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Chapter 5: Design Interventions for Sustainable Behaviour

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Biographies

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Dr Tang Tang is a Lecturer in Sustainable Design and is part of the Experience Design Research Group in the School of Design at the University of Leeds, UK. She specialises in User-centred design for Sustainable Behaviour. Her current research interests include design for healthy behaviour and participatory and co-design for social sustainability.

Abstract
This chapter brings together research from Loughborough University (UK) design scholars to present a unified framework for designing interventions for sustainable behaviour. This includes: research and design approaches towards formulating an understanding of the user's actions in context; selecting a behavioural target (where to intervene); selecting (or applying) a behavioural intervention strategy; and evaluating the behavioural interventions are presented. Relevant case study examples, drawn from two UK-research council projects, are provided to elucidate theoretical propositions. The chapter concludes by reflecting on what we have learned and where we see further developments in the field emerging.

Introduction
Over recent years significant research effort has explored ways to reduce environmental impacts of both the built environment and products. Most of this work has focussed on reducing the impact of the manufacture and disposal phases of the lifecycle leading to useful work in the fields of design for disassembly and recyclability, environmentally conscious materials and dematerialisation (Wever et al., 2008). There has however been little attention paid to the impact of the use phase of the lifecycle and the environmental impacts that can occur there, particularly as a result of the way in which the user interacts with the product. This is starting to change as more and more research is suggesting that without considering the use phase, and particularly the user behaviour element of this, sustainable designs will not be able to reach their full potential (Wever et al., 2008, Boks, 2011). As a result the new research field of Design for Sustainable Behaviour (DfSB) has emerged and is concerned with the application of behavioural theory to understand users, and behaviour changing strategies to design products, services and systems that encourage more sustainable use (Bhamra and Lilley, 2015).

In this chapter, we bring together research from Loughborough University (UK) design scholars conducted over a 10 year period (Figure 5.1) to present a unified framework for designing interventions for sustainable behaviour. The phases of research, design and development of behaviour change interventions in the framework are:

1. Understanding of the user's actions in context;
2. Selecting a behavioural target (where to intervene);
3. Selecting (or applying) a behavioural intervention strategy;
4. Evaluating the behavioural interventions.

To illustrate the development of theory and application of practice, we draw on two large UK Government funded research projects; Carbon, Control and Comfort (CCC)[1] and Low Effort Energy Demand Reduction (LEEDR)[2]. Within both projects, the design researchers at Loughborough University contributed to user research to identify behavioural determinants, as well as carrying out the designing

[1] The CCC project was an interdisciplinary project carried out within the UK social housing sector which aimed to reduce domestic energy use by 20% through the user-centred design of feedback interventions to change behaviour.
[2] The LEEDR project took an interdisciplinary approach to investigate energy and digital media use within privately owned homes in the UK with the aim of developing ICT based interventions to help householders reduce their energy demand.

and evaluation of behaviour change interventions. The chapter closes by reflecting on what we have learned and where we see further developments in the field emerging.

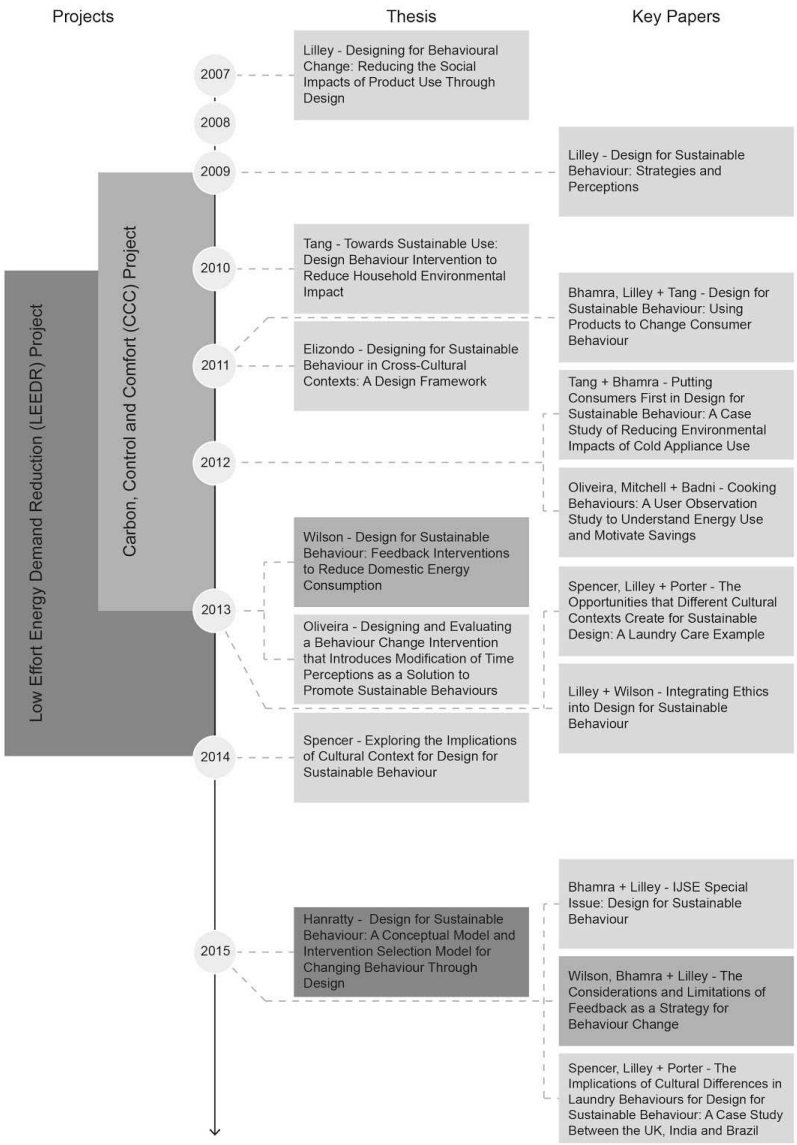

Figure 5.1 Overview of DfSB research at Loughborough University

1. Understanding of the user's actions in context

Understanding user behaviour is regarded throughout the DfSB literature as a fundamental precursor to the application of behaviour changing strategies (Tang and Bhamra, 2008, 2012). Over a number of years, researchers at Loughborough University have integrated and assimilated different behavioural psychology models into DfSB to account for the extremely complex, and often quite individualistic, social and psychological structures (Chatterton, 2011) and multiple behavioural drivers which inform users'

actions. The following section exemplifies two such endeavours using the Theory of Interpersonal Behaviour and Goal Framing.

To investigate thermal comfort in social housing to effect a reduction in CO2 emissions from heating provision, Wilson (2010, 2013), used the Theory of Interpersonal Behaviour (TIB) (Darnton, 2008). TIB was explicitly selected due to its integrative nature (combining theory from other notable behavioural psychology models) and inclusion of habits, which intercede between intention and behaviour acting as a key determinant of the actual enactment of intention. Prior domestic energy consumption studies have highlighted habits as dominant influencing factors (Steg and Vlek, 2009) and thus, their inclusion was considered essential.

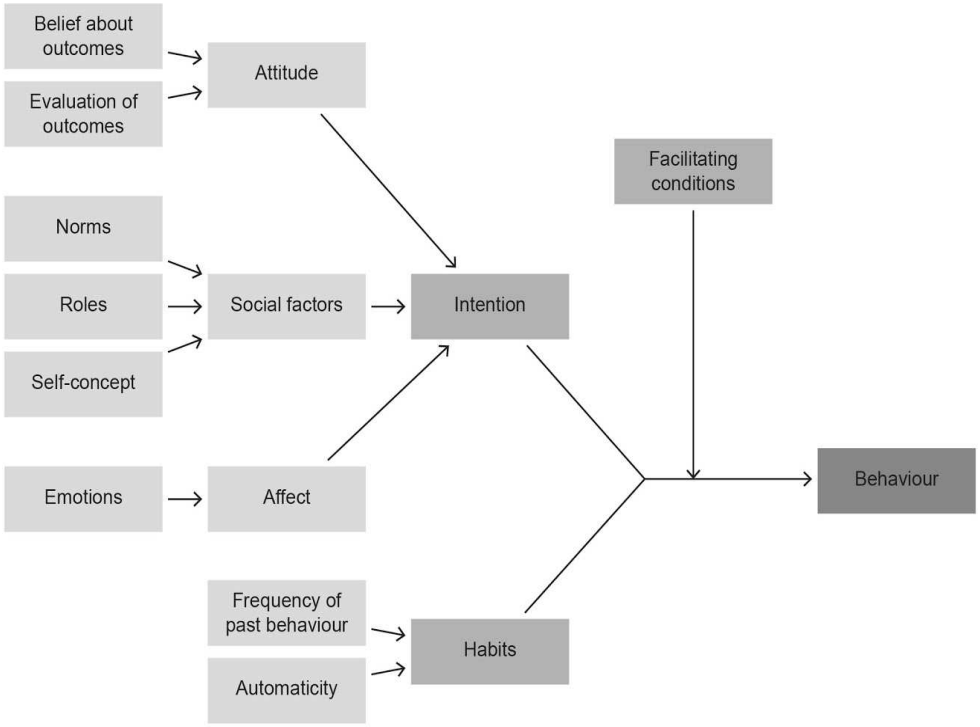

Figure 5.2 An augmented Theory of Interpersonal Behaviour (TIB) Model[3]

TIB posits that the individual is central to a rational decision-making process, with behavioural action influenced by internal and external prompts that interact with the intentions (attitudes, social factors and emotions), habits and facilitating conditions unique to the individual and their context (Jackson, 2005, Chatterton, 2011). Within this model, intention is an antecedent to behaviour, with habits interceding as a key determinant to action. Habits form a routinized action where an achieved goal is satisfactory and repeatable, leading to a reduced perception of alternatives - a form of cognitive short cutting resulting in automaticity. Habits are, therefore, not just identified and assessed by repetition of

[3] The original model was modified by Wilson to include consideration of automaticity as well as frequency of habits.

action, but also by the cognitive processes that develop through frequency and association of the facilitating conditions and intentional factors (Polites, 2005, Lally et al., 2009, Steg and Vlek, 2009). Both intention and habit are in turn ruled by the facilitating or constraining conditions, the external factors that enable or constrain behaviour (Jackson, 2005, Chatterton, 2011). Thus the original TIB model was modified to include consideration of automaticity as well as frequency of habits (Figure 5.2).

From a psychological perspective, factors that lead to forming intentions are considered to have a direct and profound influence on behavioural action and domestic energy consumption, and may be mitigated by habitual actions, such as regularly opening windows in the pursuit of fresh air. Bluyssen (2009, 2010) and Nicol and Humphreys (2002), state that air quality and thermal comfort control is determined by several physical parameters, such as air pollution or temperature with prompt change manifest through levels of unacceptable discomfort, which facilitates corrective action. The intention to act is prompted, considered and acted upon; dependent upon the facilitating conditions. Can the window be opened or closed? Can the thermostat be turned up or down? An example of this is closing the window when feeling chilly. Wilson's (2013) thermal comfort research illustrated that habitual response is also present within the pursuit of fresh air, and furthermore, is a powerful influence towards action. The propensity and vigour of the pursuit for fresh air within their study sample illustrated many of the prerequisite conditions for habitual action. Self-reported actions in both pre and post intervention studies illustrated that regardless of the indoor air quality and weather, windows were routinely opened, often without consideration for the heating system (Wilson, 2013). Can we still assume then that intentions are always considered and acted upon?

Frequency of past behaviour and high levels of automaticity was also evident within Wilson et al.'s study; actions were performed regardless of the external weather conditions and time of year when opening windows, although closing windows remained ruled by discomfort prompts rather than habitual behaviour (Wilson, 2013). Interestingly, this view of fresh air and airing out as being habitual has also been discussed by Hauge (2010), supporting a wider ritualised perspective of fresh air. In addition, an interesting comment from one of their participants encapsulated a notion of social and national identity, which has over time become automated: "*We've always been told us Welsh you've got to open your windows every morning...to air the house…my mother always used to do it...and my grandmother...*" (Wilson et al., 2013). The wider ramifications for behavioural theory are that an intention to act may be prompted and acted upon, such as the social norm of being a Welsh mother or the weighting of values towards comfort, however, cognitive process over time becomes automated with actions performed without consideration of alternatives; dependent upon the facilitating conditions, such as time of day or knowledge of heating system control. Intentions may not always be considered and acted upon, but by understanding the behaviour and its antecedents, appropriate intervention strategies can be selected.

Goal Framing

Goal Framing theory (Lindenberg and Steg, 2007) identifies why people are doing what they are doing based on the prioritisation of three goal frames: Gain, to guard and improve one's resources; Hedonic, to improve the way one feels right now; Normative, to act appropriately for the group. These high level goals can be disaggregated into seven related sub-goals (Barbopoulos, 2012). Hanratty (2015), applied

Goal Framing Theory as the theoretical basis for understanding behavioural motivation behind showering.

Table 5.1 Seven sub-goals (Barbopoulos, 2012)

Goal Frame	Sub Goal	Motive
Gain	Value for money	To get value for money, pay a reasonable price, avoid wasting money
Gain	Quality	To get something of high quality and reliability, meeting one's highest expectations
Gain and Hedonic	Safety	To feel safe, calm and prepared for the unforeseen
Hedonic	Stimulation	To get something exciting, stimulating or unique, avoiding dullness
Hedonic	Convenience	To get something pleasant and comfortable, avoiding hassle and discomfort
Normative	Social Acceptance	Acceptance To make a good impression, identifying with peers, conforming to expectations
Normative	Ethics	To act according to moral principles and obligations, avoiding guilt

The Enuf shower concept, developed as part of the LEEDR project, "is an automatic persuasive shower monitoring device" which uses feedback and behavioural prompts to encourage users to reduce showering times (Hanratty, 2015, p. 148).

To inform DfSB intervention development qualitative data was gathered from eleven participating households, located within the East Midlands, on their showering routines using ethnographic video tours. Concurrently, quantitative data on water consumption was also captured via data logging. The frequency of showering was driven by 'normative goal frames' in relation to perceived social standards of hygiene, whereas 'hedonic goal framing' (e.g. comfort, pleasure and privacy) could be detected in relation to the duration of the shower. The final goal frame – 'gain' - was observed in participants who wished to minimise showering time to maximise productive time spent on other tasks.

Through comparing these theoretical approaches across the two case studies, it becomes clear that whilst the Theory of Interpersonal Behaviour enables a rich understanding of existing behaviour it is limited in its predictive capacity. Whilst Goal Framing theory does not attempt to capture the origins or nature of the underlying knowledge, attitudes and beliefs of the individual, it does isolate potentially

powerful active user goals frames which can be leveraged through behavioural interventions, thus offering a more practical framework to guide design practice.

2. Selecting a behavioural target

One of the earliest contributions to the DfSB field from Loughborough University was that of Lilley (2007) who unified three behavioural change strategies; feedback, steering and persuasion, into a coherent framework for Industrial Designers and originated the 'axis of influence'. The axis - a continuum that illustrates power in decision-making - places the user at one end and the product diametrically positioned at the other. The aforementioned strategies are then arranged along this spectrum denoting their relative behavioural 'control' (Lilley, 2007, 2009). Whilst the classification and categorisation of DfSB strategies has subsequently been expanded and refined over a number of years both within (e.g. Lilley, 2009; Tang, 2011; Tang and Bhamra (2011) and outside of Loughborough University (e.g. Wever et al. (2008); ; Elias Elias (2011); Lidman et al. (2011); Lockton and Harrison (2012); and Zachrisson and Boks (2012)) the axis remains a constant anchor.

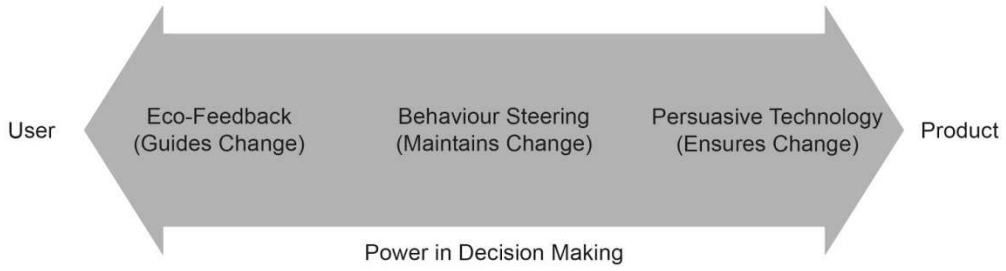

Figure 5.3 Axis of Influence (Lilley, 2007)

For the purposes of explaining and exemplifying the behaviour change approaches which can be applied in (sustainable) product design, descriptions of each of the strategies in Figure 5.3 is presented below, accompanied by an example drawn from the two aforementioned research projects.

Feedback

Feedback is an example of a consequence intervention; a performance indicator that focusses on the positive and negative costs of an enacted behaviour. Employed as a user-agentive tool, feedback can be used to link a specific interaction with a specific product to a specific cost, increasing the user's understanding of how the product works and increasing the user's consciousness of their own behaviour (Fischer, 2008, Darby, 2010). Information provided after an event can assist the user towards reflecting upon their behaviour and its cost – commonly conceptualised as a cognitive bridge between action and effect. Through this process of evaluation the antecedal structure underlying the decision making process may be challenged, resulting in an influence of behaviour (Abrahamse et al., 2005, Burgess and Nye, 2008). The principles of feedback were operationalised within the design of a feedback

intervention prototype as part of the CCC project. The aim of this device was to reduce domestic energy consumption whilst maintaining inhabitant defined comfort levels.

Returning back to the example of fresh air pursuit, one of the concepts prototyped as part of the CCC project, the Radiator Light concept, focussed on illustrating the consequences of this conflicting use of heating and windows (Wilson et al., 2013). By framing contradictory actions (such as the window being open at the same time as the heating system being active), the intention was that the user would become more aware of the problem of 'waste' energy consumption created by their behaviour, whilst also increasing their knowledge of the products and environment over which they had control over, thereby challenging, through real-time feedback, their established routines. As the radiator surface temperature increased, a light affixed to the front of the radiator would glow white (25-43˚C), changing to orange at an increased temperature (over 43˚C), (Figure 5.4). If a window was opened at the same time as the heating system being active, the light would change to red as a warning. When the light on the radiator changed between statuses, the prototype would also generate a clicking sound to alert the user of the change. If a window was opened without the heating system being active, no light would be provided as there would be no conflict on which to provide information. The user at all stages maintained control over their decision making and actions.

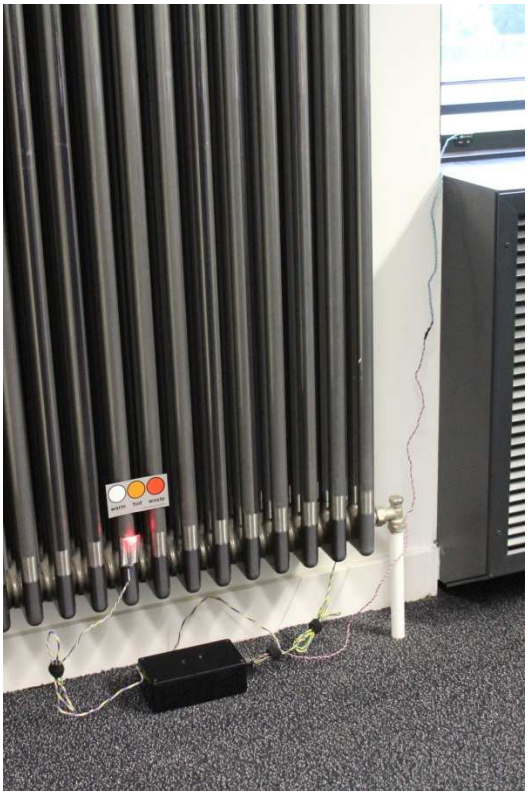

Figure 5.4 The radiator lights (feedback) attached to the radiator and window

Steering

In the centre of the axis is behaviour-steering an approach based on Jelsma and Knot's (2002) definition of scripts but expanded to include Norman's (1988) notion of affordance. Behaviour 'steers' or 'scripts', when embedded in the aesthetic or function of a product, can direct user behaviour in ways prescribed by the designer (Jelsma and Knot, 2002). Through the inscription of affordances and constraints, designers can encourage desirable behaviours whilst blocking undesirable ones (Jelsma and Knot, 2002). The EvokLamp, described below, offers a tangible example of how steering can be used within product design to target and influence behaviour.

The extent to which light has been used to create, and is synonymous with, comfortable environments is evident in the proliferation of electric fires in the UK that generate artificial light in the style of a pastiche coal fire (although the heating function of these appliances is rarely actually used) (Wilson, 2013). Coal fires visually bring to mind gratifying warmth and emotion-laden memories as the light is synonymous with the heat it produces. Developed as part of the Carbon Control and Comfort project mentioned previously, the Evoklamp is a rewarding side lamp that offsets a fluctuating ambient room temperature with inverse lighting. As the thermostat temperature is decreased by the occupant, the ideal state from an energy conservation perspective, the Evoklamp rewards the occupant with a warmer yellow/orange hued light. Conversely, if the occupant increases the room temperature via the thermostat then the lamp responds by emitting a colder blue light; penalising the user for their actions (Figure 5.5). As a safety feature, should the occupant drop the room temperature below a healthy level, the lamp glows a dim white to encourage the occupant to increase the temperature.

Figure 5.5 The Evoklamp (steering) in a hot room

Persuasive technology augments and expands Fogg's (2003) theory of captology (a synthesis of computer products and persuasive techniques) to incorporate coercive strategies to ensure change, such as intelligent context aware technologies and ubiquitous computing which negate the user's decision making processes (Lilley, 2007, 2009). The application of a persuasive technology approach can best be explained through the example of HeatMe.

Home heating is a complex behaviour which, when viewed in the context of rising UK C02 emissions, constitutes a significant sustainability challenge. Reducing the thermostat setting by 1-degree can save 310kg – 360kg carbon dioxide emissions a year (Energy Saving Trust, 2015), motivating a reduction in temperature therefore represents an important target for behavioural intervention. UK households with multiple occupancy are on the rise, with an increasing trend towards multi-generational living; several generations of a family living under the same roof. What has traditionally been considered the 'user', an individual citizen or the consideration of a family as a single unit with homogeneous needs, values and actions, has been shown to no longer apply, especially within the context of home heating. Occupants have different heating needs and get used to a certain level of heat. Also, there are times when people just want more warmth and, as a result, thermostats often get turned up and left there. Heat Me, designed as part of the LEEDR project (Hanratty, 2015) is an interactive app which seeks to persuade occupants to turn the thermostat down to 18˚C over a period of time. To avoid a sudden, jarring change in thermal comfort (often attributed to a relapse in temperature reduction) HeatMe features an 'Acclimatiser' which automates a gradual rate of reduction at less than 1˚C a week (Figure 5.6).

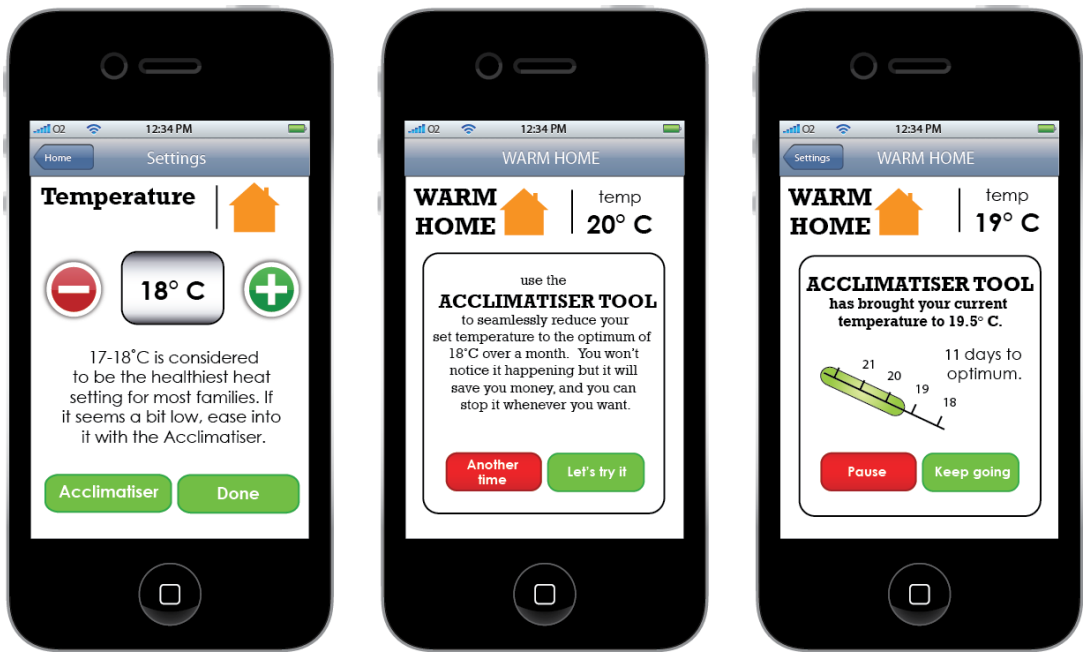

Figure 5.6 Temperature setting and Acclimatiser screen flow (Hanratty, 2015)

Increases to the baseline temperature is discouraged by in-built friction to the adjustment of the settings, however, HeatMe also acknowledges the desire for periodic 'heat boosts' and thus makes it relatively easy for users to raise the temperature (i.e. 21˚C) for limited periods (Figure 5.7).

Figure 5.7 Boost screen flows with Heat Me prompts (Hanratty, 2015)

3. Selecting a behavioural intervention strategy

"One of the commonly agreed upon research challenges in design for sustainable behaviour research is to overcome the lack of understanding of when to apply what type of behaviour-changing strategies." (Boks, 2012). Through combining the research of Lilley, Wilson and Hanratty, key selection criteria have been established for guiding the designer.

Lilley (2009) suggests that interventions should be designed using multiple strategies ascending the axis of influence from 'informative' to 'persuasive' in a sequential manner, in response to three variables; the user's level of compliance; the gravity of the consequences of actions taken; and the context in which the interaction takes place. The user's level of compliance is a function of their previous responses to behavioural intervention. For example, if an informative strategy, such as feedback, has been ignored, a behaviour steering approach may be adopted, whereas the gravity of the consequences is calculated by evaluating and weighting predicted outcomes against socio-economic and environmental concerns (Lilley and Wilson, 2013). Hanratty (2015) points to a relationship between the context of the interaction, the relative level of reflectiveness or situationality of user's thoughts and actions and the impact of the resulting behaviour in the Behaviour Intervention Selection Axis (BISA) tool.

When dealing with highly situational behaviours, which are driven by context with little cognitive thought, designers are directed to employ determining strategies with a high level of obtrusiveness to disrupt and intervene in routinized thought processes and direct behaviour. Conversely, highly reflective behaviours require only low levels of obtrusiveness and an informative strategy (such as feedback) would suffice. Through aligning the concepts of situationality and reflectiveness to the

strategies represented on the axis of influence (Figure 5.3), designers can select the required level of obtrusiveness.

Using *HeatMe* as an example, it is possible to see how the BISA could be applied in practice to inform strategy selection. The ethnographic research conducted within the family homes within the UK as part of the aforementioned LEEDR project to investigate domestic heating behaviours revealed the activation of all three goal frames; Hedonic Goal Framing in relation to comfort, Gain referring to cost and Normative in relation to the health of the children within the household. Interestingly, the latter goal frame dominated the other two in some cases where parents had prioritised their children's health. To respond to these goal frames in relation to the most prominent home heating behaviours, Hanratty (Hanratty, 2015) placed them on the axis of influence corresponding to different levels of intervention (Figure 5.8).

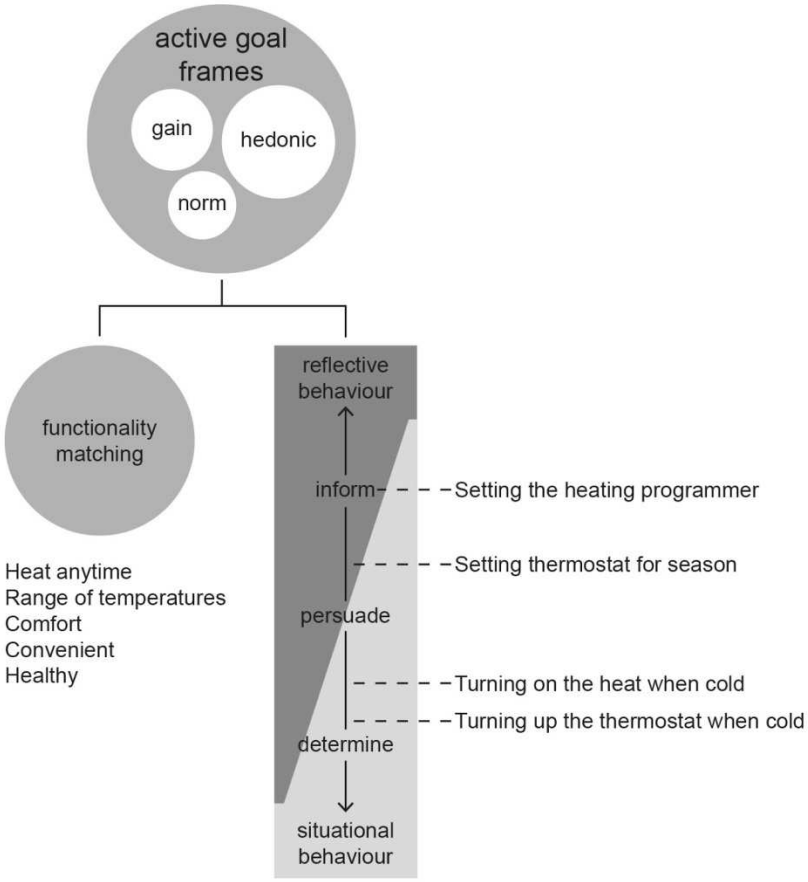

Figure 5.8 Illustration of the BISA showing motivational and behavioural aspects of heating practices (Hanratty, 2015)

As seen in Figure 5.8, setting the heating programmer is a highly reflective behaviour requiring information, whereas to influence users who turn the thermostat up when cold, a behaviour with a greater level of situationality, an intervention on the determining end of the spectrum (such as Persuasive Technology) would be advisable.

A further dimension, or approach, which could be taken into account when selecting a DfSB strategy, is the more macro-level consideration of culture (Elizondo, 2011; Spencer, 2014). Through his exploration of laundry practices in three different contexts; Brazil, India and the UK, Spencer identified a range of culturally significant and culturally independent factors. The former being influencing factors which were common amongst the samples in their respective regions such as: the external environment, other people, consumption, tools, and inputs. The latter referring to factors which were different between individuals such as; perceptions, aspirations, senses, views and income (Spencer, 2014; Spencer et al 2013; 2015). Through a better understanding of behavioural influences at different levels; individual and collective, designers can build empathy with users in different contexts and better target interventions to reach wider constituent users.

4. Evaluating the behavioural interventions

Given the speed and momentum with which the field of Design for Behavioural Change is growing, it is surprising how little attention has been given to the evaluation of behaviour changing interventions. Both the lack of any serious longitudinal studies combined with the fractured nature of research (particularly across European academic institutions such as Delft University of Technology, the Norwegian University of Science and Technology, and Chalmers University of Technology), has diverted attention almost exclusively towards the selection of strategies rather than towards the development of a unified framework for evaluation. Loughborough University, and in particular research conducted as part of the CCC project, has made steps towards the development of evaluation criteria suitable for cross-study comparisons, disaggregating the evaluation of a behaviour changing intervention into three components (Wilson et al., 2013, Wilson, 2013). These three components, framed in terms of a sustainability challenge, are: 1. *'Does the behaviour change intervention function for the context?'* (questions change depending on the behaviour change strategy employed); 2. *'Is the change in behaviour sustainable against the three pillars of sustainability, namely economic prosperity, environmental quality, and social equality?'* (Bhamra and Lofthouse, 2007), (these questions are relevant to the intervention context); and 3. Finally, an evaluation of the actual change in behaviour is sought by asking *'has the user's behaviour changed as a consequence of the behavioural intervention?'* (relevant to all behaviour changing strategies, regardless of context or strategy) (Wilson et al., 2013, Wilson, 2013). Using the example of the Radiator Light concept, referred to earlier in the chapter, the application of these evaluative components to a designed intervention can be illustrated through analysing the results of two in-home installations of the prototype device (Wilson et al, 2013).

Considering the first of these core components, *'does the behaviour change intervention function for the context?'* it is interesting to note that the evaluation criteria applicable changes depending upon the intervention strategy selected. To illustrate, if one was to consider the evaluation of a feedback intervention then one would have to evaluate whether the metric in which information was provided

was appropriate and as intended by the designer (Wilson et al., 2015). Feedback interventions, reliant on the provision of information to the user, would need to be assessed based on this functionality. Likewise a behaviour steering intervention would be evaluated on functions related to interaction expectations, such as design semiotics and affordances; and forcing or persuasive strategies would be evaluated based, for example, on installation factors and the maintenance of the intervention technology. Although present in most interventions, these specific evaluative factors in relation to these strategies are considered the most relevant due to their primary influence in determining behavioural outcomes.

The evaluation of the Radiator Light concept illustrated that through the provision of rapid, accurate and frequent information, the participants could instantaneously see any effect that their actions had on the heating system, either intentionally or unintentionally; this encouraged a period of investigation and optimisation. This demonstrates that the device *did* function as intended by the designer within the context use.

The second component, *'is the change in behaviour sustainable?'* is dependent upon the intervention context. Taking an example from the CCC project and applying it to the three pillars of sustainability, one could argue that the Radiator Light's goal was to reduce the amount of CO2 generated through a reduction in domestic energy consumption (an environmental issue), whilst ensuring that tenant comfort was maintained or increased (a social issue), in addition to reducing financial burden on the household (an economic issue). Interventions with different behaviour change goals and use contexts would clearly have different criteria against which to evaluate their sustainable impact (Wilson et al., 2013, Wilson, 2013).

Under the heading of social equality, one could also consider the ethical implications of the design and implementation of behaviour changing interventions, especially as there is no clear consensus on what is 'ethical'. Ethics has been defined as *"a rational, consistent system for determining right and wrong, usually in the context of specific actions or policies"* (Berdichevsky and Neuenschwander, 1999, p. 52). Literature reviewed refers to several approaches or systems of ethics. Following DeVries (2006) we advocate a *consequentialist* approach in which the designer *"looks to the future and considers how to act in order to reach a situation of the best consequences' for our decisions"*. The focus of this approach is to investigate the potential effects of our actions. The outcomes of these predictions are then assessed against certain values (DeVries, 2006).

Alongside the development of strategy selection methods, researchers at Loughborough University have been actively considering how designers may take account of ethical issues inherent in influencing behaviour within their practice. To this end, several tools have been developed to support novice designers (Lofthouse and Lilley, 2006, Lilley and Wilson, 2013). The following questions, for example, can be used to evaluate the ethics of the user's changed behaviour, as well as the ethics of the process through which the design intervention was created. By asking a series of questions that integrate stakeholder perspectives, rather than a generic moral framework (that simply does not exist) decisions can be made in reference to relevant moral frameworks.

- Was the designer's original intent[4] for designing a behaviour intervention ethical? What change was the designer trying to achieve?
- Was the designer's original motivation for designing a behaviour intervention ethical? Why was the designer trying to achieve this change?
- Are the intervention methods employed by the designer, in order to change the user's behaviour, ethical?
- Has the designer/user/purchaser taken moral responsibility for the design intervention?
- To what extent is the user in control of the design intervention?
- Is the level of user control over the design intervention acceptably weighted against the intent and motivation of the designer?
- Have the democratic decision making rights of all stakeholders been accounted for in the design process?
- Have the values and morals of all stakeholders been accounted for in the design process?
- Have the values of the stakeholder been evaluated against a robust ethical framework?
- Are the intended outcomes of the design intervention ethical?
- Have unintended interactions between the user and the design intervention been predicted and are ethical?
- Have unintended use contexts involving the user and the design intervention been predicted and are ethical?

In light of the absence of quantitative energy consumption data, it was not possible to conclusively attribute a reduction in environmental impacts related to energy consumption. However, the qualitative responses indicated a heightened awareness of the relationship between window opening, heat loss and (dis)comfort. Thus, the impetus to conserve energy was activated. Additionally, social benefit was derived, in the form of increased well-being, from the reduction in need to 'test' the radiator temperature by touching the surface.

The third component is to understand whether there has actually been a change in the user's behaviour, in other words, *'has the user's behaviour changed as a consequence of the behavioural intervention?'* By extension, has there been a change in the antecedent structure and habitual strength of the behaviour that has been targeted for change, depending upon the conceptualisation of human action used within the study itself as a rational, decision making process from a psychological perspective (Jackson, 2005, Chatterton, 2011), or as a more dynamic conceptualisation of human agency within a nexus of social activities and frameworks (Pettersen, 2013, Kuijer, 2014); a social practice theory perspective)? Considering the augmented Theory of Interpersonal Behaviour, as presented in Figure 5.2, relevant questions would relate to the underpinning cognitive structure of the user, both the user's intentions and degree of cognitive automaticity and repetition, and the facilitating conditions of the context of operation (Wilson et al., 2013, Wilson, 2013).

[4] For a more nuanced discussion of the difference between 'intent' and 'motivation' read Berdichevsky and Neuenschwander (1999).

The findings of the in-home evaluation of the Radiator Light revealed a perceptible change in knowledge and awareness, however, the action-awareness gap was not successfully breached, as the value weighting of consumption and comfort had not fundamentally changed, such as in the desire for fresh air.

The evaluation of this prototype, and that designed by Hanratty (2015) (e.g. *Enuf*) suggests that in order to evaluate a behavioural intervention's impact and its efficacy, it is imperative that data on existing behaviour (the baseline) and post-intervention behaviour is recorded. By establishing a baseline, not only can the interventions impact be meaningfully quantified and measured against a pre-intervention state, but the impact of external influences, such as a change in weather, government policy, or friendship groups, can be contextualised and understood. Such data may be recorded in a multitude of ways, using qualitative research techniques such as user observations (Tang and Bhamra, 2012) or, through quantitative measurement, such as the recording of energy or time usage (Oliveira et al., 2012, Oliveira, 2013). Preferably, a combination of qualitative and quantitative research techniques should be employed, such as in Hanratty (2015), who combined in-home ethnographic studies with the monitoring of domestic water and energy consumption data. Whilst quantitative data may be useful to quantify a change in a behavioural or impact metric empirically (such as number of actions repeated or a reduction in energy consumed), it fails to provide answers to the more subtle questions of how and why did the behaviour change and to what extent. By breaking down the components of an evaluation, the more common but rather limited approach to measuring behaviour change solely as a quantitative change in user action and consequence (such as energy consumption reduced by x%) can be avoided, and we can take a more three-dimensional view of the interventions impact, vital to an iterative design process.

Conclusions

As outlined in this chapter the work at Loughborough University has focussed on bringing clarity to the intervention strategies that can lead to behaviour change. The interventions developed using the three behaviour change strategies (Feedback, Steering and Persuasive Technology) have demonstrated that applying these within the design process can lead to more sustainable actions in a range of different contexts. Key to achieving this is the application of the Axis of Influence as part of understanding the context in which behaviour change is required. The particular context will mean that to be effective some interventions require the user to have more control whilst others will be more effective if the product or system is in control.

Recent developments around the selection of the strategy to be deployed have brought further clarity to this work. The Behaviour Intervention Selection Tool (BISA) has demonstrated an approach to enable designers to more easily select an appropriate DfSB strategy when developing interventions that takes into account situational behaviours within the particular context. This more detailed approach has the potential to overcome the limitations of existing DfSB approaches and result in interventions which are more successful in the long term.

It is clear however that without the effective evaluation of interventions their success cannot be judged fully. It is for this reason that a parallel research activity at Loughborough University has been to develop evaluation mechanisms for Design for Sustainable Behaviour interventions. The challenge for this research has been the time required to undertake rigorous longitudinal studies of intervention use in real world situations. However, with recent UK government research funding, these studies have been undertaken allowing the development of evaluation criteria and the start of a unified framework for the evaluation of DfSB interventions.

Overall DfSB has been shown through the research at Loughborough University, and beyond, to be effective in being able to develop interventions that begin to change user behaviour towards more sustainable actions. In addition the clear guidance that now exists though the axis of influence and the BISA tool enables more designers to apply these approaches in their work and ensure that in future Design for Sustainable Behaviour is part of a designer's tool kit.

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