Motivating Sustainable Goal Choices and Providing Effective Feedback

DOCTORAL THESIS

Michelle Grace Scott
INFORMATICS ENGINEERING - HUMAN COMPUTER INTERACTION

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Abstrato

O consumo excessivo de recursos naturais e os riscos ambientais associados são atualmente um dos problemas mundiais mais **prementes**. No mundo ocidental, o consumo doméstico e nos locais de trabalho é um dos principais responsáveis para o problema**.** Refletindo na importância de ações individuais neste domínio, esta tese concentra-se em estudar e influenciar as escolhas relativas à sustentabilidade e consumo de energia de indivíduos durantes as suas rotinas diárias. Este trabalho possui três componentes diferentes. Em primeiro lugar, a tese afirma que a escolha de objectivos para redução de consumo são frequentemente ineficazes, esta tese tenta compreender a justificação para essas más escolhas, usando a *goal setting theory,* um modelo teórico estabelecido para a mudança de comportamento. Em segundo lugar são apresentadas duas abordagens de forma a influenciar a escolha de objectivos para metas mais efetivas, uma das quais lida com mecanismo de condicionamento dos objectivos, outra explora como brinquedos cuidadosamente desenhados podem influenciar padrões de consumo das crianças a longo prazo. A seção final desta tese lida com o design de feedback para apoiar a realização de atividades ambientalmente saudáveis. As principais contribuições em torno dos objectivos incluem a constatação de que as pessoas escolhem objetivos fáceis apesar do feedback imediato quanto à sua ineficácia, e a discussão e estudo dos mecanismos condicionamento de objectivos que podem influenciar esse processo escolha. Contribuições dentro do design de brinquedos cuja função é promover valores sustentáveis, incluem uma framework teoricamente fundamentada para a concepção de tais brinquedos e um protótipo de um brinquedo concluído e testado. Finalmente, as contribuições no design de feedback eficaz e envolvente para o consumo de energia incluem a constatação de que o feedback negativo é melhor apresentado verbalmente quando comparado com representações visuais, esta observação é apresentada num sistema de feedback funcional. As discussões, conceitos, protótipos e resultados empíricos apresentados neste trabalho serão úteis tanto para psicólogos ambientais como para investigadores na área da interação humano computador e do eco-feedback.

Palavras-chave: Interação Humano-Computador; Sustentabilidade; Objectivos; Desenho aplicado a Valores; Desenho de Sistemas Interactivos; Eco-feedback.

Abstract

Overconsumption of natural resources and the associated environmental hazards are one of today's most pressing global issues. In the western world, individual consumption in homes and workplaces is a key contributor to this problem. Reflecting the importance of individual action in this domain, this thesis focuses on studying and influencing choices related to sustainability and energy consumption made by people in their daily lives. There are three main components to this work. Firstly, this thesis asserts that people frequently make ineffective consumption reduction goal choices and attempts to understand the rationale for these poor choices by fitting them to goal-setting theory, an established theoretical model of behavior change. Secondly, it presents two approaches that attempt to influence goal choice towards more effective targets, one of which deals with mechanisms for goal priming and the other of which explores the idea that carefully designed toys can exert influence on children's long term consumption behavior patterns. The final section of this thesis deals with the design of feedback to support the performance of environmentally sound activities. Key contributions surrounding goals include the finding that people choose easy sustainable goals despite immediate feedback as to their ineffectiveness and the discussion and study of goal priming mechanisms that can influence this choice process. Contributions within the design of value instilling toys include a theoretically grounded framework for the design of such toys and a completed and tested prototype toy. Finally, contributions in designing effective and engaging energy consumption feedback include the finding that negative feedback is best presented verbally compared with visually and this is exemplified and presented within a working feedback system. The discussions, concepts, prototypes and empirical findings presented in this work will be useful for both environmental psychologists and for HCI researchers studying eco-feedback.

Keywords: Human Computer Interaction; Sustainability; Goals; Value Sensitive Design; Design of Interactive Systems; Eco-Feedback.

Statement of Attribution

All of the work presented henceforth was conducted at Madeira Interactive Technologies Institute as part of the Sustainable Interaction with social Networks, context Awareness and Innovative Services (SINAIS) project at the University of Madeira, Portugal.

Sections of Chapter 3 have been published as one long paper (**Scott, M**., Barreto, M., Quintal, F. & Oakley, I. (2011). Understanding Goal Setting Behavior in the Context of Energy Consumption Reduction. *In Proceedings of INTERACT 2011*, 129-143). I was the lead investigator, responsible for concept formation, data collection and analysis and manuscript composition. M. Barreto contributed to the scenario method formation and manuscript edits. F. Quintal contributed to the development of the web interface for the online data collection and manuscript edits. I. Oakley was the supervisory author on this project and was involved throughout in concept formation and manuscript composition.

I was the lead investigator for the work completed in Chapter 4 where I was responsible for concept formation, data collection and analysis and manuscript composition. F. Quintal contributed to the development of the web interface for the online data collection. I. Oakley was the supervisory author on this project and was involved throughout in concept formation and manuscript edits.

Sections of Chapter 5 will be published in August 2013 as a short paper (Barreto, M., **Scott, M**., Oakley, I., Karapanos, E., Nunes, N., Gomes, J. and Gomes, S. (2013). Playing for the Planet: Designing Toys that Foster Sustainable Values. *To appear in proceedings of European Conference on Cognitive Ergonomics 2013,* Toulouse, France). I and M. Barreto were equally involved in all aspects of concept formation, analysis, prototype development and manuscript composition. M. Barreto conducted some sections of data collection exclusively in Portuguese with J. & S. Gomes. I. Oakley, N. Nunes and E. Karapanos were all supervisory authors on this project and were involved throughout with manuscript edits.

A version of the work conducted in Chapter 6 is under review at the journal Interacting with Computers with the title “Show me or Tell Me: Designing Avatars for

Feedback". I was lead investigator and was responsible for concept formation, data collection and analysis and manuscript composition. L. Pereira contributed to the development of the web interface for the online data collection and manuscript edits. I. Oakley was the supervisory author on this project and was involved throughout in concept formation and manuscript composition.

The feedback prototype developed in Chapter 6 was published as a demo (Gouveia, L., Pereira, L., **Scott, M**. & Oakley, I. (2012). Eco-Avatars: Visualising Disaggregated Home Energy Use. *In Proceedings of ACM DIS 2012*, Newcastle, UK). L. Gouveia contributed significantly to the programming aspects of the avatar feedback system assisted by L. Pereira. L. Pereira also contributed to manuscript edits. I was responsible for the concept formation of the prototype system and the experimental work that preceded it.

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Chapter 1

Introduction

Overconsumption of resources and environmental sustainability is a current global issue. Indeed, this problem of energy consumption and climate change is a growing concern for governments (United Nations Environment Programme, 2012). Ultimately the problem is human beings, particularly those in the western world, using resources far faster than they can be reproduced and generating pollutants faster than they biodegrade. People in developed countries use up to ten times more resources than those in developing countries. In addition, these developed countries benefit from the transfer of resources from poorer, lower consuming countries to richer, high-consuming countries (Friends of the Earth, 2009). Fossil fuel use contributes the most to carbon dioxide emissions. Consequently, environmental pollution, finite energy resources, uneven distribution of energy, CO2 emissions and climate change all result from the dependence on fossil fuels (Theis & Tomkin, 2012). One of the main drivers of climate change is the increase in greenhouse gas emissions, which have risen 70% between 1970 and 2004 due to human activities. In particular, carbon dioxide emissions have risen 80% between 1970 and 2004 and represent 77% of total greenhouse gas emissions (Intergovernmental Panel on Climate Change, 2007).

The ultimate impact of these changes is unclear, but includes predictions of hazardous climatic adjustments such as a rise in sea level, increased precipitation and the frequent occurrence of catastrophic storms (DARA, 2012). As a result, there have been interventions at the governmental level (Dolan et al, 2009) and many countries are currently implementing measures to reduce CO2 emissions. The Kyoto Protocol, which calls for the reduction of emissions came into force in 2005 and there are 193 parties (192 States and 1 regional economic integration organization) who have signed and ratified the treaty (United Nations Framework Convention on Climate Change, 2012).

Despite these political processes, resource consumption and its negative effects are problems that are growing and are not solely the responsibility of governments. The

problem lies with how humans behave as well as the technology we use. Individual involvement in resource consumption in homes and businesses accounts for 20% percent of overall use in the USA– up to 20 times greater than in the third world (US Dept of Energy, 2008). For example, in Europe, households accounted for 26.7% of energy and industry accounted for 25.3% of energy consumption in 2010 (European Commission, 2012). Resources cannot continue to be used at this rate without severely compromising our future. Accordingly, changing the way we behave is key to solving this problem (RAND Europe, 2012). The problem is that the issue of climate change is not in an individual's immediate self-interest to solve; therefore it is necessary to engage with values (Crompton & Kasser, 2009). It is important that humans work to reduce their carbon dioxide emissions and make an effort to behave in more sustainable ways to reduce the effects of climate change. Furthermore, authors have argued that psychological understandings are key in understanding why individuals engage in unsustainable consumption behaviours and in designing interventions to encourage more globally viable choices (Koger & Scott, 2007).

Therefore, the work in this thesis focuses on a psychological approach. One of the theories this work is based on is the well-established goal-setting theory, which states that certain types of goals are more effective than others and that feedback is required for goals to be effective (Locke & Latham, 2002). Understanding the types of sustainability goals people choose is necessary before those choices can be influenced. This thesis also focuses on goal priming as an attempt to influence more sustainable goal choices and psychological theories of development are also utilized in order to inform the design of toys that instill sustainable values. DiSalvo, Sengers and Brynjardóttir (2010) identified several genres of research within sustainability and Human Computer Interaction that share similar sources, problem formulation and ideas on how to solve sustainability problems. These genres were defined as: formative user studies, sustainable interaction design, persuasive technology, pervasive and participatory sensing and ambient awareness. The different types of work in this thesis fit into all of these genres apart from the genre of ambient awareness.

Thesis Aims

The overarching aim of this work is to promote environmentally sustainable consumption behaviours in the home by understanding and influencing everyday choices and providing feedback on these behaviours. One of the main ways this is accomplished is utilizing psychological theories to serve as a framework of understanding and influencing behaviour. The overall work in this thesis is broken down into three main stages: firstly the aim is to understand the choices people make regarding their energy consumption, secondly to explore ways to influence these choices to be pro-environmental and finally to provide effective feedback via visualisations towards the accomplishment of these choices. The following paragraphs consist of a description of the three stages of work in more detail and the approach taken to answer the different research questions.

Understanding Choices

Goal Setting

The first aim of this work is to understand how and why people choose their consumption goals. Goal setting theory is a psychological framework, based on the idea that conscious goals affect action (Ryan, 1970) where a goal is the object or aim of an action. The theory states that different types of goals can affect motivation and performance differently. Before attempting to change or influence consumption behaviours, it is necessary to understand what currently happens in the home regarding goal choices. Two of the most important aspects of goal setting theory are challenge and clarity. It has been shown that difficult goals produce the highest effort and performance and specific difficult goals are more effective than vague goals (Becker, 1978; Locke & Latham, 2002). This is because vague goals, such as 'do your best' have no external reference and allow for a wide range of acceptable performance levels. When performance is controllable, specificity reduces variability in performance by reducing ambiguity about what is expected. Setting goals and showing feedback together has been shown to have a greater impact on performance than just setting goals alone (Locke & Latham, 2002). This framework for understanding goal choice and motivation is applied to the domain of energy

consumption reduction in this thesis. Questions regarding how people select appropriate goals remain, partly due to an undeveloped understanding of the basis with which users select goals in this domain (Attari et al, 2010). This gave rise to the main question in this work: what types of goals do people choose for themselves when given different options and feedback?

Chapter 3 presents a short review of relevant goal setting literature and the application of this literature to previous work in energy consumption. It then presents results from a questionnaire that measured what people know and what they have misconceptions about regarding energy saving actions. Two studies follow this work that explore how people typically select goals. The first study explores how people choose goals by presenting different home scenarios and asking people to choose goals for the household presented in the scenarios. The goals vary in difficulty level (easy/hard) and in context (contextual/non-contextual). The second study extends the first by using the same scenarios, however this time goals are split into difficulty level (easy/hard) and specificity (vague/specific). The aim of these studies is to understand the preferences people have towards different types of goals. Results from these studies show that people have a preference for easy goals even when they are shown feedback that suggests they are ineffective goals.

Influencing Goals

Influencing - Priming

The second main aim of this work is to investigate mechanisms that influence the types of sustainable goals people choose. The earlier chapter on goal setting work shows that people make poor or ineffective goal choices, therefore this is an area where behaviour can be affected in a positive way by influencing the types of goals people choose. Exposing people to sights, sounds or actions has been shown to have an effect on subsequent behaviour and this effect is known as priming. It has been shown that priming of semantic concepts increases their accessibility, facilitating processing of related constructs (Neely, 1977). For example, after reading the word "lamp", people are faster at reading the word "light" compared to no priming (McNamara and Healy, 1988). Priming behaviours has also been shown to increase the likelihood that the individual will perform the primed behaviour. This has been

shown through imitation of primed behaviours (Chartrand & Bargh, 1999; Lakin & Chartrand, 2003). Aarts, Gollwitzer, and Hassin (2004) argue that people may not only automatically imitate behaviours but also may adopt and pursue a goal that is implied by another person's behaviour. In their study, participants who were presented with behavioural descriptions implying a certain goal initiated the behaviour without being aware of the influence of the description. The key assumption of this previous work is that goals can be activated subconsciously to affect outcomes.

Recently priming has been studied along with goal setting theory in the area of energy consumption to study whether priming environmental goals leads to greater energy savings. Supraliminal priming involves consciously providing participants with information in a way that appears to have no relation to the experimental task that follows. Using pictures to show behaviours is one method of supraliminal priming that has been successfully utilised to encourage energy saving in a study by McCalley et al (2006). Chapter 4 extends this work by using photographic primes in an attempt to see whether people can be influenced to choose more effective goals. The experimental method is similar to the scenario method described in Chapter 3. The goals used are all specific goals and they again vary in difficulty level (easy/difficult). Pictorial primes are used that show easy and difficult energy saving actions. There are three conditions: easy action primes, difficult action primes and no primes. Difficult primes are expected to increase difficult goal choices. The aim of this work is to elaborate on a method of influencing people to choose more effective energy saving goals in the home.

Influencing - Values

In this section of the work the focus is on values rather than on goals. Chapter 5 argues that children are a key audience to influence; at a young age children form attitudes that can be carried forward throughout their lives. The issues of climate change and global warming will arguably be a larger issue for the next generation compared to this one. Therefore, it is key to educate young people in positive environmental behaviours. Chapter 5 works to accomplish this by using Piaget's (1977) cognitive developmental theory and Kolhberg's moral development theory (Kohlberg & Hersh, 1977) to inform the design of toys to instill sustainable values.

Specifically, Piaget's concrete operational stage processes, which occur between the ages of seven and eleven years old, are the developmental target age group for this work.

To achieve these objectives, the focus is on toys and play that is essential to healthy development and learning across all ages and cultures (Isenberg & Quisenberry, 2002). Toys help children develop their basic motor or cognitive skills but also can pass on cultural knowledge or values (Goldstein, 1994) either directly, such as through educational or religious toys or indirectly such as through Barbie dolls. Although there are clear criteria for designing educational toys (Hinske, Langheinrich & Lampe, 2008), there are no clear criteria for designing toys that instill sustainable values. The main aim of this work is to present a design framework that brings the value-centric nature of toys to the forefront. This is accomplished via a value sensitive design process where values regarding sustainability are captured from all the relevant stakeholders (children, parents, educators and designers). In order for the toy to be engaging and playful, guidelines for the design of toys are also considered giving this work a multidisciplinary approach. The second aim is to design a prototype toy that stimulates moral development and encourages the development of values, with a focus on values relating to environmental sustainability. A prototype toy is designed, created and iteratively tested with children from ages 8-9.

Effective Feedback

Goal setting theory states that in order for goals to be effective, feedback must be presented. Previous work has shown feedback to reduce household energy consumption by 5 to 20 percent (Vine, Buys & Morris, 2013). The final main aim of this thesis is the design and implementation of effective energy consumption feedback. Previous work has shown that people lose interest in numerical home energy displays after around four weeks (Nunes et al, 2011). This type of numerical feedback, although promoted heavily (Dept of Energy and Climate Change, 2013) has not been shown to encourage pro-environmental behaviours in the long term. It has been argued (Fogg, 2003) that computers can effectively persuade users in tasks such as purchasing decisions (Dormann, 2000), diet management (Lee, Kiesler, & Forlizzi, 2011) and energy consumption (Kimura & Nakajima, 2010). Fogg identifies personification technologies, typically appearing as virtual pets or avatars, as one

form of persuasive tool (Benyon & Mival, 2008). Such systems emphasize anthropomorphism – users can associate emotions with digitally presented characters and may ultimately develop powerful affective connections to them. Previous work using virtual pets as a way of providing feedback, such as a polar bear on a shrinking ice cap (Dillahunt et al, 2008) have shown to increase emotional attachment and environmentally responsible behaviours. This tendency for people to attach emotions to virtual representations can be utilized to increase the long-term appeal of energy consumption feedback.

Avatars are also reported to be both expressive and engaging and have the potential to attract sustained long-term interest (Fabri et al, 2002). They have been utilised in persuasive scenarios in a range of domains including health (Lin et al, 2006), energy consumption (Mahmud et al, 2007; Dillahunt et al, 2008) and education (Baker, Wentz & Woods, 2009). Websites including pictures of people and virtual agents have been shown to increase trust in e-commerce (Head, Hassanein & Cho, 2003). This idea can be extended to use an avatar representation of a person in an energy feedback system in order to induce intrinsic motivation and engage users over the long-term. Chapter 6 presents two studies focusing on the difference between visual and verbal feedback from the avatars. The first aim of these two studies is to shed light on how avatars should present positive and negative feedback. The final aim is to design a working system that implements the findings from the studies to present feedback via avatars from sensed appliance-level energy consumption in the home. This type of system could engage in the long term and lead to long term positive changes in environmental behaviours. Including an engaging interactive element has been recommended as an effective way of presenting feedback (Fischer, 2007). Therefore this work combines energy appliance consumption data with an interactive avatar showing continuous feedback as a novel way of following this recommendation. This work also argues that avatars can be more effective persuaders by adopting more powerful and evocative communication channels.

Contributions

The contributions of this thesis are split into the three main areas of work. There is some overlap since goal setting theory and feedback are closely related.

Understanding

This work makes two main novel contributions. Firstly, data is reported showing that in the context of an interactive interface, energy saving goal choices fit the predictions derived from the theoretical model of goal setting theory. This domain specific validation of the theory will help generate effective new techniques for accurate, real-time capture of consumption activity and the development of advanced systems and interfaces for processing, storing and presenting this material. The second contribution states that users have a poor understanding of how to set effective goals that result in significant changes to consumption levels. Goal setting theory would predict that people tend to choose easy goals over hard goals regardless of feedback showing the easier choices are ineffective, and this is what was found in this work. An interpretive analysis is performed on these data and a candidate explanation is presented as to why people choose goals even when they know them to be ineffective. These findings have implications for the design of interactive systems since goal-setting theory posits that difficult goals are more effective motivators than easier goals. In this way, this work contributes to the understanding of how people make sustainable goal choices, work that has direct application to the domain of HCI and sustainability.

Influencing - Priming

Following on from understanding that people make poor choices in this area, Chapter 4 attempts to show how to influence people to make more positive choices. Goal priming is utilised to influence the choice of more effective and difficult environmental goals, with the expectation that being primed with difficult pictorial actions would increase the amount of difficult goals chosen. However, that was not the pattern of results found in this study. Participants who did not see any primes chose difficult goals more often than those who saw difficult primes. Participants in the difficult priming condition chose easy goals more often than those in the other two conditions. The main contribution of this work is that these findings support previous work that shows that social or goal priming is more complex than perceptual priming and requires salience and attention to be effective. Further work is suggested in this area, to find out whether goal priming may be more effective at encouraging difficult

goal choices presented over the long term, to people who already have an overall goal of saving energy.

Influencing - Values

The second part of this section regarding influence is shown through the application of developmental theory to the design of toys that instill sustainable values. It is important to educate and influence the next generation as well as this one about the global problem of climate change and pro-environmental behaviours. Chapter 5 makes four contributions in this space. Firstly, it presents a set of values relating to sustainability gathered from the researchers, children, parents and educators. Secondly it provides a theoretically grounded framework for value conveyance that encompasses both developmental theory and a value sensitive design process related to play. It is important to take into account the age and developmental stage of the child as well as established toy design guidelines when designing toys that instil values. Thirdly, a prototype of a toy using sustainability as a value is designed and integrated into the developmental needs of the chosen age group. The prototype is based on the value of resource management and takes into account concepts in Piaget's concrete operational stage of development as well as design guidelines for play. Finally the prototype is tested to see whether it encourages moral development among children.

Feedback

Goals require feedback in order to be effective; the final contribution in this work is the design and development of an appealing and engaging feedback system using avatars. This is split into three separate contributions in this work. Firstly, a set of domain neutral images and textual content providing positive and negative feedback intended for use in persuasive avatars is independently validated. Secondly, the results of an experiment indicating where and when to deploy each of these message modalities in order to maximize the effectiveness of a persuasive system are presented. These results showed that people prefer positive feedback to be presented visually via expressions, whereas negative feedback is better presented verbally since it is seen as less harsh. This is an important contribution for designers of persuasive feedback. Finally, these findings are used to construct a working system that senses

appliance level consumption and presents feedback about this consumption via avatars. This system could be deployed as an effective persuasive tool to reduce energy consumption in the home.

Thesis Organization

SINAIS Project

This thesis was completed within the context of a research project called Sustainable Interaction with Social Networks, Context Awareness and Innovative Services (SINAIS) and is situated in the field of Human-Computer Interaction (HCI). It is part of a broader work to reduce energy consumption in the home and while travelling. This thesis focuses specifically on the application of psychological theory to intentionally influence people's consumption behaviour. Within the SINAIS project, sensors monitoring energy consumption have been installed in 30 homes in Madeira, Portugal. These use a Non Intrusive Load Monitoring (NILM) technique (Nunes et al, 2011) to sense the consumption of individual appliances. One of the main contributions of this thesis is providing meaningful ways to portray the re-aggregation of this data to families in the home. This was accomplished by conducting lab studies that contribute to the design of systems that provide effective feedback. Allowing families to choose energy saving goals within the home, giving useful and timely feedback to families and making sure families know which are effective actions to take are all areas to which the work in this thesis will contribute.

This next chapter consists of background and relevant work related to the main theories and work covered in this thesis. The remainder of this thesis is structured around four main topic chapters. Chapter 3 describes work conducted in the area of goal setting and energy consumption reduction. The second two studies in Chapter 3 consist of work presented as a long paper at Interact 2011 on the topic of goal setting and understanding users' goal choices. Chapter 4 presents a study attempting to utilise goal priming to influence energy saving goal choices. Chapter 5 consists of work about harnessing the influence of the child in the home by contributing to the design of toys intended to instill sustainable values. Sections of this chapter have been accepted as a short paper at the conference Cognitive Ergonomics 2013. Chapter 6 is a paper under review for the "Interacting with Computers" journal on the topic of

designing persuasive energy consumption feedback using avatars. Finally Chapter 7 is a conclusion chapter where the work completed is reflected upon and suggestions for future work are given.

Chapter 2

Background and Related Work

SUSTAINABILITY

Sustainable development has been defined and often quoted as "…development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Bruntland, 1987). There are three main dimensions to sustainability, these are: social, economic and environment (Figure 1). Social aspects refer to interactions between people and institutions, such as government departments, human values, well-being, ethics and collective decision making. Economic issues include the flow of capital, commerce and individual attributes relevant to the economy. Environment refers to the diversity and interdependence of living systems, goods and services provided by ecosystems and the impact of human waste (United Nations Environment Programme, 2012). Figure 1 shows the intersections between these dimensions with sustainability forming the intersection of all three.

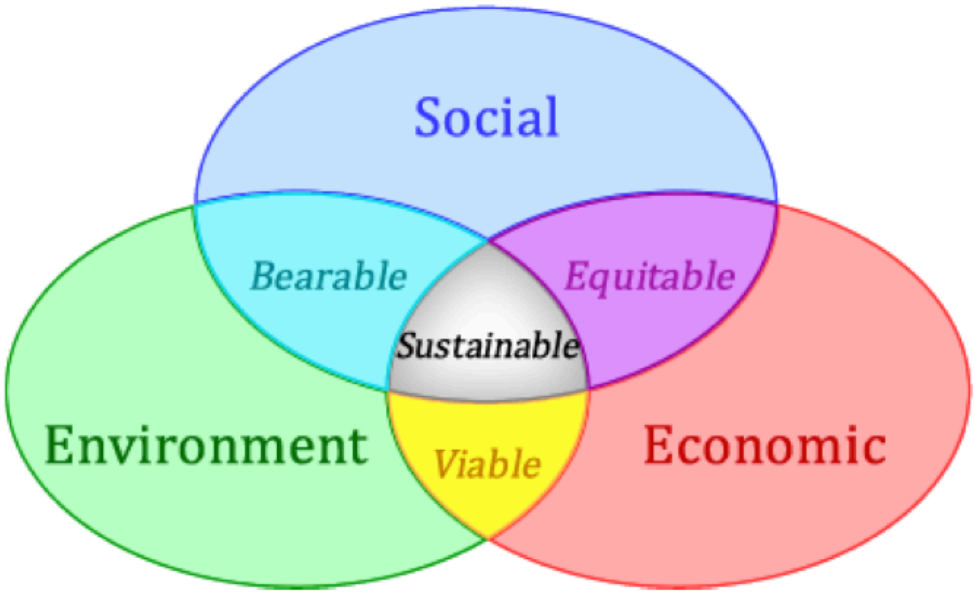

Figure 1: Three main components of the sustainability paradigm and intersections among them (Source: International Union for the Conservation of Nature)

Environmental sustainability is an increasingly important global issue. The population of the world increased from approximately 2.5 billion to 7 billion between the years of 1950 and 2012, which led to an increase in the consumption of resources. We have finite resources available and we are using these resources far faster than they can be reproduced. The increase in greenhouse gas emissions, which have risen 70% between 1970 and 2004 due to human activities, is one of the main drivers of climate change. Carbon dioxide emissions have risen 80% between 1970 and 2004 and represent 77% of total greenhouse gas emissions (Intergovernmental Panel on Climate Change, 2007). Fossil fuel use contributes the most to carbon dioxide emissions. The lifestyle led by many people on Earth is due to readily available fossil fuels; eighty-five percent of world energy comes from fossil fuels. From the mid 20th century, challenges resulting from the use of fossil fuels began to emerge. Environmental pollution, finite energy resources, uneven distribution of energy and CO2 emissions and climate change all result from the dependence on fossil fuels (Theis & Tomkin, 2012).

Climate change has led to a rise in Earth's temperature compared to the beginning of the last century and this trend is set to continue (United Nations Environment Programme, 2012). These changes will likely have many negative consequences for human beings, including, but not limited to, a rise in sea level, more frequent heat waves, heavy precipitation, and tropical storms. DARA (2012), an independent, international organisation and the Climate Vulnerable Forum (CVF), a global partnership of countries disproportionately affected by climate change published a climate vulnerability monitor report in 2012. They found that climate change has already held back development, is a significant cost to the global economy and inaction on climate change can be considered a leading global cause of death. Many countries and governments are currently implementing measures to reduce CO2 emissions. The Kyoto Protocol, which calls for the reduction of emissions, came into force in 2005 and there are 193 parties (192 States and 1 regional economic integration organization) who have signed and ratified the treaty (UNFCCC).

In spite of progress in political processes, resource consumption is growing at an unsustainable rate (Friends of the Earth, 2009). This problem requires more than an

engineering solution, there needs to be a fundamental change in how people behave (RAND Europe, 2012). Personal, individual involvement with current increased consumption rates is inarguable; direct resource consumption in homes and businesses accounts for 20% percent of overall energy use in the USA (US Dept of Energy, 2008). In Europe, households accounted for 26.7% of energy and industry accounted for 25.3% of energy consumption in 2010 (European Commission, 2012). However, resource consumption cannot continue at this rate without severely compromising our future (European Environment Agency, 2012). In order to create a more sustainable world, resource use in developed countries must be reduced (Friends of the Earth, 2009). It is important that humans work to reduce their carbon dioxide emissions and make an effort to behave in more sustainable ways to reduce the effects of climate change.

SUSTAINABILITY AND HCI

This thesis utilises a number of different approaches to the issue of sustainability and HCI. DiSalvo, Sengers and Brynjardóttir (2010) mapped out the different approaches in the field. They identified several genres of research that share similar sources, problem formulation and ideas on how to solve sustainability problems. The first genre was defined as formative user studies; this genre consists of attempting to understand users' attitudes towards sustainability as the first step towards design. Secondly, sustainable interaction design as a genre is based around using sustainability to rethink the outcomes of design. Persuasive technology as a genre is based around technologies that try to influence users in some way. The final two genres are pervasive and participatory sensing and ambient awareness. The work in this thesis fits into all of these genres except ambient awareness. The goal setting (Chapter 3) and goal priming (Chapter 4) work fit into the genre of formative user studies. The approach to designing toys that instill sustainable values described in Chapter 5 fits in to the sustainable interaction design genre. The work on avatars as feedback (Chapter 6) fits into the persuasive technology genre by conducting studies and designing a system based around attempting to persuade users to use less energy. The system described in Chapter 6 senses electricity consumption at the appliance level and therefore also fits in to the pervasive and participatory sensing genre.

DiSalvo, Sengers and Brynjardóttir (2010) also discuss the axes of difference within the field. These differences are: "sustainability as a research focus" vs. "sustainability as an application", "users as individuals" vs. "users as communities", "users as the problem" vs. "solving users' problems", "improving current lifestyles" vs. "encouraging fundamental change", "technology as an adequate solution" vs. "an inadequate solution" and "HCI as usual" vs. "HCI must be rethought". The following paragraph describes where the work in this thesis sits on these axes of difference.

The majority of work in this thesis has sustainability as the research focus rather than as an application area. However, the work described in Chapter 6 regarding persuasive technology has sustainability as the application area for research into persuasive avatars. The work described in this thesis focuses on individuals or the household rather than large communities or groups. The goal setting (Chapter 3), goal priming (Chapter 4) and avatar work (Chapter 6) takes the view that users are the problem and focuses on understanding current behaviours and influencing change. However, the design of toys that instill sustainable values (Chapter 5) focuses on solving users' problems by looking for opportunities to pass on positive values rather than attempting to change current behaviours. Most of the work presented here tries to improve current lifestyles rather than encouraging fundamental change, the only exception is in Chapter 5 where cultural change is encouraged through toys that pass on values. These values are intended to follow the child throughout life and be discussed with and encouraged by parents in the household. Another of the issues presented within DiSalvo, Sengers and Brynjardóttir's work is whether technology is an adequate or inadequate solution for encouraging sustainable behaviours. This thesis focuses on technology as an adequate solution; wider issues such as policy reform, though important, fall outside of the scope of this work. A similar stance is taken on the issue of the relevance of political differences. Although politics has a massive impact on environmental policy at the highest level, the work presented here does not focus on politics. Finally, in regards to the last of the axes of difference, "HCI as usual" vs. "HCI must be rethought", the work presented here focuses on "HCI as usual", including various approaches from psychology and design. Overall, this thesis draws from different approaches and theories with sustainability as the main context and topic of the work.

ENERGY BEHAVIOUR THEORY

There are four different types of theories (Chatterton, 2011) that can be used to interpret how people use energy:

1. Economic – energy is a commodity, consumers adapt usage in response to price
2. Psychological – energy use is affected by stimulus response mechanisms and by engaging attention
3. Sociological – practices lead to consumption of energy
4. Educational – energy use is a skill learned through experience

These types of theories are different ways of looking at energy consumption that focus on different aspects of behaviour. They can be split into two categories; the first two see the energy user as an individual who behaves in a rational or semi-rational manner. The second two focus on the context extending beyond the individual and include families, government, supply and other companies, physical infrastructure and hardware, and they also move the focus away from the moment of decision to factors that led up to that decision. These different viewpoints are complementary and are different ways of looking at the same thing. The work in this thesis focuses on psychological theories to understand and influence energy behaviours at the individual or household level. It has been argued that psychology is the essential discipline that will enable us to understand why humans behave in unsustainable ways and for informing the design of interventions for supporting individual behavioural change (Koger & Scott, 2007).

Models are simplified representations of the actual processes that occur. There are two relevant types for energy behaviours: individualist and socially oriented. Basic individualist models of behaviour tend to be described in terms of ABC (Attitude Behaviour Choice/Context/Constraint), they are grounded in economically rational views of behaviour and have been extensively adopted by governments. A simple linear example would show the individual's attitudes that lead into intentions, which then lead into behaviour. Triandis' Theory of Interpersonal Behaviour (Triandis, 1977) has been identified as being suitable for describing energy behaviour

(Martiskainen, 2007) and is a more complex model of energy consuming behaviour than the basic ABC model (Figure 2).

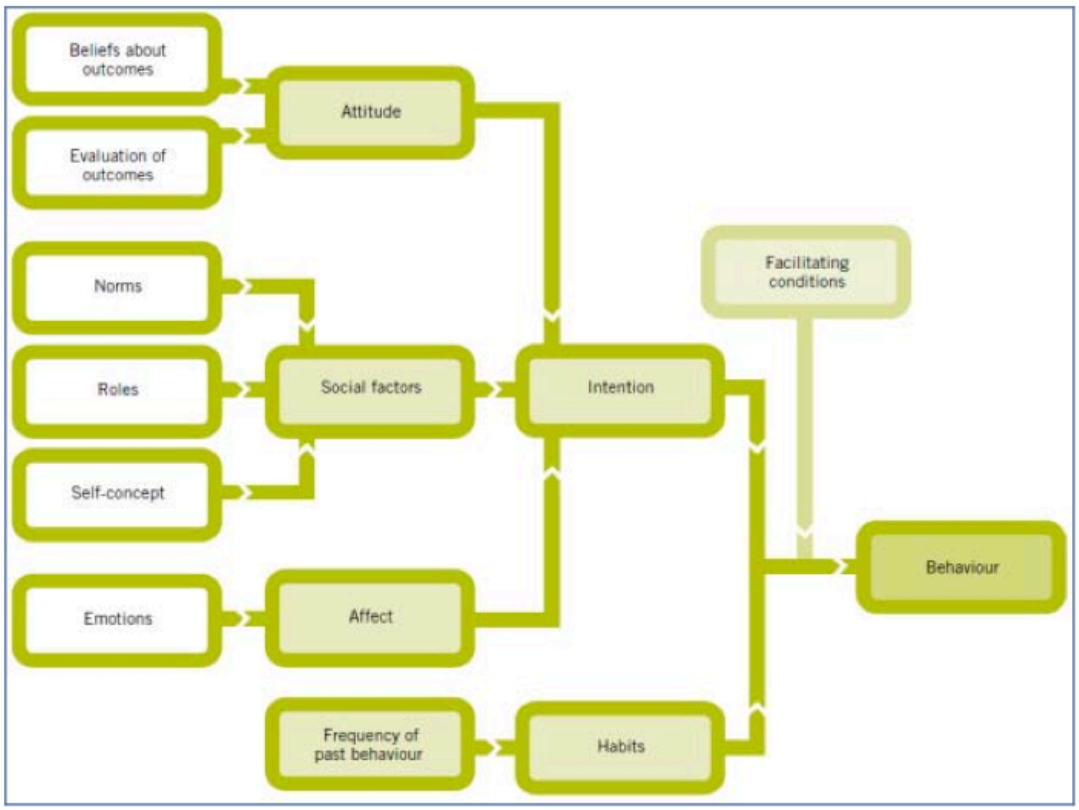

Figure 2: Triandis' Theory of Interpersonal Behaviour, 1977 (taken from Chatterton, 2011)

The core sections of the model are intentions, habits, facilitating conditions and behaviour. Intentions are made up of three elements: attitudes held by the individual, social factors relating to how the person sees themselves, and affect which represents things like mood and values. Social norms are contained within social factors. What other people do and what the individual believes other people do, are significant. Roles and self-concept are other important social factors. Habits are a separate path on the model since they are a routine behaviour that does not go through the intentions process. To be defined as habitual, behaviour must be frequent and automatic, that is, lacking awareness and conscious intent (Bargh, 1994), be difficult to control, be efficient and have a stable context. Recent work has suggested it takes on average 66 days of repetition for a habit to form (Lally, Jaarsveld, Potts & Wardle, 2010). Once intentions and habits have interacted to determine the behaviour that will be attempted, the behaviour will only be possible depending on facilitating conditions.

These are external factors, such as whether public transport is available, and can form barriers to behaviour or serve as enablers, such as the provision of recycling services. Facilitating conditions also include internal resources such as self-efficacy.

Attitudes, social factors and affect, which together form intentions within the model, can be worked with to influence and understand energy consumption behaviours. Psychology has been applied to traditional economics and termed behavioural economics to explore how humans do not make strictly rational behaviour choices (Mullainathan & Thaler, 2000). Behavioural economics states that rather than making extensive calculations about every possible option, humans rely on mental shortcuts or heuristics to make choices (Slovic, Finucane, Peters & Macgregor, 2002). There are two separate systems in the brain that process information: the experiential and rational systems (Kahneman, 2003). The rational system makes choices in a careful and considered manner whereas the experiential system consists of a range of sub-conscious processes that allow fast response to the environment or allow routine behaviours with minimal effort. Behavioural economics tends to focus on the point of decision making, rather than the Triandis model which takes into account identity and values (Camerer & Loewenstein, 2004).

Campaigning groups (Crompton & Kasser, 2009; Crompton, 2010) have recently focused on engaging pro-social or pro-environmental values within people and society in order to achieve shifts in behaviour. Crompton (2010) states that facts and rational analysis play a partial role in decision-making, emotion can be more important and just providing people information is not enough to encourage change. Problems such as climate change are not in an individual's immediate self-interest to solve, therefore it is necessary to engage with intrinsic values as these are associated with concern with such larger than self problems (Crompton, 2010). Chapter 5 discusses values and value development in more detail culminating in the prototype of an interactive toy designed to instill sustainable values in children.

Values and motivation can be categorised into two broad types: extrinsic and intrinsic (Deci, 1972). Extrinsic values are dependent on the response of others, such as praise (reward) and condemnation (punishment). Intrinsic values are those that have inherent worth, where the behaviour performed has inherent satisfaction for the person and are

associated with concern about problems that are larger than the self. In contrast, extrinsic values are not associated with concern with others or the environment. Extrinsic motivations occur when the goal of the behaviour is separable from the activity itself, either in the form of punishment avoidance or in the pursuit of a valued outcome. A person can transition from no motivation to extrinsic motivation to intrinsic motivation in a particular activity by internalizing and integrating the values and behaviour regulations typical to that domain (Deci et al, 1994; Ryan & Deci, 2000). However, this process is not automatic and extrinsic messages can undermine and suppress intrinsic values, for example, providing information on the basis of saving money can be detrimental to intrinsic motivation (Deci, Koestner, & Ryan, 1999) and developing long-term values of concern for the environment (Chatterton, 2011). Intrinsic motivation has been shown to have more powerful effects on long-term behaviour change than extrinsic (Curry, Wagner & Grothaus, 1991). Therefore, in order to have long-term effects on sustainable behaviour, intrinsic motivation must be encouraged. Research indicates that both rewards and rebukes represent key aspects of a behavior change intervention (Deci, Koestner & Ryan, 1999), but that they need be treated differently – positive feedback generally encourages users while overly negative responses can be de-motivating (Deci, 1972). Therefore, in order to be effective, feedback given to users regarding their environmental behaviours should be carefully designed taking into account the conflicting types of motivation and valence.

GOAL SETTING THEORY

Goal setting theory is an established and actionable framework for understanding how to motivate behaviour change (Locke & Latham, 2002). Fundamentally, it explores how the type and form of goals affect people's level of motivation and ability to achieve targets. Two of the most important aspects within this framework are the *challenge* and *clarity* of goals. Studies have confirmed that difficult goals promote the highest levels of effort and performance as long as they are clearly expressed and criteria for successful achievement are well identified (Becker, 1978; Locke & Latham, 2002). Vague goals, such as achieving optimal personal performance in some task, lack external reference and allow for a wide range of performance levels. Specificity decreases performance variability among users by reducing ambiguity with increasingly precise goals.

Other key factors affecting performance include those that vary among individuals, such as self-efficacy (a measure of perceived empowerment), and goal commitment. Previous goal setting work has shown that easy goals tend to have higher commitment because they require less dedication (Locke, 1996). The level of difficulty at which people set goals depends on various factors, including self-efficacy, past performance and social influences (Locke & Latham, 2006). People with higher self-efficacy choose more difficult goals for themselves than those with lower self-efficacy. They also have a higher commitment to achieving goals and are better at responding to negative feedback. Feedback is important for goals to be effective; feedback plus goals are more effective than goals alone (Locke & Latham, 2002).

There are four mechanisms through which goals affect performance (Locke & Latham, 2002). Firstly, they direct attention toward the goal and away from other activities. Secondly they lead to greater effort with more difficult goals. Thirdly, goals affect persistence; more difficult goals can lead to more prolonged effort and deadlines can lead to faster work pace compared to no deadlines. Finally, goals lead to the use of task relevant knowledge and strategies.

Researchers have also applied goal-setting theory to consumption reduction scenarios. Becker (1978) tested the effects of combined goal-setting and feedback on conservation behaviour. Two groups of 40 households were either given electrical consumption feedback or not, three times a week. The two groups were also split into those with an easy (2%) savings goal or a difficult (20%) savings goal. The results showed that the difficult-goal-plus-feedback group was the only group that used significantly less (13%) electricity.

In contrast, McCalley and Midden (2002) reported no difference in energy reduction for people who chose goal levels of between 0% and 20% kWh savings in a task that gave immediate feedback on energy conserved using a washing machine simulation. They had four conditions: feedback with no goals, feedback with a self-set goal (save between 0% and 20%), feedback with an assigned goal (save 20%) and a control condition with no goals and no feedback. Most people saved 20% compared to the control condition; this could suggest that self-set goals are more effective than

imposed goals regardless of the goal level. Indeed evidence supports this assertion. Autonomy in goal setting leads to setting higher challenges and having greater performance than when goals are assigned. Once you have chosen your own goal, you are also more committed to that goal (Wright & Kacmar, 1994).

Abrahamse et al (2007) reinforced these points by indentifying the importance of supporting users in selecting personal, specific goals. They looked at integrating goal setting with tailored feedback about energy consumption. Participants in the experimental condition received tailored recommendations via a website but their only goal was to reduce their energy consumption by 5%. Tailored feedback was given from their self-reports online via a website after two and five months. This feedback was calculated using a tool that recommended energy saving options that were relevant for their household. For example, if the householder indicated they used their thermostat at a high setting, they would receive a recommendation to reduce the temperature. Households who received this online intervention in the study ultimately saved 5.1% energy compared to the control group who used slightly more energy. Participants who received an intervention reached their goal of 5%, which is quite low compared to similar work (Becker, 1978; McCalley & Midden, 2002). The work in Chapter 3 expands upon this by allowing participants to choose their own goals from a set that includes options such as reducing consumption by percentages as well as more concrete goals such as using sleep mode on computers. Autonomy in choosing goals should create greater commitment to reach the goal. Using self-chosen and more specific goals may be a more effective technique than setting abstract percentages. Finally, He et al. (2010) suggested that adapting goals to specific situations and users is important in creating effective motivational systems.

In summary, the literature suggests that goal-setting theory has much to offer as an actionable framework for designing effective eco-feedback systems that motivate users to reduce consumption. Questions regarding how to select appropriate goals remain, in part due to the diversity of the literature on this topic and in part due to an undeveloped understanding of the basis with which users select goals in this domain (Attari et al, 2010). The work in Chapter 3 attempts to address these issues via an experimental paradigm that allows users to choose goals with different levels of difficulty and specificity and provides instant feedback on these selections.

GOAL PRIMING

Experimental work has shown that the priming of semantic concepts increases their accessibility, facilitating processing of related constructs. For example, Neely (1977) primed participants with different types of words then showed them a target and asked them whether the target was a word or non-word. There were also various experimental conditions priming related and unrelated words. Neely found that priming produced two different types of facilitation effect. The first effect happened quickly and was dependent on the prime and target being semantically related. The second, slower effect did not depend on the prime and target being semantically related but on the probability with which the type of word followed the prime in the experimental context. This finding was extended by McNamara and Healy (1988), who presented participants with pairs of words that were semantically related and measured their lexical decisions (word or non-word) and reading times. For example, after being primed by reading the word "lamp", participants were faster at reading the word "light" compared to no priming.

In a series of experiments, Bargh, Chen and Burrows (1996) demonstrated that participants who had been exposed to words within scrambled sentences relating to old age walked more slowly out of the laboratory than participants who had not been exposed. They also reported that participants were unaware of the effect of the priming on their subsequent behaviour. These findings showed that simple priming could influence behaviour without awareness. This has been shown through imitation of observed behaviours, Chartrand and Bargh (1999) found that participants unintentionally matched the motor behaviour of strangers they worked on a task with and that mimicry facilitated interactions and liking between interaction partners. Lakin & Chartrand, (2003) extended this by priming participants with words related to the concept of affiliation (non-conscious goal) before showing them a video of a confederate performing mundane tasks while touching their face. Some participants were also told that they would be working with the confederate and it was important they were able to cooperate (conscious goal). Both the conscious and non-conscious goal participants exhibited significantly more face touching than those in the no goal condition. Both of the affiliation conditions had a similar effect on mimicry and the

authors argue this shows that a non-conscious goal had the same effects on behaviour as a conscious goal.

It has been argued (Aarts, Gollwitzer, and Hassin, 2004) that people may not only automatically imitate behaviours but also may adopt and pursue a goal that is implied by another person's behaviour. Aarts et al show that if participants are presented with behavioural descriptions implying a certain goal, they may initiate this behaviour if they can, even without being aware of the influence. The key assumption of this previous work is that goals can be activated subconsciously to affect outcomes (Bargh & Chartrand, 1999).

Goal setting theory has shown specific goals to lead to higher effort and productivity compared to vague goals. The priming of context specific goals has not been greatly explored in the literature with the first study that compared specific and vague priming being conducted recently (Latham & Piccolo, 2012). They hypothesized that a context specific primed goal would lead to higher job performance compared to a general achievement primed goal. Their primes consisted of photographs; the general achievement prime showed a woman crossing a finish line in a race and the context specific prime showed employees working the same job as employees in the experiment (call centre operatives). The employees were given the primes displayed clearly in the corner of a fact sheet they usually used during work. In the control condition, there were no photographs displayed on the fact sheet. The employees had the fact sheet in front of them as they were making calls during work. Measures were taken over four consecutive workdays, with performance measured by the number of donors and the monetary value of donations that each employee succeeded in securing. Employees in the context-specific prime condition and general achievement conditions had significantly higher numbers of pledges from donors compared to those in the control condition. There were also higher numbers of pledges in the context-specific compared to the general achievement condition but this was not a significant difference. Simple photographs clearly had an effect on job performance; however, participants were exposed to these photographs over a long period of time, which could have increased their effectiveness. The authors argue that their findings support the assertion that a primed goal has a similar effect on performance as a consciously set goal.

Recently priming has been successfully utilised to encourage energy saving (McCalley et al, 2006). They used the supraliminal priming method, which involves consciously providing participants information in a way that appears to have no relation to the experimental task that follows. They used priming (via pictorial slides) to encourage saving energy. Their study had three priming conditions; participants were primed with a meta goal (pertaining to self), an action goal (pertaining to specific actions) or a neutral goal. They were shown a simulated washing machine interface that displayed feedback as kWh and asked to do washes as they would at home. The participants performed the washing trials; they then watched the priming slides depending on condition, disguised as a saving screen. The priming was shown using slides about either the participants' personal desire to save the environment (meta level goal), specific energy saving actions (action level goal) or neutral non-environmental slides (neutral level goal). After priming all the participants set explicit goals of 0, 5, 10, 15 or 20% energy savings. They then completed 20 more washing machine trials to calculate savings compared to the baseline. The authors found savings in each condition with the highest savings found in the specific actions priming condition. It was significantly different from the control condition. This method could potentially be used to encourage more difficult goal choices if difficult actions were primed.

There has been a significant amount of work conducted in the area of priming; however some work indicates that priming effects may be more complex than has been previously suggested. Evidence from cognitive neuroscience suggests that semantic priming should only occur when two factors are present (Dehaene, Changeux, Naccache, Sackur & Sergent, 2006). These are top-down attention to the prime and bottom-up stimulus strength, for example, how salient the stimulus is to the participants. These are required for the large patterns of neural activation in higher association cortices and are usually associated with conscious awareness. In priming experiments, the salience of the primed concept should be too weak to automatically cause behaviour in the absence of contextual cues (Doyen, Klein, Pichon & Cleeremans, 2012). The Bargh, Chen and Burrows (1996) experiment where slower walking speeds are found after being primed about old age has been recently replicated. The original study did not report whether the experimenter was blind to the conditions (which may have influenced the outcome), measured walking speed with a

manual stopwatch and did not clearly measure how unaware participants were of the manipulation. The replicated study (Doyen, Klein, Pichon & Cleeremans, 2012) attempted to improve on this methodology and test whether the same results were found. Their first experiment failed to replicate the Bargh, Chen and Burrows (1996) walking speed results and they found no significant differences between primed and non-primed groups. The authors also reported a small percentage of participants being aware of the primes. They carried out a second experiment where they varied the expectation of the experimenter. In half the cases, the experimenter was told that primed participants would walk more slowly due to being primed; the other half were told that participants would walk faster due to the prime. In this second experiment, the original results were only replicated when the experimenter was expecting the participant to walk slower due to the prime. In the condition where participants were expected to walk more quickly, participants did not walk faster although the experimenter expected them to, suggesting that environmental factors and primes work together. They also found that most participants were aware of the stereotype they had been primed with and that a proportion of those who walked slower were aware that they had walked slowly. Participant's awareness of the prime could have led them to have more conscious control over their behaviour than if they had been unaware. Clearly this study shows that priming has limitations and supports the cognitive neuroscience work that states attention and saliency are needed for priming to work.

Recently authors (Pashler, Coburn & Harris, 2012) have pointed out the differences between perceptual priming and social or goal priming. The findings from perceptual priming studies such as responding faster to semantically associated words after being primed are robust. On the other hand, findings from social priming studies seem harder to replicate. Pashler and colleagues attempted to replicate two priming studies by Williams and Bargh (2008). In the original work, the authors theorised that spatial distance would influence participants' thoughts and feelings. Participants were primed by marking points on a Cartesian coordinate plane in three conditions: close (2, 4; -3, -1), intermediate (8, 3; -6, -5) and distant (12, 10; -11, -8) points. The distant prime predicted weaker reported emotional attachment to family and hometown and lower estimates of calorie content of unhealthy foods compared to the close prime. Pashler and colleagues were unable to replicate these findings and conclude that the failure of

priming was not due to experimenter expectancy since in the original study the experimenter was blind to conditions. They suggest that the failure to replicate the priming effect is due to the original results being invalid and representing Type 1 errors.

To summarise, priming has the potential to influence people to choose more difficult or effective goals. However, the literature on this topic is conflicted with some previous work suggesting priming may be affected by experimenter expectations or that social priming may not be a valid method. Chapter 4 attempts to shed some light on the utility of goal priming in an energy saving context.

FEEDBACK

Feedback can reduce household energy consumption by 5 to 20 percent (Vine, Buys & Morris, 2013). The effectiveness of feedback for energy conservation is an ongoing area of research and some overall trends have emerged. In order for feedback to be as effective at reducing energy as possible, it should meet three characteristics (Midden et al, 1983). These are: feedback should be received as close to the event in time as possible, it should be related to a standard and it should be presented in a way that is meaningful to the consumer. Darby (2001) adds that feedback should be customised and personalised for individual households. In a review of household energy consumption feedback, Fischer (2007) stated several recommendations for feedback. These were: it should be computerised, interactive, be broken down by appliances and be provided over the long term. More specifically, she stated that including an engaging interactive element is an effective way of presenting feedback. She also found that showing appliance level consumption detail was an effective method of feedback. Combining energy appliance consumption data with an interactive avatar showing continuous feedback is a novel way of following these recommendations (Chapter 6). In a recent literature review, Vine, Buys & Morris (2013), identified that there is a lack of understanding about the different formats of feedback that consumers respond to most strongly. The experimental studies in Chapter 6 try to address this lack by comparing different modalities of avatar-based feedback.

One class of feedback relates to affect. Affect is a psychological term referring to the experience of feeling or emotion. It plays an important part in decision making since

it relates to the individual's mood and underlying values. Emotions can affect decisions in a subtle way, feeling positive or negative emotions can influence decisions and choices. People can react to something before they realise what they are reacting to and being in a good mood can lead to different decisions compared to being in a bad mood. Including a picture of an attractive smiling female on advertising material for loans led to an increase in people's uptake of the loan equivalent to reducing the interest rate by 25% (Dolan, Hallsworth, Halpern, King, & Vlaev, 2009). Other authors have found that feedback devices that are not aesthetically pleasing have been hidden from view and not utilised, regardless of functionality (Hargreaves, Nye & Burgess, 2010). These subtle effects could have positive or negative consequences regarding energy consumption information provision (Chatterton, 2011).

PERSUASIVE TECHNOLOGY

In his seminal book Fogg (2003) defines persuasive technology as any interactive computer system designed to change human attitudes or behaviours. Subsequent work has drawn a distinction between direct and indirect persuasion (Aleahmad et al, 2008). The former refers to clear and evident technological interventions to promote particular activities or behaviours (for example, by making specific recommendations) while the latter signifies subtle "background" presentation of information more suitable to influencing attitudes or opinions. Fogg also highlights the value that computer technology brings to persuasion: the persistence and anonymity of digital systems, their ability to process huge quantities of data and to access multi-modal information dissemination channels (e.g. SMS, video, ambient displays). In addition, he identifies personification technologies, typically appearing as virtual pets or avatars, as one form of persuasive tool (Benyon & Mival, 2008). Such systems emphasize anthropomorphism – users can associate emotions with digitally presented characters and may ultimately develop powerful affective connections to them. These links typically emerge when the personifications respond to communication and control events with behaviours such as gestures, expressions and body language (Boberg, Piippo & Ollila, 2008). The development of emotional ties can also be encouraged through techniques such as providing appearance

customization tools (Ducheneaut et al, 2009) and with the amount of time spent designing or maintaining such personalized features (Boberg, Piippo & Ollila, 2008).

Practically, personification has been shown to be an effective persuader across a range of application domains. For example, Dillahunt et al (2008) designed a virtual pet personification in order to encourage environmental sustainable travel behaviours. Implemented on a mobile phone, this system showed a group of polar bears and depending on user travel choices, the bears' environment prospered or became systematically uninhabitable. In a field study this visualization led to more committed actions, fulfilled commitments and significantly increased levels of environmental concern when compared to a control. Lin et al (2006) describe a broadly similar approach to motivating users to increase exercise levels. As users move, their step count is logged and this directly affects the behaviour and growth of virtual fish. This intervention was shown to improve step counts over a baseline in a fourteen-week study.

Research has also explored visualization beyond such virtual pet systems. For example, EcoIsland (Kimura & Nakajima, 2010) aimed to reduce home resource consumption and studied a range of modalities for presenting cues based on human-like avatars. In total, six families were studied, each of which owned a virtual island populated by one avatar representing each family member. The system used self-reported activities and presented a wide range of feedback. For example, water levels rose and fell depending on the overall consumption of all families and speech bubbles attached to specific characters highlighted the impact of individuals. The results reflected the richness and complexity of the display system - positive feedback was reported to encourage behaviour modification while negative feedback promoted attitudinal change.

Taken together, this work is compelling; it effectively demonstrates that even simple personifications can be powerful persuaders. However, it is also limited in its scope, addressing a relatively small subset of the available feedback channels available via personification technology. Specifically, one notably omitted aspect is the impact of emotions expressed by virtual personifications via lexical content or facial and body language. This thesis argues that such affective cues would be a beneficial component

contributing to the persuasive power of personifications. To support this point, the literature related to emotional communication is reviewed in the following section.

VIRTUAL EMOTIONAL COMMUNICATION

How avatars can best express their feelings and the impact this has on users has been the topic of extensive research. Many authors report the formation of strong bonds between users and avatars. Bailenson et al (2001), for example, suggests that users respond to virtual avatars as if they were human, even if they are highly stylized and unrealistic. Boberg, Piippo and Ollila (2008) report that some users go as far as seeking personal interaction and physical contact, such as hugs and touches, with virtual avatars while Benyon and Mival (2008) argue that users can come to form attachments to avatars that are sufficiently strong such that damage to their virtual representations is perceived as damage to themselves. Other work has revealed the Persona Effect (Lester, Converse, Kahler, Barlow, Stone & Bhogal, 1997) where a lifelike character can have a strong positive effect on learning. The authors compared different levels of expressiveness of an animated pedagogical agent, including animated advice, verbal advice and no advice regarding a task students had to complete. Interacting with the agents had a positive effect on the students' test scores; however, the mute agent and the task-specific verbal agent were not as effective as the more expressive agents. The authors argue that the presence of an animated agent has a positive effect on students' perception of the learning experience and that this effect could increase their motivation to learn. The Persona Effect has been empirically studied (Mulken, Andre & Muller, 1998) and the authors found that the presence of a Persona has a positive effect on participants' impression of a presentation. Participants perceived the presentations as more entertaining and less difficult, although there were no differences in comprehension and recall of the presentation compared to an absent Persona. Taken together these findings highlight the powerful effects of emotional communication shown via virtual personifications.

However, coherently explaining the quality and nature of these attachments is a current research challenge and conflicting accounts exist. Nass, Steuer and Tauber (1994) conducted a series of experiments to determine whether interactions with computers are social. They found that participants had social reactions to computers and that these reactions were not dependent on the belief that the computer was

human or human-like. Participants, despite being experienced computer users, reacted with politeness and responded socially to the computer itself. The authors argue that these social responses are automatic and unconscious and call this the "Computers as Social Actors" paradigm. This work has been extended to the Ethopoeia explanation (Nass & Moon, 2000) that suggests that interactions with humans and emotional virtual agents will unfold similarly due to humans unconsciously applying social rules to computers. Studies supporting this framework have provided evidence that people respond politely to computer agents, ethnically identify with them and apply gender stereotypes to them. In contrast, the Threshold Model of Social Influence (Blascovich, 2002) argues that social responses to virtual agents will only take place if the presentation of the agent is sufficiently realistic so that it cannot be distinguished from a human. However the author states that some categories of behaviour are more important than others, particularly that emotional expressions are more important than large limb movements. In recent work comparing these approaches Von der Putten et al (2010) examined social interaction with a virtual character that was either said to be computer or human controlled and which had either low or high behavioural realism. The results indicated no differences in participant's behaviours, a finding that strongly supports the Ethopoeia model and its assertion that humans readily form emotional bonds to artificial characters.

Research has also focused on how to design emotionally expressive and understandable avatars. Numerous display channels are available including facial expressions, body language or animations and verbal or lexical messages; all can be effective, but the design of appropriate emotional cues remains a challenge. For example, Baylor (2011) states that verbal communication should be as human as possible and that visual gestures need to be carefully designed. Kramer, Simons and Kopp (2007), demonstrate this point in their exploration of the impact of a range of non-verbal cues including self-touching (scratching), which led to positive impressions, due to the agent being rated as more natural and warm hearted and eyebrow raising, which led to negative opinions and feelings. This situation becomes more complicated when cues are presented spanning multiple modalities – evidence indicates that incongruent or poorly matched pairings of cues reduce comprehension. Hong, Wen and Huang (2002) illustrated this point in a study combining happy, neutral and sad voices with happy, neutral and sad faces. Their results indicated that it

was more difficult for users to accurately indentify emotions with incongruent cues. Similarly Creed and Beale (2008) showed that mismatches between the emotions presented vocally and via facial expressions led to inconsistencies as study participants attempted to resolve the conflicting cues into a single coherent percept. This work shows that consistency in the delivery of multi-channel messages via avatars is key to understanding them. De Gelder and Vroomen (2000) present findings that further emphasize these difficulties, suggesting that incoherent expressions take longer to interpret and lead to more neutral ratings of overall emotion (e.g. a happy voice and a sad face will be rated as somewhere between these two emotions). Together this literature stresses the important of consistent emotional cues to facilitate ease and speed of comprehension.

A smaller body of work has looked at purely graphical presentations in the same way. These typically combine printed text with pictorial avatar expressions. For instance, Carroll and Russell (1996) used a story to provide context to depicted facial expressions. Study participants were read a story, shown a photo of a face and then asked to choose an emotion for the face in a forced choice paradigm. The results indicated that contextual cues, in the form of the lexical narrative, exerted a strong influence on the perceived emotion. They conclude that facial expressions cannot be considered in isolation. More recently, Noël et al. (2009) described a study comparing emotions depicted in avatar facial expressions and short captions presented in speech bubbles. Five emotions were considered (anger, happiness, neutral, sadness and surprise) and congruent and incongruent presentations evaluated. Participants were able to identify emotions accurately independently of congruence, but facial expressions exerted a stronger influence on interpretation of the text. They also reported challenges in validating the cues they studied. For instance, the neutral avatar face was frequently reported to depict a sad expression and the sad text had a low overall recognition rate (30.8%).

In summary, the goal of the work reported in Chapter 6 is to investigate how expressive avatars can be used as a persuasive technology. It is motivated by the idea that virtual personifications are effective motivational tools (Fogg, 2003) and seeks to flesh out aspects of this idea. Specifically it suggests that previous work has focused on contextually descriptive visualizations such as the health of an environment

(Consolvo et al, 2008) or the abundance of natural resources (Dillahunt et al, 2008) rather than leveraging emotionally expressive avatars as a persuasive tool. This focus reflects the complexity of displaying emotions in avatars, particularly if multiple modalities, such as textual messages and facial and bodily expressions, are used (e.g. Baylor, 2011). Ultimately, this work argues that expressive avatars utilizing multiple modes of communication have the potential to be a powerful, compelling persuasive tool. It conducts empirical work that starts to define how this can best be achieved – how avatars can combine expressions and textual context in order to be both easily understandable and effective persuaders. This work is described in Chapter 6. Finally, using the results, a working system is presented, where avatars give feedback verbally and visually about energy consumption in the home.

ETHICS

When attempting to persuade or influence it is implicit that one value or behaviour is better than another. It is important to consider who decides that change is needed, how that change should happen and whose values matter. This issue is of ethical concern for HCI particularly for user-centered design (Disalvo, Sengers, & Brynjarsdóttir, 2010). The designers of interventions and persuasive technologies need to be aware that users may not want to change and they need to be sensitive to how they attempt to persuade or influence users. Persuasion or influence can be judged whether it is ethical by considering whether it is paternalistic, defined as "the interference with a person's liberty of action, justified by reasons referring exclusively to the welfare, good, happiness, needs, interests, or values of the person being coerced" (Dworkin, 1972). Libertarian paternalism (Thaler & Sunstein, 2008) is defined as a liberty or freedom preserving paternalism. This means that it is legitimate to influence someone else's choices if it makes them better off, as judged by themselves. The libertarian aspect means that other choices will not be removed from people, that they have the freedom to choose and that libertarian paternalism will not force any choice upon them. That is the ethical stance that this thesis takes.

The argument for influencing more pro-environmental behaviours is that the outcome would be for the common good. Environmental sustainability is such an important global issue; not sending messages about pro-environmental behaviours could encourage inaction. The potential and real current negative consequences of climate

change may outweigh the possible discomfort felt by users being influenced. However, it is important that ethics are considered when sending messages attempting to influence choices. Governments often try to influence behaviour through policy (Dolan et al, 2009) and most messages that are provided by governments are framed in some way. Unframed or neutral messages are rare and would only reinforce current behaviours. Non-intervention can be unethical since not doing something can have as many implications as doing something. Governments may also be unintentionally priming people to act in negative ways; priming needs to be better understood so that any priming that is taking place is towards positive behaviours (Dolan et al, 2009).

Persuasive technology has specific ethical implications to be considered, Fogg (2003) states that the intentions, method and outcomes of a persuasive technology need to be analysed in terms of ethics. Berdichevsky and Neuenschwander (1999) apply earlier work from the ethics of persuasion and the ethics of technology to create eight principles of the design of ethical persuasive technology. They state that the intended outcome or motivation of the persuasive technology should not be deemed unethical if the persuasion happened without the technology or the outcome occurred without persuasion. They also state the creators of a persuasive technology should assume responsibility for the outcomes of the technology and regard the user's privacy as they would their own. Creators of persuasive technology should be transparent about the motivation, methods and outcomes of the technology except where this would undermine an otherwise ethical goal. Creators of such technology should never misinform in order to achieve the persuasive end. Their golden rule of persuasion is that creators should never seek to persuade with their technology something they would not consent to be persuaded of themselves. They base their design principles on rule-based utilitarianism ethics where rules are only stipulated when always following them results in more benefits, such as how much good or happiness they bring about. If a designer violates these rules, it is likely that their design will be ethically problematic.

Persuasion distributes responsibility between the persuader and the persuaded; both must take some accountability for the outcome of the persuasion. Even in the case of false advertising where people are misled, the persuader still bears some responsibility for their own actions; false information alone does not cause an action.

The technology itself, independent of the creator or user cannot be held responsible for outcomes. Technology alone does not have intention, unlike humans; therefore ethics should focus on the motivation and method employed within the persuasion. The motivations behind the persuasive techniques in this thesis are towards increasing environmental behaviours and encouraging people to act in a pro-environmental way. This is not an unethical motivation; the ultimate intent is to reduce the impact of consumption on climate change, which has been demonstrated to have negative consequences for humanity. The persuasive technology demonstrated in Chapter 6 is clear about the intent to enhance the transparency and influence the reduction of energy consumption in the home. It also does not misinform about the data captured or presented. The targeted audience for this persuasive technology are not vulnerable. This technology would also only be installed in homes by the householder's choice; no one would be compelled to use it. The information would only be gathered by this technology with the householder's permission and only displayed within the household. Any other information collected for research purposes would only be done so with express permission.

Despite the weight of these arguments, specific parts of the population deserve special attention. Children are a vulnerable population and are the target demographic of toys that are designed to instill sustainable values in Chapter 5. This type of toy is not directly a persuasive technology; the intention is to stimulate moral development within the context of sustainability and pro-environmental behaviour. There are ethical issues in designing toys intended to instill values for children; however, the motivation behind the toy and the medium itself are not unethical. The potentially problematic area with the design of such toys is that the children would not be aware of the influence the toy has. The responsibility for the influence from this type of toy lies with the designer and the parent/guardian/educator. The value sensitive design method, discussed in Chapter 5, is intended to draw attention to values throughout the design process and is well suited for addressing ethical concerns within this space (Davis, 2009).

CHAPTER SUMMARY

This chapter began by reviewing the definition and concept of sustainability, which is the context of the work for this thesis. It then moved on to examples and statistics

regarding climate change, illustrating the seriousness of overconsumption. It emphasised how personal consumption is important and an area where individuals can help reduce the impact of climate change by reducing their consumption. Therefore, the work in this thesis focuses on this area of understanding and influencing individual consumption behaviours and choices. The section on sustainability and HCI covered the different approaches current in the field of HCI. This thesis takes various different approaches to tackling the problem of encouraging different types of pro-environmental behaviours and this is illustrated in this section.

The section on energy behaviour theory gave a broad overview of theories and models on energy behaviour before focussing on Triandis' Theory of Interpersonal Behaviour as an appropriate model for this topic of research. More recently, research has focused on changing values as a method of influencing behaviour and that is covered in this section. Influencing values can be seen as a potential long-term way of influencing behaviours and this is the focus of the work described in Chapter 5 regarding toys that instill sustainable values.

This chapter then moved on to the specific theories utilised in the experimental work in this thesis. Goal setting theory was reviewed with relevant previous work in this area suggesting that goal-setting theory has much to offer as an actionable framework for designing effective eco-feedback systems that motivate users to reduce consumption. Missing from this literature is a comprehensive understanding of how users choose different types pro-environmental goals when provided with feedback. The work in Chapter 3 tries to answer these questions with two experimental studies where users select their own goals with different levels of difficulty and specificity.

Next, work on goal priming was reviewed, previous work has used goal priming as a successful method in influencing and encouraging energy saving. However, there is conflicting evidence about the effectiveness of priming in social contexts compared to the robust evidence from perceptual priming. This led to the work in Chapter 4 attempting to understand whether goal priming is an effective method of influencing people to choose effective sustainable goals.

The next section of this chapter reviewed recommendations from the literature for creating effective energy consumption feedback, since feedback is required for goal

setting to be effective. Persuasive technology was reviewed in the context of virtual personifications of energy consumption feedback and it was demonstrated that even simple personifications could be powerful persuaders. The section on virtual emotional communication reviews the complexity of displaying emotions in avatars and argues that expressive avatars utilizing multiple modes of communication have the potential to be a powerful persuasive tool. This led into the work conducted in Chapter 6 where the most effective ways avatars can combine expressions and textual context in order to be understandable and persuasive is explored.

Finally this chapter ends with a discussion on the ethical implications of attempting to influence behaviour. This section focuses on when influencing people is justified and the precautions designers must take when creating technology or interventions intended to persuade. The 'golden rule' of persuasive technology is that creators should never seek to persuade with their technology something they would not consent to be persuaded of themselves. It is argued that as long as influencing people makes them better off and does not remove other choices from them, it is acceptable in this domain.

Chapter 3

Understanding Goal Setting Behaviour in the Context of Energy Consumption Reduction

INTRODUCTION

In the USA, energy consumption in private homes accounts for 22% of total use (US Dept Energy, 2010). With increasing pressure placed on traditional sources and mechanisms of energy generation, there is growing interest in ways to reduce these levels. One way this can be achieved is via the design of interactive systems that encourage, support and motivate individual users to reduce their levels of consumption. Indeed, this is a rapidly developing research area in Human-Computer Interaction (HCI) covering topics as diverse as novel measurement systems (Patel, Gupta & Reynolds, 2010), the design of sophisticated *eco-feedback* devices (Froehlich, Findlater & Landay, 2010) and the exploration of how psychologically grounded theories of motivation and behaviour change can best be adapted to leverage these rapid technological advances (He, Greenberg & Huang, 2010).

Goal setting theory has been extensively studied within psychology as a way of motivating behaviour change. Two of the most important aspects of goal setting theory are challenge and clarity. The most difficult goals produce the highest effort and performance. Specific, difficult goals are more effective than vague goals. Feedback is also essential for goals to be effective; goals and feedback together are more effective than goals alone (Locke & Latham, 2002). One study that tested this found a reduction of 20% energy consumption using a simulated washing machine, when energy saving goals were combined with immediate feedback (McCalley & Midden, 2002) (see Chapter 2 for more details).

This chapter explores how goal-setting theory, a psychological framework for understanding motivation and behaviour change, can be applied to the task of reducing the home energy consumption of everyday users. Although there are numerous previous studies on this topic (e.g. Abrahamse et al, 2007; McCalley & Midden, 2002), this chapter makes two main novel contributions. Firstly, we report

data that supports the application of goal setting theory within the specific domain of sustainability and within an interactive interface. Providing a domain specific validation of this theory will help generate effective new techniques for accurate, real-time capture of consumption activity and the development of advanced systems and interfaces for processing, storing and presenting this material. The second contribution relates to the notion that users have a poor understanding of how to set goals that result in significant changes to consumption levels (Attari et al, 2010). We start to explore this idea in detail and show that people tend to pick easier goals for themselves, perhaps because they feel that others will choose difficult goals in their place. This has implications for the design of interactive systems since goal-setting theory posits that difficult goals are more effective motivators than easier goals. In this way, this work contributes to our understanding of how people make sustainable goal choices, work that has direct application to the domain of HCI and sustainability.

This chapter takes steps towards achieving these objectives. Firstly it describes a survey designed to understand knowledge people have about various sustainable actions. Then it describes two studies exploring the nature of the goals users select in home energy reduction scenarios and the feasibility with which they regard them. The method used is a fast, economical and effective way to test theories in this domain and can be applied to other theoretical constructs. By casting light on users' perceptions of appropriate goals in this domain, this chapter highlights possibilities for designing systems that encourage and support users in selecting appropriate goals.

In summary, the literature suggests that goal-setting theory has much to offer as an actionable framework for designing effective eco-feedback systems that motivate users to reduce consumption. Questions regarding how to select appropriate goals remain, in part due to the diversity of the literature on this topic and in part due to an undeveloped understanding of the basis on which users select goals in this domain (Attari et al, 2010). The work in this chapter attempts to address these issues via an experimental paradigm that allows users to choose goals with different levels of difficulty and specificity and provides instant feedback on these selections. The two goal setting studies in this chapter were published in a paper with the same title as this chapter at the Interact conference in 2011.

SUSTAINABLE ACTIONS SURVEY

Firstly, the perceptions people have about their electricity provider and how well they understand their bill were measured. Secondly, the knowledge people have about sustainability and sustainable behaviours and the reasons why they would choose to save energy were also measured (see Appendix A). These surveys were conducted to gain an understanding of current knowledge and attitudes towards energy behaviours and to inform future work.

The main contribution of this survey was showing some misconceptions people have about energy saving actions and the sustainable actions that people are very aware about.

METHOD

The questionnaire was available online in English and in Portuguese. All participants completed the full questionnaire. There were nineteen items regarding how participants felt about their electricity provider, adapted from (McKnight, Choudhury & Kacmar, 2002). There were also items relating to the benevolence of the electricity company and belief in their competence and integrity. For example:

“I feel that the electricity company would act in a customers' best interest”

All items were scored from 1 (strongly disagree) to 5 (strongly agree). The next two items related to electricity bills, scored from 1 (disagree) to 3 (agree), for example:

“You feel your last bill accurately reflects your consumption behaviour”

The next sixteen items were statements regarding sustainable actions, these actions were as accurate as possible and were drawn from a literature review (e.g. Osbaldiston & Sheldon, 2003) and derived from content and tools available on the Stepgreen.org website (Mankoff et al, 2010). Other statistics were taken from trusted sources such as the US Department of Water. Participants were asked to agree, disagree or respond that they did not know to the various statements. An example of a statement is:

“Fuel efficient cars are better for the environment”

The next eight items related to beliefs about things that contribute to climate change, including toxic waste, deforestation and household energy use. These items were scored from 1 (Not at all) to 5 (Very much). The final six items related to personal reasons for reducing energy consumption, including reduction of costs, concern for environment and habit and these items were scored from 1 (Not at all important) to 5 (Highly important). All questions are shown in English in Appendix A.

Participants

Fifty-seven participants filled in the questionnaire online. Twenty-one of those took the questionnaire in English and thirty-six took it in Portuguese. Participants were split almost evenly by gender with twenty-nine males and twenty-eight females. Ages ranged from nineteen to forty-seven with a mean age of 27.16. Thirty-five participants were Portuguese, sixteen were British and there were one each from Brazil, Canada, India, Taiwan, Turkey and one who did not answer the nationality question. Twenty-nine were employed, twenty-six were students and two were unemployed. Eleven participants had finished high school, three had completed college, twenty-two had a Bachelor's degree, eighteen had completed a Master's degree and three had PhD's.

RESULTS

Perceptions of the Electricity Company

Six items were combined to create one measure of the benevolence of the electricity company and Cronbach's alpha was calculated as a measure of internal consistency ($\alpha = 0.76$). The mean rating of benevolence was 3.03 with a standard deviation of 0.71. Six items were combined to create one measure of integrity of the electricity company ($\alpha = 0.87$). The mean rating of integrity was 3.37 with a standard deviation of 0.80. The final six items regarding the electricity company were combined to form one measure of competence ($\alpha = 0.88$) and this had a mean rating of 3.48 and a standard deviation of 0.81.

Bills

The mean rating of bill accuracy was 1.98 with a standard deviation of 0.80. The mean rating of non-comprehension of electricity costs was 2.16 with a standard deviation of 0.90.

Sustainable Behaviours

	Agree	Disagree	Don't know
Fuel efficient cars are better for the environment	81.6	12.2	6.1
Driving 55-60mph gives the best fuel efficiency	34.7	34.7	30.6
Large home appliances, e.g. washing machines, are rated by energy efficiency	79.2	8.3	12.5
People eating less meat is better for the environment	42.9	30.6	26.5
Organic produce is better for the environment	66.7	4.2	29.2
Energy efficient light bulbs use a quarter of the electricity and last 10 times as long as regular bulbs	71.4	6.1	22.4
Washing clothes in a washing machine at lower temperatures uses less energy than washing at higher temperatures	81.3	8.3	10.4
Washing full loads of clothes uses less energy than washing smaller loads less often	53.1	30.6	16.3
Using a dishwasher is more energy efficient than hand washing dishes	41.7	50.0	8.3
You can buy shower heads which reduce the flow of water and therefore reduce energy consumption and waste	71.4	8.2	20.4
Boiling water in a pan with a lid on takes 20% less time than boiling without a lid	53.1	26.5	20.4
Using a games console to play a DVD uses up to 24 times the electricity than a standard DVD player	18.8	10.4	70.8
It does not consume more energy to switch an appliance from off to on than to just leave it on	73.5	4.1	22.4
Computers do not consume more energy when they are put to sleep than when they are left on	67.3	22.4	10.2
Turning off lights when you leave the room saves energy	89.8	6.1	4.1
Air drying clothes saves significant amounts of energy compared to using a dryer	87.8	6.1	6.1

Table 1: List of sustainable actions and answers chosen shown as percentages

Causes of Climate Change

Table 2 shows how participants rated various causes of climate change in descending order of how much they believed each item contributes to climate change.

	Mean	Standard Deviation
Industrial emissions	4.61	0.83
Deforestation	4.54	0.86
Burning fossil fuels	4.36	0.98
The hole in the ozone layer	4.33	0.97
Ocean dumping	4.09	1.17
Toxic wastes	4.07	1.05
Household energy use	3.37	1.12
The space program	3.02	1.18

Table 2: Mean ratings and standard deviations of the causes of climate change

Reasons to Reduce Consumption

Table 3 shows how participants rated the different reasons to reduce their own consumption in descending order of importance rating.

	Mean	Standard deviation
Personal cost savings	4.13	0.89
Concern for environment	3.98	1.06
Concern for future generations	3.89	1.18
Cost savings for employer or place you live	3.26	1.32
Habit	2.96	1.21
Status among peers, friends or family	1.80	1.05

Table 3: Mean ratings and standard deviations of reasons to reduce consumption

DISCUSSION

The ratings of the electricity company show that people do not seem to perceive electricity companies as particularly benevolent, with a mean in the middle of the scale. The ratings of competence, integrity, bill accuracy and understanding electricity cost also tended to fall in the middle of the scale. The latter two results suggest that electricity companies could improve the presentation of the bills they issue in order to help customers understand their consumption.

The items relating to sustainable behaviours show differences in awareness about sustainable actions. Almost all participants agreed that turning off lights when you leave the room saves energy, as well as air drying clothes, fuel-efficient cars and washing clothes at lower temperatures. Half of the participants disagreed that using a dishwasher could be more efficient than hand washing dishes, which is incorrect if the

dishwasher is full. Around a third of people disagreed with driving at 55-60mph for the most fuel-efficient speed, eating less meat being better for the environment and washing full loads using less energy than smaller loads. Actions such as boiling water with the lid on and putting a computer to sleep can be performed easily in the home; this shows an opportunity for areas in which to inform people where they can save energy in their routine. A high proportion of people did not know that using a games console to play DVDs can use up to 24 times the amount of energy that a DVD player uses. This is another area where people in the home can be made more aware of significant differences in the energy consumption of domestic appliances. Taken all together, this section of the survey about sustainable behaviours shows areas where people either lack knowledge or have incorrect assumptions about energy saving behaviours. These are areas where more could be done to increase awareness. One of the first steps in influencing behaviours is to create awareness of the correct behaviour (He, Greenberg & Huang, 2010).

Of all the items measuring belief in causes of climate change, household energy use was the second lowest rated. This presents an opportunity to make people more aware of the contribution of household energy consumption to climate change and the things that they can do around the home to reduce consumption.

Personal cost savings was the highest rated reason to reduce consumption, closely followed by concern for the environment and future generations. When people perform behaviours due to habit, it is more likely that they are intrinsically motivated and more likely for the behaviour to be repeated (Curry, Wagner & Grothaus, 1991). However, habit was the second lowest reason people gave for saving energy. It may be that people are not aware they are performing behaviours as habit, or it may be that they only perform sustainable actions with conscious thought.

This study led into the goal setting work detailed below. The sustainable actions survey showed where people were misinformed or had gaps in knowledge and this led to the question of how people would choose sustainable goals when given feedback as to their effectiveness. The goal setting work was conducted with people living on the subtropical island of Madeira, Portugal. Some of the actions from the sustainable actions survey would not have been relevant for most people living in Madeira, for example, air drying clothes being better than using a dryer, since very few people in

Madeira own a dryer due to the good climate. There are also very few households that have air conditioning or heating due to the climate, therefore goals relating to artificial household temperatures were also not relevant. This also means there is a limit to the generalisability of the sample. The next section will describe two studies informed by goal setting theory and that are concerned with understanding how people choose different types of goals when they are provided with immediate feedback regarding their effectiveness.

SUSTAINABLE GOALS PILOT STUDY

This study explored how people select goals in order to reduce resource consumption in home scenarios. It builds on prior work suggesting that users typically select inappropriate or ineffective goals (Attari et al, 2010) and aims to more deeply understand the factors contributing to goal choice. The study was designed with an exploratory analysis in mind. The overarching goal was to cast light on the types of goals people select, with the expectation that there would be trade-offs between easy and hard goals and goals that are known to be effective and ineffective. Two formal hypotheses were also generated. The first hypothesis is novel in the sustainability domain and relates to goal context. The second serves to check on internal consistency of the experimental setup and determine whether participants were accurately reporting their attitudes and actions. The hypotheses were:

H1: Contextual goals will be chosen more frequently within the consumption reduction scenarios than non-contextual goals.

H2: Environmental concern will be positively correlated with self-report of engaging more frequently in sustainable behaviours.

METHOD

Three scenarios depicting different home settings and lifestyles were developed. Scenarios were chosen because it was more feasible to evaluate them within a lab setting compared to providing real time feedback within homes. The use of such scenarios provides a mechanism for standardizing between participants, and is a simple and effective early-stage alternative to real system deployments that gather data about participants' current behaviours and household energy consumption. The

scenarios were instantiated as narrated descriptions accompanied by illustrative sketches and produced in a video format. Table 4 highlights key aspects of the scenarios. A set of 11 unique goals was selected for each scenario (33 total). Goals were drawn from a literature review (e.g. Osbaldiston & Sheldon, 2003) and sources such as the StepGreen social network (Mankoff et al, 2010). An additional criterion for goal selection was to include goals that varied on level of difficulty (easy/hard) and context (contextual/non-contextual) in each scenario. Table 5 shows all the goals. The easy/difficult categorization was validated independently using an online questionnaire (see Appendix B).

	High Income	Low Income	Single Woman
Scenario Details	Doctor and architect, 1 child, 5 bed house, pool	Janitor and supermarket clerk, 3 children, 3 bed house	Lives alone, 1 bed apartment, career focused
Specific Goals	Don't heat pool in summer. Turn off lights and take advantage of sunlight.	Repair leaky taps quickly. Don't use standby mode on appliances.	Use public transport to get to work. Use energy saving light bulbs.

Table 4. Scenario types and corresponding contextual goals

The questionnaire listed all 33 goals and asked participants to categorize each on a 5-item Likert scale ('Very easy', 'Somewhat easy', 'Neither difficult nor easy', 'Somewhat difficult', 'Very difficult'). Twenty naive users completed the questionnaire, ages ranged from 19 to 40 with a mean of 26, 10 were male and 10 were female. Of the 33 goals, two goals initially classified as difficult were perceived to be easy by subjects. After removing these from consideration, Cronbach's alpha showed a high level of internal consistency of the remaining goals (difficult goals = 0.72 over 9 goals in total). Similarly, two goals originally classified as easy were rated as difficult by participants. After removal of these, Cronbach's alpha showed the internal consistency of the remaining 20 goals to be high (easy goals = 0.86).

In order to create contextual goals, the scenarios were written to include three contextual hints, which were directly related to three of the eleven goals available to choose for that scenario. For example, in the scenario involving the single woman, the narrated description stated that she used regular (non energy saving) light bulbs.

Correspondingly, one of the contextual goals for this scenario was to use energy saving light bulbs. In the high-income family scenario, it was mentioned that they had a pool and one of the contextual goal choices for that scenario was to heat the pool less often to save energy. These goal choices were only available for those scenarios. On the other hand, non-contextual goals for each scenario did not relate to contextual detail provided within the scenarios. Illustrative examples of the goals used in the study can be seen in Table 4.

The main study used the three scenarios and 33 validated goals (see Table 5) and was completed by 20 participants recruited via an email advertisement on a popular university forum and the snowball sampling method (Goodman, 1961). Ages ranged from 20 to 34 with an average age of 26.5. Seventeen of the participants were male and three were female. All were educated to the graduate level or above; thirteen were in full time employment, five were students and two were unemployed.. Most of the sample was Portuguese (13), three were Indian and one each was Greek, Swedish, Taiwanese and Venezuelan. Eighteen were single and two were living with a partner. Household size ranged from one to four with an average size of 2.65, household income ranged from €10,000 to €48,000 with an average household income of approximately €27,500. Participants were given €5 compensation for their time.

The experiment started by capturing a baseline measure of environmental concern using a simple questionnaire. The level of overall environmental concern was calculated as the mean of three items measured on five-point Likert scales. An analysis of the data captured during the studies conducted in this chapter indicated this simple measurement tool exhibited a high level of internal consistency (Cronbach's alpha test reporting 0.79). The three items were as follows (see Appendix C):

In your opinion, how serious (severe) is global warming? (Likert scale labels from 'Not serious' to 'Very serious')

I feel my energy consumption is something I… ('Don't need to worry about' to 'Do need to worry about')

I feel worried about the possible effects of global warming. ('Not at all worried' to 'Extremely worried')

Participants then moved to a computer interface (built using Adobe AIR) where they were exposed to the three scenarios in a fully balanced Latin square design - three participants experienced each of the six possible presentation orders. Directly after watching each video, participants were asked to select goals from the validated list that would best enable the depicted family to reduce their resource consumption (see Appendix D). They were provided with immediate feedback on the effectiveness of the goals using a range of different metrics (e.g. money saved, or impact on carbon footprint). After selecting four goals per scenario, they were asked to rate whether or not they believed that the goals were realistic by rating whether or not the family described in the scenario would achieve each one. They were asked the following for each goal chosen:

"How often do you think the family would commit to each of the following goals you have just chosen?"

The four goals were presented with a 5-point Likert scale with the points labelled: 'Rarely/Never', 'Occasionally', 'About half the time', 'Frequently' and 'Almost Always/Always'. Finally, after completing this process for all three scenarios, the experiment closed by asking participants to report how often they engaged in the activities implied by the goals used in the study. This questionnaire included all of the thirty-three goals that had been presented in the interface previously in random order (see Appendix E). Participants were asked:

"How often do you perform each of the following energy-saving behaviours when you are in your home? Please select not applicable (N/A) if you do not own an item."

These items were presented with the same 5-point Likert scale as previously ('Rarely/Never', 'Occasionally', 'About half the time', 'Frequently' and 'Almost Always/Always'), with the addition of the point 'Not applicable'. Any 'Not applicable' answers were excluded from the analysis. Adding up scores from the final questionnaire created a measure of sustainable lifestyle, with higher scores indicating higher current sustainable behaviours. This last measure regarding participants self reports of how often they performed the goals was intended to separate out what participants felt to be ideal goals (as chosen in the scenarios), from those that they felt to be realistic goals (as performed by themselves). This is an interesting comparison

to make as people can make different choices for others than they do for themselves. In total, the experiment lasted approximately 25 minutes.

RESULTS

Goal	Times Chosen	Difficulty	Context
Turn off lights and take advantage of sunlight	15	Easy	Contextual
Use public transport to get to work	15	Difficult	Contextual
Use dishwasher only when full	14	Easy	Contextual
Turn off lights when not in room	14	Easy	General
Turn off water when not using	13	Easy	General
Wash full loads of laundry instead of half	13	Easy	Contextual
Take part in local environmental organisation	12	Difficult	General
Dry clothes outside instead of tumble drier	11	Easy	General
Use hibernate/sleep for computers	11	Easy	General
Carpool for work or errands	10	Easy	Contextual
Don't heat pool in summer	9	Easy	Contextual
Don't use standby mode on appliances	9	Easy	Contextual
Walk to destinations close by	9	Easy	General
Recycle your glass/plastic/paper	8	Difficult	General
Compete with neighbour to be more sustainable	7	Difficult	Contextual
Reduce carbon footprint	7	Difficult	General
Replace old large kitchen appliances with new energy efficient ones	7	Difficult	General
Where possible wash at 30 degrees	7	Easy	General
Do more outdoor activities	6	Easy	Contextual
Repair leaky taps quickly	5	Easy	Contextual
Switch off TV when not in the room or using	5	Easy	General
Set goal limits e.g. Equivalent to previous month	5	Difficult	General
Take stairs instead of the elevator at work	4	Easy	General
Try not to waste food by cooking too much	4	Easy	General
Don't use plastic bags at supermarket	3	Easy	General
Eat lunch at work 1 or 2 times a week	3	Easy	General
Savings a percentage of energy consumption or money over time	3	Difficult	General
Save the environment	3	Difficult	General
Collect rainwater for watering plants or garden	2	Easy	Contextual
Plant a tree	2	Difficult	General
Be vegetarian	2	Difficult	General
Use energy saving light bulbs	1	Easy	Contextual
Save 5 Euros a month	0	Difficult	General

Table 5: All goals by the number of times chosen in the scenarios (max 20), difficulty and context are also shown

Table 5 shows all of the goals chosen for each of the three scenarios ranked by popularity, their difficulty and whether they were contextual or general. Table 6 shows the top 4 popular goals along with participants' self-report of their own behaviour and their assessment of whether or not the individuals depicted in the scenarios would adopt the goals.

Hypothesis 1, which stated contextual goals would be chosen more frequently within the consumption reduction scenarios than non-contextual goals, was supported. Goals were coded as either 1 for chosen or 0 for not chosen and means calculated. A t-test ($t(17) = 3.12$, $p < 0.01$) showed participants selected goals classified as contextual (Mean = 0.44, SD = 0.10) over those goals classified as non-contextual (Mean = 0.32, SD = 0.06). A second t-test ($t(17) = 2.40$, $p < 0.05$) revealed participants selected easy goals (Mean = 0.41, SD = 0.07) over those rated as difficult (Mean = 0.28, SD = 0.16). The top thirteen most popular goals shown in Table 5 were all classified as easy goals apart from two of them.

Hypothesis 2, which stated that environmental concern would be positively correlated with self-report of engaging more frequently in sustainable behaviours, was also supported. The sum of the participants' ratings of how often they engaged in the goals used in the study was calculated as a measure of the sustainability of their lifestyles. This was significantly correlated with the level of environmental concern (Pearson's $r = 0.53$, $n = 18$, $p < 0.05$). The sum of participants' ratings of how often they engaged in the goals that were classed as difficult was also calculated as a measure of their sustainable lifestyles. The level of environmental concern also correlated significantly with the degree to which participants reported that they engaged in difficult sustainable behaviours ($r = 0.62$, $n = 18$, $p < 0.01$).

	Selected for others	User performs	How often others perform	How often user performs	Feedback over year
Use public transport to get to work	72.2%	33.3%	3.23 (0.83)	1.46 (1.76)**	€104 saved
Turn off lights and take advantage of sunlight	72.2%	88.9%	3.62 (1.12)	4.38 (1.12)	€38 saved
Turn off lights when not in the room	72.2%	100%	4.54 (0.66)	4.69 (0.48)	€6 saved
Turn off water when not using	72.2%	100%	4.31 (0.95)	4.92 (0.28)	€145 saved

Table 6: Most popular goals chosen for households in the scenarios and selves, means and corresponding standard deviations shown in parentheses. ** Significant at the .01 level

Differences between user's recommendations of goals for others and their willingness to adopt them personally are clear in this data. In particular, public transportation was recommended for those depicted in the scenarios much more frequently that it was reported to be personally suitable – a t-test showed this difference to be significant ($t(12) = -3.18$, $p < 0.01$). In contrast, participants reported themselves more willing to rely on sunlight (as opposed to artificial light) than individuals in the scenarios, this result approached significance ($t(12) = 1.87$, $p = 0.08$). A similar non-significant trend emerged in ratings for turning off water whilst not in use ($t(12) = 2.13$, $p = 0.06$). The means and standard deviations for these t-tests are shown in Table 5.

DISCUSSION

The first finding is the firm support for the hypothesis that people prefer contextual goals to non-contextual ones. Contextual goals are more actionable, relating specifically to the scenarios and are thus more likely to be carried out. The selection of more contextual goals over non-contextual ones shows that people need accurate, relevant and contextualized information when they are choosing goals. Providing

information that relates to users' specific behaviours and the contexts in which they happen will allow them to select more appropriate goals and ultimately better motivate users towards reducing consumption.

The results also indicate that people are poor at selecting optimal goals in this domain. The second and third most popular goals selected related to home lighting and were easy to accomplish but have little measureable impact. This suggests that people select goals based on the ease with which they can be achieved and seamlessly integrated into their routines and lifestyles. People seem to be more aware of the existence of easier goals, as is shown in the original sustainable actions survey at the beginning of the chapter. They may think that they are a fast way to make effective changes and be more sustainable. However, such goals are highly problematic. Not only do they have very limited impact on energy consumption, but the ease with which they can be achieved can lead to reduced levels of motivation (Locke & Latham, 2001).

Another finding in this study is that users pick different goals for others than they do for themselves. Furthermore, they overestimate the willingness of others to adopt them. As shown in Table 5, the public transportation goal was the most popular chosen for the individuals depicted in the scenarios, with participants estimating that this would be performed around half the time. However, when the same people were asked how often they performed this activity, a significantly lower rating was recorded.

Finally, perhaps unsurprisingly, higher levels of environmental concern translated into the adoption of more difficult goals; this could be due to the fact that people with higher levels are aware of the impact of their particular behaviours.

FOLLOW UP GOAL SETTING STUDY

A larger second study was conducted in order to build on the findings from the pilot study. It used the same scenarios approach as in the pilot. However, this study did revise several methodological shortcomings present in the pilot.

METHOD

The number of goals was reduced from thirty-three in the pilot to twelve in the second study. Instead of presenting eleven different goals in each scenario, the same twelve goals were presented in each scenario. This enabled a more direct comparison between scenarios. The scenarios were presented to participants in a random order to control for practice and habituation effects.

The goals were selected in order to cover a broad range of behaviours. From the thirty-three used in the pilot, the twelve in the current study were chosen to include an equal number of easy/difficult goals and of vague/specific goals. Validation of goals in the easy/difficult categorization was completed during the pilot. A similar validation for vague/specific goals was performed as part of this study. This took the form of an online questionnaire in which participants rated the goals on a 5-point Likert scale (see Appendix B). The scale was scored with the following terms: 'Very vague', 'Somewhat vague', 'Neither vague nor specific', 'Somewhat specific' and 'Very specific'. After performing this validation, 12 goals were selected such that three goals fell in to the category pairs of easy/specific, three in easy/general, three in difficult/specific and three in difficult/general. Cronbach's alpha reported the internal consistency of the specific goals as .78 and of vague goals as .70. The final goal list is shown in Table 7.

A significant change from the pilot was the removal of goals that were contextual within the individual scenarios. This addressed one of the methodological issues with the pilot: that contextual goals in each scenario might serve as a confound with the overall, scenario-independent level of specificity of the goals.

Thirty-three participants completed the study online. They were recruited via online advertisements for participants on Facebook, via email lists and through an online study website. Participants were not compensated for their time. Ages ranged from 16 to 63 with an average age of 30.5. There were 12 males and 20 females, with one person choosing not to report their gender. Just over half of the sample (17) was educated to degree level or above, ten people had completed high school and five people had completed some college. One participant did not report their education level. Sixteen participants were employed, thirteen were students, three were

unemployed and one was retired. Most of the sample was Portuguese (18), seven were from the U.S.A., three were from the U.K. and one each was from Romania and India with the remaining three choosing not to report nationality. The majority of the sample was single (22), six were married, two were living with a partner and one was divorced. The household size ranged from 1 to 8 with a mean size of 3 and household income ranged from €12,000 to €250,000 with a mean of approximately €55,000.

Goal	Specificity	Difficulty
Save a percentage of your energy bill over time	Vague	Easy
Reduce carbon footprint	Vague	Easy
Do more outdoor activities	Vague	Easy
Save the environment	Vague	Difficult
Take part in a local environmental organization	Vague	Difficult
Compete with neighbour to be more sustainable	Vague	Difficult
Switch off appliances/lights when not in the room	Specific	Easy
Turn off water when not using it	Specific	Easy
Wash full loads only and where possible at 30 degrees Celsius	Specific	Easy
Use public transport	Specific	Difficult
Replace old large kitchen appliances	Specific	Difficult
Become vegetarian	Specific	Difficult

Table 7: Goal list with levels of difficulty and specificity

All participants had Internet access at home.

The experiment began by asking for demographic information including basic details about a participant's household, such as size and income. A baseline measure of environmental concern was then collected. This was achieved differently from the pilot, with the New Ecological Paradigm (Dunlap et al, 2000), a well-established 15-item measure intended for this purpose (see Appendix F). Each item is measured on a

5-point Likert scale and an overall score of environmental concern is derived from the mean of pro-environmental responses.

Participants were then presented with the scenarios used in the pilot study (the high-income family, the low-income family and the single woman) in a random order. The list of 12 goals was presented after each scenario video. When the participant moused over a goal, feedback on the effectiveness popped up for that goal. Feedback was as accurate as possible and the majority were derived from content and tools available on the Stepgreen.org website (Mankoff et al, 2010). Other statistics were taken from trusted sources such as the US Department of Water. Participants were then asked to select three goals from the list of 12 that they felt would enable the family presented in the scenario to reduce their resource consumption (see Appendix D). After selecting three goals, they were taken to the next screen, which showed a summary of the goals chosen with the appropriate feedback for each goal. The participants were then asked:

"How often do you think the family would commit to each of the following goals you have just chosen?"

For each of the three goals chosen, participants had to choose from a 5-item Likert scale with the items: 'Rarely/Never', 'Occasionally', 'About half the time', 'Frequently' and 'Almost always/Always'. This was repeated three times for each scenario. After the scenarios were completed, participants were again presented with the list of 12 goals and asked (Appendix E):

"How often would you commit to each of the following goals?"

This item was scored exactly as the item above. We asked participants in an open-ended question if they would like to add any more goals/activities that they currently do. The study ended with a well-established 10-item measure of self-efficacy (Schwarzer & Jerusalem, 1995; see Appendix F).

The experimental hypotheses followed directly on from the pilot study and were as follows:

H1: Participants will choose specific/easy goals more often than vague/difficult goals within the scenarios and will also rate themselves as more likely to commit to specific/easy goals compared to vague/difficult goals.

H2: Participants will choose easy goals within the scenarios even though they receive feedback that shows they are ineffective goals.

H3: Participants will rate others' commitment to goals as higher than their own.

RESULTS

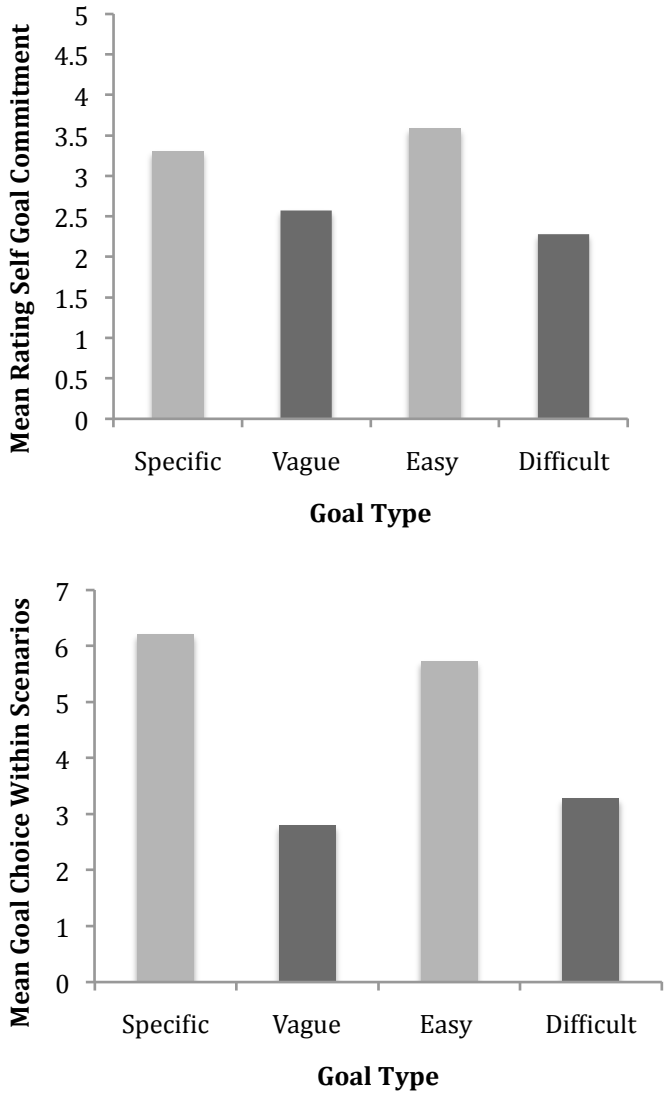

Figure 3 (top): Mean goal choices within scenarios by goal type

Figure 3 (bottom): Mean rating of own commitment by goal type (scale maximum 5)

The first hypothesis was supported. More people chose specific goals for others within the scenarios than vague goals. This result was significant ($t(32) = 6.87$, $p < 0.001$); means and standard errors are shown in Figure 3. This supports goal setting theory, which states that people prefer specific goals to vague ones. The results show that more people chose easy goals for others rather than difficult ones. This result was also significant ($t(32) = 5.61$, $p < 0.001$); means and standard errors are shown in Figure 3.

Participants also rated themselves as more likely to commit to specific goals than vague goals. This was a significant result ($t(32) = 6.98$, $p < 0.001$) as shown in Figure 3. There was also a significant difference ($t(32) = 10.37$, $p < 0.001$) in how often they thought they would commit to easy goals compared to difficult goals (see Figure 3).

Table 8 shows the list of goals in order of popularity over all three scenarios. The maximum possible for each goal is 99, where all 33 participants chose that goal in each of the three scenarios. As can be seen in the table, most of the specific and easy goals are in the top half of the table, as predicted. People prefer goals that are specific, supporting goal setting theory. Feedback for each of the goals is also shown in the table. Two of the most popular goals, switching off appliances and washing full loads of clothes at 30 degrees Celsius, are two of the least effective. These goals save around €1 a month but they were chosen, on average, by half the participants per scenario. This supports the second hypothesis that stated participants would choose easy goals within the scenarios even though they received feedback that showed they were ineffective goals.

There were some small differences in the most popular goals by scenario. In the high-income scenario, the most popular goals were: wash full loads at 30 degrees Celsius (chosen by 21 of 33 participants), switch off appliances (20 out of 33 participants) and use public transport (17 out of 33). In the low-income scenario, the most popular goals were: use public transportation (14 out of 33), turn off appliances, turn off water and do more outdoor activities were all chosen 13 times. In the single woman scenario, the most popular goals were: use public transportation (24 out of 33), wash full loads at 30 degrees Celsius (23 out of 33) and turn off appliances (17 out of 33).

Goal	Times chosen	Goal Type	Feedback
Use public transport to get to work	55	Specific Difficult	This could save €104 a year, assuming €10 a week spent on petrol replaced with €2 bus costs a day
Switch off appliances or lights when not in the room	50	Specific Easy	Save €12 yearly and 80 kilos of CO_2
Wash full loads at 30C	48	Specific Easy	This could save €13 and 71 kilos of CO_2 a year
Save a percentage of energy consumption or money over time	30	Vague Easy	This could save you e.g., 10% from your monthly bill
Turn off water when not using it	27	Specific Easy	This would save €145 yearly and 11,000 litres of water
Do more outdoor activities	25	Vague Easy	Benefit your health, more fresh air and outdoor activities can help prevent diseases and prolong your life
Replace old large kitchen appliances with new energy efficient ones	18	Specific Difficult	The initial investment of new appliance will be recovered within 3 years
Reduce carbon footprint	12	Vague Easy	A collection of several different types of actions, the result would be better for the planet and our natural resources
Compete with neighbour to be more sustainable	12	Vague Difficult	For example, installing a solar panel, this would give you free power for 20 years after the initial cost
Save the environment	9	Vague Difficult	Think about future generations and a better living environment for everyone
Take part in a local environmental organization	7	Vague Difficult	You will get some exercise and fresh air and contribute positively to your community
Be vegetarian	7	Specific Difficult	It's one of the most effective steps you can take and it can save 1600 kilos of CO_2 a year

Table 8: Goal list ranked by number of times chosen. Goal type and feedback presented are also shown

The third hypothesis that stated participants would rate others' commitment to goals as higher than their own was not supported. There were some differences between

ratings of how often others would commit to a goal compared to how often the users themselves would commit to a goal. In contrast to what was expected and to the findings in the pilot, participants rated themselves as more likely to commit to using public transportation (Mean = 3.18, SD = 1.78) compared to others (Mean = 1.76, SD = 1.03).

This was a significant result ($t(16) = -3.67$, $p < 0.01$). They also rated themselves as more likely to commit to switch off water when it is not being used (Mean = 4.54, SD = 0.78) than others (Mean = 0.85, SD = 1.73). This was a significant difference ($t(12) = -7.22$, $p < 0.001$). Participants also rated themselves as significantly ($t(16) = 2.28$, $p < 0.05$) more likely to commit to switching off appliances (Mean = 4.41, SD = 0.51) that are not in use compared to others (Mean = 3.82, SD = 1.01).

Once again there was no significant correlation found between self-efficacy and goal type chosen for others or between self-efficacy and ratings of participant commitment to goal type. Higher self-efficacy was expected to correlate with more difficult goal choices, but this was not found ($r = 0.57$, $n = 28$, $p = 0.78$).

There were also no significant correlations found between scores on the New Ecological Paradigm (NEP), a measure of pro-environmental orientation, and difficult goals ($r = 0.07$, $n = 33$, $p = 0.70$) or specific goals ($r = 0.18$, $n = 33$, $p = 0.31$) chosen for others. There was also no significant correlation between the NEP and ratings of self-commitment to goals ($r = -0.31$, $n = 30$, $p = 0.09$).

DISCUSSION

The main study showed full support for the first hypothesis. Participants chose specific and easy goals within the scenarios more often than they chose difficult and vague goals. This confirms the results from the pilot study and also confirms goal setting theory, which states that participants prefer specific goals, as they are more actionable than vague goals. The least popular goal was: be vegetarian. Even though it is a specific goal, this is probably due to that fact that it is too difficult for most people to commit to. Previous work on goal setting theory states that the level of difficulty at which people set goals depends on various factors, including self-efficacy, past

performance and social influences (Locke & Latham, 2006). The results found here show a clear preference for easy goals.

People also indicated they would personally commit more to specific goals rather than vague goals, supporting goal setting theory. The data also showed they would commit more often to easy goals rather than difficult goals, extending the findings from the pilot. One possible explanation is that difficult goals may be too much of a long-term commitment for people. Previous goal setting work has shown that easy goals tend to have higher commitment because they require less dedication (Locke, 1996). Easy goals can be rapidly integrated into a person's everyday activities, for instance, both doing more outdoor activities, and taking part in a local environmental organization have clear real world parallels. However, doing more outdoor activities was rated as an easy goal, possibly because it is perceived to be more under a person's direct control than joining an organization, which was rated as difficult. Autonomy in choosing goals is related to higher goal commitment; therefore people should be free to choose their own goals rather than having steps or actions imposed upon them. Actionable and effective recommendations are needed for people to choose appropriate sustainable behaviours.

The second hypothesis that stated participants would choose easy goals within the scenarios even though they received feedback that showed they were ineffective goals was also supported. The two least effective goals in terms of money and CO_2 savings were the second and third most popular choices. However, goal setting theory states that difficult and specific goals produce the greatest results. This finding has implications for encouraging sustainable behaviour. Easy goals such as turning off appliances or lights tend to be the ones people know most about, as shown in the survey described at the beginning of the chapter. People therefore need to be provided with more information about effective goals, perhaps presenting more difficult goals or actions in terms of smaller steps that can encourage more effective behaviour change over time.

Using public transportation to get to work was the most popular goal and is much more effective than the next two goals in popularity for the scenarios. People need concrete, effective recommendations if they are to make sustainable informed

choices. The more effective actions, such as using public transport should be the focus of information and promotion by advice-giving bodies rather than less effective actions such as switching off lights. It is clear that people know many of the less effective actions and appear to be unaware of the more effective actions. People should be given information about an action's effectiveness at the time of recommendation, along with time and effort required to perform it so they can make more informed choices about their goals.

There was no support found for the third hypothesis. A difference was expected between ratings of self and others commitment to goals. There was a difference found but not in the direction expected. More people rated their own commitment to some goals as higher than others' commitment to goals. This is different from the results in the pilot, which suggested that people would choose more difficult goals for others than for themselves. However, the wording of the question was different in the main study because it asked how often participants would be willing to commit to goals, whereas the pilot asked about their current behaviours. The interpretation of this result is that people are more honest when asked about current behaviours and overestimate about their future plans. However, this discrepancy could also be due to differences in the samples; the second sample was broader (and somewhat older) than the first, so they could simply be more aware of the changes they are able to enact in their lives. Further work needs to be done in this area to determine the extent to which people think others will shoulder the responsibility for sustainable energy use.

CONCLUSION

This chapter presented two main contributions. Firstly, the studies found support for goal setting theory within the domain of sustainability. Both the pilot and the main study showed that people prefer specific or contextual goals to vague or non-contextual ones. The second contribution shows that users have a poor understanding of how to set goals that have a significant effect on energy consumption levels. Both studies showed that people tend to pick easier goals for themselves. This may be because they feel that others will choose difficult goals in their place, as seen in the difference between self and other's commitment to goals in the pilot. Since goal

setting theory states that more difficult goals are more effective at getting real results, this has implications for the design of interactive systems.

Previous discussions of goal setting theory have typically been based on aggregate consumption data shown using simple numerical displays (e.g. McCalley & Midden, 2002). While considerable benefits have been shown in this work (such as reductions in consumption), this chapter argues that additional benefits (such as knowledge) will emerge through appropriately designed techniques based upon the theory, presented in homes and using real-time contextualised feedback (Froehlich, Findlater & Landay, 2010). Ideally, participants should be able to choose their own goals and receive feedback based on detailed data representing consumption practices (Berges, Matthews & Soibelman, 2010) from their home. They should be presented with customised information and personalised recommendations (He, Greenberg & Huang, 2010) based on the goals chosen and feedback received. This system should not be annoying, intrusive or repetitive and should adapt to users' needs as required. This chapter takes steps towards the first design of such a system by showing how users choose goals, the types of goals they choose for themselves and makes an attempt to understand the reason for these choices. The type of goal setting interface utilized in this chapter can be used to test theories cheaply and easily. It is quicker than implementing a working system in the field and can be used as a first step to designing useful systems that can have an impact on encouraging sustainable behaviour change.

Options for future work on this topic are broad. A key development would be to integrate further work exploring goal selection with real-time sensing and presentation of home energy consumption levels. This will allow the development of interfaces that provide tailored, actionable and contextually relevant goals to users. Regularly updated feedback would also offer users confirmation of the effectiveness of their actions and goals. Chapter 6 describes work based around the design of a system that senses energy consumption and provides feedback.

CHAPTER SUMMARY

This chapter began with a short overview of how goal setting theory can be applied as an actionable framework to the problem of helping people make more effective sustainable choices. The first survey reported here showed that people have some misconceptions about actions that they can take to use less energy. This led into the pilot goal setting study that gave people choices of sustainable goals categorised as easy or difficult and as general or contextual. The results from the pilot study showed that people clearly preferred goals that were contextually appropriate to the scenarios they were presented with over goals that were general. Easy goals, despite their ineffectiveness shown via immediate feedback, were also preferred compared to difficult goals. This led to a follow-up study where the goals were condensed from 33 to 11 and categorised into easy, difficult, vague and specific. This second goal setting study showed that people have a clear preference for specific and easy goals, despite feedback about their lack of effectiveness compared to the other goals presented. This work has implications for the design of systems where users choose sustainable goals or actions, in particular, the need to carefully present the most effective goals as manageable.

One of the main issues presented in this chapter is that users tend to choose easy goals, whereas difficult goals produce the best performance. Influencing people to choose more difficult goals is a key area where a difference can be made in energy consumption. The next chapter discusses work that attempts to influence people to choose more difficult goals based on the theory of goal priming.

This chapter has highlighted the need to better understand goal selection behaviour in the context of consumption reduction scenarios, so that users can be guided towards more effective and efficient goal selections. Ultimately, this work suggests that developing a better understanding of user's goals and how they select them will allow the design of better systems to reduce energy consumption.

Chapter 4

Goal Priming in the Context of Energy Consumption Reduction

INTRODUCTION

In this chapter, this thesis will now move on to the second main goal of this work: influencing the types of energy reducing goals people choose. The previous work in Chapter 3 has shown that people make poor or ineffective goal choices; therefore this is an area where choices can be influenced in a positive way. Recently goal priming has been studied along with goal setting theory in the area of energy consumption to see whether priming environmental goals leads to greater energy savings (McCalley et al, 2006). This previous work will be extended by using pictorial primes in an attempt to see if this is one way people can be influenced to choose more difficult and effective goals.

People's behaviour may be influenced if they are first exposed to words, sights, sounds or actions, known as primes, that act as cues for their subsequent actions. The priming of semantic concepts has been shown to increase their accessibility, which in turn facilitates the processing of related constructs (Neely, 1977). For example, after being primed by reading the word "lamp", people may become faster at reading the word "light" compared to no priming. Priming behaviours can also result in an increased likelihood that the individual will perform the primed behaviour. This has been shown through imitation of observed behaviours (Chartrand & Bargh, 1999; Lakin & Chartrand, 2003). It has been argued (Aarts, Gollwitzer, and Hassin, 2004) that people may not only automatically imitate behaviours but also may adopt and pursue a goal that is implied by another person's behaviour. They show that if participants are presented with behavioural descriptions implying a certain goal, they may initiate this behaviour if they can, even without being aware of the influence. The key assumption of this previous work is that goals can be activated subconsciously to affect outcomes (Bargh & Chartrand, 1999).

As discussed in the previous chapter, work on goal setting theory has shown specific goals can lead to higher effort and productivity compared to vague goals. A recent study (Latham & Piccolo, 2012) compared a context-specific primed goal to a general achievement primed goal and measured job performance. Their primes consisted of photographs, either a woman crossing a finish line in a race (general achievement prime) or employees working at the same job as employees in the experiment (context specific prime). There were no photographs shown in the control condition. The employees worked as fundraisers at a call centre and job performance was measured by the number of donors who pledged dollars to the organisation and the monetary value of donations received. Employees in the context-specific prime condition and general achievement conditions had significantly higher performance compared to those in the control condition. There was also higher performance in the context-specific compared to the general achievement condition but this difference was not significant. Simple photographs clearly had an effect on job performance and the authors argue that their findings support the assertion that a primed goal has a similar effect on performance as a consciously set goal.

However, other work in this area has showed that priming may be more complex than has been previously suggested. Recently authors (Pashler, Coburn & Harris, 2012) have pointed out the differences between perceptual priming and social or goal priming. The findings from perceptual priming studies such as responding faster to semantically associated words after being primed are robust. However, findings from social priming studies seem harder to replicate. Pashler and colleagues attempted to replicate two priming studies by Williams and Bargh (2008) where spatial distance priming was completed by marking points on a Cartesian coordinate plane. The original study had three conditions, close, intermediate and distant, the distant prime predicted weaker family ties and lowers estimates of calorie content of foods compared to the close prime. Pashler, Coburn and Harris (2012) were unable to find the same results. They conclude that the failure for priming to work is not due to experimenter expectancy since in the original study the experimenter was blind to conditions. They suggest that the failure to replicate the priming effect is due to the original results being invalid and representing Type 1 errors.

In a highly cited study, Bargh, Chen and Burrows (1996) demonstrated that participants who had been exposed to words relating to old age, walked more slowly out of the laboratory than participants who had not been exposed to these words. Doyen, Klein, Pichon and Cleeremans (2012) recently replicated this study in an attempt to improve on their methodology and test whether the same results were found. Their first experiment failed to replicate the findings. In a second experiment, the original results were only replicated when the experimenter was expecting the participant to walk slower due to the prime. They also found that most participants were aware of the social category they had been primed with and that a proportion of those who walked slower were aware that they had walked slowly. Doyen et al (2012) state that the salience of the primed concept is too weak to automatically cause behaviour in the absence of contextual cues and that attention and saliency are needed for priming to work. These failures to replicate the results show that priming has some limitations and further work needs to be completed in the area of social and goal priming to determine its effectiveness.

Priming has however been successfully utilised to encourage energy saving in one study by McCalley et al (2006). They used a commonly used method of priming called supraliminal priming, which involves consciously providing participants with information in a way that appears to have no relation to the experimental task that follows. Their study had three priming conditions; in each condition participants were primed with a meta goal (pertaining to self), an action goal (pertaining to specific actions) or a neutral goal. The also had a control condition where no goal level was primed. In each priming condition, participants were shown scenarios consisting of slides about either the participants' personal desire to save the environment (meta level goal), specific energy saving actions (action level goal) or neutral non-environmental slides (neutral level goal). The meta level slide show was about the environment in general, stating that it can be improved by being a conservationist. The action level slide show gave practical tips on how to save energy, along with pictures such as a light switch being turned off. The neutral slide show displayed photos of the university and its surroundings and the control group were shown only a blank screen. 103 participants took part in their study, they were shown a simulated washing machine interface and were asked to do washes within the interface as they would at home. The interface was a copy of a current washing machine model, with

the addition of kWh feedback. They did ten washing trials with the last six calculated as a baseline of performance. They then watched the priming slides depending on condition, disguised as a saving screen. After the priming all the participants set explicit goals of 0, 5, 10, 15 or 20% energy savings compared to the initial trials. They then completed 20 more washing machine trials to calculate savings compared to the baseline. The authors found savings in each condition, Meta (self): 13.61%; Action: 18.58%; Neutral: 17.25% (this result seemed to indicate neutrality was violated and was dropped from analysis) and Control: 10.43%. The highest saving was in the specific actions priming condition; this was significantly different from the control condition.

Previous work has shown priming to influence behaviour and contextually specific primes to be effective at influencing performance. However, there are also some conflicting findings in the literature when it comes to goal priming. In the work described below, participants primed with pictorial difficult environmental actions are expected to choose more difficult goals compared to those not primed in this way. If priming influences people to choose difficult and more effective sustainable goals then embedding simple images within eco-feedback interfaces, for example, may encourage people to make more effective sustainable goal choices in the home.

METHOD

The priming technique has been adapted from McCalley et al (2006) as described above. This method of priming has been shown to be successful in an energy saving context. A pilot of pictures showing easy (Figure 4 shows an example) and difficult (Figure 5 shows an example) energy saving actions was conducted with a group of five people to check that the pictures primed the intended goal. The pictures were selected and then validated through discussion with each of the participants in the pilot to ensure the pictures showed the desired easy or difficult actions as clearly as possible. This led to some pictures being removed or replaced for better examples of actions. All participants agreed at the end that the final set of photographs depicted the intended actions clearly. No participants from the pilot took part in the main study. After the pilot was completed and the materials were validated, the main study was conducted.

Figure 4: The recycling easy goal prime

Figure 5: The public transport difficult goal prime

The study adapted some of the method used in the goal setting work (see Chapter 3), namely the scenarios, the questions asking participants to choose goals for others and the ratings of own commitment to goals. The set of validated easy/difficult and specific environmental goals were also used here (details of validation in Chapter 3). Only specific goals were selected for this study as the work in the previous chapter showed that people prefer specific goals to vague goals. Specific goals should also be more easily primed via pictures compared to vague goals. The six vague goals were therefore removed and previously validated specific goals were added in. This led to a set of ten specific goals, with five of these classed as difficult and five classed as easy. The full list of goals and immediate feedback is shown in Table 9. The same set of scenarios from Chapter 3 was also used. The main study was a between-subjects design with three conditions: easy action goal pictures, difficult action goal pictures and a control condition with no pictures. Participants were primed and then the types

of goals they chose for others within the scenarios, others' commitment to the goals and their own potential commitment to those goals were measured.

Goal	Difficulty	Feedback
Recycle your glass/plastic/paper	Easy	70% less energy is required to recycle paper compared to producing it, 24 trees are needed to produce 1 tonne of newspaper. 1 recycled glass bottle saves enough energy to power a computer for 20 minutes. The carbon footprint of plastic is around 6kg of CO2 per kg of plastic.
Use energy efficient light bulbs	Easy	This would save €27 yearly and 473 kilos of CO2 assuming you replace 12 light bulbs throughout the year.
Switch off appliances/lights when not in the room	Easy	Save €12 yearly and 80 kilos of CO2
Turn off water when not using it	Easy	This would save €145 yearly and 11,000 litres of water
Wash full loads only and where possible at 30 degrees Celsius	Easy	This could save €13 and 71 kilos of CO2 a year
Define personal limits e.g. have lower electric bill than last month	Difficult	Set your own limits, this could help control your spending on your energy bills.
Collect rainwater to water plants	Difficult	A good way to reuse natural resources, the amount saved depends on how much it rains.
Use public transport	Difficult	This could save €104 a year, assuming €10 a week spent on petrol replaced with €2 bus costs a day
Replace old large kitchen appliances	Difficult	The initial investment of new appliance will be recovered within 3 years
Become vegetarian	Difficult	It's one of the most effective steps you can take and it can save 1600 kilos of CO2 a year

Table 9: Full list of goals, categorisation and feedback

Participants

Sixty-two participants completed the study online. They were recruited via online advertisements for participants on Facebook, via email lists and through an online study website. Participants were not compensated for their time. The mean age of participants was 28.5, the minimum age was 17 and the maximum was 57. Thirty-four reported being male and 24 female, with the remaining four declining to answer.

Forty-seven of the participants had completed degrees, six had completed some college, five had completed high school, two had completed less than high school and two declined to give information about their education level. Fourteen participants were Portuguese, thirteen were Colombian, nine were from the UK, three were Indian, three were from the USA, two were Irish, two were Romanian, two were Russian, two were Polish and one each were from various other countries. Thirty-five of the sample reported being employed, seventeen were students, seven were unemployed, two were retired and one declined to answer. Thirty-eight participants reported being single, eleven were living with a partner, ten were married, one was divorced and two did not respond. Fifty-nine participants reported having internet at home, only one did not have internet and two did not respond.

Procedure

The experiment began by showing information regarding the study and instructions including asking participants to select realistic goals for individuals in the situations to commit to. It then moved on to asking for basic demographic information. A baseline measure of environmental concern was then collected, using the New Ecological Paradigm (Dunlap et al, 2000) that was also used in the main study in Chapter 3 (see Appendix F). Each item was measured on a 5-point Likert scale and an overall score of environmental concern was derived from the mean of pro-environmental responses.

Participants were shown the pictorial primes for two seconds each before the video describing each scenario. The pictorial primes appeared in random order within each condition and each participant saw every prime for their condition. Since there were five pictorial primes (one for each goal) within the conditions and three scenarios, this led to two pictorial primes before the first and second video and one pictorial prime being shown before the third and last video. The priming was disguised as loading screen while the video was loading. Participants were then presented with the scenarios used in Chapter 3 (the high-income family, the low-income family and the single woman) in a random order. The list of 10 goals was presented after each scenario video. When the participant moused over a goal, feedback on the effectiveness popped up for that goal (see Appendix D). Feedback was the same as described in Chapter 3 and is shown in Table 1. Participants were then asked to select

three goals from the list of 10 that they felt would enable the family presented in the scenario to reduce their resource consumption. After selecting three goals, they were taken to the next screen, which showed a summary of the goals chosen with the appropriate feedback for each goal. The participants were then asked:

"How often do you think the family would commit to each of the following goals you have just chosen?"

For each of the three goals chosen, participants had to choose from a 5-item Likert scale with the items: Rarely/Never; Occasionally; About half the time; Frequently and Almost always/Always. This was repeated three times for each scenario. After the scenarios were completed, participants were again presented with the list of 10 goals and asked (Appendix F):

"How often would you commit to each of the following goals?"

This item was scored exactly as the item above. Finally, participants were asked an open-ended question, namely:

"Would you like to add any more goals/activities that you currently do?"

The experimental hypotheses were as follows:

H1: Participants primed with difficult goals will choose difficult goals within the scenarios more often than participants in the control or easy priming conditions.

H2: Participants primed with difficult goals will rate others' commitment to difficult goals as higher than participants in the control or easy priming conditions.

H3: Participants primed with difficult goals will rate themselves as more likely to commit to difficult goals compared to those in the easy or control conditions.

RESULTS

	Difficult Goals			Easy Goals		
	Chosen Mean	**Others Commitment**	**Own Commitment**	**Chosen Mean**	**Others Commitment**	**Own Commitment**
Control	3.81 (1.57)	2.49 (1.50)	2.76 (0.93)	4.90 (1.51)	3.37 (1.46)	4.17 (0.52)
Easy	3.38 (1.36)	2.50 (1.00)	2.38 (0.80)	5.10 (1.45)	4.07 (1.74)	4.25 (0.57)
Difficult	2.55 (1.40)	2.03 (1.26)	2.51 (0.69)	6.10 (1.52)	4.82 (1.46)	4.37 (0.42)

Table 10: Means of goals chosen and ratings of self and others' commitment to goals by condition, standard deviations are in brackets

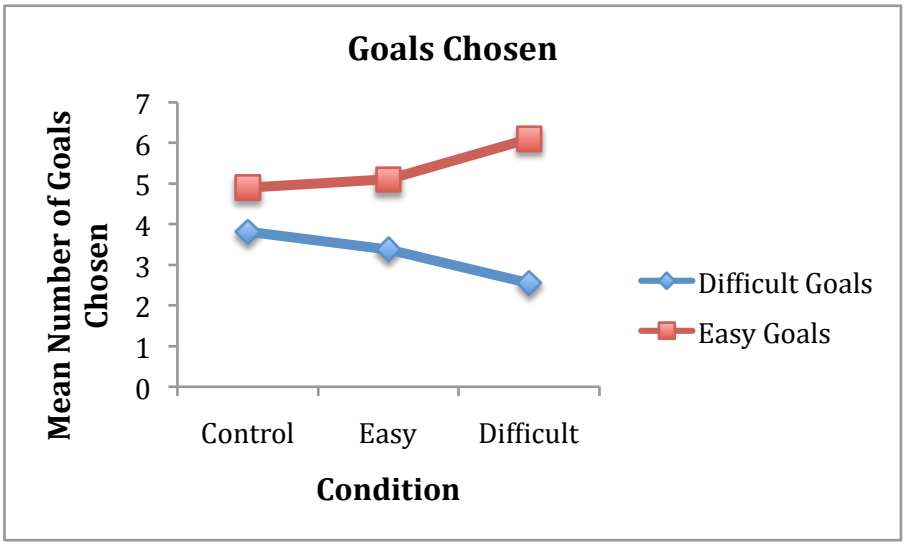

Figure 6: Mean number of goals chosen by condition

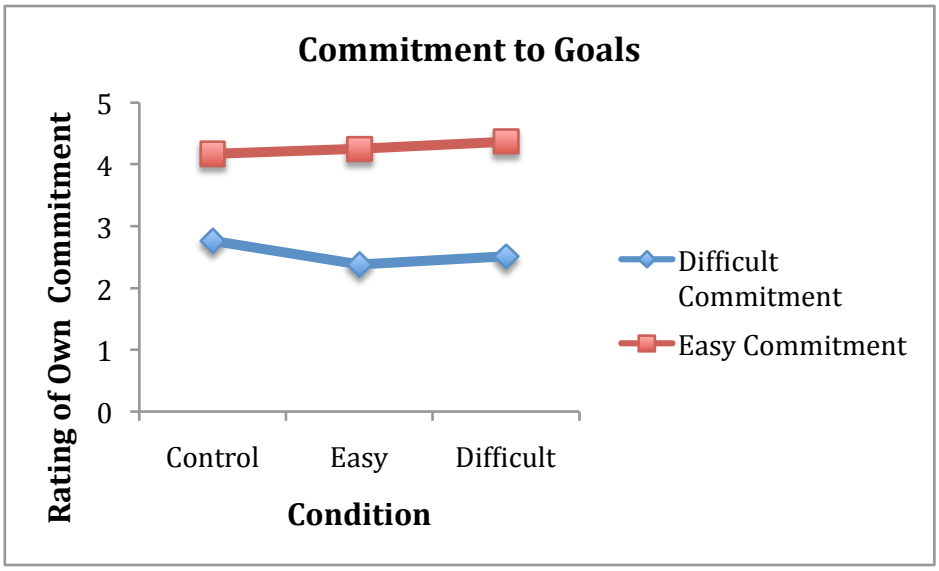

Figure 7: Own commitment to goals by condition

Hypothesis 1 was not supported. Table 10 shows the means of the goals chosen in the scenarios and participants' ratings of others' and own commitment to the goals chosen by condition. Figure 7 shows the mean number of difficult goals chosen was lowest in the difficult priming condition. The control condition had the highest mean number of difficult goals chosen. A one-way between subjects analysis of covariance (ANCOVA) was conducted using scores on the New Ecological Paradigm (NEP) as a covariate. A preliminary analysis evaluating the homogeneity-of-regression (slopes) assumption indicated that the relationship between the covariate (NEP scores) and the dependent variable (difficult goals chosen) did not differ significantly as a function of the priming condition, ($F(2, 3.54) = 1.71$, $p=0.190$). The ANCOVA showed that the difference between the conditions when choosing difficult goals was significant ($F(2, 8.28) = 3.91$, $p<0.05$) but not in the direction predicted. Post hoc comparisons (Bonferroni) showed that those in the control condition chose difficult goals significantly more often than those in the difficult condition ($p<0.05$).

Figure 7 also shows that participants in the difficult condition picked more easy goals than participants in the easy or control conditions. A one-way between subjects analysis of covariance (ANCOVA) was conducted using scores on the New Ecological Paradigm (NEP) as a covariate. A preliminary analysis evaluating the homogeneity-of-regression (slopes) assumption indicated that the relationship between the covariate (NEP scores) and the dependent variable (easy goals chosen)

did not differ significantly as a function of the priming condition, $F(2, 2.14) = 0.95$, $p=0.393$. The ANCOVA showed the difference between the conditions when choosing easy goals was significant ($F(2, 8.31) = 3.70$, $p<0.05$). Post hoc comparisons (Bonferroni) showed that those in the difficult condition chose easy goals significantly more often than those in the control condition ($p<0.05$).

Hypothesis 2 was also not supported. Table 10 also shows ratings of others' commitment to difficult goals in the difficult condition was the lowest although this difference was not significant. Finally, Table 10 shows those in the difficult condition also had higher ratings of others' commitment to easy goals compared to the other conditions.

Hypothesis 3 was also not supported. Figure 7 shows that the highest mean rating of participants' own commitment to difficult goals was in the control condition, however a one-way between subjects ANOVA showed the difference between the priming conditions was not significant. The difference between the priming conditions on ratings of own commitment to easy goals was also not significant.

Goal	Times Chosen	Category
Switch off appliances/lights when not in the room	**90**	**Easy**
Use public transport	**90**	**Difficult**
Wash full loads only and where possible at 30 degrees Celsius	**82**	**Easy**
Use energy efficient light bulbs	**69**	**Easy**
Define personal limits e.g. have lower electric bill than last month	**56**	**Difficult**
Recycle your glass/plastic/paper	**51**	**Easy**
Collect rainwater to water plants	**43**	**Difficult**
Turn off water when not using it	**40**	**Easy**
Replace old large kitchen appliances	**29**	**Difficult**
Become vegetarian	**8**	**Difficult**

Table 11: List of all goals by overall popularity

Table 11 shows the full list of goals and the number of times they were chosen across all scenarios and conditions. Overall, the most popular goals tended to be the easy and ineffective goals; this replicates the findings from Chapter 3. The top 3 most popular goals in this study are the same top 3 most popular goals in the main study in Chapter 3.

There was a significant positive correlation ($r = 0.28$, $n = 57$, $p<0.05$) found between scores on the New Ecological Paradigm (NEP), a measure of pro-environmental orientation, and own commitment to difficult goals. There were no significant correlations between NEP scores and goal choice.

DISCUSSION

None of the experimental hypotheses was supported. The pattern of results found for difficult goal choices was the opposite of what was predicted. Participants in the control condition who saw no pictorial primes chose difficult goals more often than participants in either of the other conditions. Participants who saw primes depicting difficult energy saving actions chose easy goals more often than participants who saw no primes. This could suggest that the priming manipulation did not work to influence goal choice. There were also no significant differences in ratings of others' and self-commitment to difficult goals across the priming conditions.

The findings reported here support previous work by Pashler, Coburn and Harris (2012) that suggests that goal priming is more complex than perceptual priming. Perceptual priming is a robust and easily replicated finding, which is not the case for social or goal priming. It may be that priming works better for completing tasks or influencing performance rather than goal choices. Doyen et al (2012) state that primes are too weak to automatically produce behaviour in the absence of contextual cues. Findings from cognitive neuroscience indicate that attention and saliency are needed for priming to work. For example, work done by Aarts and Dijksterhuis (2003) showed that pictures of a library could induce participants to talk less loudly, but only when they had a goal of visiting a library. This could explain why priming was not effective in the work reported in this chapter; people may not previously have had the overall goal of saving energy and the majority of the study was based around choosing goals for others around hypothetical scenarios. Perhaps pictorial primes of

energy saving actions may work to influence energy saving behaviour when people already have the goal of reducing energy. McCalley and Midden (2002) came to a similar conclusion when they found that receiving feedback without setting a goal in their washing machine interface had no effect, therefore they argue that conservation requires having a primary goal of saving energy.

The overall goal choices found here replicate the findings regarding goal choices from Chapter 3. Easy goals were more popular than difficult ones across all the conditions. It may have been that the difficult goals presented in this study were too difficult for participants to commit to. Participants who saw the primes depicting difficult actions may have thought they were too difficult to choose or commit to after seeing them and became discouraged rather than encouraged to choose these goals. The difficult goal: 'be vegetarian' may be an outlier because it was only chosen 8 times in the entire study out of a maximum possible 186 times. The next least popular goal was chosen 29 times. It may be that this goal is too much of a life change for people to commit to.

One of the limitations of this work was that participants saw the primes for only 2 seconds each before being asked to choose goals. It could be that this amount of time is not long enough for a pictorial prime to be effective. In the study by Latham and Piccolo (2012) where pictorial primes successfully improved job performance, participants were exposed to primes constantly while working. The longer length of time the pictorial primes were shown could have increased their effectiveness.

Another limitation was the lab and scenario-based nature of the study did not allow participants to choose goals relevant to their real life or us to measure changes in behaviour or attitudes over the long term. Future work should present participants with pictorial actions of energy saving actions, perhaps embedded within eco-feedback systems, and tested over the long term to determine whether they can affect consumption.

A final limitation was that only a small number of participants piloted the primes in this study. A future study should also more extensively pilot the pictorial primes in order to ensure the primes function as intended. If a larger sample correctly identified

the actions depicted on the slides, then perhaps the results here could be attributed to goal difficulty or effectiveness rather than the pictorial priming method used.

Future work could also validate goals into easy, medium and difficult categories to see if priming can influence people to choose medium difficulty goals. Difficulty should also be cross-referenced with effectiveness to see if priming can influence goal choice by effectiveness rather than just difficulty. Since the vegetarian goal seems to have been too difficult for people to choose, it may be better if future goal setting work in this area does not use this as potential goal.

To conclude, goal priming may still be useful in influencing energy saving tasks or performance rather than goal choices. Semantic priming is complex with findings such as words priming slower walking (Bargh, Chen and Burrows, 1996) being questioned and doubts raised as to whether these findings actually show priming is a valid method for changing behaviour (Doyen et al, 2012). More work needs to be done in this area to determine what types and methods of priming (if any) can be utilized to influence people to choose more difficult and effective energy saving goals. Sustainability is a complex topic and it seems that more significant or context aware interventions than simply showing pictures are needed to influence goals. A more comprehensive study, using goal priming in this topic is needed to further explore the possibility of priming as a method of influence.

CHAPTER SUMMARY

This chapter began by describing some background research that justified using priming as a method of influencing goal choice. It was noted that previous work (Chapter 3) has found that people make ineffective goal choices and consequently there is a need to persuade them to make more effective choices. Other research has shown priming to be effective at increasing job performance and at reducing consumption in a washing machine interface where people set their own consumption reduction goals. The study described in this chapter used a similar method to the goal setting study in Chapter 3. Here, participants were shown pictures of either easy or difficult energy saving actions before watching scenarios describing households and then choosing energy saving goals for those households. It was predicted that participants who were exposed to pictorial primes of difficult energy saving actions

would be more likely to choose difficult goals and have higher ratings of their own and others' commitment to those goals compared to participants in the control and easy actions priming conditions. However, the results found were not as predicted, those who saw no primes chose difficult goals more often than those who saw difficult primes. Participants in the difficult priming condition chose easy goals more often than those in the other two conditions. These findings are explained in the context of previous work that shows that social or goal priming is more complex than perceptual priming and requires salience and attention to be effective. The chapter ends with suggestions for future work in this area and argues that goal priming may be more effective at encouraging difficult goal choices when embedded within an eco-feedback system, presented over the long term to people who already have an overall goal of saving energy.

Chapter 5

Playing for the Planet: Designing Toys that Foster Sustainable Values

INTRODUCTION

Play is the activity that typifies childhood; it is also an essential part of children's healthy growth, development and learning across all ages and cultures (Isenberg & Quisenberry, 2002). Children spend a considerable part of their time playing, either using their imagination and the objects that surround them, or particular toys parents purchase. Therefore, toys for entertainment or education have a large market; they are popular and commercially viable. Toy sales in the U.S. in 2012 totalled $16.5 billion. The types of toys with the largest increases in sales from the previous year were building sets (19.7%), arts and crafts (6.9%), dolls (5.8%) and preschool (2.5%) (www.npd.com, 2012).

Playing with toys helps children develop their basic motor and cognitive skills but can also pass on cultural knowledge or values (Goldstein, 1994). Consider the difference between a mathematical or shape-based toy that educates cognitively, such as an abacus (Figure 8c), and a Barbie or Ken doll (Barbie)(Figure 8a, 8b) that instructs children about social norms, albeit in a less direct way than cognitively educational toys. Barbie dolls show a very thin depiction of the female body; this norm can have a significant and negative impact on young girls' idea of body image and self-esteem, which can continue in later life (Dittmar, Halliwell & Ive, 2006). Toys can explicitly convey values, such as religious dolls and those that reinforce gender roles (e.g. kitchen toy sets for girls; cars or weapon toys for boys). Indeed, researchers have argued that a large proportion of toys convey values. Value is a broad term and is defined here as including principles, standards and beliefs. For example, in a recent survey of 125 toys, Blakemore and Centers (2005) reported that 70% were rated as conveying either feminine or masculine attributes. Toys can pass on negative norms and values that follow children through life; they should also be able to pass on

positive norms and values through well-designed, developmentally appropriate toys.

Figure 8: Barbie (a), Barbie and Ken (b) and an abacus (c)

There are many examples of educational or entertainment toys (www.amazon.co.uk) but far fewer which are explicitly designed to instil values. For instance, there are no toys in the top 100 bestsellers on Amazon that are specifically designed to instil values. Some of the most popular toys are currently LEGO sets, collectable monster toys, bead sets, word puzzles, food sets, digital cameras, dolls, teddies, board games, math games and role play sets (www.amazon.co.uk). The top 10 bestselling toys in the U.S. in 2012 included LeapFrog tablets, a Barbie house, a scooter, a BeyBlade toy, a doll, a car and an Easy Bake oven (www.npd.com, 2012). A search on Amazon's website revealed two types of explicitly value based toys that are currently for sale. One is the board game Scruples where the player is faced with moral dilemmas and must guess how the other players would react in moral situations; the other is a photo jigsaw with old-fashioned religious pictures. This leaves possibilities in the design market for toys that could be utilized to pass on values to children.

Religious toys are a subsection of toys, which are aimed at encouraging faith or proper religious behaviour (Guignard, 2012). Examples include a plush Torah or a doll nun or priest. These toys encourage role-play or imitation of religious ceremonies or seek to pass on knowledge of religious rituals, ceremonies or symbols. The work in this chapter is based on similar principles but it is concerned with encouraging knowledge and behaviour about sustainability. For example, values such as preventing unnecessary waste and valuing the environment we live in are the focus of the work.

Children have a significant influence over parents in buying choices, especially when the product or service is for the child (Mangleburg, 1990). Toy manufacturers know that advertising has a significant effect on children. The child then uses their influence on their parents to purchase products they desire. Children also have an influence over adult behaviour in the household (Istead, 2004). This influence could be harnessed to make a difference in household values and behaviours through toys that instil values in the child. These values could follow the child through into their adult life.

Educational toys for motor or cognitive skills have clearly defined criteria for design (Hinske, Langheinrich & Lampe, 2008). These design guidelines focus on issues like providing fun, keeping the child safe, offering a challenge, being adaptable, ease of use and providing interaction. However, the criteria that are used to design toys that would help to instil values in children are not clear. This lack reflects the relative novelty of value-centric design processes. Addressing this issue, this chapter proposes a value sensitive design (Flanagan, Howe & Nissenbaum, 2005) framework (including values discovery from the designers, the direct and indirect stakeholders and value verification) that aims to support the design of toys that are specifically intended to pass on values. One of the goals of this chapter is to contribute to the elaboration of design guidelines for toys that are designed specifically to pass on values. In order to design toys that convey values, there are two key meta-issues that define a frame for this work. Firstly, the domain and nature of the values studied. Secondly, the scientific knowledge from the field of developmental psychology that impacts on how such toys should be designed. These topics are reviewed in the following sections (see Chapter 2 for more detail regarding sustainability).

First and foremost, the goal is to design a prototype toy that stimulates moral development and encourages the development of values, with a focus on values relating to environmental sustainability. Current toys in this design space include examples such as Lego made from coffee beans (Figure 9) or tree bark (Sustainable Lego). In this toy, designers used biodegradable materials rather than plastic, they are intended to pass on the value of sustainable reuse of materials. However, this sustainable Lego is only available in shades of brown and in one uniform size of

brick. This toy would not be as appealing to children as differently coloured and shaped bricks. Sustainable toys such as this do not seem to be commercially popular and therefore are not widely available. Designers should be aware that conforming to design guidelines for toys when creating sustainable toys would increase appeal and popularity. However, this work argues that a strong theoretical framework has been lacking in this area of design. It tries to fill the gap in this area by bringing together an established theoretical framework for development with an established value sensitive design process for the design of value-based sustainability toys.

Figure 9: Lego made from coffee bean skin

Secondly, children are a very specific audience who may struggle to grasp or understand concepts relating to complex issues such as sustainability, depending on the age of the child. Research on developmental psychology casts light on these concerns by suggesting a number of theoretical approaches that characterize the development and acquisition of basic skills according to age. Prominent theories include: Piaget's Stage Theory and cognitive development theory (Piaget, 1973; Piaget, Gruber & Voneche, 1977; Piaget, 1997), Vygotsky's Social Constructivism Theory and social development, (1978) and Bandura's Social learning theory (1977). Piaget proposes a set of stages that explain how children acquire a conceptual understanding of the world that surrounds them. Although the other theories of development are influential, Piaget's theory has discrete stages and capabilities. This actionable and well-defined framework allows for effective mapping of theoretical concepts to concrete design recommendations. Thus, Piaget's psychological theory of

development is the focus for a framework to create toys that help to instil values in children.

To summarize, this chapter makes four contributions. First, it provides a theoretically grounded approach to value sensitive design that encompasses both developmental theories and toy design guidelines. Secondly, it demonstrates the entire value sensitive design process (Flanagan, Howe & Nissenbaum, 2005) where there is direct contact with users and indirect stakeholders. Thirdly, it captures and presents a set of values related to sustainability from different stakeholders. Finally it presents and tests a prototype toy that aims to instil sustainability values and shows how to integrate this into the developmental needs of the chosen age group. The prototype is based on the value of resource management and takes into account concepts in Piaget's concrete operational stage of development. It also takes into account design guidelines for play. Toys of this type may help to educate children about the pressing global problem of overconsumption of resources and sustainability. Potentially, children can take their new awareness from these toys and influence their parents and other members of their household in their buying choices and behaviour in a positive way.

BACKGROUND

Developmental psychology gathers a range of contrasting theories that explain different aspects of human development. To understand how children learn and acquire basic skills some theories focus on cognitive aspects, while others are more concerned with contextual and social factors. The next section firstly focuses on a detailed description of Piaget's stages of cognitive development with particular attention paid to the concrete operational stage. It then moves on to understanding how children acquire values and how moral development occurs, by reviewing Kohlberg's value development theory (Kohlberg, 1977). Studies of children's influence that explain how children impact upon their parents' behaviours are then reviewed. Then family related sustainability research is reviewed in terms of its contributions to the present work. Finally, the next section ends with a discussion of current toy design guidelines, their relevance for the current work and a description of the design process.

PIAGET'S THEORY

Piaget (1973) suggested a number of stages where the organization of intelligence or cognitive abilities changes throughout the child's life. Two processes Piaget named *assimilation* and *accommodation* underlie the transition from one stage to the next. Assimilation is defined as the process of taking in from the environment all forms of stimulation and information and then organizing and integrating them into the individual's existing forms or structures called cognitive schemas. Accommodation refers to the modification of those structures or cognitive schemas in order to adapt to the environment. Piaget identified four factors that explain the transition from one stage to the next: *maturation* (the transition between stages happens because and as a result of the maturation of the child's nervous system); *experience* (the experience of the effects of the physical environment on the structures of intelligence); *social transmission* (information the child learns from others, parents, teachers or peers); and finally, *equilibration* (or self-regulation which coordinates the three previous factors).

Piaget proposed four stages of cognitive development. The first stage is the sensorimotor, which lasts from birth to 24 months. In this stage, children start interacting with the surrounding environment through their inborn reflexes and integrate their actions and perceptions progressively to form adaptations. From there, the child evolves the use of its senses and motor activity. This period is also one of pre-linguistic intelligence, where infants learn through rudimentary constructions of objects that objects are conserved (object permanence) and develop notions of space and time (Piaget, 1997).

The second stage is designated as preoperational and includes children from two to seven years old. It is characterized by an extraordinary increase in mental representation. The child starts to form concepts associated with the self on an egocentric basis and has difficulty seeing things from a point of view that is not their own. This stage starts with play being symbolic, where the child can represent and understand objects that are not present. In this stage, the child is unable to use logical thinking, instead relying on magical thinking. The child's is also unable to understand

the relationship between cause and effect (Piaget, Gruber & Voneche, 1977; Piaget, 1997).

Process	Description
Classification	Ability to name, identify and group sets of objects
Seriation	Ability to sort objects in any order according to size, shape, or any other characteristic
Conservation	Ability to see how physical properties remain constant as appearance and form change
Transitivity	Ability to follow a process and understand the relationship between successive stages
Decentering	Ability to consider multiple aspects of a problem to solve it
Reversibility	Ability to reverse operations or to take something back to their original state
Elimination of Egocentrism	Ability to view things from another's perspective

Table 12: Concrete operational processes defined by Piaget

The third stage, known as the concrete operational, occurs between the ages of seven and eleven years. In this stage physical actions are replaced by mental operations and the child begins to use logic appropriately (Piaget, Gruber & Voneche, 1977; Piaget, 1997). Piaget defined seven processes that important in this stage, specifically: classification, seriation, conservation, transitivity, decentering, reversibility and elimination of egocentrism. These are summarized in Table 12.

The fourth and final stage is the formal operational, which takes place during adolescence and into adulthood (Piaget, 1997). The child acquires the ability to think and argue without having concrete materials and develops the ability to think about abstract concepts. The child learns hypothetical-deductive reasoning and is able to solve problems in a logical and methodical way.

Concrete Operational Stage

This work focuses on the concepts elaborated in the third stage. This stage was chosen

because the child has developed a varied skill set by this stage and the concepts in this stage of development can be mapped directly to design recommendations. The concepts are further explained here. Classification is the ability to name and identify sets of objects according to appearance, size or other characteristic including the idea that one set of objects can include another. Children learn to categorize objects in three different aspects: simple classification, multiple classification and class inclusions. Children learn different objects are included in sub-classes, or that sub-groups may belong to major groups. Seriation refers to the ability to sort objects in any order according to size, shape, or any other characteristic. Children learn to arrange things in a sensible order such as increasing or decreasing length. Piaget pointed out this process is fundamental for the complex types of scientific reasoning including the understanding of numbers. In fact, children in this stage can master arbitrary series such as the alphabet and numbers. They can count indefinitely and work out the rules of a complex series. This process allows children to develop a systematic, coordinated method of seriating that reflects a completely developed seriation structure. Conservation is the ability to understand that the difference between quantity, length and number of items is unrelated to the arrangement of the object or items. Transitivity refers to the ability to recognize relationships among various things in a serial order, understanding the relationship between successive stages. Decentering means the child can consider multiple aspects of a problem to solve it. The child acquires the ability to stand back from a situation and take several notes of their interrelationships instead of focusing on only one aspect at a time. Reversibility means the child understands numbers or objects can be modified and returned to their original state, for instance, subtraction reverses addition and division reverses multiplication. Elimination of egocentrism refers to the ability to view things from another's perspective. The child becomes aware that others could come to conclusions different from their own.

Overall, in this stage, children reveal more logical, objective and deductive thinking with concrete objects. As the child's mind is still attached to concrete experiences, that translates to the ability to solve problems that apply only to concrete objects and not abstract concepts or hypotheses (Piaget, 1997).

MORAL DEVELOPMENT

Piaget believed that there were essentially two stages to moral development in children, the first occurring in children under 10 or 11 years old and the second stage when the child was older than 11. He found that the child undergoes a significant set of changes between the ages of 10 and 11. Before the age of 10 children think about rules as fixed whereas children older than this understand that rules are able to change. Younger children base their moral judgments on consequences and older children base them on intentions and motivations for acts (Piaget, 1932). Kohlberg (1977) expanded on this work.

Kohlberg's Moral Development Theory

A child develops morals along with cognitive skills. Kohlberg (1977) states that moral reasoning progresses in order through a series of six stages or three levels. The first level, pre-conventional, includes the punishment-obedience stage where avoidance of punishment is most important and the instrumental-relativist stage, which places importance on reciprocity. The second, conventional, level includes the interpersonal concordance stage where pleasing others and being a good person is important and the law and order stage where the maintenance of social order is important. The third and final level, the post-conventional level, includes the social contract stage where right action is defined in terms of what is acceptable to society as a whole. The final stage is the universal ethical principal orientation stage; here what is right is selected according to self-selected principles.

The ages that are focused on in this chapter are generally at stage 1 or 2 of Kohlberg's model. In his work he found that children up to the age of 10 were most concerned with receiving rewards and avoiding punishment with some smaller percentage of children also concerned with interpersonal relations in stage 3. Stage 1 shares some similarities with Piaget's first stage of moral development in that rules are fixed and set by others. In stage 2, children recognize that different individuals have different viewpoints, what is right is relative and each person is free to pursue their own individual interests. They also have an idea of fair exchange between individuals

rather than as society as a whole. In stage 3, children believe that people should live up to expectations, have good motives and concern for others. Kohlberg states that moral development does not occur due to maturing or socialization, rather, each stage is reached through thinking about moral issues. Socialization does promote development but by stimulating mental processes through discussing problems and finding their views and beliefs challenged. They also learn to coordinate different viewpoints in cooperative activities. Children then expand their viewpoints and move to the next stage of development (Crain, 1985).

SUSTAINABILITY

Recent research (Horn et al, 2011) has called for the whole family to be engaged in managing household consumption. Current eco-feedback technologies are directed towards adults rather than children, and this can miss out on harnessing the interactions between family members and a significant part of the population. While the designs in this chapter are not based around eco-feedback, it is hoped that instilling values in children at a young age will help to encourage sustainable behaviours early in life (see Chapter 2 for an in-depth discussion about sustainability).

CHILDREN'S INFLUENCE

Children have a significant influence on their parents' purchasing decisions, one estimate states that children aged 14 years old and under make $24 billion in direct purchases and influence $190 billion in family purchases in the USA (McNeal, 1998). This is especially the case when the child is the primary consumer, for example, breakfast cereals, toys, school supplies etc. Items such as these have high influence with children, as they are the most personally relevant to the child. Children also have a lesser influence over household leisure time activities such as vacations or movies compared to their purchasing influence (Mangleburg, 1990).

Further, it has been shown that brand loyalty builds from a young age and is carried through to adulthood (Mangleburg, 1990). Advertisers work to sell their products to this market, children lack the cognitive skills of adults and are more susceptible to

advertising; those below the ages of seven to eight do not understand the persuasive intent of advertising (Kunkel et al, 2004). Before the age of seven, children distinguish advertisements from other television programming, not because of persuasive intent, but because they are shorter in duration. Over the age of eight, children possess knowledge of advertising's intent and bias but their ability to use this knowledge is still developing (John, 1999). Advertisers are aware of the influence children hold in purchasing decisions and harness this influence to sell their product or service.

Children from the ages of seven to eight, who are within Piaget's concrete operational stage, have greater thoughtfulness and flexibility than those who are younger; they are able to see things from another person's perspective. These changes allow them to use a more adaptive approach when trying to influence or negotiate with parents, including using bargaining, persuasion and compromise (John, 1999). The child's influence over purchasing is affected by the stage of the decision process. In a three-stage model of problem recognition, information search and choice, children were found to have the most influence at the beginning of the process, the problem recognition stage. Influence then declines over the stages, with the least influence in the final stage of choice (John, 1999; Mangleburg, 1990).

Children also have an influence on the behaviour of their parents in the household. In a qualitative week long study of inter-generational influence on environmental behaviour, the majority of both children and parents in this study reported that the children had influenced behaviour and knowledge in the home (Istead, 2004). A review of recent work showed similar results; children have the ability to influence the knowledge, attitudes and behaviour of adults (Duvall & Zint, 2007). Children who enjoy learning or participating in education are more likely to share information with their parents and this contributes to their influence (Istead, 2004). This type of influence would be useful when trying to create a more sustainable lifestyle in the home. Two recommendations that make it more likely that children will influence parents are if the toy can include parental involvement and if it includes hands-on or action oriented activity (Duvall & Zint, 2007). Toys that pass on values, which follow these recommendations, can be more likely to be talked about and passed on as

influence towards the parent.

EXISTING DESIGN GUIDELINES FOR TOYS

Specific areas of product design have long targeted children as their main consumers. Toy design is generally driven by factors such as gender differences and preferences, age ranges and market tendencies (Dittmar, Halliwell & Ive, 2006; Goldstein, 1994; Guigmar, 2012; Hinske, Langheinrich & Lampe, 2008). More recently, children have been involved in the co-design of such products in order to make them as widely appealing and accessible as possible (Horn et al, 2011).

Recent work has focused on creating general guidelines for the design of toys. Hinske et al. (2008) presented a summary and reviewed design guidelines for traditional as well as educational toys coming from a variety of studies. These guidelines focused on supporting the design of toys that promote social interaction, creativity, safe and enjoyable experiences, while respecting the child's abilities and being challenging enough to facilitate the learning of new ones. To achieve these goals, educational toys need to provide clear challenges and feedback as well as stimulate sensory and cognitive curiosity.

Educational projects and playground designers have adapted design guidelines proposed by the Principles of Universal Design (Ruffino et al, 2006). These principles, known as Universal Design for Play (UDP) Guidelines are summarized in the following six principles: 1) the toy is appealing (communicates perceptible information); 2) how to play with the toy is clear (simple and intuitive use); 3) the toy is easy to use (equitable use and low physical effort); 4) the toy is adjustable (flexible use, size and space for approach and use); 5) the toy promotes development; and finally, 6) the toy can be played with in different ways. This chapter focuses on this set of guidelines for this work. The designed prototype will need to fit within play guidelines in order to be sure that children will actually want to and enjoy playing with it.

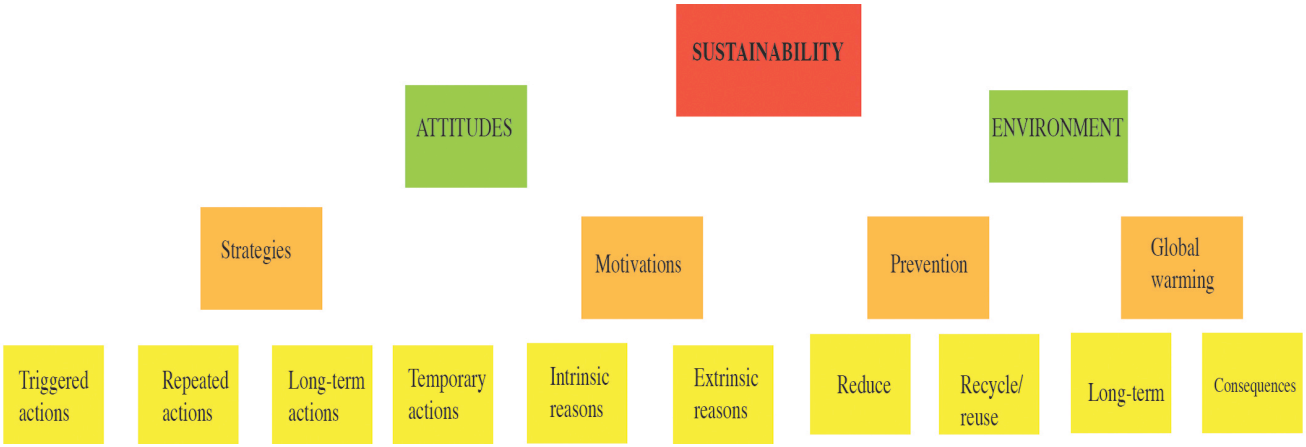

Figure 10: The higher levels of the affinity diagram created by the research team

These guidelines are applicable to the design of all toys. Although valuable, they emphasize the play activity, the toy properties and its usability, separate from the cognitive abilities of the child and the emotional and social impact on a child's growth and personal development. They make little or no comment on issues such as value development, a key area where this chapter aims to contribute.

Therefore, a previously established value sensitive design process (Flanagan, Howe & Nissenbaum, 2005) is followed. Data is collected from the direct stakeholders, in this case children aged 8 to 9, about what sustainability means to them. Data is also collected from the indirect stakeholders, parents and educators, about sustainability related values. In this way, it is ensured that the values are meaningful to all the stakeholders. An interactive application designed to pass on the chosen sustainable value is implemented and prototyped. Finally, value verification takes place where the prototype is tested with children to ensure that the intended values are included.

DESIGNING FOR VALUES

This work proposes to combine the guidelines on the design of educational toys with cognitive development processes suggested by Piaget's theory (Piaget, 1973; Piaget, Gruber & Voneche, 1977; Piaget, 1997) to develop toys that instil values associated with sustainability. There are several different approaches to design that consider values, such as Value Sensitive Design (Friedman, Kahn & Borning, 2008), Worth Centered Design (Cockton, 2006) and Value Centered Design (Cockton, 2004). Value

sensitive design is a comprehensive method of technology design that accounts for human values throughout the design process. Here, value is defined not only as the monetary cost of an object but rather refers to what people feel is important. Value centered design differs from value sensitive design in that it is not rooted in moral considerations. It still has a focus on value, however these values are not restricted to ethical ones. Worth centered design has evolved out of value centered design and was conceptualised in order to avoid confusion around the idea of values. The idea of worth is very broad and is defined as a motivator and brings compensation for whatever is invested in it, such as money or time. Designing worth means designing things that will motivate people to buy, learn, use or recommend an interactive product (Cockton, 2006). One approach suggested by Flanagan, Howe and Nissenbaum (2005) integrates value sensitive design, reflective practice, participatory design and game design. This approach to design, including utilising users as primary participants in the design process (participatory design) and prototyping and playtesting (game design) fit particularly well with the type of interactive value-instilling toy the research team intended to design.

The design process suggested by Flanagan, Howe & Nissenbaum (2005) was followed to elicit values from the different stakeholders, design, iteratively test and verify a prototype toy. The first phase of the process was one of value discovery, to create a list of values related to sustainability. The team started by organizing a number of sessions to learn the values associated with sustainability from the different parties involved. The collection of values involved direct stakeholders such as the children, and indirect stakeholders such as parents and educators, as well as the designers and researchers. The following paragraphs describe the process and steps taken to collect values for each of the parties.

Project/Designer Values

Initially the researcher values were to design a toy that would be interactive, engaging, fun and facilitated learning about sustainability-related values or concepts. Since sustainability is a vague and very broad concept, it was essential to step back from the literature and find the main concepts associated with this field from among

the researchers. A brainstorming session was held where the ideas were generated from the following question: "What is sustainability?" The main ideas revealed three directions or focus points: long term consequences associated with sustainability problems, prevention efforts needed to avoid such consequences and attitudes that would support such tasks. The next step after the brainstorming session was organizing the concepts and ideas by creating an affinity diagram (Figure 9). This process allowed the structuring of ideas and translated these into values. These values were then listed into higher-level categories. The end result indicated sustainability values for the researchers were associated with 'primitive emotions', 'feelings related to sense of duty and guilt', 'a number of human needs', 'feelings associated with kindness', 'knowledge about the subject' and finally, 'a connection to the larger community' (Table 13).

Categories	Values
Primitive emotions	Selfishness, anger, fear or powerlessness
Sense of duty and guilt	Responsibility or lack of, accountability, preservation and efficiency
Human needs	Selflessness, sacrifice, humbleness, and morals
Kindness	Empathy, caring and consideration
Knowledge	Creativity, having a clear conscience, education, empowerment, learning and awareness.
Connection to the larger community	Giving back, dignity, respect and enjoying and respecting nature.

Table 13: Researcher values by category

User Values

In order to collect the values children associated with sustainability, a session was prepared with a group of 15 children aged 8 or 9 years old. A set of pictorial scenarios depicting sustainability related behaviours was used to elicit responses and values

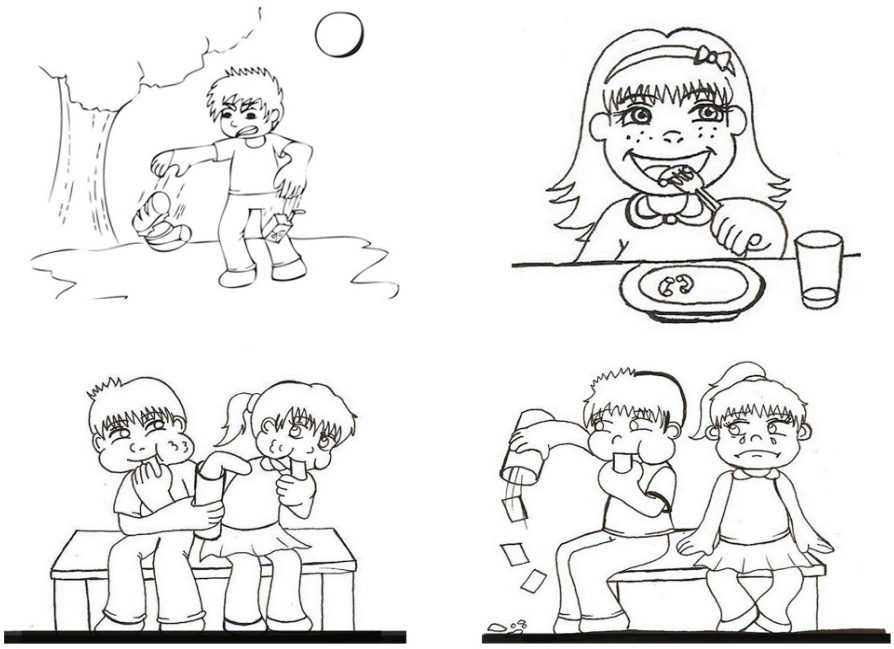

Figure 11: An example of a scenario (food consumption)

from this group of children. The set of scenarios included seven categories of sustainable behaviours and each category included four different depictions of each behaviour (Figure 11). The seven sets were about garbage management, recycling, laundry management, food consumption, water consumption, outdoor activities and electricity consumption. The scenarios were collected from the affinity diagram created by the research team.

The session was organized in two halves, in the first half the children looked at the pictures and chose from the four options of behaviours what they thought that the characters in the scenarios should do. In the second half, a group discussion took place around the choices they made in the first half of the session. There were three groups, each consisting of five children and a researcher, who explored reasons and justifications the children presented for choosing each behaviour. The sessions were recorded and transcribed and later analysed by the team. Each researcher listed the values in the transcription of the sessions and these were later discussed as a team. The final result was a unified list of values that represented the children's views about sustainability.

The research team classified the final 40 values into six categories, based on the group

discussion conducted with the participants (Table 14). The categories were 'resources', 'knowledge', 'feelings', 'community', 'environment' and 'myself'. The first group consisted of values related to the usage of resources, in order to avoid waste. As this participant's opinion demonstrates *"his parents are wasting money, they buy the food and he throws it away and does not eat"* (male, 8 years old). The second group, knowledge, consisted of values linked to learning, having information about concrete behaviours or actions and included knowledge of other people. An example is this participant's statement: *"we should not leave the water running we should use a glass"* (male, 8 years old). The third group, feelings, was composed of values that referred to emotional reactions when the scenarios portrayed both non-friendly and environmentally friendly behaviours. As this participant commented about a garbage scenario presented *"she is pretending but she should pick it up, a lot of people do the same as her"*(male, 8 years old). The fourth group entitled community, referred to a set of values where others, either parents, people who live in the same street, country or even human beings as a collective group, were essential to address sustainability issues. As this participant commented: *"if each person uses a car it will pollute more than the bus full of people"* (female, 9 years old). The environment group consisted of values users gathered from the scenarios and their local context, through which they provided clear examples, such as *"there are people who throw bottles in the sea, I have found them there on the beach"* (male, 8 years old). And finally, the group myself, consisted of values based around personal characteristics from the characters provided in the scenarios and also from the participants and their daily routine. As shared by this participant *"when I go home my mother takes my baby brother in the elevator but I take the stairs, it is just two floors, two sets of stairs"* (male, 8 years old).

Indirect Stakeholder Values

As well as defining the designer and user values for the design process, the values from the last group of stakeholders, parents and educators, were sought. Ten parents and educators were given a questionnaire consisting of open-ended questions about their attitudes to sustainability (see Appendix G). Half of the parents and educators were male and half were female, ages ranged from 22 to 50 years old with a median age of 31. Nine of the participants were Portuguese and one was British and three of

the ten participants identified themselves as educators.

Categories	List of values
Resources	Reduce, reuse, recycle, self-sufficient, save, efficiency, comfort versus saving, money or cost
Knowledge	Learning, knowledge about other people, specific knowledge, long-term consequences, negative consequences
Feelings	Empathy, respect, selfish, inconsiderate, polite or well-mannered, rude, guilt, careless, altruism, fun – playful, enjoyable
Community	Protection, ethics and sense of fairness, communication, preservation, share, comparison, help, awareness, accountability, children influence parents
Environment	Clean, unsanitary/unhealthy
Myself	Autonomy, personal effort, obedience to avoid punishment, initiative, being thrifty

Table 14: User values by category

When asked to define what sustainability is, the main theme that emerged was one of protecting the environment for the future, for example, "*...important to preserve the earth intact for future generations*" (female teacher, no age given). A group consisting of parents and educators would perhaps be expected to focus on the future wellbeing of the children they care for or teach. The second main theme from this section was the use of resources, for example "*...about making decisions on how much one really needs to consume*" (male, 31 years old) and "*...know how to use the resources we have in the best way, always thinking of continuing the use and reuse*" (male, 42 years old). When asked about the most important aspect of sustainability for parents and educators, the main theme from this section was one of balance, for example: "*Humans must find a balance with the world that does not mortgage the future or past*" (male, 30 years old) and "*Harmony between resources and needs*" (male, 34 years old).

Teaching children about sustainability was the second major section of the questionnaire. One parent stated why it is important for children to be educated about sustainability: "*Because children can correct themselves and their parents, so we can educate new forms of sustainable lifestyle for further generations"* (male, teacher, 41 years old). Other common reasons were that children need to be aware of the consequences of their actions and that children are the future. This shows an awareness of the importance in educating the next generation about sustainability. In general, participants felt that the children they were in contact with were already somewhat aware of the issue of sustainability, either through school *"...my daughter learns in school about how to save electricity, how to recycle, so learns how to preserve the environment free from pollution and destruction*" (female, 30 years old) or through education at home "*we do things like: turning off the lights and electrical equipment, shower instead of baths, A-Class electric equipment and lamps, walk instead using the car*" (male, teacher, 41 years old). However, three out of the ten participants felt that the children currently knew little about sustainability. Examples of ways that the participants taught children about sustainability include recycling, encouraging less waste, turning off appliances and showering instead of bathing.

The last section of the questionnaire dealt with the participants' own current sustainability related behaviours. Most participants reported that they currently recycle, other actions taken include switching off devices when they are not in use, taking the stairs instead of the elevator and conserving water where possible. The most important reasons for reducing energy consumption were cited as: concern for the wellbeing of future generations, personal cost savings, and concern for the state of the environment. Finally we were interested in what obstacles participants saw in the way of their adoption of sustainable behaviours. Two main themes were time and other people's attitudes, for example "*Many people don't care about the use of recycling points, others use it incorrectly or throw garbage in the street. The educational issue is the main problem*" (male, teacher, 41 years old) and *"...natural resistance to new practices*" (male, 34 years old).

Value Systemisation

Values	Description
Efficiency	Avoid waste
Communication	Interact with others and learn to share
Preservation	Protect and save the environment
Awareness	Being conscious about environmental issues
Accountability	Feel responsible for
Knowledge	Have general and specific information
Learning	Acquire skills
Costs	Learn to the difference between save, afford and worth
Respect	Think of others and of the environment
Fairness	Do the right thing
Empathy	Understand and consider others
Personal Effort	Commit and do more than required
Future generations	Being selfless, humble, protective
Thoughtful	Being considerate and polite
Creativity	Transformation and initiative
Necessity	Dependence and importance of the environment for humankind survival
Negative Consequences	Avoid punishment and unsanitary conditions
Management of resources	Reduce, reuse, recycle, balance usage and consumption
Ability to act	Feel empowered, ability to act and the children's influence on their parents
Cooperation	Sharing and cooperation between different generations

Table 15: List of values common to all stakeholders

Once the values were collected from all stakeholders the next phase was systematically organising them into a single list. In order to do this, the team analysed each list individually, and discussed it as a group. Only values common to the designers, children and parents/educators were considered for the final list. Values with the same essential meaning but different names were eliminated or combined and when in doubt, the research team would go back to the session transcripts or the survey data to support each elimination, replacement or integration of a particular item. The end result (shown in Table 15) was a final list of 20 sustainability values

common to all the stakeholders.

This list of 20 values is the first contribution of this chapter. There have been several international surveys attempting to understand attitudes towards sustainability or values relating to development and the environment. However, these findings relate to either high level contextual concerns such as freedom and democracy, capitalism or equality or attitudes regarding global environmental concerns, government policies or individual behaviours (Leiserowitz, Kates & Parris, 2006). The novel contribution of the value list presented in this chapter breaks down the vague concept of sustainability into actionable values, common to several stakeholder groups. From this list of 20 the 'management of resources' value was chosen as the focus for the prototype toy. 'Management of resources' in this sense is meant to encapsulate the ideals of reduce, reuse and recycle and the balanced use of resources. This value emerged independently in the discussions with each of the different stakeholder groups. The next section of this chapter will move on to the design and iteration of the prototype toy.

PROTOTYPE DESIGN

The next phase was the generation of ideas that could help integrate the 'management of resources' value into concepts. These concepts would provide children with learning tools and knowledge about concrete actions and consequences when interacting with the environment. The researchers generated a list of ideas that included books illustrating environmental knowledge, card games, toys that recharge through outdoor activities and educational puzzles about environmentally friendly actions. One concept was selected for a first set of tests. This concept involved providing a kit with recyclable materials that children could manipulate and transform into new toys or objects.

The generation of this concept was based on the following constraints: it had to be based on the management of resources value, it should be interactive, enable knowledge and learning about concrete environmental behaviours and consequences, it should combine both virtual and physical aspects and utilise Piaget's processes

within the concrete operational stage. This type of activity is hands-on, which means it can promote intergenerational discussion and learning (Duvall & Zint, 2007). Using materials that would normally be thrown away should teach children, in a way that will be fun for them that there can be secondary uses for objects and that waste can be avoided. Virtual toys or toys that combine physical and virtual play are becoming more and more popular with children, therefore we decided to design a prototype that would take advantage of this popularity (www.npd.com, 2012) As a result, an initial participatory design session was conducted to understand how children would reuse and transform physical materials into physical toys before beginning work on the virtual aspects.

Figure 12: Children's recycled materials kit session

Participatory Design Session

This session (Figure 12) had 10 participants from the same group of children who participated in the previous value brainstorming session. The session lasted 45 minutes and children were given a kit comprising recyclable materials. Specifically, each kit contained one milk carton, one yoghurt container, plastic packages and cardboard paper packages. Glass containers were not included as a matter of safety. Children were instructed to build a toy using the materials in their kit, scissors, glue

and coloring pencils. The work session was recorded and transcribed. The research team analyzed the children's responses to the exercise, how they manipulated the materials and gathered the most important features to inform the design of the future toy or application.

The participants naturally collaborated when building their toy, either by providing suggestions, exchanging materials or helping others after finishing their own activity. This supports the idea that this type of toy can encourage moral development through discussion of ideas, coordination of different viewpoints and cooperation (Crain, 1985). The toys built by the participants were toys they were familiar with, or made as part of their symbolic play (Piaget, Gruber & Voneche, 1977; Piaget, 1997). This participant shared: *"This is Maria and this is the Fast PC. This was my sister's doll she is older than me, and this is my computer"* (U2, male, 8 years old). Among the toys the children built were a computer, a moneybox, dolls that resembled the ones they had at home, a castle and a pop-up book.

When asked what they enjoyed about the activity, children mentioned the fact they could transform old materials into different objects with different purposes, with one participant thinking people should not throw away garbage since it can be reused to build other things, something he does sometimes at home (U8, male, 8 years old). They seemed to enjoy that they had to physically manipulate the materials as stated by this participant: *"I liked to make things up, this is related to the constructions I made with the Lego I have at home and I used to also use some sticks to complete the constructions*" (U8, male, 8 years old). This session generated the idea of creating an interactive sharing application where children were given a set of virtual materials they would have to transform into a toy. This concept was transformed into the application game called PlayGreen.

IMPLEMENTATION

The concept PlayGreen was integrated into a low fidelity prototype built using digital mock-ups. The game contained two features: the first was where the user could play with and transform the materials given, and the second was where the user could share their final objects with other friends using the application. In the first space,

Figure 13: Three scenarios depicting the materials

participants were given the instructions and an example of scenarios where the materials given in the set were used in a daily routine (Figure 13). The introduction of this scenario aimed to give children further knowledge about how such materials were currently used, and to stimulate their creativity. Afterwards, PlayGreen presented the area where the provided set of three recyclable materials could be manipulated and transformed to create a new object (Figure 14). For each created object, the user would receive a new recyclable material to their collection. This collection was displayed in the second space, where the user could exchange other materials with

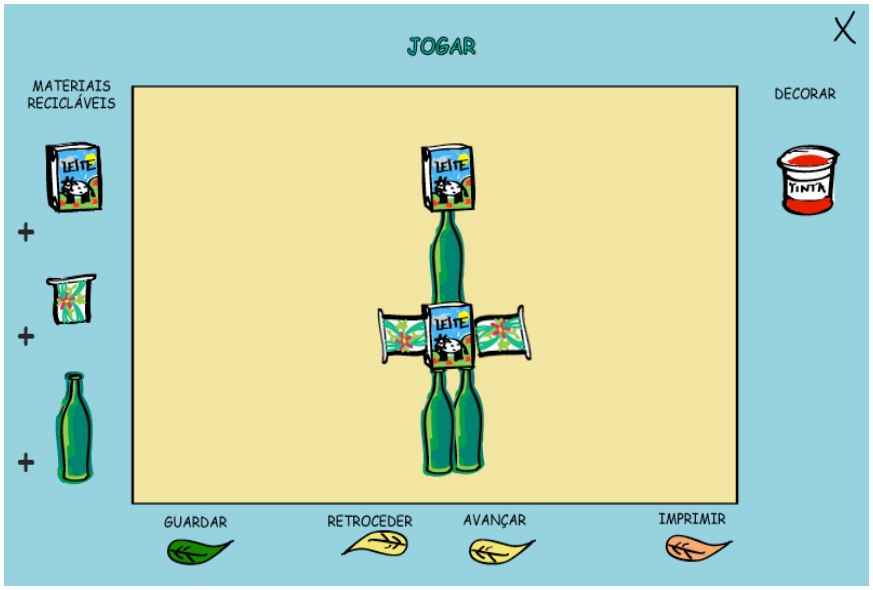

Figure 14: PlayGreen Prototype

friends, through the chat. This feature was added to promote collaboration between users, since this was an aspect that came across in the previous participatory design session. The exchange space, as designated in the prototype, also allowed users to compare their final creations or objects with their friends.

The concept incorporated Piaget's concrete operational processes (Piaget, Gruber & Voneche, 1977; Piaget, 1997) in the game flow. It included real life scenarios of where the materials were used to provide users with the ability to analyse the different aspects of such objects, and also how to manipulate these until a final object was created (seriation, reversibility, transitivity and classification). The exchange section allowed users to observe and interpret others' transformed objects, and promote collaboration between players (elimination of egocentrism and decentering).

Figure 15: Wizard-of-Oz testing session

VERIFICATION

Ethical Issues

Although the design of toys that instil values has potentially significant ethical implications (e.g. in terms of manipulating minors), we feel such implications are

mitigated as this chapter focuses on the relatively ethically unproblematic area of values relating to sustainability and over-consumption of resources (see Chapter 2 for more details regarding ethical implications). Arguably the problem of energy consumption and climate change will be a larger problem for the next generation than it is currently and this is a growing concern for governments and families (Bernstein, Bosch & Canziani, 2007). In accordance with the value sensitive design method, the views of children, parents and educators regarding sustainability were gathered. This methodology is intended to draw attention to values throughout the design process and is well suited for addressing ethical concerns within this space (Davis, 2009). There were no comments that stated the toys were unethical from any of the stakeholders. The toy was designed to be appealing in order for the child to want to play with it but at no point were they compelled to play with the toy.

The PlayGreen concept was tested through a Wizard-of-Oz technique (Figure 15). Six participants, aged 8 to 9 years old, three boys and three girls, were recruited from the previous group to participate in the playtesting session. Each session was recorded, and lasted around 10 to 12 minutes. The session was composed of three sections: 1) introduction – children were asked general questions about their weekend to make them more at ease with the researchers; 2) game testing; 3) experience evaluation, where the participants were questioned about the game, favourite and least favourite moments and how they felt while playing.

Overall, the participants enjoyed the game and found it a fun experience. They enjoyed that they were using recycled items: "*I liked most building the toy and because I was using recyclable materials… I liked everything about the game*" (U5, male, 8 years old). In terms of how they felt about the game, they felt relaxed, amused and even good about themselves, for example: "*I felt good playing the game*" (U4, female, 8 years old). The part the children enjoyed most about the testing session was where they manipulated the materials to create new objects: "*I liked everything in the game. We could probably get more materials the more creations we completed. We could have more than just 3 materials and then we could build a lot more things. I would like that"* (U4, male, 8 years old). This validated the previous findings from the participatory design session.

The feature about exchanging materials and the ability to chat with their friends did not seem to attract the user's attention. This might have been due to the fact that for the playtesting session, this part of the game was merely exploratory, and users were not given a precise task. Once it was explained what those features allowed them to do, they disclosed that they would like to share their creations, stating: *"I would like to see what toys others built because I am curious... it could help me to get more materials to build things if I could exchange with them"* (U5, male, 8 years old). This is encouraging evidence that this type of toy could help children's moral development around sustainability. Moral development occurs by discussing ideas and finding beliefs challenged (Kohlberg, 1977). Learning to collaborate and coordinate different viewpoints with other children is also part of the progression through moral development (Crain, 1985).

Testing the concept of PlayGreen allowed the verification and observation of the Piaget concrete operational processes within the game context (classification, seriation, transitivity, decentering, reversibility and elimination of egocentrism), with the exception of one (conservation). When users manipulated the recyclable materials in the play section, they correctly identified the materials and used them for a different purpose, either by rotating the materials and trying different angles or by revealing an understanding of the whole construction process (classification and transitivity). Users also transformed the materials in terms of their shape or size, and worked with those characteristics, for example, building a church by aligning the materials according to its shape and dimensions (seriation). As stated by this user *"I know a church that has a door more or less like this (pointing to the milk carton in the game) and a big tower like this (pointing to the glass bottle). This almost looks like a church"* (U3, male, 8 years old). When exploring the collection of objects created by their friends in the exchange section, users could clearly identify the final objects, and provide suggestions on what the list of objects would allow them to do (decentering, reversibility and elimination of egocentrism). As one user suggested, *"Here I would make a toy using two glasses"* (U2, male, 8 years old).

Overall, it was found that users showed signs of engagement. In fact, transforming the recyclable materials was what they found most entertaining. This prototype was shown to engage children about this sustainable value, help to encourage moral

development and make them feel good about themselves. Our prototype conformed to some of the UDP guidelines for play (Ruffino et al, 2006), that state the toy should be appealing, easy to use, promote development and be able to be played with in different ways. One area the prototype could be improved is by conforming to the simple and intuitive use guideline and by making the sharing aspect clearer to children. The sharing feature should either be integrated into the play space or the transition from one section of the game into the other should be modified. By conforming to the UDP guidelines, it was ensured that the prototype would be enjoyable to play with, which should help to enable passing on the value as intended.

CONCLUSION AND FUTURE WORK

This chapter explores the design of toys that promote sustainability related value development within children between the ages of seven to eleven years old. Considering this is a complex task, several fields are brought together in an exploratory analysis of the design space. This chapter presents four main contributions. First it argues that in order to design toys that can pass on sustainable related values to children and that are commercially successful, a multidisciplinary approach is required. These toys should be designed taking into account developmental theory, toy design principles and sustainable values. Secondly, an example of a value sensitive design process is demonstrated. This process facilitated direct contact with the users who differ in terms of cognitive skills from the research team, and also have a different understanding relating to environmental issues. Thirdly, a set of values related to sustainability was presented. The values were collected from among children aged 7 to 10 years old, parents and educators. These values allowed for a better understanding of how children within this age range and other stakeholders perceive environmental issues. Finally, an application designed around the value of resource management taking into account theories of cognitive and moral development and toy design guidelines was described and tested with children in the target age range.

The contributions reveal that one way to achieve this design challenge is to combine multidisciplinary fields, namely, developmental psychology, product and service

design, and sustainability. Designing a toy from recycled materials, such as coffee Lego (http://www.colorstokyo.com/), which does not take into consideration guidelines such as the Universal Design for Play Guidelines (Ruffino et al, 2006), is not going to be enjoyed by children. While the idea to use recycled parts for toys is a good one, care must be taken when designing toys in order to make them appealing for children and commercially popular. Without commercial appeal, the toy will never reach a large enough market of children to make it worthwhile.

When designing for children, it is also essential to consider their cognitive development. Children acquire cognitive skills and understand concepts at specific ages; well-defined cognitive abilities and processes are a result of natural processes of maturation, experience and social influence (Piaget, 1973). In other words, learning occurs via leveraging a developing set of capabilities and skills. In terms of design, products or services aimed towards children, in order to be accepted, need to take into account the developmental requirements and capabilities of the age range (or developmental stage) they target. Play is a key activity children perform throughout their childhood. It helps develop imagination and creativity (Duvall & Zint, 2007) and helps them learn to socialize and understand the world surrounding them. Designing toys that complement play activities and build on them to convey values offers an opportunity for designers to positively shape children's understanding of the world.

Although the domain of sustainability is attracting more and more attention in the interaction design community (Horn et al, 2011) much of the work is simplistic – often just illustrating or highlighting energy use. In truth, sustainability is a complex topic that sits at the centre of a wide range of trade-offs (e.g. between efficiency, convenience and comfort or between short and long term rewards). This work argues that deeper understandings of the eco-system of values that surround sustainability issues is an important prerequisite for the design of systems and artefacts that can meaningfully intervene in this area. It presents and demonstrates a value-sensitive design process intended to achieve this and describes one application prototype that emerged from these efforts. We argue that future work need adopt similar methods in order to effectively engage with complex, multi-layered topics such as sustainability and intend the work in this paper to serve as an example of how this can be achieved.

Sustainability related values comprise actions and beliefs only part of the global community holds and puts into practice. It is important, particularly in developed countries, that more of the population takes into account these values in their day-to-day life. By including children in this process, the next generation will hopefully grow and build future lifestyles grounded on values such as: recycling resources; respecting the environment and natural resources; and responsible consumption. The current work shows an application that can introduce children between the ages of seven to eleven years old to these values. Ultimately, we hope that applications similar to the one presented in this work can encourage the generation of children currently growing up to value the environment and help to preserve the world we live in for their own and future generations.

For future work on this prototype, more recyclable materials should be added to increase the challenge level and therefore, engagement and learning. In terms of the finalized objects, a space to explain or name the objects should be added, as some children may want to clarify what their intentions were when creating the objects. The testing session showed that other values such as learning and knowledge could be added, as suggested by an older user. By integrating quizzes related to the activities or materials, there are a number of values that come into play, such as the need to learn and have more information and manipulating, transforming and creating new objects. This would facilitate the acquisition of skills such as creativity, awareness, initiative and problem solving. The next phase of this work could be conducting a long-term follow-up study to assess if the value of resource management was instilled in children and further transferred into the household context. For example, testing what the users and their parents learned from PlayGreen could be assessed through diary studies. This would enable researchers to see whether there were any modifications in the family's household behaviours and their routines.

CHAPTER SUMMARY

This chapter started with a description of how toys can have an effect on children's norms or values, even when this may be unintentional or indirect. It was argued that

this effect could be harnessed to pass on pro-environmental values in children through toys designed specifically for this purpose. This value could be carried through to later life and potentially influence the rest of the household purchasing or behaviour. It was noted that there is a current gap in recommendations for designers of such value instilling toys. A literature review followed with sections covering cognitive and moral theories of development, children's influence in the home and existing design guidelines for toys. In order to ensure that the value encompassed within the toy was related to sustainability, the value sensitive design method was followed and sustainable values were collected from the designers, children and parents/educators. Following this method led to a list of 20 values common to all groups relating to sustainability. From this list, the value of resource management was selected for the toy to be designed around. The chapter then moved on to describe a first iteration of the toy tested with children. This took the form of physical recyclable materials that the children could manipulate into creating new toys. This first round of testing led to the development of a prototype application where children could manipulate virtual recyclable materials on a screen to create a toy and share these creations with friends. These testing phases showed children collaborating and communicating with each other, a key requirement for enabling moral development. The chapter concludes with a discussion of how a multidisciplinary approach to value-instilling toys is required for the toy to be successful and fun to play with and with suggestions for future work in this area.

Chapter 6

Show Me or Tell Me: Designing Avatars for Eco-Feedback

INTRODUCTION

People frequently behave in ways that harm or damage themselves, others or their environment; they smoke, make poor dietary and exercise choices and waste natural resources through excessive or inefficient consumption. Frequently they are aware of the negative impact of their actions (West, 2005). A substantial psychological literature addresses this issue by seeking to understand, encourage and motivate behaviour change, typically towards objectively positive outcomes such as smoking cessation (Curry, Wagner & Grothaus, 1991), increased exercise levels (Consolvo et al, 2008) and reduced energy consumption (Abrahamse et al, 2005). The potential impact of such research is substantial. Behaviour change research has shown considerable potential in supporting people to consume less (Abrahamse et. al, 2005) and authors have argued that psychological understandings are key in understanding why individuals engage in unsustainable consumption behaviours and in designing interventions to encourage more globally viable choices (Koger & Scott, 2007).

Persuasive Technology is defined as any interactive computer system designed to change human attitudes or behaviours (Fogg, 2003). It is a powerful tool for instantiating theoretical understandings and facilitating real behaviour change. In an influential framing of this issue, Fogg (2003) argues that computers can effectively persuade users in tasks as diverse as purchasing decisions (Dormann, 2000), diet management (Lee, Kiesler, & Forlizzi, 2011) and energy consumption (Kimura & Nakajima, 2010). Techniques that are enabled by computers include the dynamic delivery of just-in-time notifications, the highlighting of contextually relevant cues and the display of rich, interactive, engaging visualisations such as avatars (Fogg, 2003). This chapter focuses on design issues for one of these persuasive tools: expressive graphical avatars. Technologically, such personalized visualisations are an

ideal platform for persuasion. They are an everyday feature of today's digital media platforms, such as games (and game consoles) (Xbox LIVE Avatars) and social networking services such as Second Life or Cyworld. Via modular third party services such as Buddy Poke (www.buddypoke.com) avatars can be easily integrated into common tools such as websites. Creating a humanized website, including emotive text, pictures of people and virtual agents, has been shown to increase trust in e-commerce (Head, Hassanein & Cho, 2003). Avatars are also frequently reported to be both expressive and engaging and have the potential to attract sustained long-term interest (Fabri et al, 2002). Reflecting these advantages, authors have included avatars (or virtual pets (Dillahunt et al, 2008; Lin et al, 2006), a highly related concept) in persuasive scenarios in a range of domains including health (Lin et al, 2006), energy consumption (Mahmud et al, 2007; Dillahunt et al, 2008) and education (Baker, Wentz & Woods, 2009). However, such systems are typically designed *ad-hoc* and rely on simple metaphors, such as the growth of a garden of flowers (Consolvo et al, 2008) or the abundance of natural animals in a scene (Lin et al, 2006). This chapter argues that avatars can be more effective persuaders by adopting more powerful and evocative communication channels (see Chapter 2 for further details regarding persuasion and emotional communication).

However, despite the prevalence of avatar systems, there is relatively little literature relating to how they can be systematically designed in order to be persuasive. In a recent review paper Baylor (2011) provides an explanation for this by highlighting the complexity of designing persuasive avatars. She specifically identifies appropriately conveying emotional expressions to enhance persuasion as a challenging design problem. Practical work on this topic has confirmed these notions. For example, in an educational scenario, Baylor and Kim (2009) found that avatar facial expressions effectively motivated learners while deictic gestures negatively impacted student attitudes. The authors suggest that difficulties in interpreting the gestures reduced the effectiveness of the communication.

This chapter extends this work. Specifically, it seeks to shed light on how avatars should present positive and negative feedback. Theng and Aung (2011) presented avatars with happy and sad facial expressions to children depending on their performance in a quiz. Although the emotional communication was reported to

increase understanding, the authors found lower levels of motivation when the children were shown the sad faces. This finding directly relates to the body of literature indicating that excessive negative feedback discourages behaviour change (Deci, 1972). Research indicates that both rewards and rebukes represent key aspects of a behaviour change intervention (Deci, Koestner & Ryan, 1999), but that they need be treated differently – positive feedback generally encourages users while overly negative responses can be de-motivating (Deci, 1972). This chapter explicitly contrasts the presentation of such messages in an avatar via two modalities: verbal (textual messages) versus visual (expressions and body language). Prior to a full comparison of these modalities, a validation study is conducted to best match verbal captions with graphical emotions. Finally, the findings from the studies were used to design a working system that senses energy consumption and gives feedback via avatars.

There are three main contributions in this chapter. Firstly, we validate a set of domain neutral images and textual content providing positive and negative feedback intended for use in persuasive avatars. Secondly, we present the results of an experiment indicating where and when to deploy each of these message modalities in order to maximize the effectiveness of a persuasive system. Finally, we use these findings to construct an avatar system that could be deployed as an effective persuasive tool to reduce energy consumption in the home.

The remainder of this chapter is structured as follows: firstly a description of a validation study where categories of verbal content are assessed for suitability as feedback for graphical avatars; secondly a study where we compare between visual and verbal positive and negative feedback for avatars and a discussion of the results of this work; and thirdly we end with the description of a working system that senses energy consumption and displays feedback to users via avatars designed according to the results of the previous studies.

STIMULI VALIDATION STUDY

This study was conducted in order to select and validate emotionally expressive stimuli, in the form of textual captions and pictures of avatars, for future use. This experiment replicates some parts of previous work (Noel, Dumoulin and Lindgaard,

2009). Their participants saw human and avatar faces (happy, sad, neutral, angry or surprised) accompanied by congruent or incongruent text. The authors were interested in incongruencies between text and expressions. Firstly, participants were asked to categorise the emotion displayed by the face and by the text from a set (angry, disgusted, fearful, happy, neutral, sad, surprised, other – specify). Secondly, the participants rated the faces (displayed below the text) on appropriateness and intensity

Figure 16: Full set of visual avatars with verbal humanised captions

and the text on trustworthiness, sincerity and convincingness (all on scales of 7 items from 'not at all' to 'very'). In the current study, the emotional range used had five levels spanning very sad to very happy, including a neutral middle. These are three of the seven main emotions used in previous relevant work, the others being surprise, anger, fear and disgust (Fabri et al, 2002). This dimension was selected because we were interested in a clear positive and negative range of emotion. The study presented participants with graphical avatars and captions and asked them to rate the individual cues in terms of their persuasiveness, happiness and trustworthiness and the pair of cues in terms of their consistency.

One set of graphical avatars was used, all of which are shown in Figure 16. The graphical avatars were generated from existing templates on the BuddyPoke service (www.buddypoke.com). The five expressions used were selected according to categories on the BuddyPoke system and validated via subjective assessment by an experimenter. The particular avatar character, a manga-like cartoon human, was

selected as it is gender-neutral both in terms of its facial appearance and its clothing. The choice of a gender-neutral avatar was to ensure we used the same cue set while also minimizing the influence of participant gender on the experimental results. Items in five different categories of caption (goal-related; social; performance; humanized; and comparison) were presented. These categories of caption were chosen to reflect some commonly used behaviour change interventions e.g. goal setting and feedback (Locke & Latham, 2002), social pressure and comparison to others (Lin et al, 2006) and also an attempt to utilize the tendency to treat virtual avatars as human (Bailenson et al, 2001). They were generated and agreed upon by the researchers, the goal related category mentioned goals at every level, the social category mentioned teams and support, performance was focused on the single user, the humanized captions involved the avatar talking directly to the user and the comparison category mentioned performance in relation to others. The full set is presented in Table 16. A screenshot of the final experimental interface is presented in Figure 17.

Category	**Emotion**				
	Very Sad	**Sad**	**Neutral**	**Happy**	**Very Happy**
Goal related	You didn't even come close to your goals.	You seem to have forgotten your goals.	You could set more goals.	Good, you achieved almost all your goals.	Congratulations on achieving all your goals!
Social	Everyone feels like you are failing them.	You're letting the team down.	Try to support your teammates.	Everyone is happy with your help.	You are really supporting everyone!
Performance	You are failing miserably.	You can do better work.	You seem to be on track.	You have done well.	Nice, you did a really great job!
Humanized	You've totally let me down.	I'm disappointed with you.	I want you to keep working.	I like your work so far.	I couldn't be more proud of you!
Comparison	Everyone is better than you.	You're doing somewhat worse than others.	You are doing similar to others.	You're starting to do better than others.	You've done much better than others!

Table 16: Full set of captions

In each trial in the study, a graphical avatar expression was shown with one of the emotionally corresponding captions – the graphical and textual equivalent cues always showed equivalent emotions. The full complement of avatar and caption combinations were generated and presented in a random order. Each pair appeared twice, a mean was taken of the two pairs for each participant in the analysis. This led to a total of 50 trials. The experiment took approximately 40 minutes to complete.

Participants

Twenty participants came in to the lab and completed the study. Participants were recruited through an online advertisement via the university email list. The ages of the participants ranged from 21 to 33 with a mean age of 25.8. Six of the participants were female and 14 were male. 14 of the participants were educated to undergraduate level or higher, one had some college and five had completed high school. All of participants were students. The majority of participants were Portuguese, 12 in total, while six were from USA and the final two were from India and Kenya. All reported their English levels to be good or higher. Participants were compensated for completing the study with a 10 Euro voucher for a popular local retailer.

Procedure

The experiment was conducted at a computer terminal in a lab. The opening screen showed one of the avatars with a speech bubble and a welcome message and detailed experimental instructions were available to view. Due to the self-explanatory nature of the experiment viewing of the instructions was not enforced. This page also captured basic demographics: language; age; employment; nationality; education level and gender. After entering data, participants clicked a button to move to the experiment itself.

Each trial consisted of an avatar and caption being displayed on the screen. Participants were asked to make five ratings on nine-item Likert scales (see Figure 17). These were labelled as ‘avatar happiness’ and ‘caption happiness’ (both scales ranging from ‘Very unhappy’ to ‘Very happy’), the consistency of the avatar with the caption (from ‘Very inconsistent’ to ‘Very consistent’), the persuasiveness of the

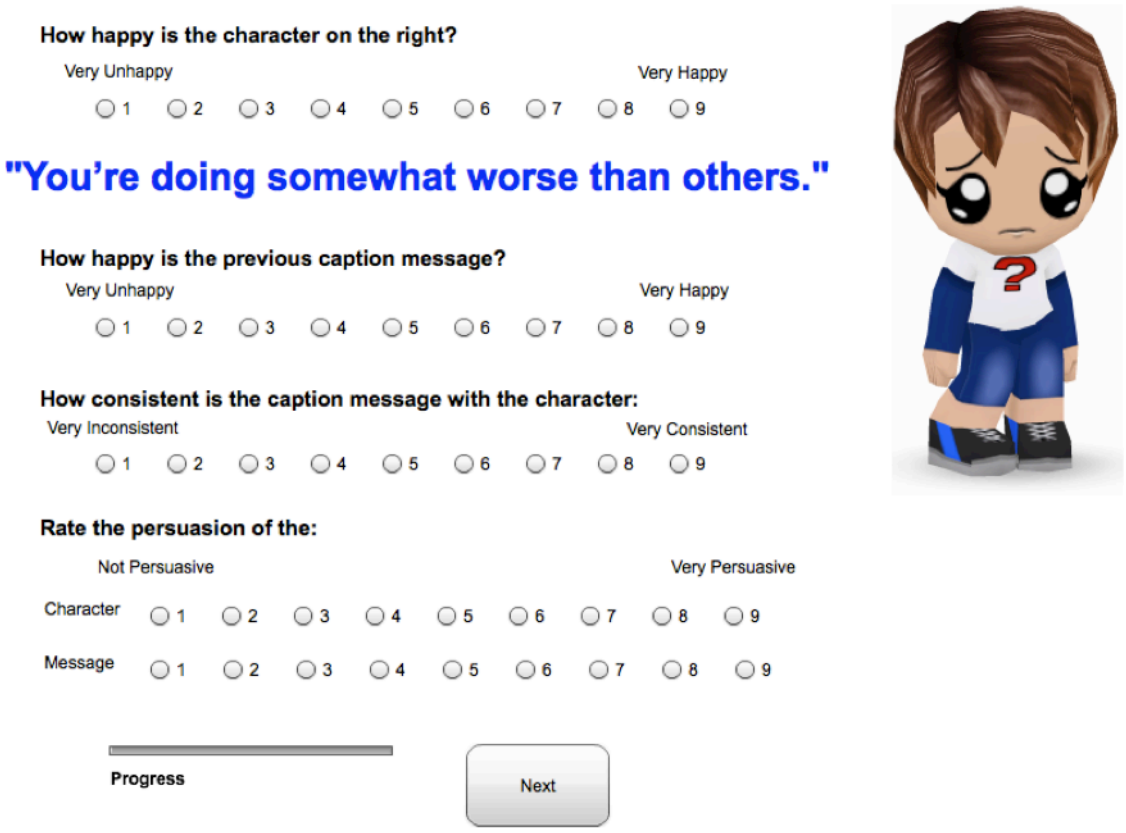

Figure 17: Screenshot of validation study

avatar and caption (from 'Not persuasive' to 'Very persuasive') and how trustworthy the avatar and caption appeared (from 'Not trustworthy' to 'Very trustworthy').

After completing these ratings, participants were asked to answer some open-ended questions on paper. These included general thoughts, how expressive or irritating they felt the combination of text and avatars was and how expressive or irritating they were separately (see Appendix H).

This study was intended to be exploratory and was conducted in order to select the most persuasive, consistent and trustworthy captions to use in future work. As such, we had no formal hypotheses as to which category of caption would be found to be the most persuasive, consistent and trustworthy.

RESULTS

Ratings

Rating Scale	Emotion Level - Visual					
	Very Happy	Happy	Neutral	Sad	Very Sad	Within Subjects ANOVA
Happiness	8.31 (.11)	7.12 (.14)	4.89 (.08)	2.10 (.13)	1.64 (.12)	$F(4,36) = 655.78$, $p<0.01$
Trustworthiness	7.51 (.21)	7.27 (.19)	6.35 (.23)	6.98 (.20)	7.13 (.17)	$F(4,36) = 14.25$, $p<0.01$
Persuasiveness	7.56 (.21)	7.26 (.17)	6.15 (.24)	7.18 (.22)	7.27 (.20)	$F(4,36) = 18.04$, $p<0.01$

Table 17: Mean ratings of persuasiveness, trustworthiness and happiness by the emotion level of the expressions. Standard Errors are shown in brackets. F values calculated from repeated measures ANOVA on the mean ratings for each emotion level are also shown

Table 17 shows the raw data and output of a set of within-subjects ANOVA tests run with the emotion levels of the expressions as the factors. The mean ratings of happiness in the table show clearly that participants rated the happiest expression as happiest and so on. A within-subjects ANOVA showed a significant main effect of emotion level of the expression on ratings of happiness. Pairwise (LSD) comparisons showed the neutral emotion level to be significantly different than the other levels of emotion on ratings of happiness ($p<0.01$). There was a significant main effect of emotion level on ratings of persuasion and trustworthiness. Significantly higher ratings of trust and persuasion were recorded for the very happy emotion ($p<0.01$) compared to the other emotions shown by the avatar. Post hoc comparisons showed the neutral emotion level to be significantly different than the other levels of emotion on ratings of persuasiveness and trustworthiness. As can be seen in the table, the neutral expressions were rated as the least persuasive and trustworthy.

Rating Scale	Emotion Level - Verbal					
	Very Happy	**Happy**	**Neutral**	**Sad**	**Very Sad**	**Within Subjects ANOVA**
Happiness	7.87 (.12)	6.73 (.10)	4.76 (.09)	2.77 (.12)	1.66 (.11)	F (4,36) = 583.9, p<0.01
Consistency	7.45 (.22)	7.54 (.15)	6.47 (.24)	6.77 (.21)	7.18 (21)	F (4,36) = 8.52, p<0.01
Trustworthiness	7.63 (.17)	7.31 (.17)	6.70 (.20)	7.20 (.19)	7.37 (.21)	F (4,36) = 9.93, p<0.01
Persuasiveness	7.55 (.16)	7.27 (.16)	6.60 (.19)	7.19 (.16)	7.48 (.18)	F (4,36) = 11.94, p<0.01

Table 18: Mean ratings of persuasiveness, consistency, trustworthiness and happiness by the emotion level of the captions. Standard Errors are shown in brackets. F values calculated from repeated measures ANOVA on the mean ratings for each happiness level are also shown

Table 18 shows the raw data and output of a set of within-subjects ANOVA tests run with the emotion levels of the captions as the factors. It also shows the ratings for the degree of consistency reported between visual and verbal cues. Ratings of happiness showed a significant main effect: higher ratings were assigned to happier emotions, indicating the captions successfully communicated their intended messages. This trend was borne out by significance in the post-hoc (LSD) tests between every happiness level ($p<0.01$). There were significant main effects of caption category on ratings of consistency, trustworthiness and persuasiveness. Ratings of the trustworthiness and persuasiveness of the individual verbal cues and consistency of the pair revealed significant trends. In all cases, these took the form of lower ratings for the neutral emotion, suggesting that, however they are instantiated (goal, social, performance, humanised or comparison), neutral statements lack trustworthiness, persuasiveness and, ultimately, are challenging to interpret. This finding was significant in post hoc tests ($p<0.01$).

Rating Scale	Caption Category					
	Goal	**Social**	**Performance**	**Humanised**	**Comparison**	**Within Subjects ANOVA**
Persuasiveness	6.96 (.20)	7.23 (.15)	7.51 (.16)	7.56 (.15)	6.80 (.18)	F (4,36) = 9.95, p<0.01
Consistency	6.88 (.19)	7.03 (.19)	7.17 (.17)	7.44 (.19)	6.87 (.17)	F (4,36) = 4.87, p<0.01
Trustworthiness	7.26 (.19)	7.20 (.16)	7.40 (.19)	7.49 (.17)	6.86 (.19)	F (4,36) = 7.92, p<0.01

Table 19: Mean ratings of persuasiveness, consistency, and trustworthiness by caption category. Standard Errors are shown in brackets. F values calculated from repeated measures ANOVA on the mean ratings for each caption category are also shown

A similar set of within-subjects ANOVA's were run with category of caption as the factor. The means and output are shown in Table 19. There were significant main effects of category on ratings of persuasiveness, consistency and trustworthiness. As can be seen in Table 19, the humanised category was rated as the most persuasive, consistent and trustworthy. Pairwise comparisons (LSD) indicated that the humanised captions were rated significantly higher than all the other categories, apart from performance, on ratings of persuasiveness and consistency ($p<0.05$). Due to the number of comparisons run on this data, it is advised that caution be taken in interpreting the results significant at the 5% level. Pairwise comparisons also showed that the humanised category was significantly different from the comparison category only on ratings of trustworthiness ($p<0.01$).

Qualitative Measures

All 20 participants answered open-ended questions regarding the avatars and captions. The first main theme to emerge was that almost half of the participants wanted a greater range of expressions for the avatars. One stated: "the avatars were very limited in terms of expressions, there should have been more of them". The second theme that emerged was that the extreme emotions were easier to interpret. Users suggested that the avatars were better at expressing emotions at each end of the spectrum rather than

neutral emotions: “avatars seemed very expressive and would be appropriate for extremes but not for ‘you're doing better than others’”. Another user stated: “the one that’s kind of in the middle…she doesn’t look happy or sad, just kind of in the middle looks slightly emotionless…it only really suited the ones where it said ‘you are exactly the same as others’”. This matches the quantitative finding that the neutral avatars were the lowest rated on persuasiveness, trustworthiness and consistency. A third theme was that the combination of captions and expressions was more meaningful than either of them separately. For instance, one remarked: “the text helps put a context to feelings”. The final theme to emerge was that the potential for nuance and increased expressive weight was another reported benefit of the combined message modalities. Once participant stated: “I think that the image and caption complement each other, because sometimes the same expression might mean different things”. Participants did not report that the avatars and captions were irritating or annoying.

DISCUSSION

The character and caption analyses showed that participants clearly rated the emotion levels of the captions and characters according to the five pre-defined emotions. This confirms the captions and characters effectively expressed an affective spectrum ranging from very sad to very happy. The mean happiness ratings for both character and caption at each emotion level were also numerically very similar, reinforcing the consistency expressed between the captions and expressions. In the qualitative interviews, people commented that the combination of caption and visual expression was more meaningful and more contextually appropriate than having them displayed separately. Consistency of the cue pairs was also explicitly measured. Of the five emotions studied, the neutral expression and caption were seen as the least consistent pair. This suggests that the neutral emotion is the least easy to understand – participants found it hard to relate the two neutral emotional expressions to one another.

Participants also found it hard to understand the neutral expressions by themselves – they were rated as significantly less trustworthy and persuasive than the other

emotions for both the avatars and the captions. In contrast, the more extreme emotions, particularly at the positive end of the scale, were rated as significantly more persuasive and trustworthy. The qualitative interviews also support this point, with participants stating that the stronger emotions were easier to understand. Perhaps unsurprisingly, this suggests that such low intensity expressions of emotion are unlikely to be effective or convincing motivators.

Examining the data describing the five different caption categories, it is clear all were effective: scores are close and consistent across all four of the attribute scales. However, of the four categories, the humanised category led to significantly optimal scores for persuasiveness, trustworthiness and consistency, suggesting that participants identified most strongly with an avatar that appeared to be addressing them personally and directly. In summary, this study suggests adopting a personal point of view in textual feedback accompanying graphical avatars will be easiest to understand and most effective. As suggested by previous work, a humanised design helps to engender trust (Head, Hassanein & Cho, 2003).

VALIDATED CAPTION STUDY

Overview

The goal of this study was to explore the impact of presenting positive and negative information to users via different communication channels, specifically emotional content expressed through graphical avatars and textual captions associated with them. The ultimate aim was to contrast how users perceive information in these two modalities in order to inform the design of persuasive technology. The study was based on the humanised category of captions, previously identified as the most persuasive and trustworthy as well as consistent with the graphical depictions of the avatars.

The study involved presenting pairs of avatars, one featuring a varying emotional graphical expression and the other with a fixed neutral graphical expression and a varying emotional humanised caption. Participants were asked to choose which avatar they felt was happier. The full spectrum of five emotions (very happy to very sad)

was presented in both modalities and the study followed an exhaustive forced choice design. Barring identical pairs, each possible combination of avatars was shown in a random order to each participant twice (verbal vs. verbal, verbal vs. visual, visual vs. visual, visual vs. verbal). In these pairs, the screen location of the avatar images was switched such that no images appeared consistently on the left or the right. The final screen layout can be seen in Figure 18. This design led to a total of 90 comparisons in each study. Prior to commencing the study, a practice set of ten comparisons was displayed. These trials were generated randomly from the available set of combinations and there was no noticeable break between the practice and experimental trials. The experiment took no longer than ten minutes to complete.

Figure 18: Screen layout of study

Participants

Forty-six participants completed the study. The ages of the participants ranged from 19 to 45 with a mean age of 28.9. Twenty-eight of the participants were male and 18 were female. The majority of participants were educated to undergraduate level or higher, 35 in total, seven had some college and five had completed high school. Twenty-eight participants were employed, 17 were students and one was unemployed. The majority of participants came from the U.K., 19 in total, the rest were from 14 different countries. All reported their English levels to be good or higher. Participants were not compensated.

Procedure

The experiment was conducted online. All materials were in English. The opening screen showed one of the avatars with a speech bubble and welcome message and detailed experimental instructions were available (optionally) to view. A brief questionnaire captured demographics, to ensure that each participant completed the study once only.

Each trial in the study started with a blank screen showing a fixation spot. Participants were required to press the spacebar to move on. They were then presented with two avatars, one on the left and one on the right of the screen, and the question: "Which one is happier?" A screenshot of the study can be seen in Figure 18. The 'F' key was used to select the leftmost avatar and the 'J' key to select the rightmost avatar. The trial then ended and the fixation spot for the next trial appeared.

Results and Discussion

Overall Happiness

	Visual Raw	% age	Verbal Raw	% age
Very Happy	829	19.6	639	15.1
Happy	719	17.0	549	13
Neutral	461	10.9	422	10
Sad	77	1.8	265	6.3
Very Sad	58	1.4	211	5.0
Total	**2144**	**50.7**	**2068**	**49.3**

Table 20: Times each avatar was chosen as happiest and corresponding percentage

Rather than analyse binary data, analyses were conducted on the percentage of times each stimulus was selected as the happiest of the presented pair. Each avatar had a maximum possible 20% chance of being chosen as happiest. This data is shown in Table 20. A two-way within-subjects ANOVA on the variables of emotion (very happy to very sad) and type (verbal and visual) revealed a significant main effect of emotion on happiness ratings, ($F(4,42) = 1705.40$, $p<0.01$), but not of type ($F(1,45) = 3.36$, $p = 0.73$). There was a significant interaction effect ($F(4, 1) = 138.43$, $p < 0.01$) shown in Figure 19. This can be interpreted as indicating that the visual avatars

expressed the most extreme emotions – they were rated as happier at the happy end and less happy at the sad end of the scale compared to those in the verbal case.

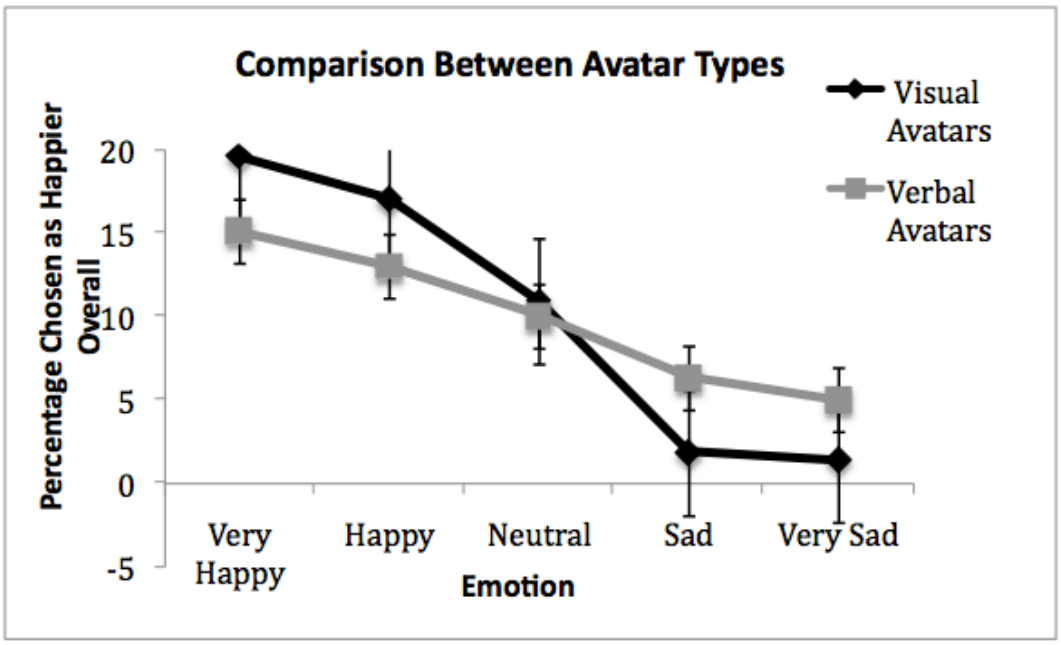

Figure 19: Comparison between avatar types on the overall percentage (maximum possible 20%) they were chosen as happiest

Emotion Level Comparison

In order to compare the effectiveness of verbal and visual avatars at each specific emotion level, the percentage of times each stimulus was selected as happier than another expressing the same emotion level was calculated. These data are illustrated in Figure 20. Separate within-subjects t-tests were then run to compare between avatars of the same emotional level in the verbal and visual conditions. These revealed significant differences at $p<0.01$ for every emotion bar the neutral emotion. To ensure an acceptable family-wise error rate in this set of five t-tests, the critical value for significance was set at $p<0.01$.

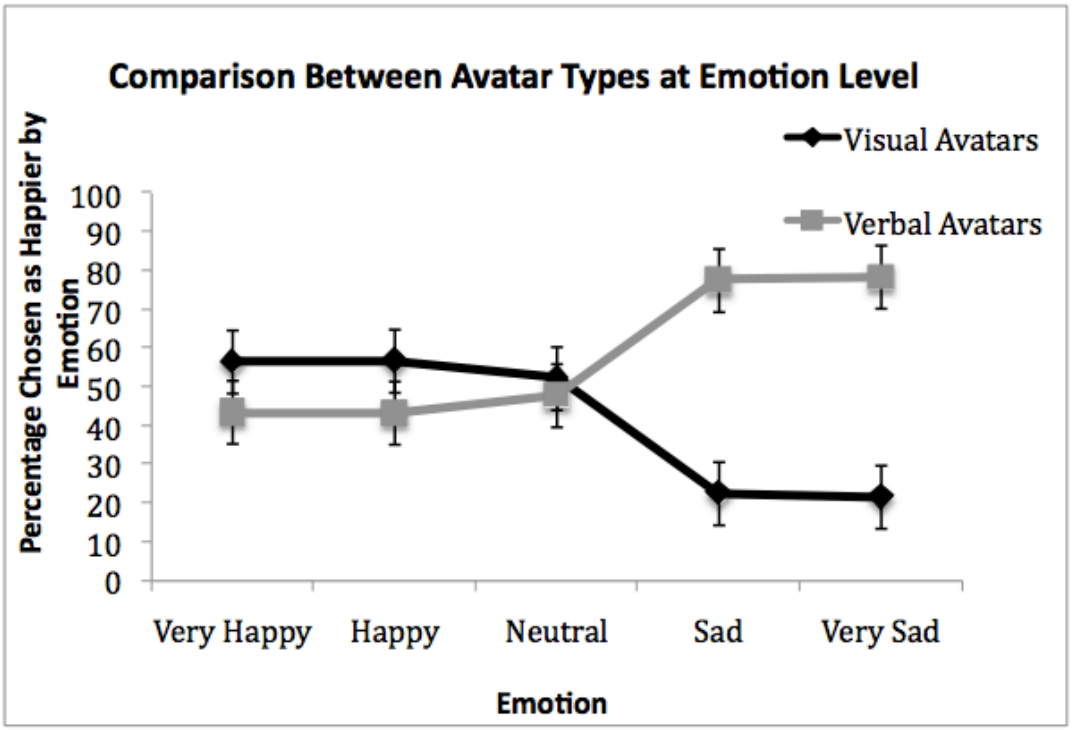

Figure 20: Comparison between avatar types at each emotion level, percentage chosen as happiest for each emotion is shown

As can be seen in Figure 20, there is a clear crossover in this data. The visual very happy and happy avatars were more frequently selected as happy when compared to the verbal happy avatars and conversely, the verbal sad and very sad avatars were more regularly rated as happier than the visual sad avatars. This shows that avatars based on visual expressions are easier to interpret than those that use verbal expressions. This reinforces the point that participants viewed the visual avatars as more emotional. It is also worth noting that, although this effect is less pronounced at the happy end of the spectrum, it is very distinct for the depiction of sad and very sad emotions. This highlights the power of the visual depictions of sadness and suggests that the unhappy avatars were highly effective at conveying their messages.

OVERALL DISCUSSION

These two studies explored how avatars should best present positive and negative feedback in order to effectively persuade users. The first study validated different categories of captions to accompany graphical avatars and was used to select the category of caption that was found to be most persuasive, trustworthy and consistent. The second study presented the graphical avatars and chosen category of caption in a

forced choice paradigm to determine which channel of communication was perceived as happiest, visual or verbal. The two studies had conflicting objectives, the first tried to find consistency between the visual and verbal modes, whereas in the second study we attempted to tease apart the effects of these different channels.

Study one showed that humanised captions were the most persuasive, trustworthy and consistent. There were not large differences in the categories for study one however, suggesting that the other categories may also be useful as persuasive feedback. In study two, visual feedback was found to be more powerful than verbal feedback, the visual happy avatars were seen as happier and the visual sad avatars were seen as sadder, than the verbal avatars. Study one also showed a similar pattern, the mean very happy and happy ratings of the characters were higher than the mean very happy and happy ratings of the captions. Study one also showed higher ratings of trust and persuasion for the very happy visual avatar compared to the very sad. In general, the cartoon-style avatars also appear to be effective communicators of emotion, supporting the Ethopoeia theory (Nass & Moon, 2000) that suggests that humans respond to computers socially without the need for fully realistic, human-like presentations.

Participants in both studies gave very similar happiness ratings for the different levels of emotion in the visual avatars; they elicited highly consistent subjective assessments across the two studies. They also showed a higher recognition rate than that reported in comparable work (e.g. Noël et al, 2009). This could be due to the choice of avatar. Noel et al used a computer-generated face, which may have presented more subtle or ambiguous cues to people compared to the cartoon style deployed in the current work. Regardless, the neutral emotion was challenging to interpret in both studies - it was least trustworthy and persuasive for both the captions and the character in study one and there were no differences in study two between verbal and visual for the neutral emotion. This suggests that, in a persuasive technology system, there may be no need to present neutral feedback. It may be clearer and less confusing for users to see only positive or negative feedback. However, it also may be true that abrupt changes from positive and negative presentations may be undesirable, potentially confusing or annoying users. We identify managing the transition from positive to negative

feedback, ideally by avoiding ambiguous neutral content, as an area that deserves further study.

Previous work on using avatars representing people as a means of feedback (e.g. Benyon & Mival, 2008) omitted the impact of emotional expressions from these characters. The two studies in this chapter attempted to address this gap and understand how to best use avatars to present positive and negative feedback in a persuasive system. This was achieved by, firstly, validating the visual avatars and the types of verbal feedback and, secondly, by showing when it is best to use visual or verbal and positive or negative feedback in a persuasive system. These results suggest design implications for persuasive technology; positive feedback should be delivered via visual expressions. Negative feedback should be delivered via verbal feedback instead of visual expressions; this may help reduce the potential for de-motivation. Positive feedback generally encourages users while overly negative responses can be de-motivating (Deci, 1972). We also suggest that in order to utilize avatars as a channel for persuasive feedback, it is important to carefully select the captions and expressions that will be shown. The user understanding the message the avatar is trying to convey is of paramount importance when designing feedback. Consistency between expression and message is also required in order for the user to easily interpret the feedback. The avatars and messages designed in this chapter showed readily identifiable emotions and strong consistency between the captions and the expressions presented, which we argue allows this media to be used confidently in a persuasive system.

One of the limitations of this work is the inconsistency of showing a neutral avatar expression with the different levels of emotional messages in the second study. This was an attempt to separate the expressions from the verbal messages, however, consistency is key to message understanding and this may have contributed to the higher happiness ratings for the consistent visual feedback. Future work could address this by comparing the text with more consistent expressions. Future work in this area could also focus on long-term field studies to analyse whether there would be any changes in attitudes or behaviours and whether avatars can be utilised to increase motivation. Applications could be developed for use in long-term behaviour change

scenarios that introduce gamification techniques with the objective of capturing and maintaining users long-term attention and engagement.

This chapter will now move on to a working example of such a system. The following section provides a brief description of Eco-Avatars (Gouveia et al, 2012), a fully functional application that senses energy consumption from appliances in the home. This application was created in collaboration with colleagues and presented as a working demo at the Designing Interactive Systems conference in 2012. The application allows each family member to assign specific appliances to an avatar that represents them, appliances can also be shared between household members and in this case, the consumption feedback is also shared (Figure 21). The avatar then displays positive or negative aggregate feedback, designed according to findings in the studies just described, that is specific to the family member. The avatars can also communicate between themselves regarding their energy consumption by facing each other and giving each other messages (see Figure 22). This system is presented in further detail below.

ECO-AVATARS SYSTEM DESCRIPTION

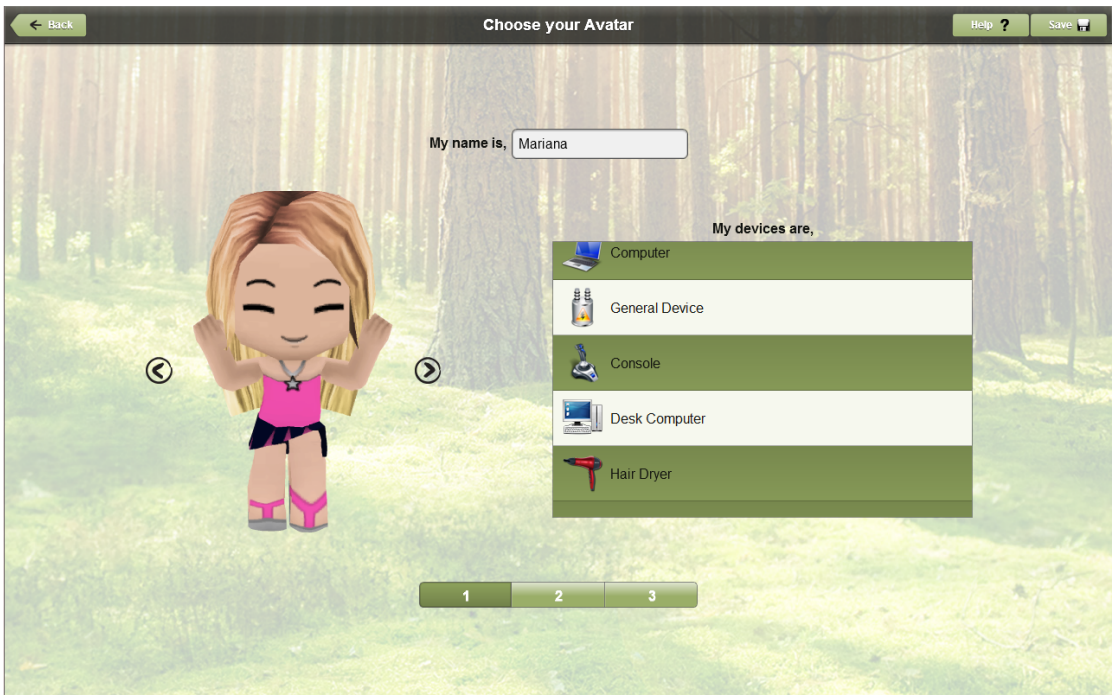

Figure 21: Eco-avatars avatar choice and set up screen

The energy consumption of most homes is collective because all occupants contribute. Correspondingly, energy feedback, be it in the form of bills, or smart meters is aggregate, summing the usage of many users over a substantial period of time. This lack of individual impact and the delay between consumption activities and feedback represent significant motivational challenges. Essentially, it is hard for users to understand or care about the impact of their actions when this is obscured by the input of others and obfuscated by significant delays in receiving feedback. The eco-avatars application is based on the idea that an avatar in a shared graphical visualisation can represent each member of a household. Specific consumption activities are then associated with each user, and their avatar rapidly and immediately alters its depiction to represent the user's individual actions in the wider context of those performed in the entire household. The goal of this is to allow every member of a household to understand their personal and collective consumption patterns and to encourage them to consume less. Two main motivational strategies informed the design of the system: social pressure and humanisation.

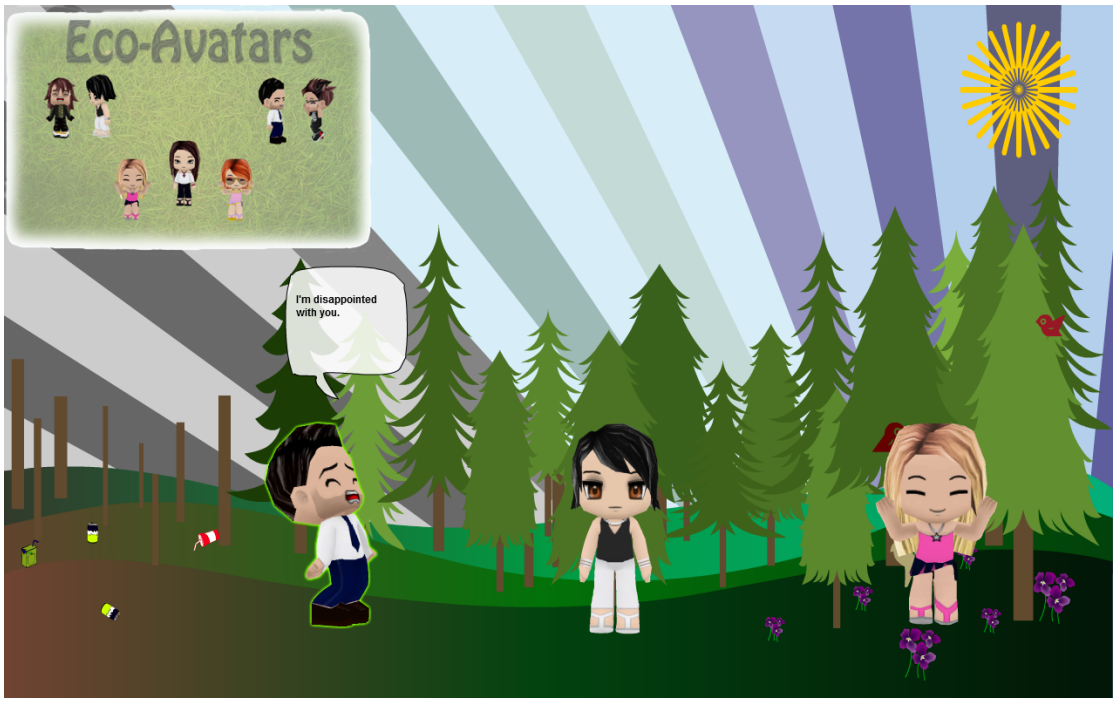

Figure 22: Eco-avatars consumption feedback screen

Social pressure is inherent in the system in that it shows individual and group behaviour. One design goal was that it should be immediately clear from the

visualisation which avatars, and by inference users, are behaving more or less sustainably. By directly observing such contrasts, we argue that understanding the consumption impact of particular activities and individuals will become clear. Social pressure present in normal family dynamics may then provide a motivational foundation for optimising consumption and saving energy.

Humanisation, or strengthening the connection between householders and their avatars was also a key design objective. To achieve this the avatars were designed to express feelings from very happy to very sad using a pre-defined set of facial emotions and textual messages taken from the previous work in this chapter. To further this concept of humanisation, the avatars were also able to interact with one another, turning to face each other and communicating and commenting on each other using humanised textual messages.

Eco-avatars was implemented in Adobe Flash and runs on the Adobe AIR runtime, allowing quick deployment across different platforms and devices. Aggregate and disaggregate consumption information was computed using a bespoke Non-Intrusive Load Monitoring (NILM) system (Nunes, Pereira, Quintal & Berges, 2012) that can be installed on a home's main electric supply and remotely queried by the avatar application using standard TCP socket connections. The NILM system is capable of analyzing changes to overall electrical load in order to deduce what specific appliances have been turned on, off or adjusted. The NILM system was designed and implemented as a part of the wider SINAIS project (http://sinais.m-iti.org/).

Eco-avatars has three modes: 1) configuration, 2) consumption and 3) environment. In the configuration mode the user creates a family of avatars (one per family member) and customizes each individual avatar by naming it, and selecting a gender and appearance (from a set of 10 options). They also manually associate a specific set of home appliances with the avatar. These associations are used to attribute consumption to particular users in the consumption and environment modules.

The consumption module displays a picture of a family member's avatar and a comparative chart of individual energy consumption (kW/h or projected costs) so that family members can compare and contrast each other's performance. It also displays

general energy saving tips and consumption goals and is designed as a fairly typical eco-feedback display.

Finally, the environment module (Figure 22) shows an expressive and personal view of consumption activities. It incorporates a number of features to highlight consumption and sustainability issues. Firstly, it consists of a static forest background, populated with all the avatars from a family. The background shows a healthy forest (right side of Figure 22) gradually transitioning to a desolate, deforested landscape (left side of Figure 22). Avatars are positioned against this background according to the consumption activities of their real world counterparts; high consumption results in a leftward drift towards the polluted area of the scene. The avatars also have more direct and immediate feedback mechanisms. They show very happy to very sad expressions and have a lightly glowing aura, which changes colour from red to green in response to specific low consumption actions, or goals and commitments met. Finally, the avatars can interact with one another by commenting on each other's performance. They achieve this by turning to look at each and using the previously studied humanised captions to express messages (see Figure 22).

Eco-avatars was designed to help a household reduce their energy consumption by revealing and contrasting individual usage levels via playful, expressive characters. Future work on this system will involve deploying and evaluating its effects in a field study. Future development of the application will focus on improving the quality of the media and introducing gamification techniques with the objective of capturing and maintaining users long term attention and engagement. Long-term field studies should be conducted to analyse whether there would be any changes in energy consumption attitudes or behaviours.

CONCLUSION

In sum, this chapter contributes to the body of knowledge about how to use avatars as a persuasive technology. It argues this type of presentation has the potential to engage users long-term, a key pressing issue for practical applications. Long-term engagement with users will be an important component of successful behaviour change interventions. This chapter has described two studies that validate a series of

emotional avatar media and then contrast how it is interpreted from the perspective of motivating persuasion. These understandings are then instantiated in the design of a novel eco-feedback avatar system intended for use in home scenarios. Future work will focus on deploying a working system within people's homes in order to test the persuasiveness and trustworthiness of the feedback, as well as long-term engagement and behaviour change. Such a persuasive system that encourages long-term engagement could have real effects on raising awareness and reducing energy consumption in homes.

CHAPTER SUMMARY

This chapter began by summarising negative behaviours that people frequently perform and arguing that one way to influence positive behaviour change is to design persuasive technologies. One potential persuasive tool is utilising avatars as a means of providing people with feedback on their behaviours, which was the focus of this chapter. Two studies were conducted; the first was intended to assist in the design of positive and negative feedback and the second was intended to evaluate the different types of feedback. The first study showed avatars alongside a verbal caption and asked participants to rate the captions on persuasiveness, trustworthiness and the consistency of the visual avatar with the verbal caption. Humanised captions, where the avatar seemed to be talking directly to the participants, were rated the highest on all three dimensions. These captions were then used in the second study, which asked participants to select the happiest stimuli from pairs of visual avatars with different emotional expressions, presented alongside a visual avatar with a neutral expression and a caption that varied in its emotional expression. Participants rated the visual avatars as happier than the verbal avatars at the very happy and happy end of the spectrum of emotion. At the very sad and sad end of the spectrum, verbal avatars were rated as happier than visual avatars. Negative feedback can be de-motivating whereas positive feedback generally encourages users (Deci, 1972), therefore it was recommended that positive feedback be given visually and negative feedback given verbally. The findings from the two studies were incorporated into a working system that senses electricity consumption in the home at the appliance level and provides feedback via avatars. It was argued that this type of feedback system could be engaging over the long term.

Chapter 7

Conclusions and Future Work

The overarching goal of this thesis was to explore mechanisms of how to promote environmentally sustainable consumption behaviours in the home by understanding and influencing everyday choices and providing feedback on these behaviours. This thesis contributes to this aim in three ways. Firstly, by understanding the choices people make regarding their energy consumption and arguing this understanding is necessary to effect changes regarding goal choice. Secondly, by exploring ways to influence everyday choices to be positive and pro-environmental, in particular, through goal priming and the design of toys intended to instil sustainable values in children. Finally, by providing effective novel feedback towards the accomplishment of these goals. The following paragraphs summarise the contributions of this thesis, its limitations and finally areas for future work are highlighted.

Contributions

Understanding – Goal Choices

Determining how to best reduce consumption remains a challenging task for many users. Informed by goal setting theory, two lab studies were conducted (based on the presentation of detailed scenarios and the solicitation of goal selections for the individuals depicted) in order to better understand how users make such decisions. The first study explored how people choose goals by presenting different home scenarios and asking people to choose goals for the household presented in the scenarios. The goals varied in difficulty level (easy/hard) and in context (contextual/non-contextual). The second study extended the first by using the same scenarios but this time goals were split into difficulty level (easy/hard) and specificity (vague/specific). The goal of these studies was to understand the preferences people have towards different types of goals.

The first contribution of this work showed that energy saving goal choices are in line with the predictions derived from goal setting theory (Locke & Latham, 2002). The theory states that challenging and clear goals are the most effective at producing

results but that people tend towards choosing easier goals. This domain specific validation of the theory has implications for HCI designers in this area, namely those easy ineffective goals should be de-emphasised.

The second contribution from this work is to show that people tend to choose easy goals over hard goals regardless of feedback showing the easier choices are ineffective. This is again what goal setting theory would predict. Goal setting theory suggests that easy goals lead to low levels of commitment and motivation, suggesting such choices may be doubly ineffective (Locke & Latham, 2002). Difficult goals lead to greater persistence and effort. Designers of interactive systems who include goal setting as a motivator for sustainable behaviour change should take into account the ease and specificity of the goals they provide as choices. They should provide information about the effectiveness of goals, since goals and feedback together are more effective than goals alone (Locke & Latham, 2002), and present more difficult goals or actions in terms of smaller steps that can encourage more effective behaviour change over time. People need concrete, effective recommendations if they are to make sustainable informed choices about their lifestyle.

In an ideal goal setting system, people should be able to choose their own goals and receive feedback based on detailed disaggregated data representing consumption practices from their home (Berges, Matthews & Soibelman, 2010). They should be presented with customized information and personalized recommendations based on the goals chosen and feedback received (He, Greenberg & Huang, 2010). This work takes steps towards the first design of such a system by showing how users choose goals, the types of goals they choose for themselves and makes an attempt to understand the reason for these choices, work that has direct application to the domain of HCI and sustainability.

Influencing – Goal Priming

Following on from understanding that people make poor choices in this area, the second main aim of this thesis was showing how to influence more positive choices. Influencing more difficult and effective energy saving goals was firstly attempted through goal priming. Previous work had shown priming to be effective at increasing job performance and at reducing consumption in a washing machine interface where

people set their own consumption reduction goals (McCalley et al, 2006). In the study in Chapter 4, participants were shown pictures of either easy or difficult energy saving actions before watching scenarios describing households and then chose energy saving goals for those households. It was predicted that participants who were exposed to pictorial primes of difficult energy saving actions would be more likely to choose difficult goals and have higher ratings of self and others' commitment to those goals compared to participants in the control and easy actions priming conditions. However, the results found were not as predicted, those who saw no primes chose difficult goals more often than those who saw difficult primes and those in the difficult priming condition chose easy goals more often than those in the other two conditions.

These findings were explained by reference to previous work that shows that social or goal priming is more complex than perceptual priming and requires salience and attention to be effective (Pashler, Coburn & Harris, 2012). It may be that the difficult primes were de-motivating in that they showed actions that people felt were too difficult to commit to. This work contributes to the broader research on goal priming and argues that priming may be more effective at influencing difficult energy-saving goal choices over the long term when people already have an overall goal of saving energy.

Influencing – Designing Value Instilling Toys

Influencing pro-environmental values was accomplished by contributing to the design of toys that instil sustainable values. Toys are essential to development and help children with their basic motor or cognitive skills but they can also pass on cultural knowledge or values (Goldstein, 1994) either directly or indirectly. Developmental theories were applied to the design of toys that instil sustainable values. The theories focused on were Kohlberg's (1977) moral development theory and Piaget's (1973) cognitive development theory. More specifically, Piaget's concrete operational stage processes, which occur between the ages of seven and eleven years old were targeted for the development of the toy. Chapter 5 argued that the design of type of toy should take into account children's cognitive development and their learning skills, as well as conforming to toy design guidelines. Although there are clear criteria for designing educational toys, there are no clear criteria for designing toys that instil sustainable

values, therefore a value sensitive design process was utilised. This multidisciplinary approach is essential for toys to be engaging and effective and was employed in this work.

Chapter 5 made four contributions in this area. Firstly, it presented a set of values relating to sustainability gathered from the various stakeholders including researchers, children, parents and educators. This value set is novel, as it breaks down the vague concept of sustainability into actionable values, common to several stakeholder groups. Secondly, it provided a theoretically grounded framework for value conveyance that encompassed both developmental theory and a value sensitive design process related to play (Kohlberg, 1977). Thirdly, a prototype of a toy using resource management as a value was designed and integrated into the developmental needs of the chosen age group. The prototype took into account concepts in Piaget's concrete operational stage of development as well as design guidelines for play. Finally the prototype was tested and verified as to how it encourages moral development among children by encouraging discussion and collaboration between them, the pre-requisites for moral development according to Kohlberg.

Campaigning groups (Crompton & Kasser, 2009) have begun to focus on engaging pro-social or pro-environmental values within people and society in order to achieve shifts in behaviour. It has been shown that facts and rational analysis play a part in decision-making but that emotion can also play an important part and only providing people with information is not enough to encourage change (Crompton, 2010). Therefore the work in Chapter 5 focuses on one way of influencing values at an early age. Problems such as climate change are not in an individual's immediate self-interest to solve; therefore it is necessary to engage with values to have a long-term effect on sustainability issues. Deeper understandings of the eco-system of values that surround sustainability issues is an important prerequisite for the design of systems and artifacts that can meaningfully intervene in this area.

Feedback – Designing Avatars for Persuasion

Goals require feedback in order to be effective and feedback has been shown to reduce household energy consumption by 5 to 20 percent (Vine, Buys & Morris, 2013). The overall contribution in this section was the design and development of an

appealing and engaging energy feedback system using avatars. Two lab studies were described that presented participants with avatars that communicated verbally via text and visually via expressions. In the first study, participants rated five different categories of captions and corresponding avatars. The results showed that the most persuasive, consistent and trustworthy verbal feedback was given in a humanized form. This enabled the first contribution of this work, the independent validation of a set of domain neutral images and textual content providing positive and negative feedback intended for use in persuasive avatars.

In the second study participants chose the happiest avatar from a pair, one of which was visual and one verbal. The results showed that participants found visual avatars more expressive and easier to understand than their verbal counterparts, and that users respond differently when presented with negative or positive emotions. This led to the second contribution: the practical finding that positive feedback is better presented visually via expressions as it is most evocative, whereas negative feedback is better presented verbally since it is seen as less harsh. Finally, the last contribution was a working system that senses appliance-level energy consumption in the home and shows feedback to users via avatars. This type of system should engage in the long term, by encouraging intrinsic motivation (Curry, Wagner & Grothaus, 1991) via identification with the avatars (Benyon & Mival, 2008; Dillahunt et al, 2008) and lead to long-term positive changes in environmental behaviours.

These results suggest design implications for persuasive technology: positive feedback should be delivered via visual expressions whereas negative feedback should be delivered via verbal feedback which may be less likely to de-motivate people. In general, the cartoon-style avatars also appear to be effective communicators of emotion suggesting that humans respond to computers socially without the need for fully realistic, human-like presentations as suggested by the Ethopoeia model (Nass & Moon, 2000). In order to utilize avatars as a channel for persuasive feedback, it is important to carefully select the captions and expressions that will be shown. Conveying an understandable message is of paramount importance when designing feedback. Consistency between expression and message is also required in order for the user to easily interpret the feedback (Hong, Wen & Huang, 2002; Creed & Beale, 2008). The work in this chapter showed that readily

identifiable emotions and strong consistency between the captions and the expressions allows the media presented to be used confidently in a persuasive system.

Limitations

One of the main limitations of the work in this thesis is the lab-based and short-term nature of most of the experimental studies. Fieldwork conducted over the long-term would add to the value of the experimental findings. However, typically in the field of HCI the whole cycle of design, testing over the long term and production is relatively rare. The focus tends to be on the design and production of new interfaces or technologies. The work here studied how best to design interfaces or applications to encourage sustainability.

More specific limitations include the small number of participants that completed the pilot priming work in Chapter 4 and the small sample of children that tested the application in Chapter 5. Both studies could have been improved if a larger pool of participants had taken part. The goal priming work may also have been more successful if the primes had been shown for a longer amount of time.

The verification of the application designed in Chapter 5 would be more effective if it had been tested over the long-term. Unfortunately, this was not within the scope of the work conducted here. Measuring the development of values within a child and whether these values are passed along to other members of a household is a significant undertaking. It would be useful to conduct long-term work, however, the work that was completed stands alone as a theoretical framework for the design of toys that instil sustainable values and is a significant first step towards the successful creation of such toys.

Limitations of the work in Chapter 6 on the design of persuasive avatars include the limited set of media used and the method of comparing visual avatars with verbal counterparts that had a neutral expression. The persuasiveness of the system designed at the end of the chapter can only be tested in the field over the long-term. However, the work makes a significant contribution to the design of such persuasive eco-feedback systems despite these limitations.

Future Work

This section highlights opportunities for future research in the different topic areas explored in this thesis. This section is separated into the three main areas addressed in the thesis: understanding, influencing and feedback.

Understanding - Goal Choices

Future work that could be conducted in this area would be to explore goal selection with real-time sensing and presentation of home energy consumption levels. This could lead to the development of interfaces that provide tailored, actionable and contextually relevant goals to users. Regularly updated feedback would also offer users confirmation of the effectiveness of their actions and goals. Chapter 6 describes work based around the design of a system that senses energy consumption and provides feedback; goal setting could be added to this interface and tested in the field and over the long-term. Further work also needs to be done in this area to determine the extent to which people think others will shoulder the responsibility for sustainable energy use.

One of the main issues presented in this work is that users tend to choose easy goals, whereas difficult goals produce the best performance. Influencing people to choose more difficult goals is a key area where a difference can be made in energy consumption. Chapter 4 discusses work that attempts to influence people to choose more difficult goals based on the well-established theory of goal priming. There is a need to better understand how users can be guided towards more effective and efficient goal selections.

Influencing - Goal Priming

Further work should be done in this area to determine what types and methods of priming (if any) can be utilized to influence people in choosing more difficult and effective energy saving goals. Sustainability is a complex topic and it seems that more significant or context aware interventions than simply showing pictures are needed to influence goals. A more comprehensive study, perhaps validating goals into easy, medium and difficult categories could be conducted to see if priming can influence people to choose medium difficulty goals. Difficulty should also be cross-referenced

with effectiveness to see if priming can influence goal choice by effectiveness rather than just difficulty.

Future work could also present participants with pictorial actions of energy saving actions for longer than a couple of seconds. They could be embedded within eco-feedback systems tested over the long term to determine whether they can affect consumption. A future study should also more extensively pilot the pictorial primes in order to ensure the primes show the actions they were intended to. The sample that piloted the primes in this study was very small, only five participants. If a larger sample correctly identified the actions depicted on the slides, then perhaps the results here could be attributed to goal difficulty or effectiveness rather than the pictorial priming method not depicting the primes they were intended to.

Influencing – Designing Value Instilling Toys

The prototype that was developed could be extended with more recyclable materials added to increase the challenge level and therefore engagement and learning. A screen to explain or name the objects should be added, as some children may want to clarify what their intentions are when creating the objects. An older user suggested that extra learning and knowledge challenges could be added. Integrating quizzes related to the activities or materials could facilitate the acquisition of skills such as creativity, awareness, initiative and problem solving.

The next phase of this work should be conducting a long-term follow-up study to assess if the value of resource management was transferred into the household context. Diary studies could be used to test whether the users learned long-term values or changed their attitudes in the long term from PlayGreen. This would also enable researchers to see whether there was an effect of the child's influence in the family's household behaviors and their routines.

Feedback – Designing Avatars for Persuasion

Future work should look at the difficulty of presenting neutral feedback. It may be clearer and less confusing for users to see only positive or negative feedback rather than including neutral feedback that may be difficult to understand. However, it also

may be true that abrupt changes between positive and negative presentations may be undesirable, potentially confusing or annoying users. Managing the transition from positive to negative feedback, potentially by avoiding ambiguous neutral content, is an area that deserves further study.

Eco-avatars was designed to help a household reduce their energy consumption by revealing and contrasting individual usage levels via playful, expressive characters. Future work on this system should involve deploying and evaluating its effects in a long-term field study. Future development of the application should focus on improving the quality of the media and introducing gamification techniques with the objective of capturing and maintaining users' long-term attention and engagement. Long-term field studies should be conducted to analyse whether there would be any changes in energy consumption attitudes or behaviours.

CHAPTER SUMMARY

This thesis aimed to encourage environmentally sustainable behaviours in the home, a current crucial global issue. The work presented here has focused on different aspects of solving this problem, including influencing values at a young age, understanding current sustainability-related goal choices and providing effective feedback for those choices. There were three main sections of this thesis. The first involved understanding the choices people make regarding their energy consumption. The second attempted to influence those energy choices to be positive and pro-environmental, through goal priming and the design of sustainability value-instilling toys. The third and final section focused on the design of effective novel feedback towards the accomplishment of the sustainability-related goals. All the different sections are intended to work towards helping people to make the most effective choices for themselves and for the overall well being of the planet and global community. However, this work is not intended to be interpreted as the only way to accomplish these goals; it is focused on the HCI aspects of sustainability as one part of a larger effort aimed at effecting a necessary cultural shift in attitudes towards energy consumption and the sustainability of our planet.

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Appendix A

Environmental Attitudes Online Survey

Environmental Attitudes

1. Consent Form

Statement of Purpose

The Laboratory for Usage-centered Software Engineering (LabUSE) is a research and development unit associated with the University of Madeira. We are currently working on a project to study people's attitudes to sustainability and energy companies.

Currently we are in the testing phase, and participants that volunteer shall not be monetarily compensated. In this phase, participants are asked to answer a questionnaire, which will take approximately 10 minutes to complete.

Confidentiality and Anonymity

Information obtained about you for this study will be kept strictly private. The results of the study may be published for scientific purposes. These results could include your data. However, your identity will never be given out and all your data will be kept anonymous.

Refusal or Withdrawal Without Penalty

Your taking part in this study is your choice. There will be no penalty if you decide not to take part in the study. You are free to skip any questions or to leave the study at any time. Your choice to leave the study will not affect you in any way.

Questions

If you have any questions, concerns, or complaints about the research or a research-related issue, please contact Michelle Scott who will be glad to answer any of your questions. Michelle Scott can be contacted through email (mscott@m-iti.org) or phone on +351 291721216.

*** 1. I confirm that I have read and understood the information about the above study and I agree to take part in this study. I understand that my participation is voluntary, and that I am free to withdraw at any time, without any given reason or penalty.**

- ○ Yes
- ○ No

Environmental Attitudes

2. Page 2

1. Are you male or female?

- Male
- Female

2. Please enter your age:

3. Please enter your nationality:

4. What is your current employment status?

- Employed
- Unemployed
- Student
- Retired

5. What is your highest education level?

- High school e.g. high school diploma/A levels
- Vocational qualification
- University degree
- Postgraduate degree

Environmental Attitudes

3. Page 3

1. Please answer the following questions related to the electricity company you currently use:

	Strongly disagree		Neither agree or disagree		Strongly agree
I feel that the electricity company is good at what it does	○	○	○	○	○
I always feel confident that I can rely on the electricity company to do their part when I interact with them	○	○	○	○	○
The electricity company does not do a capable job of meeting customer needs	○	○	○	○	○
The electricity company is interested in their own wellbeing, not the customer's wellbeing	○	○	○	○	○
I feel that the electricity company would act in a customers' best interest	○	○	○	○	○
In general, the electricity company is incompetent at serving their customers	○	○	○	○	○
I feel fine doing business with the electricity company since they generally fulfill their agreements	○	○	○	○	○
If a customer required help, the electricity company would do their best to help	○	○	○	○	○
I am not comfortable relying on the electricity company to meet their obligations	○	○	○	○	○

Environmental Attitudes

4. Page 4

1. Please answer the following questions related to your beliefs about the electricity company you currently use:

	Strongly disagree		Neither agree or disagree		Strongly agree
The electricity is competent and effective in providing a service					
If I required help, the electricity company would not do their best to help me					
I believe that the electricity company would not act in my best interest					
I would characterise the electricity company as honest					
The electricity company performs the role of providing services very well					
The electricity company is not sincere and genuine					
The electricity company would not keep it's commitments					
The electricity company is truthful in their dealings with me					
The electricity company is interested in my wellbeing, not just their own					
Overall, the electricity company is not a capable and efficient energy provider					

Environmental Attitudes

2. Please answer the following questions regarding your electricity bill:

	Disagree	Neither agree or disagree	Agree
When you received your last bill, you thought it was too high even though you hadn't changed your consumption behaviour			
When you received your last bill, you thought it was too high even though you knew you had increased your consumption behaviour			
When you receive a bill you can't tell how much you spent or how much electricity costs			
You feel your last bill accurately reflects your consumption behaviour			

Environmental Attitudes

5. Page 5

1. Please answer the following questions about sustainability:

	Agree	Disagree	Don't know
Organic produce is worse for the environment	○	○	○
Fuel efficient cars are better for the environment	○	○	○
It consumes more energy to switch an electrical appliance from off to on than to just leave it on	○	○	○
Large home appliances, e.g. washing machines, are rated by energy efficiency	○	○	○
Using a games console to play a DVD uses up to 24 times the electricity than a standard DVD player	○	○	○
Air drying clothes saves significant amounts of energy compared to using a dryer	○	○	○
Driving at 55-60mph gives the best fuel efficiency	○	○	○
People eating less meat is better for the environment	○	○	○
Washing full loads of clothes uses less energy than washing smaller loads less often	○	○	○
You can buy shower heads which reduce the flow of water and therefore reduce energy consumption and waste	○	○	○
Turning off lights when you leave the room saves energy	○	○	○
Energy efficient light bulbs use a quarter of the electricity and last ten times as long as regular bulbs	○	○	○
Boiling water in a pan with a lid off takes 20% less time than boiling with a lid	○	○	○
Sometimes computers consume more energy when they are put to sleep than when they are left on	○	○	○
Using a dishwasher is more energy efficient than hand washing dishes	○	○	○
Washing clothes in a washing machine at higher temperatures uses less energy than washing	○	○	○

Environmental Attitudes

at lower temperatures

Environmental Attitudes

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1. How much do you feel each of the following increases global warming? If you are not sure, please make your best guess.

	Not at all				Very much
Ocean dumping	○	○	○	○	○
Burning fossil fuels	○	○	○	○	○
The space program	○	○	○	○	○
Industrial emissions	○	○	○	○	○
Toxic wastes	○	○	○	○	○
Household energy use	○	○	○	○	○
The hole in the ozone layer	○	○	○	○	○
Deforestation	○	○	○	○	○

2. People reduce their energy consumption for many reasons. Please indicate how important they following reasons are for reducing energy consumption are to you.

	Not at all important	Somewhat important	Important	Very important	Highly important
Concern for the wellbeing of future generations	○	○	○	○	○
Personal cost savings	○	○	○	○	○
Habit	○	○	○	○	○
Concern for the state of the environment	○	○	○	○	○
Status among peers, friends or family	○	○	○	○	○
Cost savings for an employer or the place you live	○	○	○	○	○

Environmental Attitudes

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Many thanks for your interest in our survey!

Appendix B

Goal Validation

Please rate each of these sustainable goals on the scales accompanying them. For each goal, please think about how easy or difficult the goal would be to carry out and how specific or general the goal is.

Please rate how easy or difficult you feel these goals would be to carry out:

Very Easy	Somewhat Easy	Neither difficult nor easy	Somewhat difficult	Very difficult
1	2	3	4	5

Please rate how general or specific you feel these goals are:

Very general	Somewhat general	Neither general nor specific	Somewhat specific	Very specific
1	2	3	4	5

1. Save a percentage of energy consumption or money over time
2. Switch off the TV when not in the room or using it
3. Wash full loads of laundry instead of half loads
4. Don’t use plastic bags at the supermarket, for example, take own cloth bags
5. Recycle your glass/plastic/paper

6. Save the environment

7. Use public transport to get to work

8. Eat lunch at work 1 or 2 times a week

9. Use dishwasher only when full

10. Use energy saving light bulbs

11. Take part in a local environmental organisation

12. Save 5 Euros a month

13. Reduce carbon footprint

14. Turn off lights when not in the room

15. Turn off water when not using it

16. Do more outdoor activities

17. Carpool for work or errands

18. Don't use standby mode on appliances

19. Try not to waste food by cooking too much

20. Take the stairs instead of elevator at work

21. Repair leaky taps quickly

22. Replace old large kitchen appliances with new energy efficient ones

23. Set own goal limits, for example, make your bill cost equivalent to the previous month

24. Collect rainwater or levada water for watering plants or garden

25. Compete with neighbour to be more sustainable

26. Where possible wash laundry at 30 degrees

27. Use hibernate/sleep for computers

28. Turn off lights and take advantage of sunlight

29. Don't heat pool in summer

30. Dry clothes outside instead of using a tumble drier

31. Walk to destinations close by

32. Plant a tree

33. Be vegetarian

Appendix C

Environmental Attitudes Questions

In your opinion, how serious (severe) is global warming?

Not Serious	1	2	3	4	5	Very Serious

I feel my energy consumption is something I.....

Don't need to worry about	1	2	3	4	5	Do need to worry about

I feel worried about the possible effects of global warming

Not at all worried	1	2	3	4	5	Extremely worried

Appendix D

Goal Setting Online Study Screenshot of Goal Choice and Feedback

Scenario 1

Please select three environmental goals that the individuals from this situation could follow in order to save energy. If you mouse over the goals you will be able to see what/how much each one of them allows you to save.

- [ ] Save a percentage of energy consumption or money over time.
- [ ] Switch off appliances or lights when not in the room.
- [ ] Save the environment.
- [ ] Use public transport to get to work.
- [ ] Take part in a local environmental organization.
- [ ] Reduce carbon footprint.
- [ ] Turn off water when not using it.
- [ ] Do more outdoor activities.
- [ ] Replace old large kitchen appliances with new energy efficient ones.
- [ ] Compete with neighbour to be more sustainable.
- [ ] Wash clothes full loads of clothes only and at 30 degrees Celcius where possible.
- [ ] Become vegetarian.

Did you know that:

This would save €12 yearly and 80 kilos of CO_2

Submit Goals

Appendix E

Goal Setting Online Study – Own Goal Self-Report Measures

How often do you perform each of the following energy-saving behaviors when you are in your home? Please select Not Applicable (N/A) if you do not own an item.

	N/A	Rarely or Never	Occasionally	About half the time	Frequently	Almost always or Always
Save a percentage of energy consumption or money over time	0	1	2	3	4	5
Switch off the TV when not in the room or using it	0	1	2	3	4	5
Wash full loads of laundry instead of half loads	0	1	2	3	4	5
Don’t use plastic bags at the supermarket, for example, take own cloth bags	0	1	2	3	4	5
Recycle your glass/plastic/paper	0	1	2	3	4	5
Save the environment	0	1	2	3	4	5
Use public transport to get to work	0	1	2	3	4	5
Eat lunch at work 1 or 2 times a week	0	1	2	3	4	5
Use dishwasher only when full	0	1	2	3	4	5
Use energy saving light bulbs	0	1	2	3	4	5
Take part in a local environmental organisation	0	1	2	3	4	5
Save 5 Euros a month	0	1	2	3	4	5
Reduce carbon footprint	0	1	2	3	4	5
Turn off lights when not in the room	0	1	2	3	4	5
Turn off water when not using it	0	1	2	3	4	5
Do more outdoor activities	0	1	2	3	4	5
Carpool for work or errands	0	1	2	3	4	5
Don’t use standby mode on appliances	0	1	2	3	4	5
Try not to waste food by cooking too much	0	1	2	3	4	5
Take the stairs instead of elevator at work	0	1	2	3	4	5
Repair leaky taps quickly	0	1	2	3	4	5
Replace old large kitchen appliances with new energy efficient ones	0	1	2	3	4	5
Set own goal limits, for example, make your bill cost equivalent to the previous month	0	1	2	3	4	5
Collect rainwater or levada water for watering plants or garden	0	1	2	3	4	5

	N/A	Rarely or Never	Occasionally	About half the time	Frequently	Almost always or Always
Compete with neighbour to be more sustainable	0	1	2	3	4	5
Where possible wash laundry at 30 degrees	0	1	2	3	4	5
Use hibernate/sleep for computers	0	1	2	3	4	5
Turn off lights and take advantage of sunlight	0	1	2	3	4	5
Don’t heat pool in summer	0	1	2	3	4	5
Dry clothes outside instead of tumble drier	0	1	2	3	4	5
Walk to destinations close by	0	1	2	3	4	5
Plant a tree	0	1	2	3	4	5
Be vegetarian	0	1	2	3	4	5

Appendix F

Goal Setting Online Study – NEP, Goal List and Feedback, Own Commitment to Goals Measures and Self-Efficacy Scale

Listed below are statements about the relationship between humans and the environment. For each one, please indicate whether you Strongly Agree, Mildly Agree are Unsure, Mildly Disagree or Strongly Disagree with it.

	Strongly Agree	Mildly Agree	Unsure	Mildly Disagree	Strongly Disagree
We are approaching the limit of the number of people the earth can support					
Humans have the right to modify the natural environment to suit their needs					
When humans interfere with nature it often produces disastrous consequences					
Human ingenuity will insure that we do NOT make the earth unlivable					
Humans are severely abusing the environment					
The earth has plenty of natural resources if we just learn how to develop them					
Plants and animals have as much right as humans to exist					
The balance of nature is strong enough to cope with the impacts					

of modern industrial nations					
Despite our special abilities humans are still subject to the laws of nature					
The so-called ecological crisis facing humankind has been greatly exaggerated					
The earth is like a spaceship with very limited room and resources					
Humans were meant to rule over the rest of nature					
The balance of nature is very delicate and easily upset					
Humans will eventually learn enough about how nature works to be able to control it					
If things continue on their present course, we will soon experience a major ecological catastrophe					

Goals List

Save a percentage of energy consumption or money over time.

Feedback: This could save you for example, 10% from your monthly bill

Switch off appliances or lights when not in the room.

Feedback: This would save €12 yearly and 80 kilos of CO2

Save the environment.

Feedback: Think about future generations, we could have a better living environment for everyone. Save the environment also saves money and energy.

Use public transport to get to work.

Feedback: This could save €104 a year, assuming €10 a week spent on petrol replaced with €2 bus costs a day.

Take part in a local environmental organization.

Feedback: You will get some exercise and fresh air and contribute positively to your community.

Reduce carbon footprint.

Feedback: This would involve a collection of several different types of actions, the result would be better for the planet and our natural resources. There would be a better quality of life for us and for future generations.

Turn off water when not using it.

Feedback: This would save €145 yearly and 11,000 litres of water.

Do more outdoor activities.

Feedback: This would benefit your health, more fresh air and outdoor activities can help prevent diseases and prolong your life. This also contributes to a better quality of life and would use less energy in your home.

Replace old large kitchen appliances with new energy efficient ones.

Feedback: Save money, energy and water, reduce the impact of your day-to-day appliance usage. The initial investment of new appliance will be recovered within 3 years.

Compete with neighbour to be more sustainable.

Feedback: Friendly competition between neighbours can help encourage sustainable behaviour. For example, installing a solar panel, this would give you free power for 20 years after the initial cost.

Wash clothes full loads of clothes only and at 30 degrees Celcius where possible.

Feedback: This could save €13 and 71 kilos of CO2 a year.

Become vegetarian.

Feedback: Being vegetarian is good for your health and for the environment, it will also give you cheaper food bills. It's one of the most effective steps you can take and it can save 1600 kilos of CO2 a year.

End Questionnaire

How often would you be willing to commit to each of the following goals?

Rarely/Never Occasionally About half the time Frequently Almost always/Always

List of same goals as above.

Self Efficacy Scale (Schwarzer & Jerusalem, 1995)

1. I can always manage to solve difficult problems if I try hard enough
2. If someone opposes me, I can find the means and ways to get what I want
3. It is easy for me to stick to my aims and accomplish my goals
4. I am confident that I could deal efficiently with unexpected events
5. Thanks to my resourcefulness, I know how to handle unforeseen situations
6. I can solve most problems if I invest the necessary effort
7. I can remain calm when facing difficulties because I can rely on my coping abilities
8. When I am confronted with a problem, I can usually find several solutions
9. If I am in trouble, I can usually think of a solution
10. I can usually handle whatever comes my way

Scored from 1 = Not at all true, 2 = Hardly true, 3 = Moderately true, 4 = Exactly true

Final page:

If there are any other sustainable activities or goals that you currently do, please list them here:

Appendix G

Indirect Stakeholders – Open Ended Questionnaire

Could you please complete the following sentence: "Sustainability is....."

1. What is the most important aspect of sustainability for you? Why is that?

2. Why is it important for you to teach (your) children about sustainability?

3. How aware do you think your children/children you teach are about sustainability?

4. Could you give examples of how you teach (your) children about sustainability?

5. Can you give us examples of sustainable behaviors that you practice at home/workplace/school?

6. What kind of obstacles do you find when trying to adopt sustainable behaviors?

Appendix H

Avatar Questions – Open Ended

Question 1: Do you have any thoughts about the avatars or the study in general?

Question 2: Did you find the combinations of the avatars and the text to be expressive?

Question 3: Do you think that you would find it just as expressive without the text? Or without the avatar?

Question 4: Did you find any of the avatars/text irritating?