

- What the user thinks is right or wrong: Which values does the user have, and which ones are most important? What does the user think is morally right or wrong to do? Is the user affected by any cultural or community values that may prescribe or forbid certain behaviours?

These insights are based on exploring behavioural psychology models such as the CADM model (Klöckner and Blöbaum, 2010, Zachrisson and Boks, 2012). This structure will form the basis for the selection of design principles in step 4.

The factors in these four groups may all affect the behaviour of the user in different ways and may be of importance for how a product should be designed in order to realise the affect that the designer is striving for. It is also possible that the users will have to be divided into groups according to which factors are most important for them or differences in the factors, such as different attitudes towards the consequences. The booklet suggests that one way of doing this can be by making personas representing the different user groups. Though there are other ways to do this, using personas is explicitly suggested to the students as they are relatively familiar with using this technique and it proved indeed to be a kind of 'anchor' to them in an otherwise very novel and at times confusing process.

STEP 4: SELECT TYPE OF PRINCIPLES TO USE

In this fourth step it is explained how there are numerous design principles that are directed towards behaviour change, but that some design principles likely will work better for certain users and in certain situations, than for/in others. To identify which principles may be more likely than others to be successful in a specific project, this section of the booklet includes a guide intended to help identify the most promising types of design principles according to the result of the analysis in step 3. For this it makes use of a landscape that allows sorting design principles based on two parameters: the degree of control that a product allows the user to have over his or her behaviour, and degree of subtlety or obtrusiveness that is designed into the solution (Figure 4). Our research (Zachrisson and Boks, 2011, Zachrisson and Boks, 2012) revealed these two dimensions as important ways to distinguish between design principles, although recent unpublished research has revealed a substantial amount of additional dimensions that may assist distinguishing between and selecting design principles.

The guide continues with an elaborate discussion on which level of control and obtrusiveness may be appropriate based on the results of the analysis in step 3. It uses simple diagrams to illustrate how this choice can be made. One of those diagrams is depicted in Figure 5; it is used to explain that habits are routine behaviours that are performed more or less automatic, and that because of this, the user is not always aware of the behaviour and it is therefore not necessarily in line with what the user wants, what the user thinks is right or what it is easiest to do. To change a habit, the user should be made aware of the habitual behaviour and be motivated change it. Once the behaviour is no longer automatic, it may be changed according to what the user wants or the influence of the surroundings.

Once the designer has decided which principles to use, the same control-obtrusiveness landscape as depicted in Figure 4 can be used to summarize the results, in order to get an overview, communicate them and include them in the design process. Figure 6 shows how, based on user research done in previous steps, it can be visualised what solutions on a certain part of the landscape may be most appropriate for affecting the behaviour of the identified personas.


***Figure 4:*** *Control-Obtrusiveness landscape*

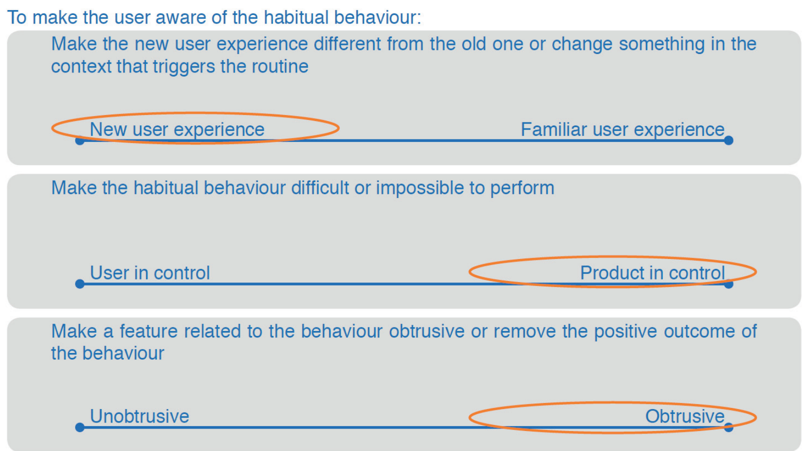


***Figure 5:*** *Example of diagram explaining how to use the landscape*

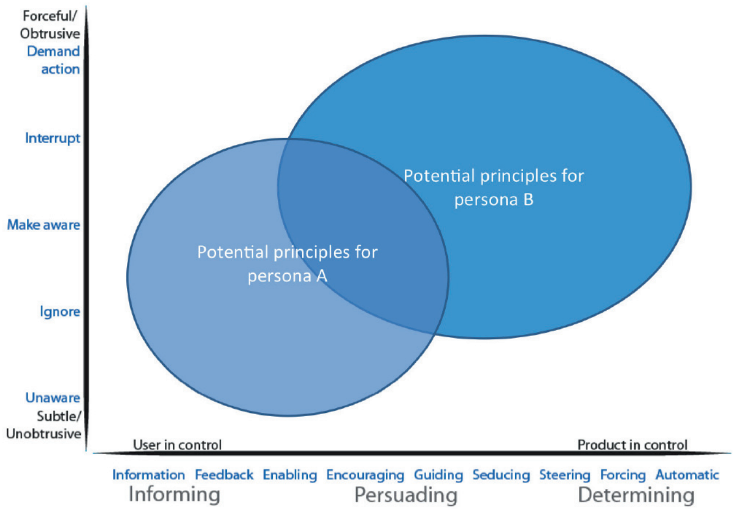


***Figure 6:*** *Placing personas on the obtrusiveness-control landscape*

STEP 5: GENERATE IDEAS

Once the requirements for the new design have been identified, idea generation follows. This creative problem solving step is basically the same as in any other design process; commonly used methods include brainstorming, creative workshops, Forced Functions, etc. The purpose is to figure out how the product could be designed to fulfil all requirements, both regarding behaviour change and other requirements the design project might have such as price, durability, aesthetics, ergonomics etc. Whether the idea generation should focus on the identified areas in the landscape, allowing for a focused idea generation process, or whether a more general idea generation process should be the basis for selecting appropriate ideas that fit to the identified areas, is left up to the preferences of the individual designer. We have found that students typically choose the latter way: they do not let themselves be restricted by the confines of the identified search area; they rather select relevant ideas from a broader search.

STEP 6: EVALUATE AND SELECT IDEAS

After ideas have been generated, it is often a challenge to evaluate the ideas in a structured way and actually identify which ideas are most promising. In a regular design project, this is often solved by an assessing how ideas will fulfil a list of requirements, typically formulated as 'musts, should and coulds'. The same can be done regarding the requirements derived from the desired behaviour change, but to make sure that the ideas actually solve the original challenges it might be useful to evaluate based on the personas and the guide, rather than merely the requirements or design dilemmas derived from these. Once the most promising ideas have been selected a regular user centred design process can be followed, which usually includes concept development, prototype building, user testing and final detailing. The booklet explains how designers should be aware that it can be problematic to test whether changes in behaviour are actually accomplished in a traditional user test and might require more longitudinal testing outside a laboratory context.

# Experiences with the booklet in the 2012 course

With the introduction of the booklet as the main guide for the course assignment, and with the different assignments for the interim reports scheduled in accordance with the steps in the booklet, the focus of the course per 2012 became strongly directed towards DfSB. Here, we would like to discuss our experiences with integrating DFSB in teaching sustainable product design from two perspectives: a research-based education, and an education-based research level.

## *4.1 Research-based education (general course) level*

The transition from a traditionally focused ecodesign project to a sustainable behaviour focused project description allows for a number of reflections. The main issue to discuss is whether the new course outline has met the learning objectives, and proved to be good vehicle for the teaching philosophy.

With the new starting point now having explicitly become ‘practices’ and ‘behaviours’, students over time shifted from analysing “cookers, toasters and kettles” to topics such as ambient temperatures while sleeping (finding solutions for reducing energy consumption for heating sleeping rooms), laundry practices (avoiding washing clothes that do not need washing), dishwashing practices and preventing food waste, neither of which take a clear product-level starting point. A consequence of taking a starting point in behaviour has been that less attention for product level environmental analysis, such as through disassembly and benchmarking, has been paid. This is partly a logical consequence of a behaviour focus, and partly also because of time restrictions as user research is time consuming.

An important observation has been that the students, by taking a starting point in behaviour rather than products, clearly acquired a broader perspective, both in terms of stakeholders to analyse, and in terms of solutions considered. The broader perspective also allowed for a broader spectrum of dilemmas to be identified. This can be illustrated by the fact that several groups selected and developed services, product-service systems or integrated solutions as the most promising solution to change behaviour. Figure 7 shows an example of such a solution where an app was designed to interact with an electronic device controlling a heater via Bluetooth: the persona for which this solution was developed cannot be bothered to adjust sleeping room temperature to low, healthy levels, but since the smart phone is used as alarm clock, the app can be left with the responsibility to take care of this task, providing a win-win situation for the user.

Another improvement is that in order to identify the main reasons why people do not behave sustainably, the groups used a broader variety of investigative tools than in 2011, and were more skilled in doing so, probably thanks to the lecture-based tutorials (although most groups still benefit considerably from a thorough teacher check for ambiguity and logic in the questions to be asked). In addition to surveys and interviews, frequent use was made of diary probes, photo probes, story-telling, user observation through shadowing, and focus groups. In addition, some groups were proactive in developing customised approaches to measure factors like temperatures and cleanliness.


***Figure 7**: Example of a product-service based solution developed by one of the student groups*

Although many groups gathered useful amounts of empirical data through these methods, meaningful quantification of characteristics of products and behaviour, in a way that allows for making dilemmas explicit, remains challenging for students. Still many groups succeeded in explicating dilemmas in more qualitative or intuitive ways. The majority of groups chose to follow the approach suggested by the booklet, and translated the gathered empirical data into personas that were subsequently placed in the landscape (see example in Figure 8).

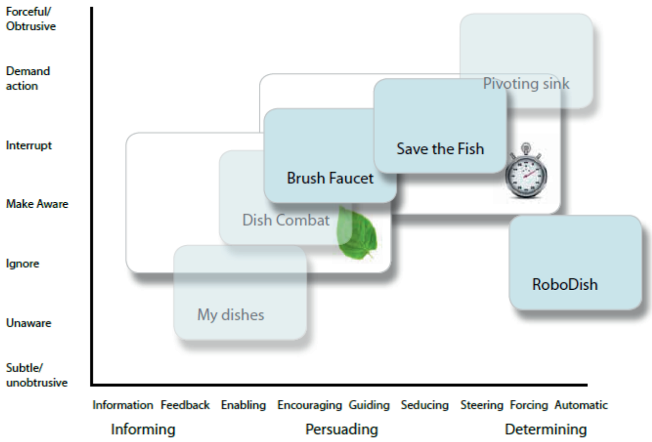


***Figure 8:** Personas on landscape from student assignment*

This helped the students to translate the empirical data, through explicating design dilemmas, into a design brief and a list of requirements for solutions that were most likely to change the chosen target behaviours. After this, the projects became typical design projects, with ideation, concept generation, and subsequent concept testing. They were also challenged to develop a marketing plan, requiring them to think how their final concept should be promoted in order to actually be used by the target persona.

### *Education based research (or booklet development) level*

The purpose of the research project discussed above is to develop a tool to help design practitioners apply insight from the field of DfSB in their projects. To achieve this, it is not only necessary to extract the relevant information from the DfSB research, but alto so present it in an easily comprehensible way that supports the way designers work. Although the design students may not be considered fully trained designers, they have undergone several years of training to gain the perspectives and ways of working of design practitioners. From a research perspective, experiences from developing the booklet and monitoring the students' experiences were of a great value. When developing the booklet and planning how the approach should be communicated to the students, the necessity of explaining DfSB in the context of a design process became clear. The main reason for this is that the behaviour perspective requires slightly different focus in several of the separate steps in a traditional user centred design process. Not only when the desired behaviour is identified and the appropriate design principles to achieve this are selected, but also when determining the user research methods to apply and the user data is analysed. In the booklet this was presented as a stepwise approach, which the students seemed to find useful. However, during the project, it became apparent that the description in the booklet contained too much text and possibly too much detail. The students found it at times uninspiring, unnecessarily complex and therefore difficult to include in their projects. This experience may be expected to have an even greater consequence for design practitioners than for the students, as they often will have less time and focus available to make the effort, and thus have less motivation. After all, the students were forced to apply the method in the booklet or give good reasons not to, whereas design practitioners will choose their tools and methods rather freely. Consequently, the experiences from the course will have direct consequences for the next version of the tool, which should still explain the process and the connection to a traditional user centred approach, but in a less dictating and more inspirational way. An important development will probably be to expand the amount of dimensions that describes the different properties of the potential design principles, and rather allow the designers to select the once they believe are most relevant for the particular project.

## Conclusion

Using a behaviour-focused approach, we feel we have succeeded in teaching a course that has, more than before, contributed to students taking a holistic perspective on how to reduce environmental impacts related to consumer practices. This is in line with our teaching philosophy. Students seem also to have become more experienced in using user-centred research methods that they will benefit from in other design projects as well. In that sense, the course has now moved on from being a specific sustainable product design course, to a more regular design course where sustainability criteria are addressed in an intertwined way (Lozano, 2010); instead of teaching sustainable design, we are rather teaching how to study user behaviour from a holistic perspective, and how to do research in the first place. The strong link with an on-going PhD research project ensured research-based education offering state-of-the-art insights to students, which has repaid the project with important understanding on how insights from behavioural psychology can be conveyed to design practitioners.

It turns out that for bachelor level students it is a challenge simultaneously cope with both 1) a behavioural (rather than product) focus and 2) a research and analysis (rather than just ideation) focus, in combination with 3) the sustainability context which also requires new tools and ways of thinking to learn, and 4) an open problem formulation. Students feel on thin ice for a while and may resort to approaches they are familiar with, but challenging them to use unfamiliar research methods and focus on extensive written justification of their design decisions provides many with a new-found appreciation for research and analysis as a complementary activity in the design process. It should be noted that students who participate in this course are generally very good students as the high school grade point average needed to successfully apply to the Industrial Design program at NTNU is among the highest in Norway across all studies (one in six applicants is admitted). Therefore the relative success of this course may not be copied automatically to other bachelor level curricula.

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PAPER 7. ZACHRISSON, J. STORRØ, G. AND BOKS, C. (2011) *USING A GUIDE TO SELECT DESIGN STRATEGIES FOR BEHAVIOUR CHANGE; THEORY VS. PRACTICE.* PROCEEDINGS OF ECODESIGN 2011, KYOTO, JAPAN, NOVEMBER 30 – DESEMBER 2.

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PAPER 8. ZACHRISSON, J. AND BOKS, C. (2011) *OBTRUSIVENESS AND DESIGN FOR SUSTAINABLE BEHAVIOUR*, PRESENTED AT CONSUMER 11, BONN, GERMANY, JULI 18 - 20

**Keywords:** Behaviour, Social Psychology, Product Design, Obtrusiveness, Design strategies

**Abstract**

There is a great potential for reducing the environmental impacts of product use by changing the way users interact with products. To achieve such a behaviour change, there is a need for a toolbox to help designers select appropriate design strategies. A first step in the direction of such a toolbox has already been taken, utilizing a distribution of design strategies according to the distribution of control. This paper investigates the potential of adding another dimension to the distribution of design strategies, by investigating the potential of variations of obtrusiveness. Through a literature review, some potential consequences variations in obtrusiveness may have on the behaviour are identified. This is finally presented together with the guidelines for distribution of control, as a combined set of preliminary guidelines.

**Introduction**

In recent research there is consensus about the large potential for achieving environmental benefits from altering users' behaviour and the way they interact with products (e.g. Jackson, 2005). Within the product design domain, ranges of strategies for affecting user behaviour have been proposed (e.g. Lockton et al., 2010). This research has shown the aforementioned potential and identified design strategies, but there has been limited discussion in literature about when and in which context the different strategies are most likely to be effective. "Ideally industrial designers should be equipped with a decision-making tool, enabling evaluation of alternatives in order to choose the strategies best suited for each project (Pettersen and Boks, 2008).

Recent studies show progress towards the development of such a tool (Bhamra et al., 2008, Zachrisson and Boks, 2010). These studies have aimed at identifying principles for when design for sustainable behaviour strategies should be applied, by combining models from social psychology with the distribution of control among the design strategies. The distribution of control, referring to the degree of control the product allows the user to have, has been a prominent way of structuring the design strategies (e.g. Lilley, 2007, Wever et al., 2008). This distribution creates a spectrum (see Figure 1), where one end consists of strategies giving the user complete control, primarily building on principles such as information and feedback. In the other end of the spectrum the user has no control and the behaviour is completely determined by the product, either through automation or forcing the user to certain behaviour. In between these two extremities, there are a large variety of strategies enabling the intended behaviour, making the behaviour easier or making it more difficult to not behave the intended way. However, there are several other properties that also can be used to describe and distribute the strategies (e.g. Jelsma, 2006). Combining multiple properties can create more dimensions to the distribution of the strategies. This may increase the granularity of the selection of appropriate strategies and open up for a deeper understanding of how the strategies can affect the behaviour.

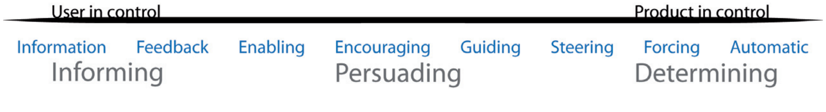


Figure 34, Distribution of control. In one end of the spectrum, the user is in complete control, in the other, the user has no control. Between theses two extremities, there are numerous variations of control.

The aim of this study is to investigate the potential of combining an additional dimension with the distribution of control, namely the obtrusiveness of the strategies. The structure of the paper is as follows. Firstly, a literature review of the effect variations in obtrusiveness may have on behaviour is presented. Secondly, a proposal for how the obtrusiveness-control landscape may be understood is presented. Finally, the two are combined into a suggestion for more elaborate guidelines for selecting different levels of obtrusiveness.

**The effect of obtrusiveness**

The notion of considering the obtrusiveness of design solutions is not novel. Understanding and controlling the amount of attention a product or feature demands from the user has received substantial attention in the last decades (See for example McCrickard and Chewar, 2003, Horvitz et al., 1999, McCrickard et al., 2003, Matthews et al., 2004). Some of this research has been directed towards reducing the obtrusiveness to make a design easily acceptable or fitting for particular situations (Hansson et al., 2001, Hansson and Ljungstrand, 2000, Weiser and Brown, 1996). Others have aimed at understanding how variations in obtrusiveness may be appropriate according to the situation. McCrickard et al. (2003) identify that when designing alerts in a computer system, there are often three conflicting design objectives; "interruption to primary tasks, reaction to specific notifications, and comprehension of information over time". They point out that "there should be a balance between attention and utility (McCrickard et al., 2003). McCrickard & Chewar (2003) present a framework for this "attention-utility trade-off". This framework is illustrated by a cube with interruption, reaction and comprehension as the three dimensions (see Figure 2) and can be used as a tool to analyse the obtrusiveness of an alert. Where in this framework the appropriate alert should be positioned, depends on the urgency, importance and type of information that is to be conveyed. The way information is presented affects how it will be adopted (Roberts and Baker, 2003). Fisher (2008) explains this by the understanding that "the information needs to capture attention and be understood before it can become effective".

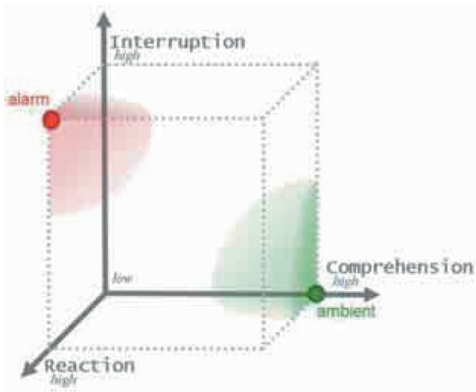


Figure 2: Attention-utility trade-off (McCrickard and Chewar, 2003). A three dimensional space created by the axis: Interruption, Comprehension and Reaction.

Matthews et al. (2004) also recognize the need for determining how much attention a design should require. They describe variation in the notification level where "notification levels represent relative information importance". The more important a stimulus, the more attention it should consume" (Matthews et al., 2004). They define five notification levels; "ignore, change blind, make aware, interrupt, and demand action". These represent a scale, from notifications that should demand no attention to notifications that demands attention and requires that the user performs an action to stop the alert. Also McCrickard & Chewar (2003) point out that urgent, important information should be presented in a way that immediately draws the users attention.

Drawing the attention of the user is also a key feature of one of the most promising strategies to break habits, identified by social psychology. "A vital ingredient for changing habits is to 'unfreeze' existing behaviour to raise the behaviour from the level of practical to discursive consciousness" (Jackson, 2005). By changing something in the situation around the habitual behaviour, the person may become aware of the behaviour and thus the habit may be broken (Jager, 2003, Verplanken and Wood, 2006). For this to be effective it is important to focus the attention of the user to the situational cues, to avoid the habits from blocking the attention (Klöckner and Matthies, 2004). "Attention-grasping facilities are likely to cause behavioural changes that should be stable and observable over a longer period of time" (Holland et al., 2006). However, obtrusive designs may also have negative effects on the user and be harder to become accepted. Users may experience intrusive interference as both annoying and distracting (Pettersen, 2009). In an experiment aiming at making students conserve water and energy by placing informational signs in university showers, Aronson & O'Leary (1982) found that "making the signs more obtrusive increased compliance but also increased resentment".

The potential of controlling the attention of the user has also been identified as a dimension of which strategies for behaviour change may be distributed. In 2006, Jelsma presented a paper describing different properties of a script. He defines a script as "a material structure that, by its specific layout, exerts force on the actions of its user" (Page 223, Jelsma, 2006). One of the properties he identifies is the "force" of the script, which he describes as "restricting the opportunities for undesired use, or strengthening the stimuli for desired use"(Page 223, Jelsma, 2006). By varying the strength of the stimuli, the product may require more or less attention from the user and thus have various degrees of obtrusiveness.

**Discussion - the obtrusiveness-control landscape**

This literature review has identified the potential of using variation in how much attention a product demands from the user, as a way to affect the behaviour. As the purpose of this paper is to discuss how this variation may be used as a distribution of strategies in addition to the control spectrum, a clear understanding of its properties is required. The "force" property described by Jelsma may be a relevant starting point for such an understanding. The "force" describes a distribution of obtrusiveness, but it also includes the restriction of opportunities for undesired use. As this is also one of the primary consequences of the distribution of control, this mutual dependency makes it difficult to use the two properties to describe a strategy simultaneously. However, the strength of the stimuli does not have to affect the opportunities for undesired use. It may only be a measure of how strongly the stimuli attract the attention of the user or how obtrusive the strategy is. This distinction may be clarified by an example. Consider various strategies for avoiding users leaving the refrigerator door open for longer than a given amount of time, e.g. 30 seconds. The amount of time a refrigerator door is open, has a significant effect on the amount of energy the refrigerator consumes (Elias, 2009). First consider strategies at the informing end of the control spectrum. Such strategies could simply be a sign reminding the user to close to door, or a small lamp being lit when the door has been open for 30 seconds. These would be unobtrusive ways of letting the user know that the door should be shut. However, the reminder could also be the sounding of an alarm and blinking of bright light. These strategies would still leave the user in control, but demands much more attention and would thus be much more obtrusive. Then consider strategies at the determining end of the spectrum. An unobtrusive strategy could be to have the door closing automatically after 30 seconds. If this closing of the door was accompanied by the alarm and flashing light, it would again be more obtrusive.

If analysing the properties of behaviour changing design strategies, a two dimensional landscape may be perceived, consisting of the distribution of control on one axis and the obtrusiveness on the other (see Figure 3). To describe the distribution of obtrusiveness, Figure 1 uses the terms introduced by Matthews et al. (2004).


Figure 3: The obtrusiveness-control landscape. A two dimensional landscape of design strategies created by the axis of Obtrusiveness and distribution of control. Illustrated with 9 examples of strategies with variations of both dimensions.

In Figure 1 a number of examples illustrate the type of strategies that may be found in different areas of the landscape. To explain the landscape in more detail, these examples will be described and reasons given for their position in the landscape.

The Power Aware Cord by the Interactive institute is an electrical cord that pulses light to resemble the current flowing through the cord (Backlund et al., 2006). This is a design that leaves the user entirely in control by only providing feedback on the amount of energy being used. The feedback is presented in a subtle way, which may be easy to ignore for many users.

The Element, also by the Interactive institute, is a radiator consisting of 35 light bulbs of 60 watts. This will result in heating and a very bright light source. Also this design leaves the user entirely in control and only provides feedback. However, the intensity of the light makes the feedback more obtrusive than the Power Aware Cord.

This fridge alarm detects when the door has been left open for more than 30 seconds and reacts by sounding an alarm. This is still just feedback leaving the user in control, but could be considered significantly more obtrusive as the alarm is almost impossible to ignore and will subsequently trigger the user to turn it off.

A “non-eco” button on a washing machine would be an opt-out alternative to the “eco” buttons commonly seen today. This would make it easier for the user to choose the “eco” alternative, without forcing the user. The option is presented in an unobtrusive way and may result in the intended behaviour without demanding any attention at all.

Dishwasher-detergent in tablet form, with the estimated detergent needed for one washing in one tablet, is a way to make it easier for the user to use the “right” amount of detergent. The user will become aware of it when adding detergent to the dishwasher, but it does not require the user to do anything special.

The Ecokettle is an electrical water boiler that is meant to make it easier for the user to avoid boiling more water than necessary. The user fills up water in a reservoir and then determines how much water to boil by pressing a button once for each cup of water to boil. This is a design that leaves the user in control, but it also requires that the user is aware of what he or she is doing to operate it.

An automatic gear in a car is an example where the product is in complete control over which gear to use while driving. The changing of gears is done entirely automatic, without the user having to be aware of it being done at all.

Some benches are designed to avoid people laying down on them. By spreading the seats out and curve the individual seat it becomes (almost) impossible to lie down and sleep on the bench. This is forcing a certain type of behaviour but requires limited attention from those who uses the bench.

A speed bump is an example of a design that forces the user to behave in a particular way (drive slowly) and requires that the user becomes aware and adjusts the behaviour accordingly.

**Implications of the obtrusiveness dimension**

A shift from a one-dimensional distribution of strategies to a two dimensional space may prove to have a number of advantages. First of all, it will enable a higher granularity of the design strategies by adding an additional property, by which the strategies may be identified. This may enable a distinction between different strategies, which would not be possible on a one-dimensional distribution. This will not only open up for more precise identification of the strategies, but also potentially enable a more precise recommendation of strategies for a given situation. Secondly, the additional dimension describes properties of the strategies that were not identified by the first dimension. This additional property enables a more precise understanding of how the various strategies may affect the behaviour of the user and thus contribute to a better chance for achieving the intended behaviour change. The literature review of the effects variations in obtrusiveness may have on the user, can be summarised as following:

The higher the importance or urgency, the more obtrusive the strategy may be.

Habits may be broken by making the person aware of the habitual behaviour. For a strategy to achieve this, it should be obtrusive enough to gain the attention of the user.

The more obtrusive a strategy is, the grater is the chance that it will be experienced as annoying or distracting by the user.

In 2010 a set of preliminary guidelines for selecting design strategies were presented (Zachrisson and Boks). These guidelines were based on the assumption that understanding of the user and the context may help to make informed decisions of which strategies to apply. The preliminary guidelines focused on the distribution of control as a means of distinguishing between the different design strategies. The distribution of obtrusiveness presented in this paper, may be a valuable contribution to the preliminary guidelines. A first sketch of how the preliminary guidelines from 2010, reinforced by the insight provided by this paper, may be seen in Figure 4.

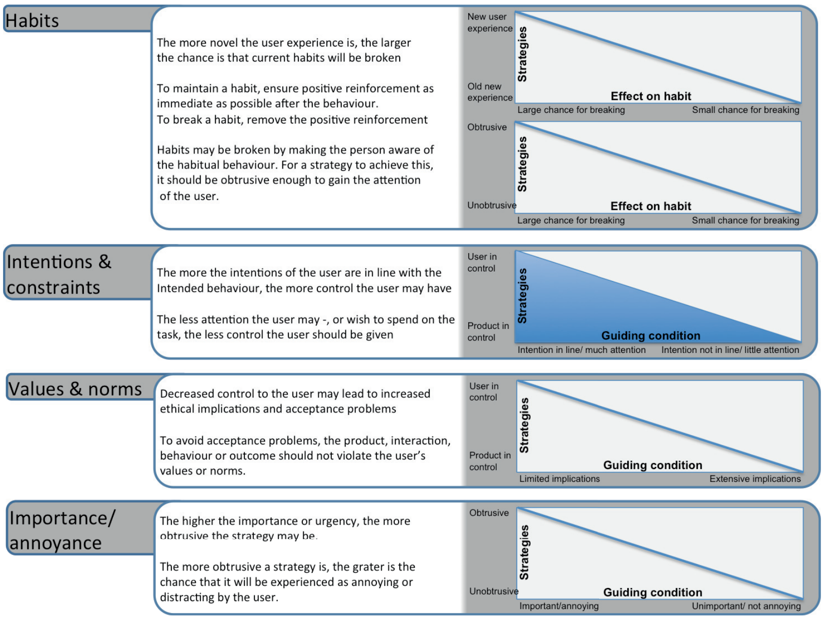


Figure 4. Preliminary guidelines reinforced by the implications of the obtrusiveness dimension.

**Conclusion**

This paper has introduced the obtrusiveness of behaviour changing design strategies as an alternative to the more commonly used "distribution of control". By combining these two dimensions, a previously presented set of guidelines for when different types of strategies may be expected to have the intended effect, may be reinforced. However, as these guidelines are derived from literature, and to a certain degree adopted from other research disciplines, they should at this stage only be considered as indications of possible relations. Before they can be considered as a proper tool to help designers select design strategies, they should be tested and developed further. To ensure that the selection of strategies really is improved by the guidelines, and that the format of the guidelines is suitable for a product design context, they should be applied in realistic design projects. By letting designers try to use the guidelines in their projects, valuable information may be retrieved both about the value of the recommendations the guidelines provide and how the format of the guidelines may be adjusted to accommodate the abilities and needs of the designers better.

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# THE CONFERENCE POSTERS

POSTER 1. ZACHRISSON, J. AND BOKS, C. (2011) *A FRAMEWORK FOR SELECTING SUSTAINABLE BEHAVIOR DESIGN STRATEGIES*. POSTER PRESENTED AT *OF ISSST IEEE*. CHICAGO, USA, MAY 16TH - 18TH.

The process of selecting

NTNU

# Sustainable Behaviour Design Strategies

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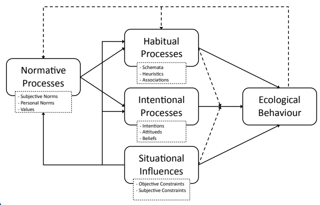
## Selecting strategies for provoking sustainable usage of products

*This poster presents the preliminary results of an ongoing research project at NTNU. The goal of the project is to* ***develop a toolbox*** *that may enable designers to make informed decisions about* ***which behaviour-changing design-strategy to apply*** *in a given project. In this poster, the structure of the logic behind the toolbox is framed out. It is based on the assumption that knowledge about the factors that affect the behaviour, can predict how certain properties of design strategies may affect the potential of the strategies.*

## Factors affecting behaviour

To understand how to change the way people behave, it is necessary to understand how behaviour is affected. One of the fields that have investigated this is social psychology. **Social psychological** research has resulted in the development of numerous behaviour models. Some of these models are aiming at identifying all the factors that are affecting behaviour, and how they are related to each other. One such model is the Comprehensive Action Determination Model Klöckner & Blöbaum (2010).




1 What affects behaviour?

## Methods to investigate the factors

To apply the understanding of behavioural factors identified by social psychology, it is necessary to investigate the target group. In product design, methods from **user centred design** may be suitable tools. However, not all user research methods are suitable to investigate all the behavioural factors. For the designer to select the appropriate methods, it is useful to have an overview over which methods is suitable to investigate which behavioural factor.

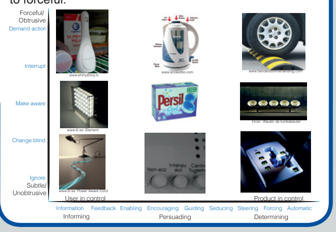
■ = Recommended

| | Habits | Beliefs | Attitude | Intention | Objective constraints | Subjective constraints | Social norms | Personal norms | Values |
|---|---|---|---|---|---|---|---|---|---|
| Interview | | ■ | ■ | ■ | | ■ | ■ | ■ | ■ |
| Focus group | | ■ | ■ | ■ | | ■ | ■ | ■ | ■ |
| Survey | | ■ | ■ | ■ | | ■ | ■ | ■ | ■ |
| Verbal protocol | | ■ | ■ | ■ | | ■ | ■ | ■ | ■ |
| Conjoint technique | | | ■ | | | | | ■ | ■ |
| Wants and needs analysis | | | ■ | | | | | ■ | ■ |
| Card sorting | | ■ | | | | | | | |
| Group task analysis | | ■ | | | | | | | |
| Probes | | ■ | ■ | ■ | | ■ | ■ | ■ | ■ |
| | | | | | | | | | |
| Observation | | | | | ■ | | | | |
| Studying documentation | | | | | | | ■ | | |
| Video ethnography | | | | | ■ | | | | |
| Shadowing | | | | | ■ | | | | |
| User testing | | | | | ■ | | | | |
| Empathic design | | | | | ■ | | | | |
| Cultural focused research | | | | | | | ■ | | |
| | | | | | | | | | |
| Applied ethnography | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Contextual enquiry | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |

2 How to gather the information?

## Distribution of design strategies

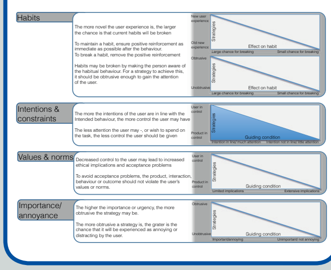
Before designers can utilize the insight of the factors that influence the behaviour of the target group, it is necessary to understand how design may affect behaviour. A number of behaviour-changing design-strategies are available, but to be able to select the appropriate ones, the designer must be able to **compare and distribute** the strategies according to relevant properties. Two such properties may be the **distribution of control**, between the user and the product, and the **obtrusiveness** of the design, from subtle to forceful.




3 How can design affect behaviour?

## Guidelines for selecting design strategies

The purpose of this proposed toolbox is to **help designers select design strategies**. The previous steps have pointed out sources of information this selection could draw upon. However, to make this understanding easily applied in design projects, the consequences need to be pointed out and communicated in a comprehendible manner. This research project suggests presenting the translation as **a set of guidelines**. These guidelines are formulated as recommendations of properties the design should have to achieve certain effects on the specific behavioural factors. Several of the guidelines are accompanied by graphs describing the relation between variations in the strategies and the behavioural factors.




4 When to use the design strategies?

## The development towards a toolbox

This poster presents the logic behind a toolbox for selecting design strategies to change behaviour through the design of products. It is based on the assumption that some design strategies will be more appropriate to use in certain situations than others. It combines understanding of the factors affecting behaviour from social psychology, information about the target group by methods from user centred design and understanding of behaviour-changing design-strategies from the design for sustainable behaviour research. The goal is that **the final toolbox** will provide the designers with **recommendations for how to investigate** the relevant information of the target group and usage situation and **guidelines for how to use** this information to select the best design strategies for the project.

5 Informed selection of design strategies

Poster for ISSST IEEE in Chicago, May 16-18th 2011

POSTER 2. DAAE, J., & BOKS, C. (2012) *SELECTING BEHAVIOUR CHANGING DESIGN PRINCIPLES*, POSTER PRESENTED AT *THE BEHAVIOR, ENERGY AND CLIMATE CHANGE*, SACRAMENTO, USA, NOVEMBER 12TH – 14TH.

# Selecting behaviour changing design principles

## Introduction

A significant share of the environmental impact from many consumer products happens during the use phase. Often, the environmental impact caused during the use phase of a product will vary, depending on how the product is being used. Therefore there is a significant potential environmental benefit from designing products in a way that makes people use them optimally. The research and proposed design process presented on this poster is a preliminary result of a PhD project at the Norwegian University of Science and Technology (NTNU). The goal of the project is to help designers make informed decisions about how to design products that will be used in the most sustainable way. This research both builds upon theories from social psychology and design research, and experience from design projects either at the university or in collaboration with companies.

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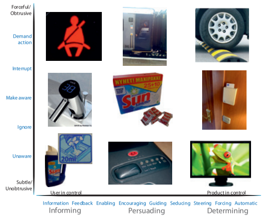
## Design principle landscape

To understand when to use which design principles, it is necessary to distinguish between different principles. One way to do this is by considering how much control the user has over the behaviour and how much attention it demands.




## The case study

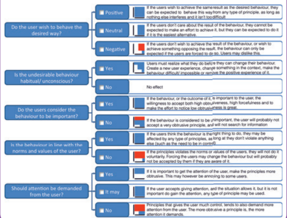
The description of the process presented on this poster is illustrated by examples from a student project. The project was conducted by students in the 3rd year of the Industrial Design study at NTNU during an Ecodesign course. During the course, the students should choose an activity they assumed had the potential to be conducted in a more environmentally friendly way. The students were then to gather information through a number of different user research methods, to find out how people performed the activity and the reasons why they did it the way they did – meaning studying their norms and value, routines, habits, attitudes, et cetera. The students were then to process this insight, through the method presented on this poster, and to come up with solutions for how the behaviour may be made more environmentally friendly. Most of the illustrations on this poster are taken from a group of students focussing on laundry behaviour, in particular addressing the problem that many people run their washing machines half full, add clean clothes just to fill it up and/or wash their clothes with unnecessarily warm water.

User analysis

Design process

## Guide to the landscape

This guide helps to identify when principles with different levels of control and obtrusiveness are likely to be accepted and lead to the desired behaviour. The guide is based upon insight from social psychology and product design.

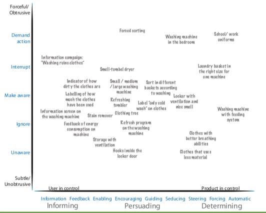


## User studies and personas

To understand how the landscape relates to the target group for the project, it is necessary to identify the most important types of users the target group consists of. In the field of user centred design, the information about the users are gathered using a variety of methods, such as interviews, observation, applied ethnography, etc. depending on the project. This information is analysed, and the users are categorized according to aspects relevant for this project. The description of each of these categories represents an archetype user and is called a persona. In this approach to behaviour changing design, the users are categorized according to the main factors that affect their behaviour.

## Position ideas in landscape

Once the ideas for design solutions have been generated, they can be positioned within the landscape according to their level of control and obtrusiveness. This is by no means a precise process, but is based on the designers understanding of the ideas.

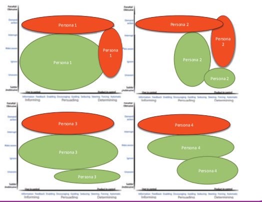


## Final concept

The final concept should be the one that not only fulfils the requirements best and seems most promising, but which also has a low environmental impact. This may be identified using LCA or a CAD program sustainability-plugin.

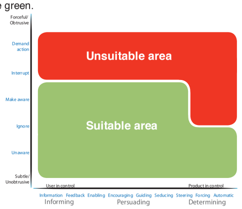

## Personas in the landscape

By using the guide for each persona, it is possible to identify the solution space in the landscape that have the potential to lead to the desired behaviour change (green), and the solution spaces that are likely to not be accepted by the persona (red). The blank areas have no great potential for either one.



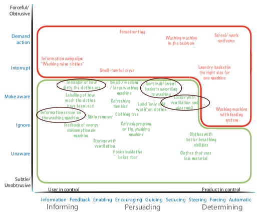
## Combine the personas

Once the solution spaces for each persona have been identified, it is possible to combine these to identify the solution space for the entire target group. If a solution space is unsuitable for at least one persona, it should be red, and if a solution space is green for at least one persona and not red for any, it should be green.



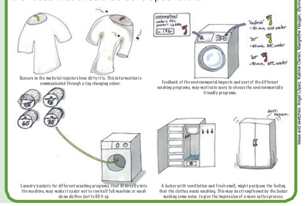

## Evaluate ideas

By combining the positioning of the ideas in the landscape with the indication of suitable and unsuitable areas, you get an indication of which ideas are likely to result in the desired behaviour for the target group of the project.



## Selecting concepts

As all the ideas in the green area have the potential to affect the target group, it is important to select the most promising, not only from a behaviour change perspective. The designers can apply all their regular methods, such as fulfilment of requirements, feasibility evaluation, gut feeling, etc. to select the ideas that should be developed further.

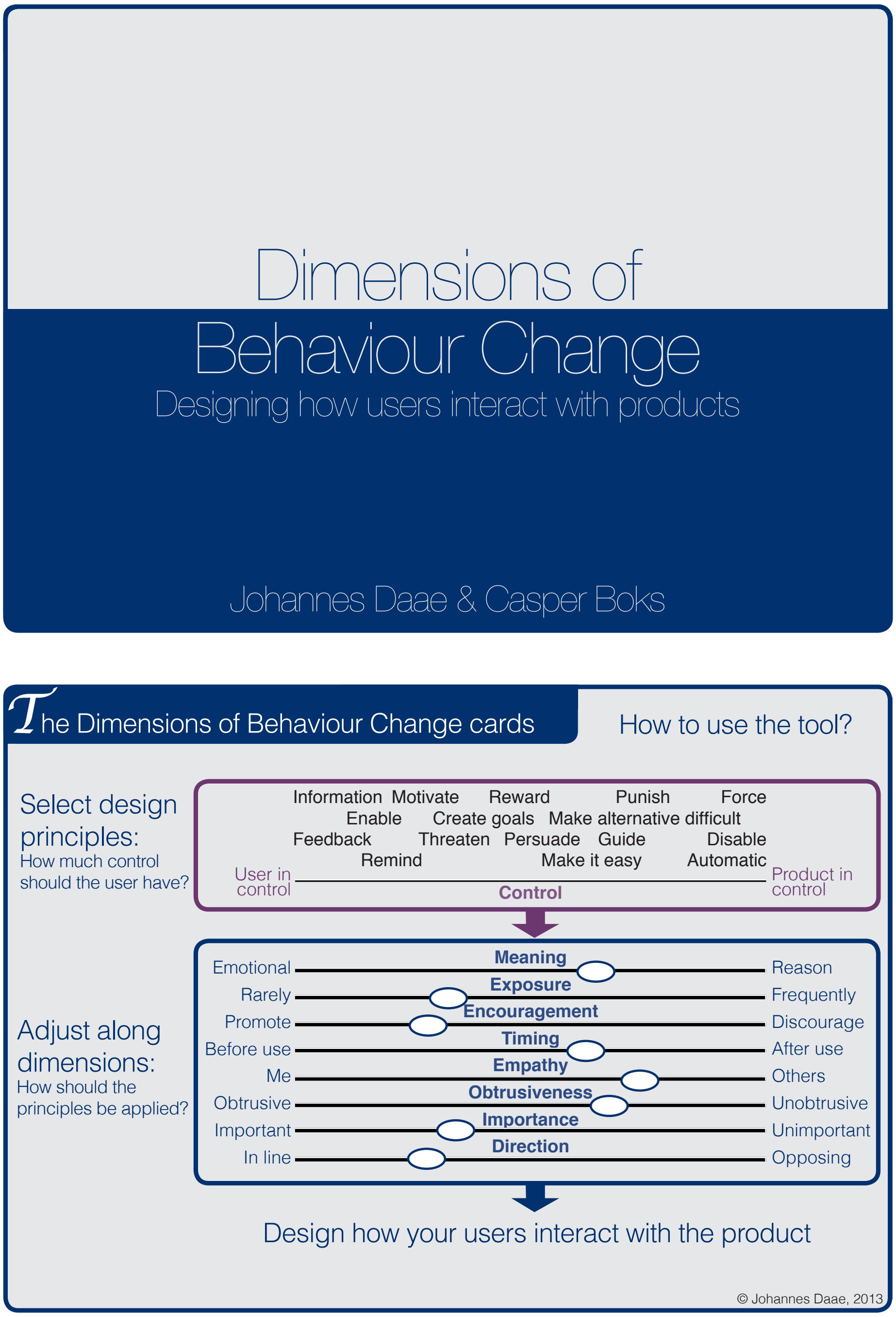


Poster for BECC, Sacramento, November 2012

NTNU

Johannes Zachrisson Daae & Casper Boks

# PART III. THE DIMENSIONS OF BEHAVIOUR CHANGE CARDS

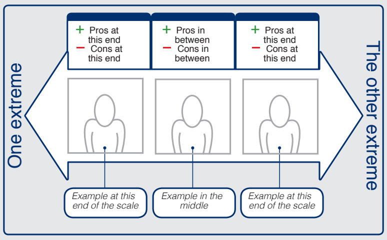



Dimensions of Behaviour Change card 1.

## The two sides of the cards

The card deck contains:

- 2 cards explaining the tool
- 1 card presenting 16 design principles according to how much control over the behaviour they give the user
- 8 cards presenting dimensions for how your users will experience the design and the design principles you apply




**The front sides**
Each dimension is presented on one card. On the front of the card, the dimension is described as a line between two extremes. An example, and some general pros and cons are given for each extreme and for the area between.

**The backsides**
The backside of each dimension card contains additional examples to explain the variation along that dimension.

As an additional support, the backside of this card contains an introduction to the most important factors that may affect user behaviour, based on behavioural psychology. Understanding which of these factors are most important for your target groups behaviour may help you identify the most promising design principles and variations of dimensions to affect the behaviour of your target group.

Feedback or comments?
Please contact johannes.daae@ntnu.no



## Understanding the target group

To find out how to change a target behaviour, it is necessary to understand why users behave the way they do. It is likely that the behaviour is caused by one or more of the following reasons. By identifying the most dominating of these reasons, it is possible to gain some understanding of how to change the behaviour.

**The user tries to achieve a goal**
Users may behave in a way they believe is the best or because they have a positive attitude towards this behaviour. Can they achieve their goal through the desired behaviour? Is it possible to convince them to change their goal? Can the alternative be presented in a way that makes them change their behaviour?

**It is the easiest thing to do**
Sometimes users behave in a particular way just because it is easy or it requires less effort than behaving in another way. Is it possible to change the behaviour by making the desired behaviour easier? Or by making the undesired more difficult?

**Its how the user always do it**
Sometimes users behave in a way just out of habit or because they are not even aware of their behaviour. A habit requires repetition in stable circumstances with positive reinforcement. By changing one of these conditions, for instance by changing the experience of using the product or removing the positive outcome, the habit might be broken and the behaviour changed.

**Others expect it to be done that way**
Sometimes users behave in certain ways because they believe it is the socially accepted thing to do or because they believe others expect it. It may not be feasible to change the social norms, but is it possible to make the user believe the desired behaviour is what is expected of him/her?

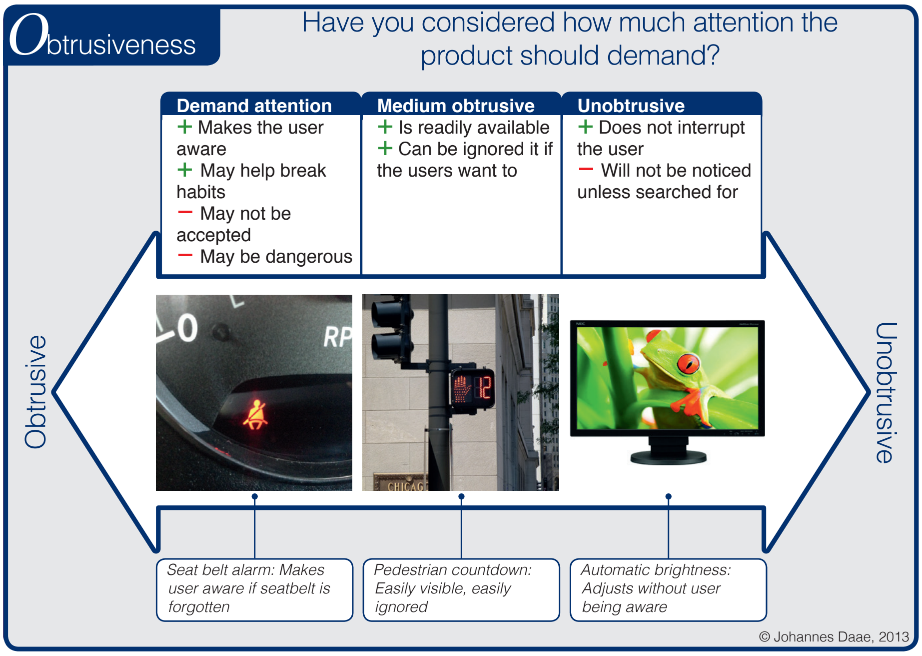
**It is the morally right thing to do**
Users may also behave according to their values or norms. It may be difficult to change these but perhaps it is possible to present the desired behaviour in a way that is in line with their values or norms.



Dimensions of Behaviour Change card 2.

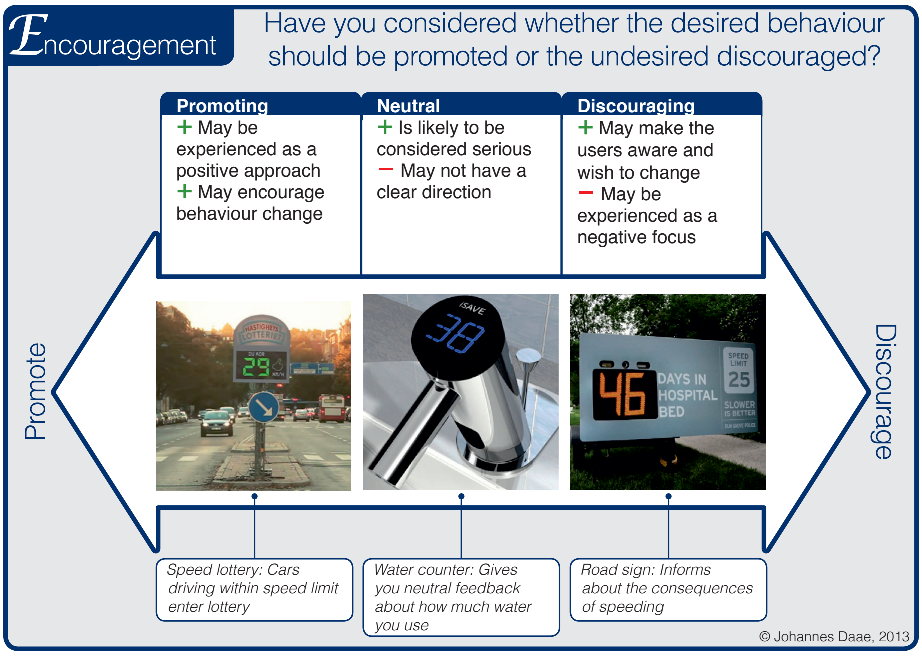


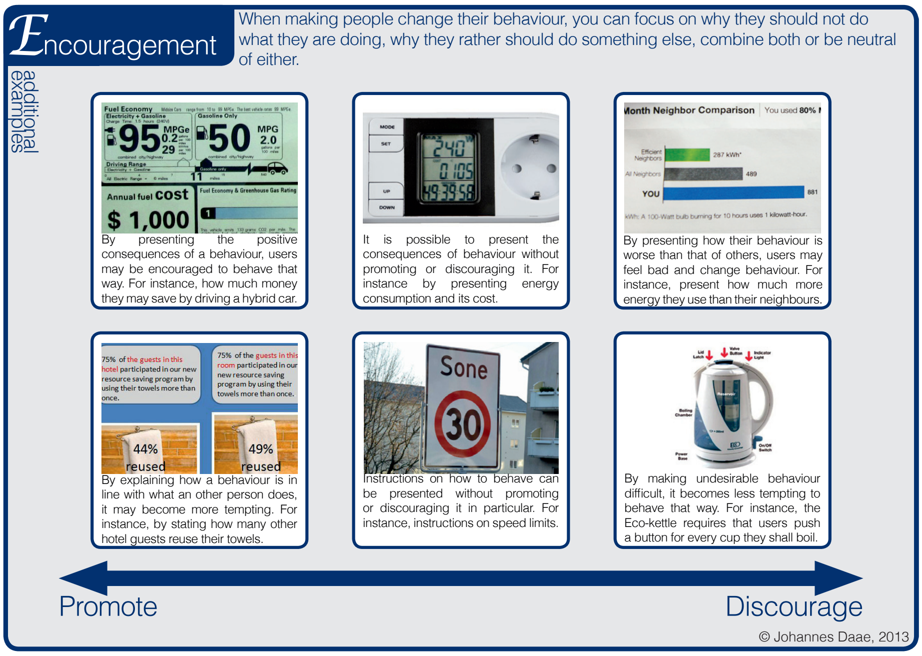
Dimensions of Behaviour Change card 3.





Dimensions of Behaviour Change card 4.




Dimensions of Behaviour Change card 5.

## Meaning

Have you considered if the user will wish to behave the desired way simply because it is fun or because it makes sense?

**If it is fun**
+ Users who don't care can be motivated
− It may be considered unserious

**If it makes sense**
+ Can help users understand the importance
− Often requires attention

Emotional — Reason

*Funny trash can: Makes children wish to collect trash*


*Speed lottery: Informs driving speed and makes it into a game*

*Energy meter: Informs about consumption and cost*



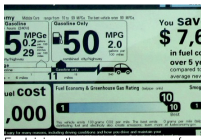
## Meaning

additional examples

Sometimes people do things because the think it is the right thing to do or because of the consequences, other times people might do something just because it is enjoyable or fun, or emotional in some other way.

Everyday activities may become fun if they become competitions or games. For instance the bottle-bank-arcade makes recycling of bottles into a game.


Sometimes it can be enjoyable to behave in a rational way. For instance, driving in a way that saves fuel and compete against your self to see how low consumption you can manage.



Explaining the consequences of an action may make people want to change it. For instance, how much money people save on fuel by changing to a hybrid car.

Sometimes users are emotionally triggered to behave a particular way. For instance, if the water level in a goldfish bowl reflects the water usage, people might use less water.

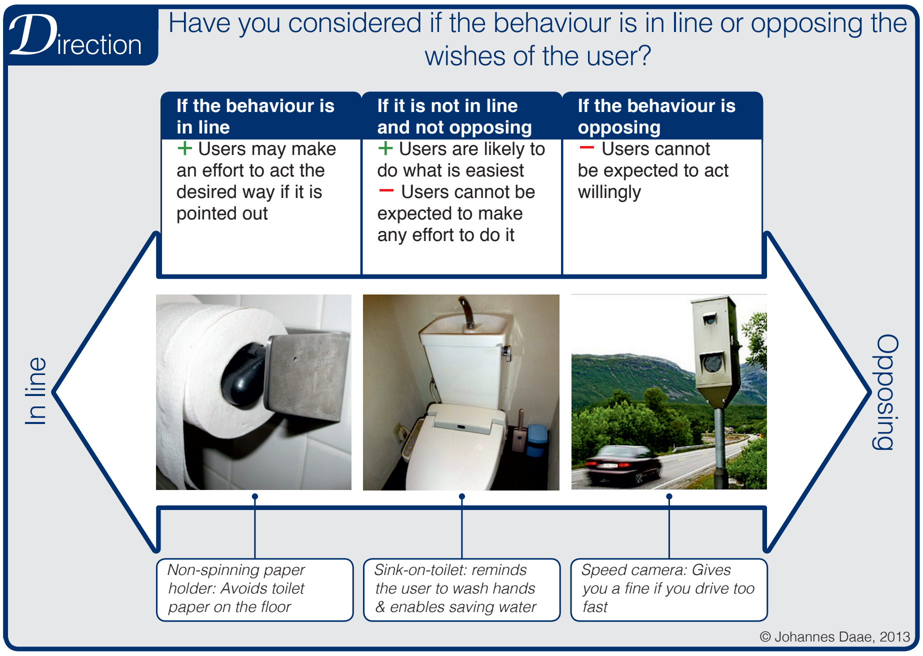

Sometimes the rational behaviour can be described in a humoristic way. For instance a sign saying: "Cars parked in front of this gate will be disassembled and sold to Poland".

Users may feel something is rational to do because their behaviour is seen by others. For instance, maybe more people wash their hands at public toilets as others can see them?

Emotional — Reason

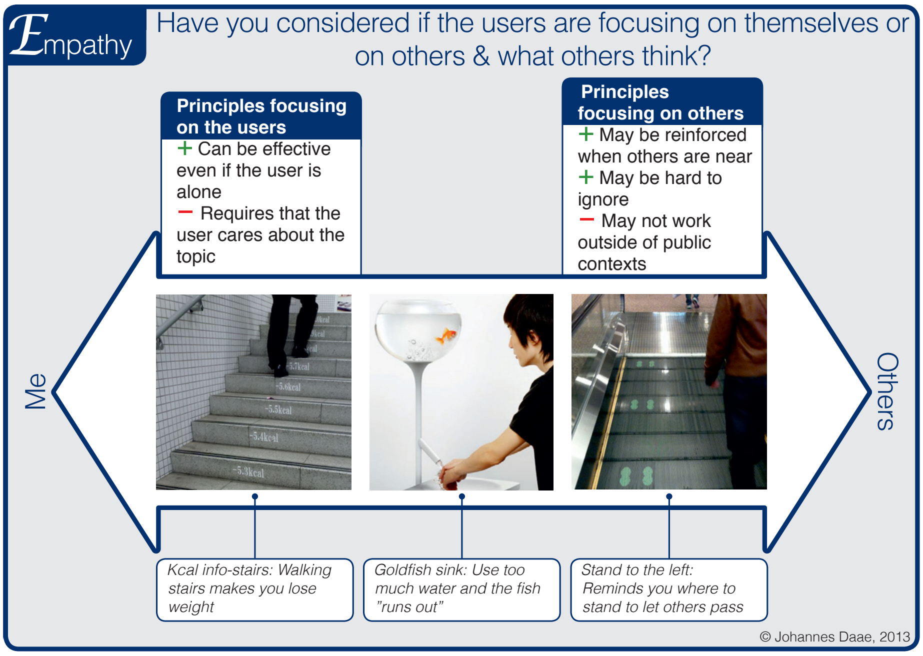


Dimensions of Behaviour Change card 6.



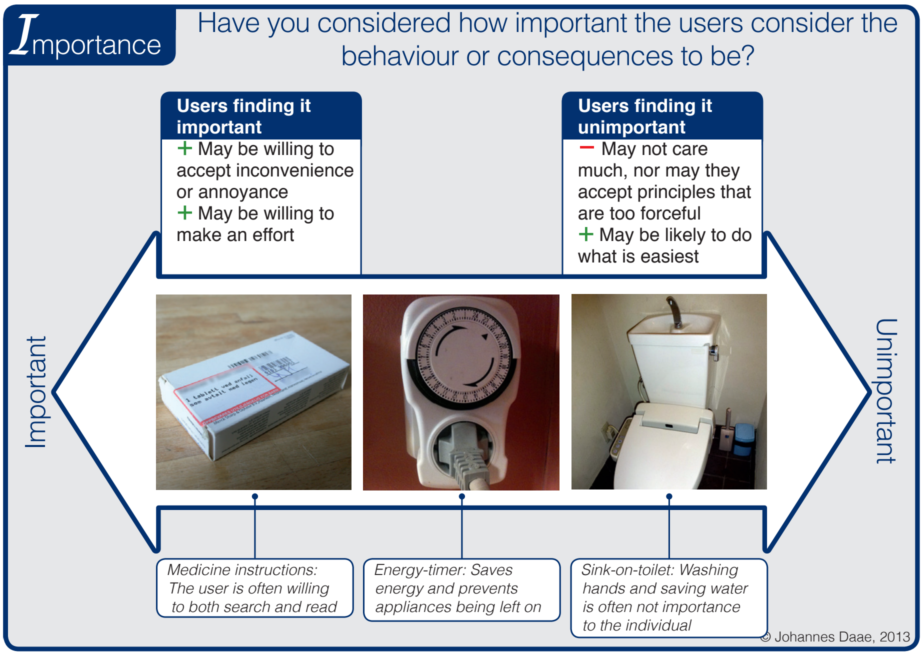


Dimensions of Behaviour Change card 7.





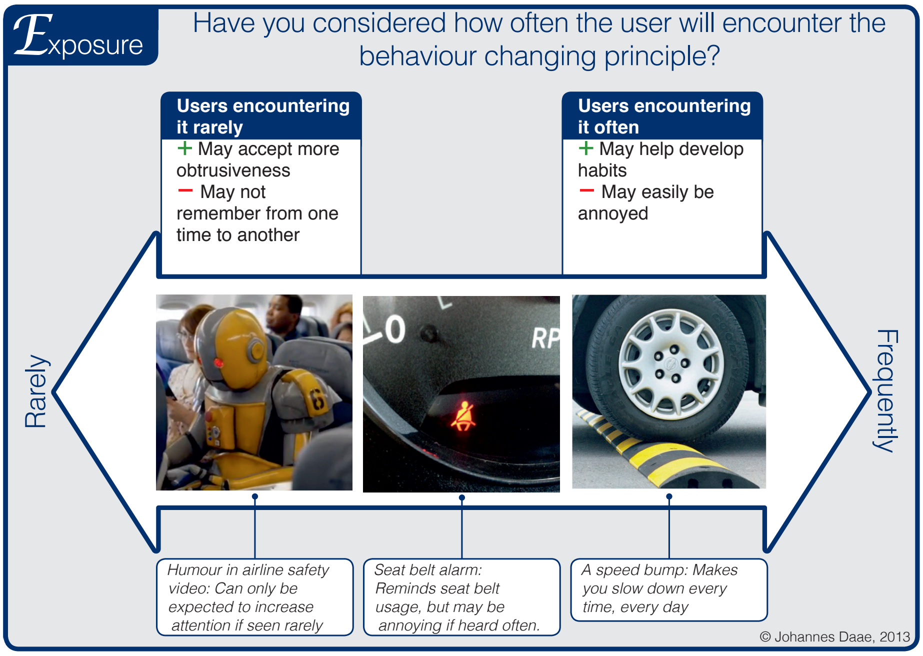
Dimensions of Behaviour Change card 8.

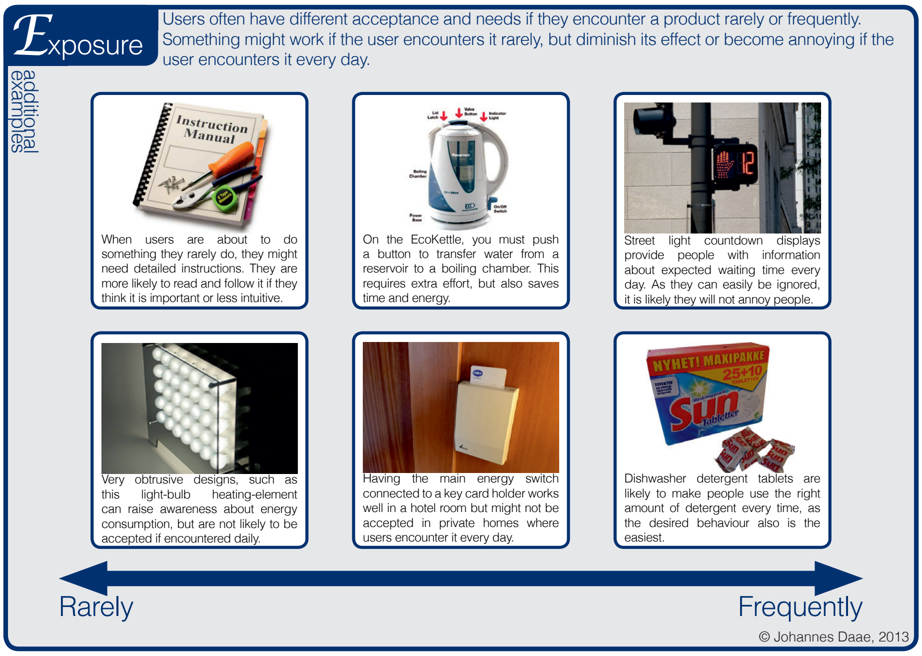




Dimensions of Behaviour Change card 9.


Dimensions of Behaviour Change card 10.




Dimensions of Behaviour Change card 11.