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A classification of user research methods for design for sustainable behaviour

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ABSTRACT

It is crucial to have insight in users and their context when designing products to create behaviour change. The discipline of User Centred Design has developed, appropriated and modified numerous methods to provide this type of insight, but limited attention has been directed towards what insight various methods may provide. This paper presents a review of user research methods from the User Centred Design literature, and assesses their potential for acquiring specific insight. The review focuses on the investigation of those factors that affect behaviour according to social psychology literature, which may assist designers to create solutions that stimulate sustainable or avoid unsustainable behaviour. The result of the analysis is an overview of which methods are most suitable to use when investigating particular aspects of behaviour. This result is compared with experiences in two case studies from literature, indicating the potential value of the results and in particular the value of distinguishing between methods suitable to investigate internal or external factors, and conscious or unconscious factors.

1. Introduction

Recent research suggests consensus about the large potential for environmental benefits from altering users' behaviour and the way they interact with products (e.g. House of Lords, 2011; McMahon and Bhamra, 2012; Tukker et al., 2008). The way users interact with products is strongly affected by the way they are designed (Norman, 1988). This provides designers with an opportunity to reduce environmental impacts by designing products in such a way that they will be used in the most sustainable ways. This realization has resulted in the development of a research field, often referred to as Design for Sustainable Behaviour (DfSB) (Pettersen and Boks, 2009). The field builds on the work of 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 scripts is "a kind of user manual inscribed into an artefact" where the design of a product guides the way it is being used (Jelsma, 1997), which is strongly related to Donald Norman's (1988) concept of affordances. The field as we know it today was first explored about a decade ago (Bhamra, 2004; Lilley et al., 2005; Rodriguez and Boks, 2005) and has since then resulted in an active research community from which several PhD theses have emerged (e.g. Lilley, 2007; Lockton, 2013; Pettersen, 2013). Topics in focus have been the identification of a number of strategies or principles for how products can be designed to affect behaviour (Lilley, 2007; Lockton, 2013; Tang, 2010), and the application of these in a number of studies (e.g. Daae et al., 2014; Desmedt et al., 2009; Tang and Bhamra, 2012). User centred design and interaction design have been found to be promising approaches to inform this development (Wever et al., 2008).

Even though there is extensive literature on user-centred methods, little information is presented about what they really can tell us about the user, the situation or the context, in particular in the context of behaviour change. Although experienced user researchers and user centred designers might have a well-developed implicit understanding of this, the number of researchers and designers targeting behaviour change is growing rapidly. This increases the need to provide an overview of this topic targeting the specific needs of DfSB, which can support experienced and educate less experienced practitioners. The objective of this paper is therefore to make the initial steps of providing this information, and more specifically, to provide this support for DfSB research. To structure the investigation and make sure that they result in a coherent overview that is relevant for DfSB, the investigation focuses on whether the different methods can provide

Acronyms: DfSB, Design for Sustainable Behaviour; CADM, The Comprehensive Action Determination Model; TPB, The Theory of Planned Behaviour; NAM, The Norm-Activation Model.

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information about the behavioural factors identified by social psychology. These factors are central to the understanding of behaviour in the DfSB literature (e.g. Tang, 2010; Wilson, 2013; Zachrisson and Boks, 2012). To align the results with the way user centred designers normally work, the descriptions of the user research methods and their potential strengths and weaknesses are gathered from the User Centred Design literature. This provides a natural focus for the review and ensures that scope, purpose and description of the methods are similar. The limitation to this particular literature does represent a risk of omitting relevant information from other research fields, but to the authors' knowledge, a similar overview of how to investigate the behavioural factors from social psychology does not exist.

The paper first provides a brief introduction to User Centred Design and behaviour models from social psychology, resulting in the selection of one model. Secondly, it reviews selected user research methods according to their strengths to investigate 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.

1.1. User Centred Design

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 was 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 as it is often regarded to be 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 (e.g. Aldersey-Williams et al., 1999; Courage and Baxter, 2005; 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) state that there are five basic methods for gathering data, namely questionnaires, interviews, focus groups and workshops, naturalistic observation and studying documentation. Some methods, for example probes or empathic design, may not really be combinations of any of these. However, such a simplification may aid the understanding of how different methods relate to each other.

1.2. Factors affecting behaviour

Throughout the years, numerous theories and models have been developed and presented in the psychological literature, contributing to unravel the complexity of behaviour determination and prediction. In 2005, Jackson presented a review of models describing behaviour and behavioural change. He points out that many of the models lack focus on key causal influences, as they often focus 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 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, Klöckner and Blöbaum presented a first version of a Comprehensive Action Determination Model (CADM – see Fig. 1). This model builds on four theories that are acknowledged for their strength of explaining behaviour, but also criticized for not integrating all 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 aimed to remove the limitations of each theory, thereby creating a model encompassing both the internal and external factors. They tested the model in an empirical study against the NAM and the TPB, as well as against 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). As the CADM already is known in the DfSB literature (e.g. Zachrisson and Boks, 2012) and includes a comprehensive overview of the factors that can affect behaviour, the model was found to be suitable to structure the analysis in this paper.

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 do not distinguish between them (Jager, 2003; Robertson, 1967; Verplanken and Wood, 2006). This simplification is applied in the following analysis, as the distinction creates more complexity without contributing with any obvious identification or explanation power. Therefore, the term *habit* is used in this paper without making this distinction.
- 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) and result in what is often called *perceived behavioural control*. 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).

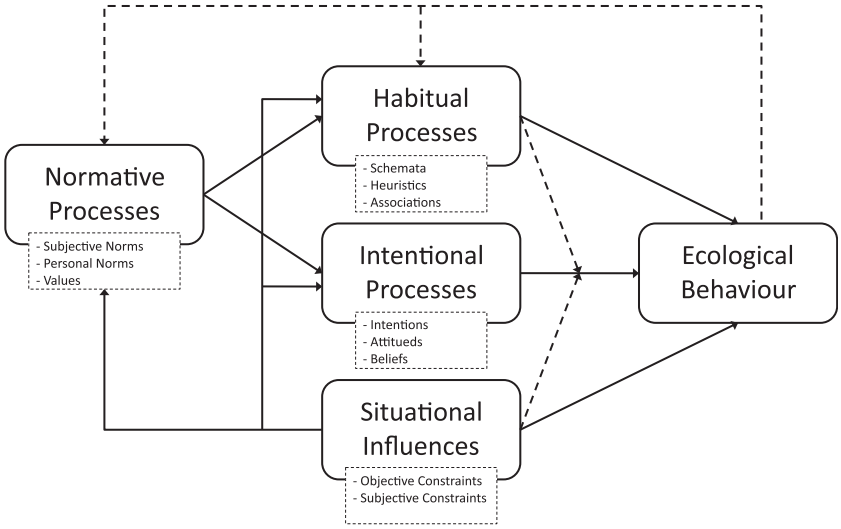

Fig. 1. The comprehensive action determination model (CADM) (Klöckner and Blöbaum, 2010).

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 a comprehensive overview of the factors affecting ecological behaviour, which makes it suitable to support the current analysis. By identifying which factors the different methods are suitable to provide information about, 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. Table 1 aims to provide this understanding.

2. Methods

The user research methods under investigation were collected from reviewing User Centred Design literature with overviews and descriptions of user research methods. As the focus is to create an overview over methods that provide insight about the user, only those methods that aim at gathering information about the user or context were included. Methods 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 of applying user centred design methods that some descriptions in literature refer to and which may influence the validity of the information provided by participating users that are studied, are social desirability and prestige response bias. Social desirability occurs if participants answer that what they think is most socially acceptable rather than the truth. Prestige response

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)

bias occurs when participants answer what they think the researcher wants to hear (Courage and Baxter, 2005). Courage and Baxter (2005) discuss these factors in relation to interviews and questionnaires, and claim that these effects can be avoided if the researcher is aware of them, and is careful in the way questions are 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) point out that the lack of these biases is one of the advantages of observations compared to methods where the user talks about the behaviour.

There are two properties of behavioural factors identified by the CADM, which are significant for how to investigate them. One of these is pointed out by Jackson (2005) when he identified that the factors can either be internal or external. Internal factors exist within the user and include factors such as attitudes, values, habits and personal norms. External factors exist outside the user, and include objective constraints and social norms. As internal factors exist within the user, is it necessary to gain information from the user to investigate these. The external factors can however be investigated without communicating with the user, although this does not necessarily exclude the possibility of gaining information about the external factors directly from users.

The other property concerns whether the factor is conscious or unconscious to the user. Klöckner et al. (2003) stated that habits are to be considered as unconscious, as they are conducted without deliberate thinking. People are therefore less likely to be able to provide information about what they did out of habit. Similarly, Frey (1988) points out that there can be unconscious reasons why the subjective possibility set over-extend or under-extend the objective possibility set. An objective constraint that the user is aware of is also a subjective constraint. Thus, if the two categories are considered mutually exclusive, objective constraints should also be considered as unconscious for the user and as 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 approaches for how the different factors can be investigated:

- Factors that users are conscious about are best investigated through communicating with users.
- Factors that users are not conscious about are best investigated by what users do.

By categorising 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 Fig. 2. The included factors are the ones identified by the CADM (Fig. 1) model and are categorised according to their explanations (Table 1). Objective constraints may also include subjective constraints the user is aware of, which is indicated by including objective constraints in brackets under “conscious”. Similarly, social norms are defined as the perceived opinion of others (see Table 1) and are thus conscious, but may also affect behaviour without the user being aware of it. To indicate this potential ambiguity, it is also included in brackets, under unconscious.

2.1. The review of the user research methods

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

The methods are divided into three categories, according to how they gather information. The categorization of some of the methods may be ambiguous, as some may be considered to belong to different categories depending on how they are applied. For instance, a diary study can focus on what users do and how they do it rather than what users think and feel, and may thus be positioned somewhere between the two categories. It then focuses on what users do, but depends on users reporting about this themselves. However, the proposed categorization is based on how the methods are described in the literature and their core functions. Thus, only the methods that per definition combine information with and without input from the user are placed in the combined category. Below, each method is presented with a description and a summary of what the literature describes as its purpose, followed by a discussion of the potential for the individual method investigating the factors identified by the factor matrix (Fig. 2). This discussion is based on the identification of aspects in the description or purpose that qualifies or disqualifies the method for investigating certain factors.

2.2. Methods for communicating with users

These methods are based on information provided by the user, which gives access to internal factors (see Table 3). But as the information 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 methods are also not suitable to provide information about factors that the user is not consciously aware of.

2.3. Discussion about methods for communicating with 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 methods will be less suitable for investigating sensitive topics than methods 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

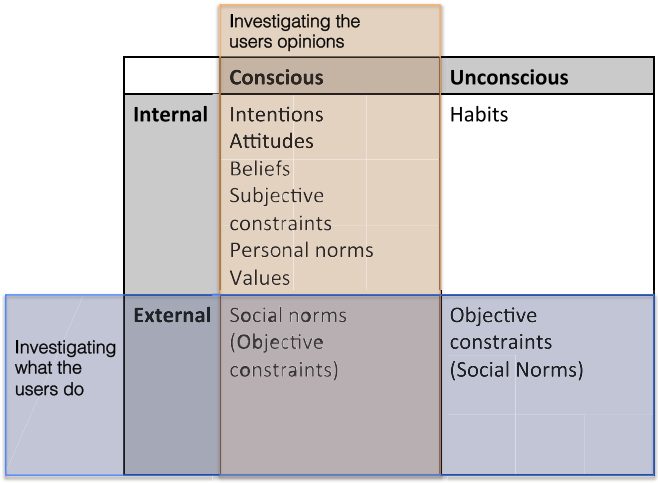

Fig. 2. Factor matrix.

Table 2
Methods included in the review.

4.1: Methods for communicating with the user	4.2: Methods for investigating what users do:	4.3: Methods investigating both what users do that include communicating with 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	
Card sorting	Culture-focused research	
Group task analysis		
Probes/diary study		

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. *Wants and needs 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. Similar 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 only beliefs about the specific task.

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

2.4. Methods for investigating what users do

These methods gather information about the user or the context indirectly, either through observing behaviour or studying other relevant information (see Table 4). This allows access to information that the user may be unaware of, but is not suitable for investigating factors that exist in the mind of the user.

Table 3
Methods for communicating with 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). There are several types of interviews with different strengths and weaknesses. For instance, individual interviews are more suitable to investigate sensitive topics than methods involving more people (Aldersey-Williams et al., 1999), and narrative or unstructured interviews are suitable for investigating less obvious aspects of the topic.
A Focus Group is a group discussion about a product or a topic (Aldersey-Williams et al., 1999; Courage and Baxter, 2005; Gibbs, 2004, 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).	Distribution of surveys and questionnaires make them particularly useful for getting 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 organize 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., 2005, Crystal and Ellington, 2004, Courage and Baxter, 2005).	The task analysis aims at explaining 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., 2005), 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).

Table 4
Methods for investigating what 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 and Wall, 1995, Kujala, 2003, Whitney and Kumar, 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 (Whitney and Kumar, 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 (Whitney and Kumar, 2003).	This cannot only provide demographic information, but also insight about behaviour, beliefs and goals (Whitney and Kumar, 2003).

2.5. Discussion about the methods for investigating what users do

Based on the factor matrix, these methods 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, *objective constraints* are found in the physical world around the behaviour, whereas *social norms* are found in the society around the user. As *social norms* are a non-physical factor, they cannot be directly observed. Thus, methods based purely on observation, such as *observation, video ethnography, shadowing, user testing* and *empathic design*, will be primarily 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 was aware of them, and would thus be included in the *subjective constraints* as well. The two latter methods could also uncover information about *social norms* when this is included in the documentation.

2.6. Methods investigating both what users do and communicating with 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 (see Table 5).

2.7. Reflections upon the methods investigating both what users do and communicating with 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 for investigating the factors identified in 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 and thereby provide richer datasets.

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 Holtzblatt (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

Table 5
Methods investigating both what users do and communicating with 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 understand how people use products (Steen, 2008) with focus on observing behaviour in a 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 users really are, how they work (Beyer and Holtzblatt, 1999) and insight into the context of the usage situation (Courage and Baxter, 2005).

or not. If true, *applied ethnography* should also have a similar ability to investigate habits. The same might be true when other methods with different focuses are combined. This is a well-known technique and is called 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 methods can be anything from video interviews to physical measurements (Aldersey-Williams et al., 1999; Love, 2005). It may 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. Results

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.

4. Discussion

As a first step in connecting the review of user-centred design methods to the reality of user research and design projects, two user research studies described in literature are analysed below. The focus in the analysis is on analysing to what extent the choice of methods, the intended output and the resulting knowledge match with the description and conclusion in the method review. Both studies are focussing on reducing the environmental impact caused by refrigerator usage, based on input gathered from user research.

4.1. Comparison 1

In 2009, Elias (2009) presented a report describing a project with user research as input to a design process. 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 for 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 supported the uncovering of habitual

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	■	■	■	■	■	■	■	■	■

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 centred design research methods was presented by Bhamra et al. (2008). In this study they aim "to solve environmental problems of use behaviour and activities around the refrigerator and freezer". The study first used interview and survey, followed by observation and an interview about the observation, making it a version of contextual inquiry, and another survey. After this, they conducted a 24-h video-observation and finally another survey.

The observations resulted in the identification of a number of specific behaviours related to where different items were positioned in the refrigerator and constraints that affected where users place the food in the refrigerator. 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.

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.

4.3. General 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 and the acceptance of this understanding of behaviour in the DfSB literature.

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 user's priority of design elements or understanding of how a product functions. The analysis of how the factors should be investigated could therefore be simplified by using the term *intentional processes* as presented in the CADM model, and combine norms and values to "*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/researcher 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 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. identified questionnaires, interviews, focus groups and workshops, naturalistic observation and studying documentation as the five basic techniques. 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 is 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 not only to 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 aims 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 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.

Experienced user researchers may to some extent already have developed experience with the type of information about the user that different user research methods are suitable to provide. However, the increasing attention DfSB has received the last years, which requires extraordinary insight in different aspects of behaviour, has increased the number of researchers, students and practitioners that contribute to the field or apply the approach. As not all of these are expert user researchers, guidance in the feasibility and appropriateness of using various user research methods is deemed a valuable contribution to this field. has also increased. It is nevertheless not unlikely that also experienced user researchers may benefit from being reminded by the overview of pros and cons of the methods or draw upon it when explaining their choice of methods for clients. In this sense, the results of the analysis may also be beneficial for others than those focussing on DfSB. Although it is necessary to be aware that the validity of the analysis may depend on the interpretation and application of the methods, and thus primarily targets user centred designers.

The classification and analysis of the user research methods described in this paper represents a simplified version of reality. A finer granulation of the included methods such as interviews may be relevant depending on the goal of the method or how it is conducted. Similarly, the distinction between methods to investigate opinions of users, what users do, or both, is a choice fuelled by a desire for simplification. It is possible to argue that some of the methods could be positioned elsewhere than they are; in particular that some more methods combine the two, such as user testing or probes. The classification in this paper is based on the descriptions of the methods gathered from the review, and the resulting understanding of the core functions of the methods. A third aspect that is simplified for the sake of the analysis is the categorisation of behavioural factors into either conscious or unconscious. In particular, there may be unconscious aspects of the conscious factors and vice versa, for instance (elements of) habitual behaviours that users are aware of or social norms that affect the behaviour of users, without them realising it. However, similarly to the rest of the analysis, the focus has been on the core functions and understanding of the factors.

The focus on reviewing the descriptions and insight from the User Centred Design literature is a limitation that can potentially omit relevant information about the methods from other research fields. Most of the methods included in the review originate from other fields, particularly from social sciences. The literature of these fields encompasses elaborate descriptions and extensive reporting of experience from application of the methods. Undoubtedly, additional contributions to the analysis described in this paper could have been identified by also including this literature, and thus improve the granularity and validity of the results, but this was not within the scope of this paper.

5. Conclusions

The objective of this study was to investigate what type of insight designers and researchers can expect to gain by applying different user research methods. By investigating behavioural factors from social psychology and how they are commonly addressed by various user centred design research methods, a table that matches factors with methods was created. The development of this table, was based on the identification of two pairs of properties of the factors: Conscious/unconscious and internal/external. 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 the different methods. This division was further specified according to strengths or limitations of the methods described in literature. Both the conscious/unconscious and internal/external, and the resulting recommendations are considered valuable for DfSB researchers and practitioners, but may also be of interest for others working with user centred design, especially those working on behaviour change and/or those that are relatively less experienced in applying a wide variety of methods. The overview of the expected outcome of the different methods can both help select the appropriate methods for projects and provide arguments of why the chosen methods are appropriate, for instance when planning projects with clients.

The 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 suggests relevance and validity of the results of the analysis in this paper. 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 robust guidelines for selecting user research methods in studying design for sustainable behaviour.

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