DESIGNING INDIVIDUALISATION OF ECO INFORMATION

VIA A USER CENTRED DESIGN APPROACH

A thesis submitted for the degree of Doctor of Philosophy

By

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DECLARATION

I declare that this thesis was written by myself and the work presented herein is my own. All mentions of other work have been duly cited in the bibliography. I confirm that this work has not been submitted for any other degree or professional qualification.

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ABSTRACT

This thesis stemmed from the likely future scenario that the advancement of technologies will enable new ways for information display in everyday life. Following an initial review of existing research related to sustainable behaviour change and emerging technologies, a focus group study was conducted to explore people's expectations for a ubiquitous eco information device at the point of purchase. It was found that there was a need for eco information provision that resembles eco labelling, but provides information in an interactive manner. This led to the definition of the research aim, which was 'to encourage sustainable individual consumer behaviour at the point of purchase by proposing the design of eco information individualisation'.

A literature review was undertaken to i) identify consumer issues of existing eco labelling practice and opportunities for improvement; ii) investigate the state-of-the-art of the development of various eco information solutions; and iii) explore the opportunities for eco information provision enabled by various contextual technologies. The literature revealed that nowadays consumers are facing difficulties in perceiving and understanding eco labels, and a number of the issues can potentially be tackled using a design approach.

This thesis proposed the first conceptual framework of eco information individualisation for designers. 'Eco information individualisation' is a concept of tailoring eco labels according to the specific needs of individual users using contextual technologies. With technologies embedded on the product and the user, both of them can act as data carriers and have a traceable record (a 'life history'). Information can be exchanged ubiquitously. An enabled product can be intelligent enough to appeal to a user with particular preferences.

A second focus group study was conducted to evaluate the framework. A card sorting study was carried out to understand user's perception towards information conveyed on existing eco labels to inform the refinement of the framework. A design tool was developed to support designers in the designing of eco information individualisation. The tool was applied and evaluated in a design workshop. A mobile app prototype was then built based on a design output generated from the workshop.

Findings from these studies have provided a greater understanding of designing for eco information individualisation, in particular through the creation of the framework, the design tool and the app, as well as the identification of user requirements for eco information design.

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PUBLICATIONS ARISING FROM THIS PHD

Journal paper

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Conference papers

Kwok, S. Y., Harrison, D., & Qin, S. (2013). Design for Sustainable Behaviour : Proposing a New Eco-feedback Device Based on Augmented Reality Technology. *In Sustainable Innovation 2013: Towards Sustainable Product Design 18th International Conference* (pp. 118–130). Epsom: University for the Creative Arts.

Kwok, S. Y., Harrison, D., & Qin, S. (2014). Designing an Individualised Eco Information System: a Conceptual Framework. *In 19th DMI: Academic Design Management Conference: Design Management in an Era of Disruption*. London.

Kwok, S. Y., & Harrison, D. (2015). Design of Individualized Eco Labels Using Social Media. *Proceedings of the 17th International Conference on Human-Computer Interaction with Mobile Devices and Services Adjunct, 1050–1053*. doi:10.1145/2786567.2794328

Kwok, S. Y., Skatova, A., Shipp, V., & Crabtree, A. (2015). The Ethical Challenges of Experience Sampling Using Wearable Cameras. *Proceedings of the 17th International Conference on Human-Computer Interaction with Mobile Devices and Services Adjunct, 1054–1057*. doi:10.1145/2786567.2794325

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Chapter 1
Introduction

1.1. BACKGROUND TO THE RESEARCH

Sustainable design is a field of research that tackles the environmental, economic and social impacts incurred throughout a product's life cycle. Much of the existing works have focused on reducing the impacts associated with the earlier stages of a product's life, such as ore extraction, material processing, manufacturing, packaging and distribution, partly because a very different challenge is posed by the later stages of a product's life (i.e. 'product use' and 'end-of-life'). Instead of mass producers, these impacts from these later stages are more closely related to consumers – the many different individuals who make different personal choices about different things.

What products do they buy? How do they use the products? How do they dispose them? The collective effects of these consumer behaviours are responsible for a significant portion of society's impact on the environment. Not only their consumption has direct environmental impacts, their purchasing choice also has indirect influences on the environment through affecting manufacturers and firms providing commodities and services. However it has been very difficult to keep track of the happenings to a product after it leaves the factory, causing the difficulty in working towards optimised consumption patterns.

Amongst the existing practices of environmental regulation, eco labelling is one of the most pertinent tools that address consumer behaviour directly. But numerous studies indicate that existing eco labels fail, at least partly, to provide sufficient information and to communicate with consumers effectively (Hartikainen, Roininen, Katajajuuri, & Pulkkinen, 2013; Upham, Dendler, & Bleda, 2011; van Amstel, Driessen, & Glasbergen, 2008).

Nevertheless, it is believed new opportunities in encouraging sustainable consumer behaviour have been unlocked by the theoretical and technological developments of various

research disciplines. This research project was initiated by the following beliefs, for which the literature was found to provide some support:

- By adopting the theories, strategies and methods suggested by research fields such as user centred design, design for behaviour change and environmental psychology, new tools can be developed to cope with the environmental consequences associated with individual behaviours; there exists much potential for improving the design of eco information provision.
- With the advancement of technology, it is becoming easier to keep track of consumer's behaviour and to understand their preferences. The aid of various technologies has made it possible to create product labels that appeal to consumers by adapting to their specific needs, hence providing an opportunity to promote sustainable behaviour.

1.2. THE AIM OF THIS RESEARCH

This research project first began with a *preliminary aim*:

To encourage sustainable individual consumer behaviour at the point of purchase by developing a new ubiquitous eco information device that utilises the power of emerging technologies and knowledge of design intervention strategies

The *preliminary aim* led to an investigation into the various design intervention strategies to encourage individual sustainable behaviour via a review of literature, survey of existing related tools and an exploratory study (DS1). It was found that there was a user need for eco information provision that resembles to eco labelling, but in an interative and ubiquitous manner. The findings of this research clarification stage led to the decision to focus on the opportunities in designing eco information individualisation for consumers. *Eco information individualisation* is a proposed concept of tailoring eco labels according to the specific needs and the contexts faced by an individual user. With technologies embedded on the user and the product, both of them can act as data carriers and have a traceable record (a 'life history'). They can exchange digital information ubiquitously, so an enabled product can be intellligent enough to appeal to the particular preferences of a user.

The *aim* of the research project then became:

To encourage sustainable individual consumer behaviour at the point of purchase by proposing the designing of eco information individualisation

This resulted in the following *overarching research question:*

How can we encourage sustainable individual consumer behaviour by providing individualised eco information at the point of purchase?

The research question was then divided into three more *detailed research questions:*

Q1. What are the user requirements for eco information design?

Q2 How to design eco information individualisation to support sustainable consumer behaviour?

Q3. How feasible is it to use a tool to support the design of eco information individualisation?

The three research questions have been addressed through a series of studies, as denoted in Figure 1.1. Here boxes of different colours are used to indicate the research stages which the studies belong to. The four colours - namely brown, red, green and blue – correspond to the four stages specified in the *Design Research Methodology (DRM)*. More details about this are provided in Section 3.4.

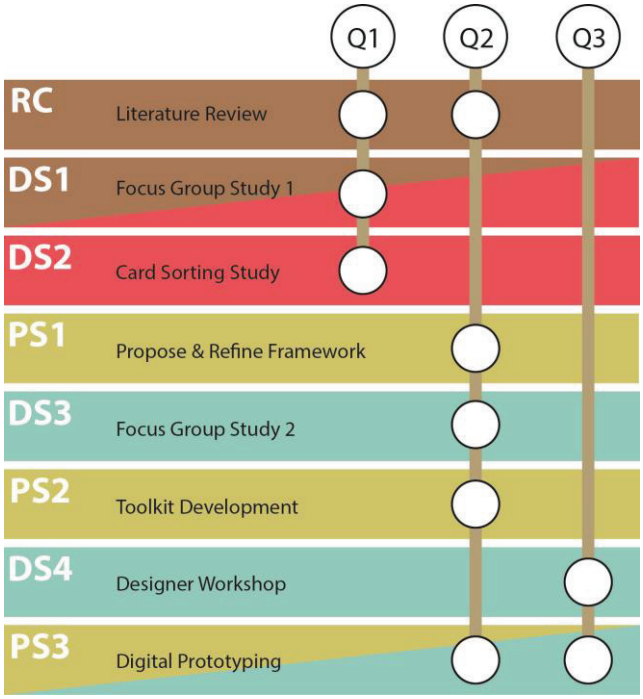


Figure 1.1 Research questions against DRM stages

The focus of this thesis is on the individualistion of eco information and its potential impact on individual consumer behaviour. Nevertheless this does not necessarily restrict the findings in this work to this usage domain. The findings might well have larger and more general applications, in fields such as marketing and education.

1.3. CONTRIBUTIONS

This thesis makes four key contributions to the field of design research. This thesis proposes the first conceptual framework on individualised eco information system using a design approach. A design tool has been created to facilitate the communication of the concept of eco information individualisation to designers. Through a series of empirical studies aiming to inform the design of the framework and the tool, a deeper understanding of user's needs for eco information at the point of purchase and of user's perception of existing eco labels has been gained. A working digital prototype of eco information individualisation has been developed as a result of these studies.

1.4. OVERVIEW OF THE THESIS

This thesis consists of a further nine chapters:

Chapter 2: Literature review

This chapter covers the background of this multi-disciplinary project that involved the review of literature from a number of fields. The review of literature was a continuous process that happened throughout the time of this PhD. It can roughly be divided into three parts.

Part 1 of the literative review was conducted to gain an understanding of eco labelling, in particular its background, the effectiveness and issues of existing practice, and the opportunities for improving the design of eco labels. A reference model linking all identified influencing factors is provided in Figure 2.13 to summarise the findings of this part.

Part 2 discusses the approaches taken by researchers from disciplines such as design for sustainable behaviour (DfSB) and human computer interaction (HCI), and then presents the state-of-the-art of the development of various eco-feedback/ eco information solutions. Because of a lack of detailed studies on the features of the latest eco-feedback/ eco-information applications, three surveys were undertaken by the author of this thesis to

review web-based eco-calculators, mobile app eco-calculators and eco labels available on the market.

Part 3 examines the opportunities enabled by various contextual technologies in providing eco information to consumers with consideration of the contextual data of the user and the product. This part was carried out after the exploratory focus group study (DS1). Together with the findings from the focus groups, this part helped clarify the research direction and the definition of the research questions.

Chapter 3: Research methodology

This chapter examines research paradigms, relevant theoretical perspectives, research approaches, methodologies and methods, and the rationale of selecting the adopted research approaches and methods. The *Design Research Methodology (DRM)* was adopted to guide the research activities of this project, as illustrated in Figure 3.9. Four descriptive studies and three prescriptive studies were carried out.

Chapter 4: Exploring the needs for a ubiquitous eco information device

This chapter describes a focus group study (DS1) that explored the opportunities provided by technologies in encouraging sustainable purchasing behaviour. The study aimed to investigate people's views on ubiquitous eco information provision and to understand their needs and expectations of such a device. Three outcomes were derived from the focus group discussions.

Firstly, people's views on a ubiquitous eco feedback device with an augmented reality display were canvased. Generally the participants accepted the envisaged device on conditions, such as their privacy and autonomy had to be protected, amongst other concerns. Secondly, the participants generated ideas and drawings about the device functions they preferred, which could be summarised into three working modes and two functions. The ubiquitous eco information provision device that the participants envisaged resembled a ubiquitous eco labelling system. They also gave insights about the contents and the formats of the eco information to be displayed. Thirdly, the participants discussed the potential of changing behaviour with the envisaged device, and the answer was positive. In some circumstances, people would welcome eco information provision at the point of sale.

Chapter 5: Proposing the concept of eco information individualisation

This chapter builds upon the insights gained from the previous chapters and proposes the conceptual framework of eco information individualisation to guide future designs of a novel

contextual individualised eco information system. Eco information individualisation is a concept that sees both user and product as data carriers and tailors eco labels according to the specific needs of individual users using contextual technologies. Two example scenarios of application are provided to exemplify the idea.

This chapter also reports on another focus group study (DS3) that aimed to evaluate the value of the conceptual framework. The designers who took part in the focus groups expressed positive comments about the conceptual framework as a support tool for designers in designing such kind of system, and discussed the role of user centred design in designing eco information individualisation.

Chapter 6: Understanding user's perception of existing eco labels

This chapter uncovers how users make sense of existing eco labels through a card sorting study (DS2). The study aimed to understand how people categorise, perceive and think about existing eco labels. Three conclusions were drawn from the results. The first conclusion was a user-centred organisational scheme for categorising eco information, derived from the results triangulated by an exploratory analysis and a clustering analysis. The second conclusion was that there exists more than one 'appropriate' classification scheme (or a 'single best fit'). The third conclusion was an understanding about how people perceive and understand eco labels.

Chapter 7: Framework refinement & development of the design tool

This chapter pairs with Chapter 5 to form the proposal of eco information individualisation (PS1). While Chapter 5 has generated the initial conceptual framework, this chapter refines the framework by providing more detailed information on the contexts of personal data and product data. Based on the user context model proposed by Kofod-Petersen & Aamodt (2003), this chapter renders a new user context model for eco information individualisation (Figure 7.2). And a classification scheme of eco information is proposed based on the findings from the card sorting study (DS2).

Driven by these refinements and a further review of literature, the 'Eco information individualisation design tool' was developed (PS2) with the aim to support designers in the designing of individualised eco information. The tool consists of a short guidebook and 25 cards that provide structured information on user context, product context and technologies in relation to eco information individualisation.

Chapter 8: Design workshop day: design tool evaluation

The design tool was applied in a design workshop (DS4) that also served as an evaluation of the tool. The participating designers generated a range of individualised eco label designs without and with the aid of the design tool, and were asked to answer a questionnaire related to the usability and usefulness of the tool and their workshop experience.

This chapter reports on the results collected from the workshop, and discussed how the research questions were answered positively: i) With the aid of the design tool, It is possible for designers to learn the idea of eco information individualisation in a short time; ii) The design outputs from the workshop were principally feasible; iii) Positive responses were received with regard to the usefulness and usability of the tool, areas for improvement were identified.

Chapter 9: Digital prototyping

The focus of this chapter is the development of a working digital prototype (PS3). One of the design outputs from the workshop was developed into a smartphone application that demonstrated the basic features of eco information individualisation. Three goals were achieved. The generative process of prototyping has: i) provided a preliminary gauge of the technological feasibility of eco information individualisation; ii) helped communicate the concept of designing eco information individualisation; and iii) resulted in a working prototype that can be used for testing.

Chapter 10: Conclusion

This chapter reviews the outcomes of this research and discusses how the research questions set out previously are answered. Contributions to knowledge are stated in relation to the findings. The chapter also reflects upon the research limitations and recommends areas for future research.

Chapter 2
Literature review

2.1. INTRODUCTION

This chapter reviews a wide scope of literature to form the basis for this research inquiry. Figure 2.1 shows the scope of the literature reviewed. Four broad topics are covered in the following sections:

- **Section 2.2**: Impact of individuals on sustainable consumption;
- **Section 2.3**: Eco labelling and how it is related to consumer behaviour;
- **Section 2.4**: The state-of-the-art of a range of eco information/ eco feedback tools;
- **Section 2.5**: The opportunities for eco labelling enabled by emerging technologies.

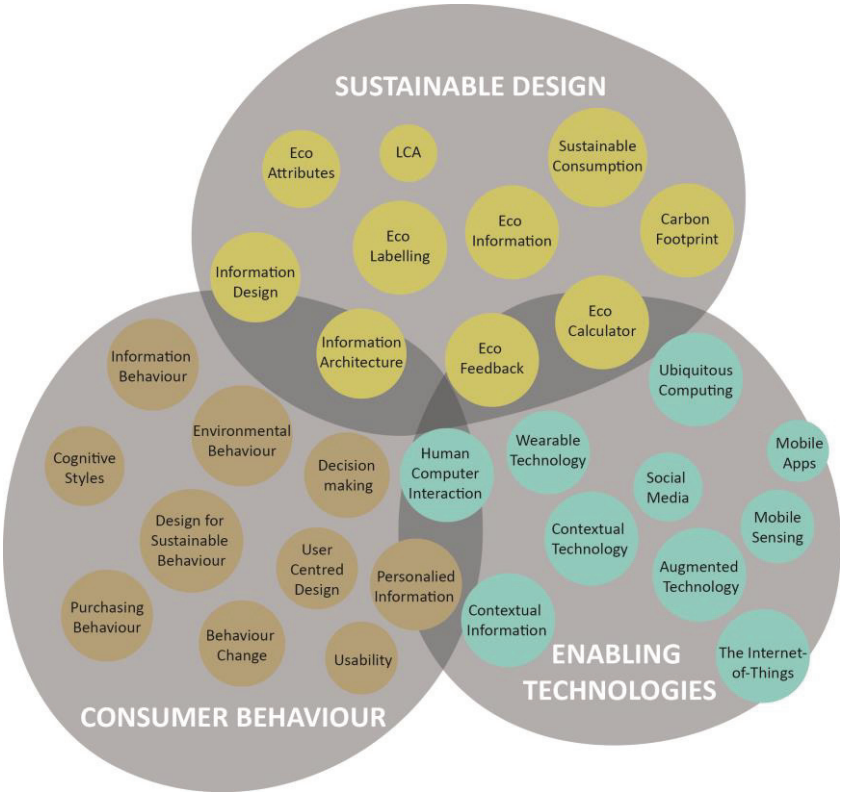


Figure 2.1 Scope of literature review

2.2. IMPACT OF INDIVIDUALS ON SUSTAINABLE CONSUMPTION

2.2.1. Sustainable consumption

Many environmental problems, including global warming, urban air pollution, water shortages and loss of biodiversity, are rooted in human behaviour. Changes in human behaviour are believed to be needed to reduce environmental impacts, for technical efficiency gains tend to be overtaken by consumption growth (Steg & Vlek, 2009).

The collective effects of individual consumers are significant for a shift toward more sustainable consumption patterns. Not only does their consumption behaviour have direct environmental impacts, their purchasing choice also has indirect influences on the environment through affecting manufacturers and companies providing commodities and services (Han & Hansen, 2012; OECD, 1997).

2.2.2. Provision of information as a tool for sustainable consumption

Alongside other traditional means of environmental regulation, such as permits, mandatory standards, taxes and subsidies, and voluntary agreements, provision of information on the environmental effects of consumption is often put forward as an appealing tool to increase consumer attention toward environmental risks associated with consumption (Bjørner, Hansen, & Russell, 2004; Cohen & Vandenbergh, 2012; Tanneurs & Vezzoli, 2008; Thøgersen, 2002). A product label is an information tool which is arguably one of the most prominent measures to facilitate sustainable consumption and production (Baddeley, Cheng, & Wolfe, 2011; Dendler, 2014; Koos, 2011).

2.3. ECO LABELLING

2.3.1. Definition of eco-labelling

Eco-labelling is defined as a practice providing information to consumers about a product with improved environmental performance and efficiency. An 'eco-label' is a label which "identifies overall, proven environmental preference of a product or service within a specific product/service category based on life cycle considerations". In contrast to a self-styled environmental symbol or claim statement developed by a manufacturer or service provider, an eco-label is awarded by an impartial third party to products that meet established environmental leadership criteria (Global Ecolabelling Network, 2004, 2013).

The International Organization for Standardisation (ISO) has identified three broad types of voluntary labels: the type I label that includes multi-criteria third-party programmes intended for end consumers, type II that includes self-declared environmental claims, and type III that provides quantified unweighted environmental data in environmental product declarations. The type III includes, e.g. declarations on resource and energy consumption based on standardised Life Cycle Assessments and are primarily intended for business-to-business information (British Standards Institution, 2006). Eco-labelling fits under the type I designation (Bratt, Hallstedt, Robèrt, Broman, & Oldmark, 2011; Global Ecolabelling Network, 2013). The hope is that consumers will then be able to distinguish these products from others, and consumers' choices will give producers of relatively environmental-friendly products a competitive advantage, while discouraging less environmental-friendly products and also to give companies an incentive to develop new products that are more friendly to the environment, thereby stimulating the potential for market-driven continuous environmental improvement (Basu, Chau, & Grote, 2003; Boström & Klintman, 2011; Global Ecolabelling Network, 2013; Thøgersen, 2002). It is also hoped that eco-labelling will help increase consumer attention toward, and knowledge about, the environmental risks associated with consumption (Thøgersen, 2002).

2.3.2. Brief history and development of eco labelling

Environmental eco-labelling programmes have a history of 30 years, starting with the German Blue Angel launched in 1978. Ten years later a proliferation of eco-labelling programmes started. Nowadays eco-labelling programmes exist in large numbers and many forms at national, European and international levels (Basu et al., 2003; Bratt et al., 2011; Thøgersen, 2000). Currently there are more than 400 different eco-labels or certification schemes in 207 countries(Cohen & Vandenbergh, 2012; Ottman, 2011, p. 165); 13 eco-label schemes exist in Europe covering some 240 product groups, including electrical/electronic, cleaning products, paper products, garden and household product, textiles, items used in offices, services and tourism (Dolley, Oldman, & Poll, 2003). They are typically voluntary and range from government-sponsored, e.g. German Blue Angel, to private systems, e.g. Green Seal in the U.S. (Cason & Gangadharan, 2002). For example, in 1992, Denmark had 400 to 600 private labels, in addition to 36 labeling schemes issued by public authorities. In 1996, 63% of the packaged goods in the major supermarkets in Oslo exhibited environmental claims. Among those only a minority of 8% of the goods carried a third-party environmental label (Thøgersen, 2002).

2.3.3. Effectiveness of eco labelling

2.3.3.1. Measuring effectiveness of eco labelling is complicated

Measuring the effectiveness of eco-labelling can be very complicated. In a narrow sense, it is reflected in the reduction in pollution and resource use that can be attributed to the labelling. To calculate its efficiency, the costs of using this measure ought to be included. A full picture of eco-labelling's success also includes positive and negative effects on consumer/citizens' perceptions about, attentiveness toward, and readiness to act to solve environmental problems (OECD, 1997; Thøgersen, 2002).

Lynch (1994) separates the effectiveness of environmental labelling into three related concepts: "i) *concrete effectiveness*, the extent to which a program actually reduces environmental impacts or improves environmental quality; ii) *behavioural effectiveness*, the degree to which consumer and manufacturer activities (e.g., market shift) are influenced by a labelling program; and iii) *potential effectiveness,* those aspects of labelling that affect consumer awareness and attitudes, which are often (but not necessarily) related to changes in actual behaviour".

Global Ecolabelling Network (2004) identify three indicators which efforts to measure the effectiveness of ecolabelling programs have generally focused on, namely i) improvement in environmental quality of certified products, ii) industry participation, and iii) consumer recognition and demand.

While these concepts help to delineate the situation, complications remain both in a narrow and in a wider sense, since it is difficult to isolate and measure the benefits of eco-labelling as distinct from benefits achieved via other economic, environmental and social policies, notably environmental education and information about the labels (Global Ecolabelling Network, 2004; Morris, 1997; OECD, 1997; Thøgersen, 2002). Morris (1997) even declares that "there is no way of measuring the impact of an eco-label on the environment", and "the impact of each product on environmental quality would be contingent on so many factors that it would not be possible to know which product had the lowest impact". It basically implies measuring *concrete effectiveness* is extremely impractical, if not impossible.

2.3.3.2. Efforts in measuring effectiveness are incomplete

With a majority of national eco labelling programs having only been established in 1990's, efforts to measure effectiveness are incomplete. Environmental effectiveness has mostly been evaluated indirectly on the basis of consumers' awareness, knowledge or trust in labels,

and consumer demand for labelled products. These studies implicitly or explicitly assume these factors are fundamental prerequisites for the use of a label in decision making, in other words they focus on measuring the '*potential effectiveness'.* Another commonly seen assessment method is to measure the changes in producer behaviour (a kind of *behavioural effectiveness*). (Cohen & Vandenbergh, 2012; Global Ecolabelling Network, 2004; Lynch, 1994; OECD, 1997; Thøgersen, 2000).

A good deal of survey evidence show that consumer awareness regarding eco-labelled products has grown substantially. Awareness of national eco-labels had increased by more than 50% only a few years after their introduction. Survey evidences indicate that consumers readily express a willingness to incorporate environmental information into consumption decisions, and accept higher prices for environmentally friendlier products (Basu et al., 2003; Bjørner et al., 2004; Cohen & Vandenbergh, 2012; Loureiro & Lotade, 2005; O'Brien & Teisl, 2004; Shams, 1995). A survey study on green shopping (buying organic food) suggests that consumers start to buy green products for unselfish reasons, i.e. the common good (Thøgersen, 2011). Nevertheless, evidence also suggests 'what people say may differ substantially from what they actually do', as shown by a survey on 'food miles' concept and consumer buying behaviour in UK supermarkets (Kemp, Insch, Holdsworth, & Knight, 2010; Morris, 1997).

In terms of *behavioural* effectiveness, most evidence on the effectiveness of an environmental label and its actual effects on consumers' behaviour is, however, anecdotal and does not satisfy the standards of rigorous empirical research since these studies lack random assignment or quasi-experimental designs. The causal relationship between eco labels and environmental outcomes cannot be established from these studies (Bjørner et al., 2004; Cohen & Vandenbergh, 2012; OECD, 1997).

Only few eco-labelling schemes have been sufficiently thoroughly evaluated to be able to draw conclusions about their success (Thøgersen, 2002). Results from five empirical studies on the effect of environmental labels and product characteristics are summarised in Table 2.1 (Bjørner et al., 2004).

These evidences suggest that, under the right conditions, eco-labelling can lead to a substantial reduction in pollution and resource use (Thøgersen, 2002). It appears to be a general view that the market pressure created by ''green'' consumers and investors provides reasons for optimism (Bjørner et al., 2004; Tan, Tan, & Khoo, 2012).

Table 2.1 Five empirical studies on the effect of environmental labels and product charcteristics (Bjørner et al., 2004)

Reference	Method/ data	Market	Type of label or environmental characteristic	Did label have an effect?
(Henion & Henion, 1972)	Real market experiment in four stores	Detergents	Content of phosphate	Yes
(M. Teisl, Roe, & Hicks, 2002)	Real market behavior using aggregate monthly time series data (using an 'almost ideal demand system')	Canned seafood and substitute meat products	Dolphin-safe label	Yes
(Blarney & Bennett, 2001) (Bennett & Blamey, 2001)	Real market behavior in discrete choice models (also combined with stated preference data)	Toilet paper	Unbleached Recycled	No Yes
(Nimon & Beghin, 1999)	Hedonic regression using catalog prices	Apparels	Environmentally friendly dyes Organic cotton	No Yes
(Roe, Teisl, Levy, & Russell, 2001) (Mario F. Teisl, Roe, & Levy, 1999)	Hypothetical market (validated with hedonic regression based on electricity prices)	Electricity	Certified green electricity	Yes

2.3.4. Carbon label: a representative example of eco label

A significant and growing proportion of the environmental claims and eco labelling are now focusing on carbon emissions and climate change, which is considered to be one of the most pressing problems of our time (Abrahamse, Steg, Vlek, & Rothengatter, 2007; Baddeley et al., 2011; Bristow, Wardman, Zanni, & Chintakayala, 2010; Cohen & Vandenbergh, 2012).

Carbon labelling schemes have been introduced to inform the consumers about a product's carbon footprint throughout its entire life cycle. They generally indicate the amount of greenhouse gas emission associated with the product from its production and processing stage, through transportation, intended usage and disposal, aiming to help consumers to make informed choices about which products to purchase and how to use them, thereby filling the climate-policy gap by influencing the behaviour of consumers and corporate supply chains (Baddeley et al., 2011; M. Vandenbergh, Dietz, & Stern, 2011). Pilot programs are being implemented in countries such as United Kingdom, Switzerland, the Netherlands, and Japan. As of 2009, there are 34 carbon footprinting schemes worldwide (Baddeley et al., 2011). Carbon labelling is in its infancy as companies, third-party

certification organizations, and government agencies experiment with methodology and label design. There is an emerging global standardised protocol for estimating the life-cycle carbon footprint of products, yet no such standardised approach to labelling has emerged. (Cohen & Vandenbergh, 2012; Tan et al., 2012; M. Vandenbergh et al., 2011).

Carbon labelling, a member of the eco-labelling family, shares similar difficulty and complexity in measuring effectiveness. The empirical evidence on the potential impact of carbon labelling is sparse (Baddeley et al., 2011). Results of a study on Finnish consumers' perceptions of carbon labelling of food products showed that the general attitudes towards carbon labels were positive. 90% of respondents in the study held the belief that the information on a product's carbon footprint would have at least a small impact on their food choice purchases, although due to several factors carbon labels do not have a strong impact on buying decisions (Hartikainen et al., 2013).

More can be learnt from our experience with similar product labels. There is sufficient evidence that consumer purchase decisions (whether directly or indirectly through retailer actions) will respond (at the margin) to credible claims that certain products have better environmental qualities than others. Cohen & Vandenbergh (2012) have reviewed numerous industry case studies such as U.S. Energy Star label, 'dolphin-safe tuna' label (M. Teisl et al., 2002) and the Nordic Swan eco label (Bjørner et al., 2004) to demonstrate the potential for consumer labels to have a significant effect on products sold in the market.

Vandenbergh et al. (2011) point out a more potent incentive than the immediate impacts of consumer choices, which is to spur changes in supply chain by identifying potential savings in production costs while developing the data to underpin carbon labelling.

However the question remains whether carbon labelling can be expected to bring about any meaningful reduction in emissions. As Sharp & Wheeler (2013) point out, even though carbon labels have been forecast as only having a modest impact in product choice, given the sheer volume of products that are purchased, even a small behavioural change can be significant if it is undertaken by a large population. Since the opportunity costs for a labelling system is remarkably small, it is appropriate to seek a portfolio of measures in the hope that a combination will enable us to avoid crossing important thresholds (Baddeley et al., 2011; M. Vandenbergh et al., 2011).

2.3.5. Issues and concerns related to eco labelling

Bostrom & Klintman (2011, p. 145) describe typical actors that potentially can be involved in labelling, as shown in Figure 2.2.

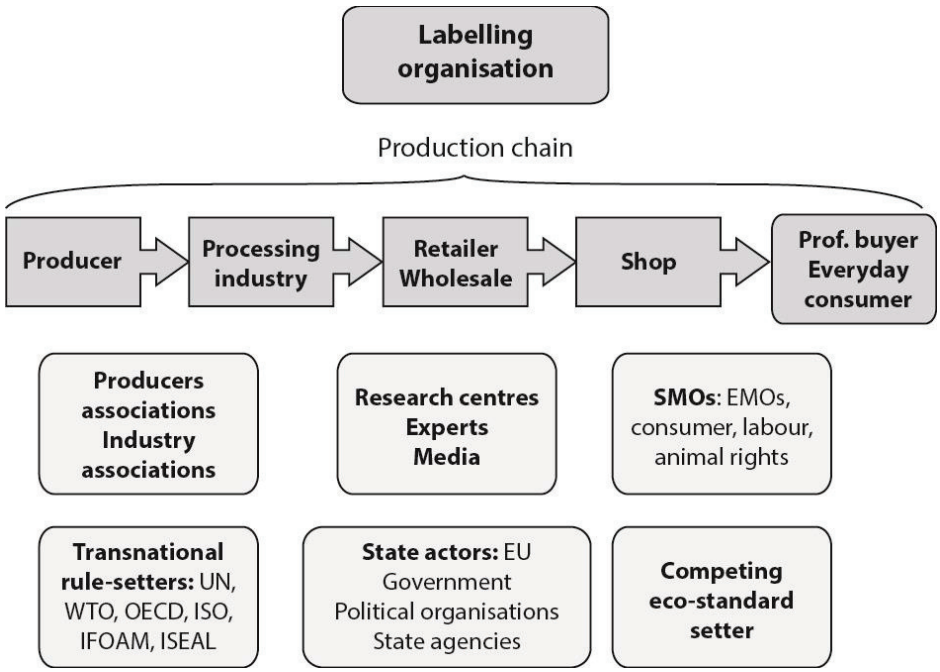


Figure 2.2 Actors involved in labelling (Boström & Klintman, 2011, p. 145)

While various environmental claims and eco labelling have emerged in the marketplace (e.g. recyclable, eco-friendly, low energy, recycled content, etc.), they have also led to some confusion, concerns and scepticism on different levels. The most widely articulated concerns can be broadly divided into three areas, namely trade issues, credibility issues and consumer issues. Although multiple stakeholders are usually involved, some concerns are particularly relevant to specific major actors, as summarised in Table 2.2. Trade issues and credibility issues are not the major focus of this thesis, but a brief summary of these issues is given below, followed by a detailed description of various consumer issues.

Table 2.2 Summary of concerns related to eco labelling and carbon labelling

Area	Concerns	Most involved actor(s)
Trade issues	Leakage effect outside any labelling scheme	State actors, producers
	International trade treaties serve as barrier to carbon labelling system	Transnational rule setters, producers
	Supply of information	Producers, third parties organisations

Credibility issues	Label certification and verification	Producers, third parties organisations
	Methodological challenges in implementation of carbon labelling	Research centres, third parties organisations
Consumer issues	Psychological factors: i. Attitude: motivation and purchase intention Norm: 'bandwagon' effect and the 'snob' effect Perception: ability of the consumer i) Understanding: issue-relevant knowledge & comprehension ii) Awareness: recognition of labels iii) Attention Trust: confidence in green claims Habit: repeat purchase Practical problems: Information asymmetry Information overload: cost of information search and processing Others: Rebound effect: continued consumerism	Consumers

2.3.5.1. Trade issues

Trade issues include the i) leakage effect, ii) international trade treaties serve as barrier to carbon labelling system and iii) the supply of information.

Leakage effect refers to the unclear implication of climate legislation due to production relocation to countries with less stringent requirements. Policymakers are worried that requiring carbon emission reductions in their home country will shift production to other countries with less stringent requirements. Not only it might reduce the impact of the climate legislation, theoretically it is possible to cause even more severe emissions because the production technologies employed in the new production sites may be dirtier than existing pre-regulated processes in the home country. Carbon labels may help alleviate some of the leakage concerns arise with other carbon emissions regulatory schemes, in both cases with and without a global standard for carbon labelling (Cohen & Vandenbergh, 2012; Wiedmann et al., 2008).

Depending on how the issues are framed in the broader policy context, carbon labelling can be viewed as promoting the freedom of individuals in the consuming (usually developed) country to have access to information which will enable them to express relative preferences for less carbon-intensive consumption, or be framed in policy debates as discouraging free trade, economic opportunity and the 'sovereignty of the producing (often

developing) country'. Two of the World Trade Organisation (WTO) international trade treaties, the General Agreement on Tariffs and Trade (GATT) and the Agreement on Technical Barriers to Trade (TBT Agreement), may serve as barriers to carbon labelling systems (Baddeley et al., 2011; Cohen & Vandenbergh, 2012; M. P. Vandenbergh & Cohen, 2010).

It is complicated and costly to supply reliable information about the product's environmental impacts (Baddeley et al., 2011). The incentives for companies in doing this remain a question. It is generally agree that the major incentive of disclosing this information is the benefits, such as sales increase, brought to companies by claims about their products' credence attributes (Ippolito & Mathios, 1990).

2.3.5.2. Credibility issues

Credibility issues include i) label certification and verification and ii) methodological challenges in implementation of carbon labelling.

Credible certification and monitoring of eco labels, particularly carbon label, is essential in the development of a meaningful labelling market. Third-party organisations are believed to be beneficial for preventing fraudulent claims or 'greenwashing', in order to increase legitimacy, credibility and acceptance of labels (Baddeley et al., 2011; Bhardwaj, 2012; Brazil, Caulfield, & Rieser-Schüssler, 2013; Cason & Gangadharan, 2002; Cohen & Vandenbergh, 2012; Koos, 2011; Thøgersen, 2000, 2011; M. Vandenbergh et al., 2011). Two important life cycle protocols are developed using standardised carbon footprint methodologies and a multistakeholder approach, which are the Publically Available Standard (PAS) 2050 introduced by the British Standards Institute in 2008 (Baddeley et al., 2011) and the Greenhouse Gas Protocol's (2011) Product Life Cycle Accounting and Reporting Standard. In 2013, the International Organization for Standardization (ISO) has developed a carbon-labelling standard, ISO 14067 (British Standards Institution, 2013). Besides, governments (e.g. France, UK and Germany), businesses (e.g. Walmart) and non-governmental organisations (e.g. WWF) are trying to condense existing product labels through implementation of some form of 'meta' scheme (Dendler, 2014).

At a practical level, numerous intractable problems are associated with the implementation of a reliable, standardised eco labelling scheme (Dendler, 2014; Gaussin et al., 2013; Morris, 1997). Amongst various eco labelling programs, carbon labelling program has the most established theoretical foundation. There already exist comprehensive standards (British Standards Institution, 2013; Greenhouse Gas Protocol, 2011) to guide

transparent life-cycle measures for products. Even so, they are not detailed enough to provide aggregation rules or sector-specific assumptions (Cohen & Vandenbergh, 2012). More works have to be done to standardise carbon footprint calculation and to develop consistent, reliable and comparable carbon labels (Cohen & Vandenbergh, 2012; Gaussin et al., 2013; Tan et al., 2012). The large number of assumptions and compromises involved in measuring and verifying the carbon emissions of a product's life cycle still poses significant methodological challenges to implementing a reliable carbon labelling program (Cohen & Vandenbergh, 2012).

For example, two identical products might have different manufacturing carbon footprints if they are manufactured at different facilities, or are transported to their destination via different paths, or are used/ disposed in different ways by the consumer. Koning et al. (2009) clearly demonstrate this idea by examining the uncertainties in the estimated carbon footprints of a liquid and a compact powder detergent.

Cohen & Vandenbergh (2012) used the example of an all-electric vehicle to illustrate the discrepancies which arise between the carbon footprint label and the emission realised by one consumer, the actual emission depends on what kind of fuel mix is used. The various possible solutions envisioned in their paper are thought provoking:

- 'do nothing (i.e. maintain one carbon footprint label);
- prepare different labels depending on the local source of electricity;
- develop a more complex label that provides multiple values that depend on the local source of electricity;
- or determine that the high degree of variability and lack of clear superiority among products are such that carbon labels for this product category should not be a priority.'

These ideas are very interesting and provide an initial step towards the the approach of eco label individualisation.

2.3.5.3. Consumer issues

Regarding the possible reasons behind the limited market penetration of eco labelling schemes, this section has loosely categorised a list of consumer concerns into two groups, psychological factors and practical problems. Some of these concepts correlate closely with the trade issues and credibility issues mentioned above. Some psychological factors and practical problems listed here are actually two sides of the same coin.

The psychological factors related to consumer behaviour on eco labelling are attitude, norm, perception, trust and habit. The practical problems identified with consumer behaviour are information asymmetry, information overload and the costs of search.

i) ***Attitude: motivation and purchase intention***

It is generally agreed that consumers welcome informative product labelling. It is found that 64% - 91% of consumers in Denmark, Norway, Sweden, and Finland agreed that eco labels are needed. A positive attitude toward eco labels depends on whether the consumer believes he or she can help attain a valued goal. A large majority of consumers are motivated to pay attention to eco-labels when they shop, at least sometimes (Leire & Thidell, 2005; Thøgersen, 2002).

Early adopters of a new eco label mostly employ a high effort adoption process, which builds on both motivation (intention to buy sustainable product) and ability (issue-relevant knowledge). Strong motivation of the consumers means they will search for more if they need it (Thøgersen, Haugaard, & Olesen, 2010).

Bjørner et al. (2004) differentiate various types of information provision programs and the corresponding user motivation. Hazard warning labels, such as those on cigarettes, concern users who want to protect themselves or people around him. The second type of label provides information on wider, more diffuse environmental effects on which the consumer's individual behaviour can only have a tiny, perhaps unobservable, impact (Koos, 2011). The third type of label mentioned is the 'ethical' label, such as those related to animal welfare (e.g. the US dolphin-safe tuna label) or 'fair trade' label with developing countries. The degree of consumer motivation varies depending on how these distinct types of information relate to the consumer's personal relevance and personal values (Noel, 2008, p. 90). It is also suggested that attitudes influence which information about a product a consumer pays attention to (Thøgersen, 2002).

ii) ***Norm: 'bandwagon' effect and the 'snob' effect***

Cohen & Vandenbergh (2012) suggest it is possible that the trend of sustainable consumption and carbon neutrality may be associated with the 'snob' effect and the 'bandwagon' effect.

Economists have long recognised that consumer demand for products might be driven by the 'status' associated with consumption. The 'bandwagon' effect is based on the desire to be associated with a certain social group, possibly fashionable or stylish. The 'snob'

effect is the opposite, the desire to be different from the masses. Depending upon the nature of the social norms in a society at a particular time, a low carbon footprint lifestyle might be desirable for either reason (Cohen & Vandenbergh, 2012).

iii) ***Perception: ability of the consumer***

The perception of the consumer refers to the ability of the consumer to perceive and understand the eco labels, and it is affected by three factors: understanding, awareness and attention.

Understanding: issue-relevant knowledge & comprehension

Consumers rely heavily on the information supplied on labels to make their purchasing decision, unfortunately there is a considerable possibility that this information may be misinterpreted (Morris, 1997), and consumers often have a hard time understanding labels (Leire & Thidell, 2005; Thøgersen, 2002; van Amstel et al., 2008). A study of UK public and stakeholder perceptions of grocery carbon labelling finds that it is very difficult for public to make sense of labelled emissions values without additional information. Only a very small percentage of consumers can make substantial use of carbon labels (Upham et al., 2011). Similarly it is found that Australian householders have low pre-existing carbon knowledge and are consequently poor at distinguishing between high and low carbon emitting grocery products, unaided (Sharp & Wheeler, 2013). Study also finds that only about 5 per cent of a representative sample of U.S. consumers showed a thorough understanding of the terms “recycled” and “recyclable” (Hastak, Horst, & Mazis, 1994).

More accurate understanding is likely to be associated with higher recognition (awareness) of a label (Thøgersen, 2002). Other factors such as the method and extent of promotion, the label’s self-relevance and the clarity of its environmental profile also influence consumers' understanding (Thøgersen, 2002).

There is still a lack of knowledge of how consumers understand and respond to labels. In particular, few studies examine the use of labels in natural settings where individuals are often distracted, under time constraints or exposed to different options than in laboratory studies. Empirical testing in natural environments is likely to provide evidence to further develop the scientific basis for carbon labelling (M. Vandenbergh et al., 2011).

Awareness: recognition of labels

In reality, less than a thorough understanding may be sufficient for decision-making. Knowing the existence of a label is prerequisite for using it in decision making, so consumer awareness of labels is one of the specific metrics used to measure environmental label effectiveness. The general public's awareness of the underlying environmental issues is an important determinant of success (Lynch, 1994).

Studies have been conducted on the recognition of a label, which is considered to be an indicator of label awareness. Among those recognising a label, from 9 to 95 per cent, depending on the label, had an adequate understanding of its environmental implications (Thøgersen, 2002). Three interview surveys on consumer recognition of various food labels were commissioned during the 1990s by the Swedish Consumer Agency, these surveys indicate that recognition is relatively high, typically over 50%, and still increasing (van Amstel et al., 2008).

Label recognition is generally correlated with the length of time the label is on the market. It also depends on the type and amount of promotion backing the label. The multitude of labels existing on the market however causes difficulty in recognising and understanding the labels (Atănăsoaie, 2013; Thøgersen, 2002).

Although high levels of consumer awareness are correlated to consumer behaviour changes, significant changes in consumer behaviour are not guaranteed (Atănăsoaie, 2013; Lynch, 1994).

Perception of eco-labels varies amongst different ethnic groups. A research study in Malaysia (Rahbar & Wahid, 2010) shows that Malay, Chinese and Indian differ in their awareness, recognition and perception of the eco-label.

Attention

Attention to eco-label and related information is a useful indicator to reflect consumers' intention (attitude) to buy eco-labelled products. Thøgersen (2000, 2002) studied the frequency of paying attention to eco-labels in Britain, Ireland, Italy, Germany and the Nordic countries. A large majority of consumers in these countries show a fair degree of attentiveness to eco-labels and environmental information.

iv) ***Trust: confidence in green claims***

As Boström & Klintman (2011) state, "dealing with matters of (mis)trust and credibility is at the heart of green labelling activities".

The underlying rationale in labelling is to govern consumer behaviour through signalling a specific quality of a product, which usually cannot be directly observed by the consumer. The main tasks in successfully displaying labels for consumers are to agree on certain standards, and to convey the standard and disseminate information in an understandable, trustful way (Koos, 2011). Trust in the source of information is pivotal in connection to the organised communication of standards and is crucial for the willingness to consider labels in a purchasing decision (Koos, 2011; Tanneurs & Vezzoli, 2008; Thøgersen, 2002). However a lack of trust is caused by the increasing distance between consumer and producer, both geographically and mentally (Nilsson, Tunçer, & Thidell, 2004).

The book Eco-Standards, Product Labelling and Green Consumerism (Boström & Klintman, 2011) argues that labellers and stakeholders involved in labelling processes often wrongly presume 'simple trust', a kind of simple, unreserved consumer trust in experts by treating green labelling schemes as 'purely scientific knowledge reflectors'. This presumption might lead to a 'blind public mistrust' in eco standards that is democratically and ecologically harmful. To deal with this problematic polarity the authors suggest some ways to develop 'mutual, reflective trust', a new type of trust relationship among consumers and other stakeholders. The central concept is to allow repeated interaction over time in organised networks that comprise a wide range of actors in order to result in common expectations about proper behaviour.

v) ***Habit: repeat purchase***

It should be noted that purchasing decisions of eco-labelled products are not independent from the consumers' buying history (Thøgersen, 2002). Consumer behaviours with environmental consequences are possibly habitual, little attention is given to environmental information provided, instead behaviour is guided by values in a more reflective process (Biel, Dahlstrand, & Grankvist, 2005). Evidence can be found from studies in Denmark and Sweden on organic food products purchasing behaviour (Grankvist & Biel, 2001; Thøgersen, 1998; van Amstel et al., 2008). For people who shop ordinary food products regularly, it requires a change of habit to purchase eco-labelled alternatives (Grankvist & Biel, 2001). Alternatively, consumers who purchase organic food on a regular basis show a loyalty to the label and

repeat their purchasing. They still have faith in the label even when there is a lack of information (van Amstel et al., 2008).

It is found that a person's beliefs about product attributes and consequences of buying labelled products depend on the length of one's experience with buying such products. Beliefs are changed or strengthened based on experience. Experience has a direct and positive influence on the attitude toward buying (labelled) organic products. The longer the experience of buying such a product results in a more positive attitude toward doing so and lessens the consideration of pros and cons (Thøgersen, 2002).

vi) ***Information asymmetry***

Information asymmetry refers to the case when consumers are handicapped by their deficient knowledge on the quality and pricing of goods in comparison to producers. Eco-labels are a tool to overcome this asymmetry by providing environmental classifications (Koos, 2011; Russell & Krarup, 2005).

An analysis of five eco-labels in the Netherlands (van Amstel et al., 2008) reveals that eco-labels fail to communicate adequately, and they do not diminish the information gap between the buyer and the seller. Four main shortcomings of the eco-labels identified are the incompetency in assuring consumers about the product's ecological impact, the insufficient communication about producers' compliance, the ambiguity about environmental themes and the confusion relating to recommendations in labelling schemes.

vii) ***Information overload: cost of information search and processing***

The number of labels can be a sign of a differentiated and developed market for sustainable goods, however the plurality or fragmentation of labels may possibly lead to consumer confusion. With an increasing amount of similar yet slightly different labels, evaluation of label information will be increasingly difficult (Koos, 2011).

Information overload occurs when there is too much information to the extent that the information becomes dysfunctional. In such cases, the amounts of information available make it more difficult or more time consuming to reach a decision, or make it less likely that the consumer will attend to some critical information (Jacoby, 1984).

Kimura et al. (2008) conducted a study on the impact of the amount and accessibility of information on consumers' value judgement of food products. It was found that a large amount of information only leads to a higher value in an active-search condition. In a read-

only condition, a moderate amount of information was valued significantly higher than little information.

According to the traditional utility-maximising model of consumer behaviour suggested by economic theory, the rational consumer will choose a combination of price and quality that is consistent with one's utility function and constraint, under the assumption that consumers have perfect information. However, in a realistic situation, information asymmetry is likely to exist. Consumers may be able to determine quality attributes, or 'search' goods, such as colour or size, but they may not be able to observe 'credence' goods, e.g. product's potential harm to the health. The role of labels is to turn a 'credence' attribute into a 'search' attribute so that consumers can compare and make more informed (utility-maximising) decisions. For consumers, if the value of additional information exceeds the cost of search, they will prefer to have this information for decision making. The demand for information happens on the condition that consumers know the value of the information. (Cohen & Vandenbergh, 2012)

viii) ***Rebound effect: continued consumerism***

Lastly, it is worth considering the risk of the 'rebound effect'. People are worried that environmental claims on products may legitimise continued consumerism, and that the possible environmental gain from a shift to less harmful products may be offset by the continued growth of consumption (Thøgersen, 2002). For example, a consumer who switches to 'green power' through their electricity provider may feel better about her use of electricity, and then increase usage, partially or even fully offsetting the emission reductions from purchasing green power. Alternatively, a consumer who has her green consumption reduced may use that saving to purchase an extra consumer product. Her carbon footprint would thus remain unchanged (Cohen & Vandenbergh, 2012). Considerable evidence can be found on the rebound effect relating to energy efficiency enhancements, yet there is little evidence to date on any rebound effect from voluntary purchases of carbon emission reductions (Cohen & Vandenbergh, 2012).

2.3.6. Additional theories/ models related to consumer behaviour

Related approaches to designing behaviour change exist in different fields and disciplines. The strategic design intended to result in certain user behaviour might loosely be described as ‘Design with Intent’ (Lockton, Harrison, & Stanton, 2008). Some areas of *Design for Sustainable Behaviour (DfSB)* also overlap with environmental psychology, which is a broad

field that 'deals with the reciprocal relationships between humans and the built and natural environment' (Bell, Greene, Fisher, & Baum, 1996). A wide range of studies in environmental psychology (Steg & Vlek, 2009; Stern, 2000) focused on studying and promoting pro-environmental behaviour, i.e. behaviour that harms the environment as little as possible or even benefits the environment. Behaviour change is also approached by researchers from human-computer interaction (HCI) and ubiquitous computing (UbiComp) perspectives (Froehlich et al. 2010; Strengers 2011).

Five psychological factors related to consumer behaviour and their decision making process are described in the Section 2.3.5.3. These factors, namely attitude, norm, perception, trust and habit, have been addressed by a range of models or theories in the fields of psychology, design or HCI. To provide further background information, this section includes graphical representations of eight theories/ models that explain the relationships of these psychological factors. Illustrated in the following are the Theory of Planned Behaviour (Ajzen, 1991) (Figure 2.3), the ecological behaviour as a function of environmental attitude extended by responsibility feelings (F. G. Kaiser, Ranney, Hartig, & Bowler, 1995) (Figure 2.4), the proposed model of responsible environmental behaviour (Hines, 1984)(Figure 2.5), the model of predicting paying attention to eco-labels and the purchase of labelled products (Thøgersen, 2000) (Figure 2.6), the Theory of Reasoned Action (F. Kaiser, Wolfing, & Fuhrer, 1999) (Figure 2.7), the Fogg behaviour model for persuasive design (B. Fogg, 2009) (Figure 2.8), the Design Behaviour Intervention Model linking antecedents of behavioural and habitual change with varying levels of design intervention strategies (Bhamra, Lilley, & Tang, 2011) (Figure 2.9) and the simplified model of the individual eco label adoption process (Thøgersen et al., 2010) (Figure 2.10). Relevant influencing factors identified from these theories/ models are included in Figure 2.13 together with other factors of the existing situation of eco labelling in relation to consumer behaviour.

It should be noted that, despite the existence of these theories/ models, there is still a lack of knowledge of how consumers understand and respond to labels (M. Vandenbergh et al., 2011). All published studies on eco labelling are purely descriptive and do not answer the question ‘Why consumers know, notice, and use eco labels’ (Thøgersen, 2000).

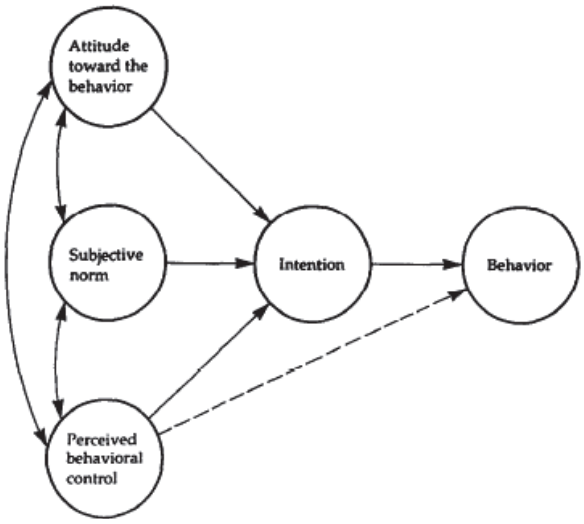


Figure 2.3 Theory of planned behaviour (Ajzen, 1991)

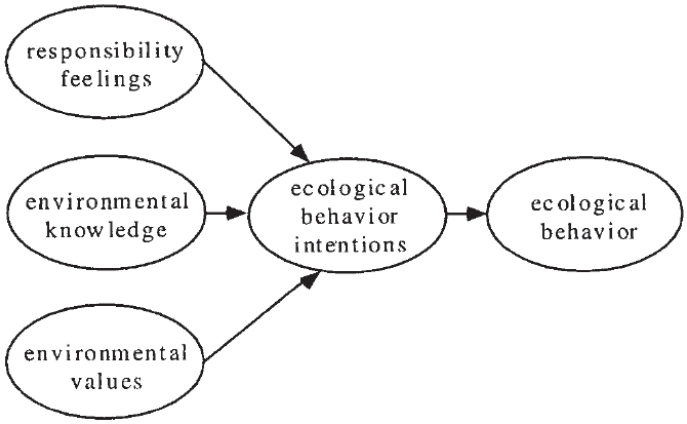


Figure 2.4 Ecological behaviour as a function of environmental attitude extended by responsibility feelings (F. G. Kaiser et al., 1995)

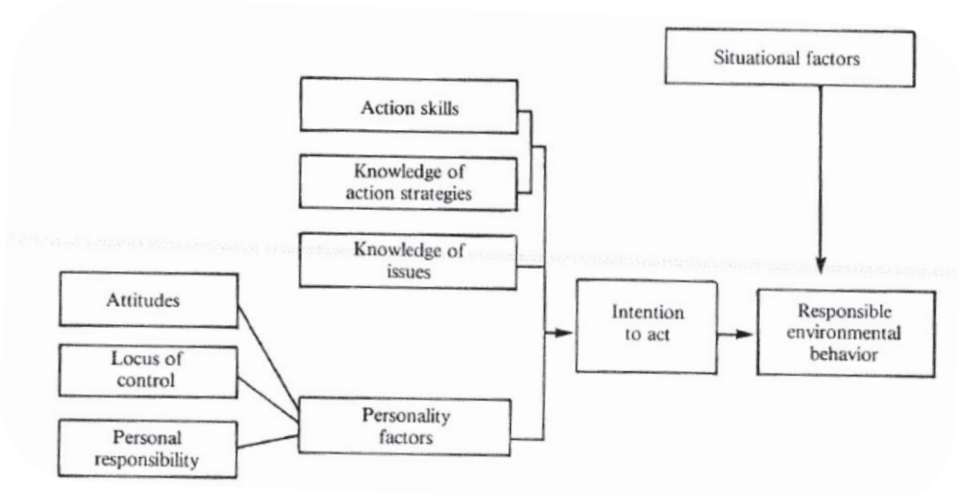


Figure 2.5 The proposed model of responsible environmental behaviour (Hines, 1984)

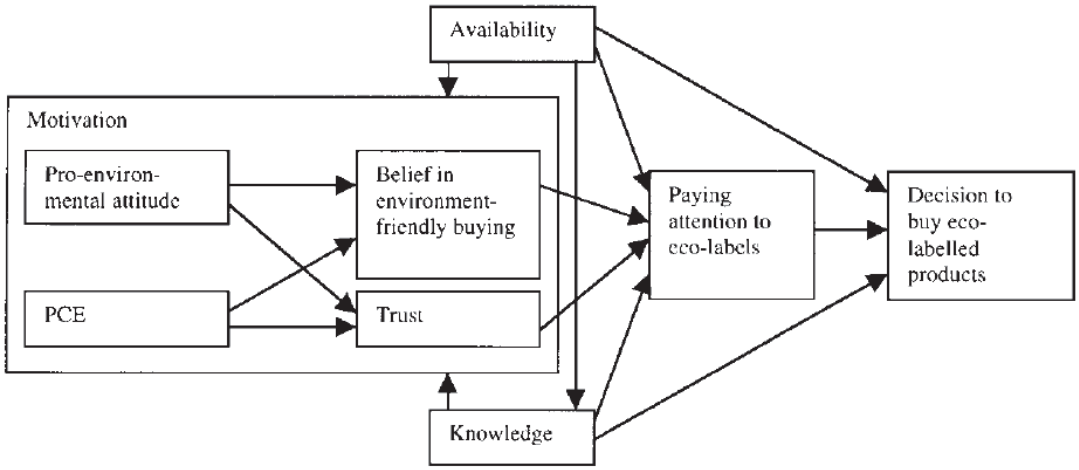


Figure 2.6 Predicting paying attention to eco-labels and the purchase of labelled products (Thøgersen, 2000)

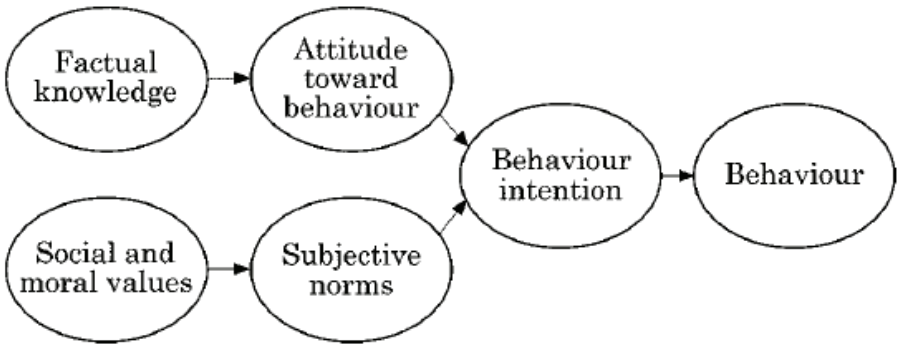


Figure 2.7 The theory of reasoned action (F. Kaiser et al., 1999)

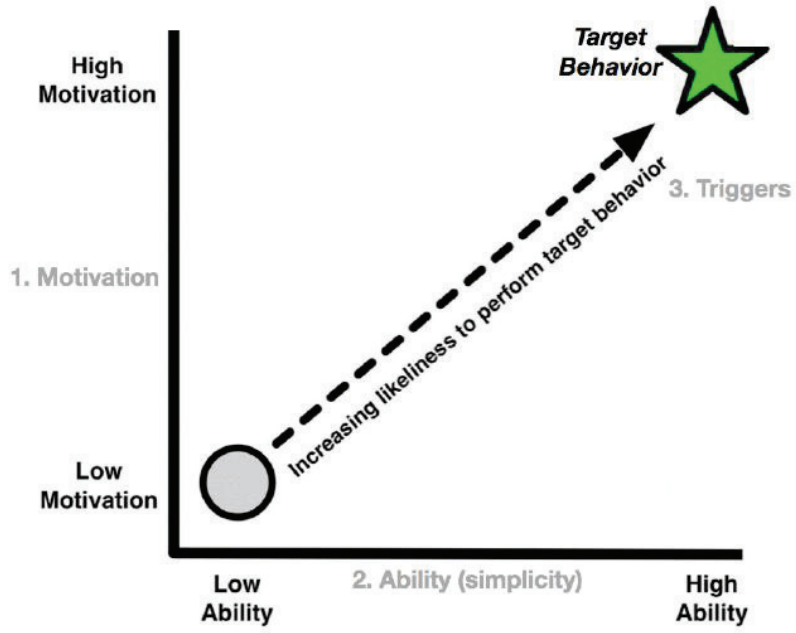


Figure 2.8 The Fogg behaviour model for persuasive design (B. Fogg, 2009)

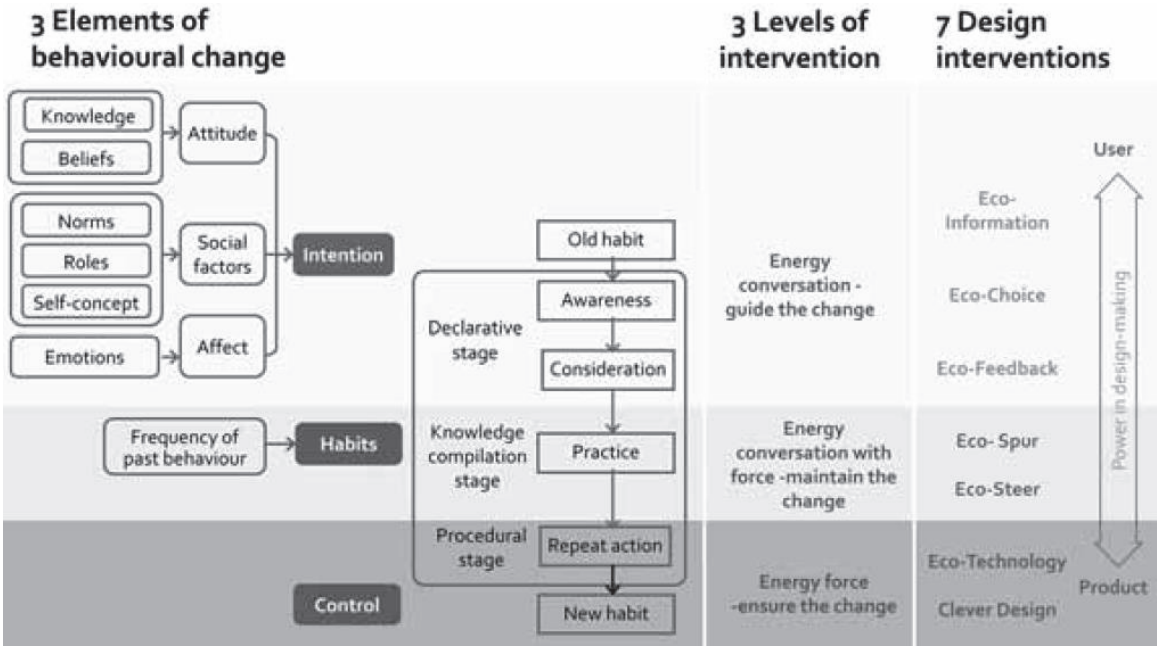


Figure 2.9 Design Behaviour Intervention Model, Linking antecedents of behavioural and habitual change with varying levels of design intervention strategies (Bhamra et al., 2011)

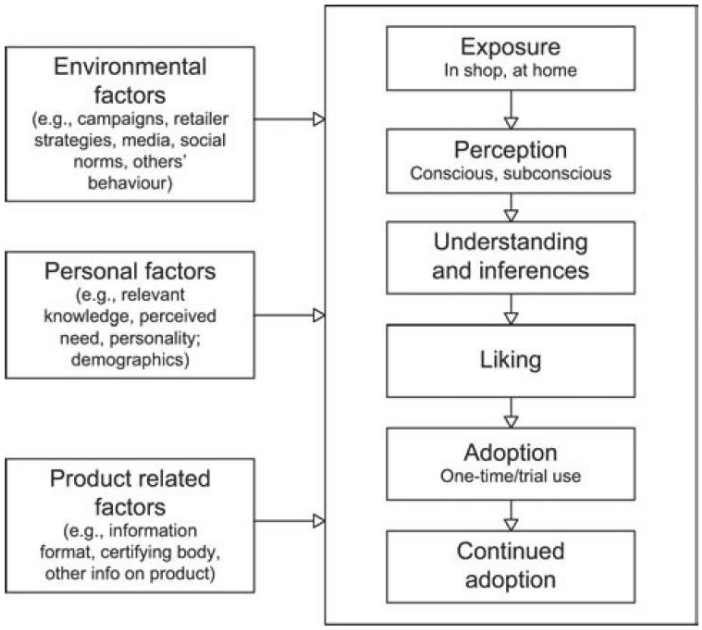


Figure 2.10 The simplified model of the individual eco label adoption process (Thøgersen et al., 2010).

2.3.7. Opportunities for improving eco label design

There is no doubt about the importance of a well-designed label in labelling practice, as it significantly impacts an individual's perceptions of the eco-friendliness of products. The long-run provision of eco-information is believed to have a strong role, especially in cases where

individuals hold incorrect perceptions (Mario F. Teisl, Rubin, & Noblet, 2008). However, despite various known issues related to trade, credibility and consumers' concerns, to date, little research has been done to guide the design of eco labels that are clear, accurate and effective at informing consumers.

2.3.7.1. Level of information detail

In the early stage of the label design process, an important question to be asked should be "what and how much information should be included on the label?". In other words, what is the level of information detail? There exists a dilemma in deciding the amount of information to be displayed on the label. On the one hand research has found that more detailed environmental labels are more credible, on the other hand research indicates the label design should be simple and interpreting the label should not require more mental mathematics than simple comparisons between products (Hartikainen et al., 2013; O'Brien & Teisl, 2004; M. Vandenbergh et al., 2011).

Teisl (2003) suggests the inclusion of detailed information on a label increases consumer satisfaction compared to a label with only a summary eco-label score, and detailed information regarding carbon emissions is effective for educating consumers about the environmental consequences of a product.

However Kimura et al. (2008, 2010) state a large amount of information is not always effective because it adds to the risk of information overload. In contradiction to Teisl(2003) study, there are numerous previous studies on consumer acceptance of food labels indicated that shorter descriptions produced a more positive impression of a product than a longer description did. A possible explanation is the level of information detail in Teisl's (2003) study was smaller than that used in other food label surveys, thus information overload has been avoided.

In summary, it is generally agreed that the lower the analytical complexity, the better for the buyer decision process (Thøgersen, 2002). A plausible solution to determine the level of information detail is to offer flexibility in information accessibility by changing its presentation style (Kimura et al., 2010) , for example, to encourage an active-search condition which utilises the value of detailed information.

2.3.7.2. Actionable information: supporting actual behaviour

One critical issue in carbon labelling is the provision of actionable information to consumers, beyond conveying static information about the product life cycle (Cohen & Vandenbergh,

2012). An example given by Cohen & Vandenbergh (2012) is the water temperature used in washing clothes, which is the most significant factor in carbon emission from home laundry activities (White, 2009). Consumers often use warmer water than suggested on the product instructions. For carbon labelling, it brings the question of which carbon footprint to be calculated and displayed, the actual consumer usage or the suggested usage (i.e. cold water) on the instructions? The PAS 2050 standard resolves this problem by calling for 'actual usage' to be the guiding principle, and Cohen & Vandenbergh (2012) also recommend the idea of updating the label periodically to reflect changes in actual usage.

Another suggestion on helping consumers to carry out intention is to provide specific, task-related information. When competing options are present, consumers need specific and reliable information for consideration; the same is needed when they are asked to change a behavioural routine. A good eco label assists consumers to carry out intentions to choose environmental-friendly products. Among people with a high buying intention, knowing the Ø-label has a substantial effect on buying frequency. This effect however does not apply among those with a low buying intention (Bell et al., 1996; Thøgersen, 2002).

A feature that will support specific action is to allow comparisons of carbon footprints to be made among same product category or different categories. A study shows that the majority of Finnish consumers of food products (84% of respondents) prefer carbon labels which enable comparison. Their requests for the type of information given are however diverse (Hartikainen et al., 2013).

To make the information actionable, the consumers must have understanding of the labels and the conveyed information to a certain extent. Therefore in addition to 'displaying information', some people suggest that carbon (or eco) labels should be used to help educate consumers. Cohen & Vandenbergh (2012) suppose the educational function of label clutter is unlikely to be desirable, and suggest complementary approaches such as point-of-sale brochures, product inserts, mobile phone apps and marketing campaigns.

2.3.7.3. Increase consumer confidence

Another important potential of carbon labels is to increase consumer confidence in green claims by improving credibility and significance of green claims, for example, via the implementation of national/ international standards or third party certification (Thøgersen, 2002). Apart from gaining credibility from a large authoritative organisation, a transparent and open information system is also argued to be useful. For instance, open-source

databases on the environmental implications of supply chains can facilitate the widespread availability of accurate information. An example is Sustainability Consortium (www.sustainabilityconsortium. org/) (M. Vandenbergh et al., 2011).

It is easier to sell green products which demand no or a low compromise from consumers, and consumers have high confidence in it making an environmental difference.

2.3.7.4. Design process... Where to begin?

Labelling the carbon emissions associated with consumer goods could be expensive. Before starting a labelling scheme, a selection of the most promising initial products should be identified based on various criteria to ensure the benefits brought would exceed the marginal costs. (Cohen & Vandenbergh, 2012; M. Vandenbergh et al., 2011). Cohen & Vandenbergh (2012) sketch out five principles for determining which goods are best suited for carbon labels:

1. 'The first is that the screening methodology must identify goods for which changes in consumption (whether substitution or reduced use) could yield relatively large carbon emission reductions.'
2. 'The screening methodology must be able to account for the costs of information gathering… the complexity of the issues at each of the important stages in the life cycle of a product suggests that a system that seeks a high degree of precision will collapse under the weight of heavy transaction costs. Goods with more complex or shifting supply chains, for example, may not be promising initial candidates for carbon labelling.'
3. 'The screening for the most promising products should account for each step in the life cycle of a good, including production, transport, storage and sales, consumption, and disposal. However, it may not be necessary to conduct a detailed analysis of all aspects of any one step in the life cycle of a good.'
4. 'The screening methodology should account for the behavioural plasticity of consumers (Dietz, Gardner, Gilligan, Stern, & Vandenbergh, 2009)—i.e. the extent to which behaviour is likely to change following a new policy (in this case, introduction of a carbon label),whether the behaviour change involves reduced consumption of the good or substitution with a good with a smaller carbon footprint.'
5. 'For a voluntary government or private system, an important fifth principle is that the screening of goods for labelling should account for those goods that firms may have the greatest incentive to label (i.e., the behavioural plasticity of the firm).'

These five principles are consistent to the guiding principles set by Global Ecolabelling Network (2004) for developing a successful eco labelling program, while the later places more emphasis on credibility and compliance to legislation.

Although the challenges of life-cycle assessment (LCA) are substantial, research and development of carbon labelling systems is still worth more investigation. It is believed that the value of the labels does not come from providing perfect information, but better information than the consumer has at present. A carbon labelling system should not be compared with ideal alternative instruments but with the viable options for the relevant time frame. LCA is an active area of research and the accuracy of the label can evolve over time (Cohen & Vandenbergh, 2012; M. Vandenbergh et al., 2011).

The design of a labelling system can benefit from using new technologies. Examples include smart-phone barcode-scanner apps developed by SnowShoe Food (http:// snowshoefood.com/) and the GoodGuide (www.goodguide.com/) (M. Vandenbergh et al., 2011). And empirical testing in natural environment can improve the chances for success before committing to the development of a system (M. Vandenbergh et al., 2011).

2.4. ECO-FEEDBACK AND ECO-INFORMATION SOLUTIONS: STATE-OF-THE-ART

In the last ten years there has been growth in academic work by researchers in multiple disciplines on eco information provision. The research work in this area has been reviewed with an eye to finding techniques and approaches which could be combined with eco labelling to enhance and individualise product labelling.

Design for Sustainable Behaviour (DfSB) is an emerging research field under the banner of sustainable design, exploring how design can influence user behaviour to reduce negative social or environmental use impacts. Research on DfSB has been focused on understanding the psychological and behavioural factors of behavioural change, and identifying intervention strategies to be applied within a design context (Bhamra et al., 2011; Elizondo, 2011; Lilley & Lofthouse, 2009; Lockton, 2013; Wever, van Kuijk, & Boks, 2008). 'Eco-Feedback' and 'Eco-Information' are two of the seven design intervention strategies identified by Bhamra et al. (2011) (Figure 2.9).

The aim of 'eco-feedback' defined by by Bhamra et al. (2011) is 'to inform users clearly about what they are doing and to facilitate consumers to make environmentally and

socially responsible decisions through offering real-time feedback'. The term 'eco-feedback' is also used by Lockton (2013), Lilley (2009) and Wever et al. (2008), but the boundaries of 'feedback' vary from making a 'recommendation' about what the user should do to simply 'prompting' or 'cueing' a different behaviour (Lockton, 2013). In some respects an 'eco-feedback' strategy resembles an 'eco-information' strategy which aims 'to make consumables visible, understandable and accessible to inspire consumers to reflect upon their use of resources' (Bhamra et al., 2011). Both of these inform users about the environmental impacts incurred by their decisions, while the later does not necessarily respond to an input (such as user behaviour) as the former does. Another difference is the degree of 'power in decision-making' given to the user, 'eco-information' gives user more control ('power in decision-making') than 'eco-feedback' which assigns partial control to the product.

Amongst the HCI/ UbiComp research community, eco-feedback is often seen as an extension of persuasive technology (B. J. Fogg, 2002). HCI/ UbiComp researchers have built eco-feedback technologies for a variety of domains including energy consumption, water usage, transportation, and waste disposal practices (Jon Froehlich, Findlater, Landay, Findlater, & Science, 2010). However there is a distinct lack of attention to knowledge from environmental psychology, design and feedback intervention. The performance in usability and engagement remains a major challenge (Spagnolli et al., 2011).

Nowadays there are four major eco-feedback/ eco-information solutions that promote sustainable behaviour in everyday life. In addition to eco labelling, these eco feedback/ eco information solutions include energy monitors, web-based eco-calculators and mobile app eco-calculators (Kwok, Harrison, & Qin, 2013). Three surveys were conducted by the author of this thesis to investigate the state-of-the-art development of eco-calculators and eco labels, because these solutions can motivate individual behaviour more directly (compared to energy monitor), and there had not been any published studies that survey the options available on the market.

2.4.1. Energy monitor (Energy feedback in buildings)

Energy feedback system in buildings is an active area of research (Carrico & Riemer, 2011; Fischer, 2008; Jain, Taylor, & Peschiera, 2012; Murtagh et al., 2013; Peschiera & Taylor, 2012; Pierce & Paulos, 2012; Vassileva, Dahlquist, Wallin, & Campillo, 2013; Villalta et al., 2011). The majority of the research focuses on specific settings, namely domestic or workplace buildings. Users are presented with feedback based on electricity consumption data, which is

typically displayed to users via a computational visualisation (Pierce & Paulos, 2012), i.e. energy monitors.

This system lacks the ability to address the specific behaviour of an individual. People generally do not know which and whose behaviours significantly affect resource use and cannot receive specific feedback on the results of their behavioural changes (Gatersleben, Steg, & Vlek, 2002).

2.4.2. Web-based eco-calculator

To learn about an individual's personal carbon footprint, one of the most direct methods is to calculate with an eco-calculator, which is similar to a simplified LCA-based calculation tool. Numerous eco-calculators are available to the public in the form of web-based applications or smartphone apps. A survey of eight web-based eco-calculators was conducted in 2013 by the author of this thesis (Kwok et al., 2013). The results are presented in Appendix 2 to elucidate the development of this type of eco-feedback application at the time.

All web-based eco-calculators studied calculate the emissions associated with a person or a household, based on estimates made by users about their consumption related to a selection of these activities: shopping, home energy, driving & flying, food & diet, recycling & waste, indirect emission (e.g. bank service) and living environment.

Their feedback provides users a gross estimation of how environmental friendly their lifestyles are, usually in comparison to a national average. However they do not address specific behaviour nor inform users of the impacts associated with specific decisions.

2.4.3. Mobile app eco-calculator

Mobile phones are rapidly becoming the central computer and communication device in people's lives (Lane et al., 2010). In April 2013, a survey was carried out by the author of this thesis to compare the nineteen eco-calculator mobile apps on the two major mobile platforms, *iOS* and *Android* (Kwok et al., 2013). The results are shown in Appendix 1.

These mobile app eco-calculators can be used to calculate environmental impacts in three areas, namely personal use, household and business. Despite the distinctiveness offered by mobile devices, most of the apps function similarly as the web-based eco-calculators presented above. 17 apps out of 19 require the user to enter estimates about their consumptions, and provide feedback based on these gross estimations. Only 2 of the apps have some limited ability for automatic detection of user behaviour. One notifies the

user when their phone battery is fully charged. Another monitors driving behaviour using accelerometer and GPS sensors and provides real-time feedback on carbon emissions and advises on improving driving behaviours (Fiat Group Research and Innovation Centre, 2010).

2.4.4. Existing eco labels

Section 2.3 has introduced the definition, background, effectiveness, issues and opportunities of eco labelling. This section provides further information on the current development of eco labelling by reporting the results of a survey on existing eco labels conducted by the author of this thesis.

Ecolabel Index (http://www.ecolabelindex.com/) is the largest global directory of eco labels (Ecolabel Index, 2014). It was tracking 458 ecolabels in 197 countries and 25 industry sectors when the survey was conducted in 2014. Excluding unsuitable eco labels (such as labels with no image or with image of very poor quality), 405 labels were retrieved from the *Ecolabel Index* (ibid.) to inform the creation of the map of existing eco labels shown in Figure 2.11. (See Appendix 3 for a larger version of the map.) This map classifies existing eco labels according to their information formats, based on the author's interpretation. (A card sorting study (DS2) was later conducted to gain a more objective perspective on how other people categorise these eco labels, as reported in Chapter 6.)

In this map, nine types of information formats are identified. The labels are grouped according to their information formats, namely certification symbol, text, number, scale, rating, traffic light symbol, photo, performance highlight and QR code. Some labels satisfy the requirements of more than one format and are placed in the intersection of multiple sets. For example, the 'cradle-to-cradle' label is considered a certification symbol as well as a rating label as it categorises a product into five achievement levels, therefore it is placed within the overlapping area of 'certification symbol' and 'rating'.

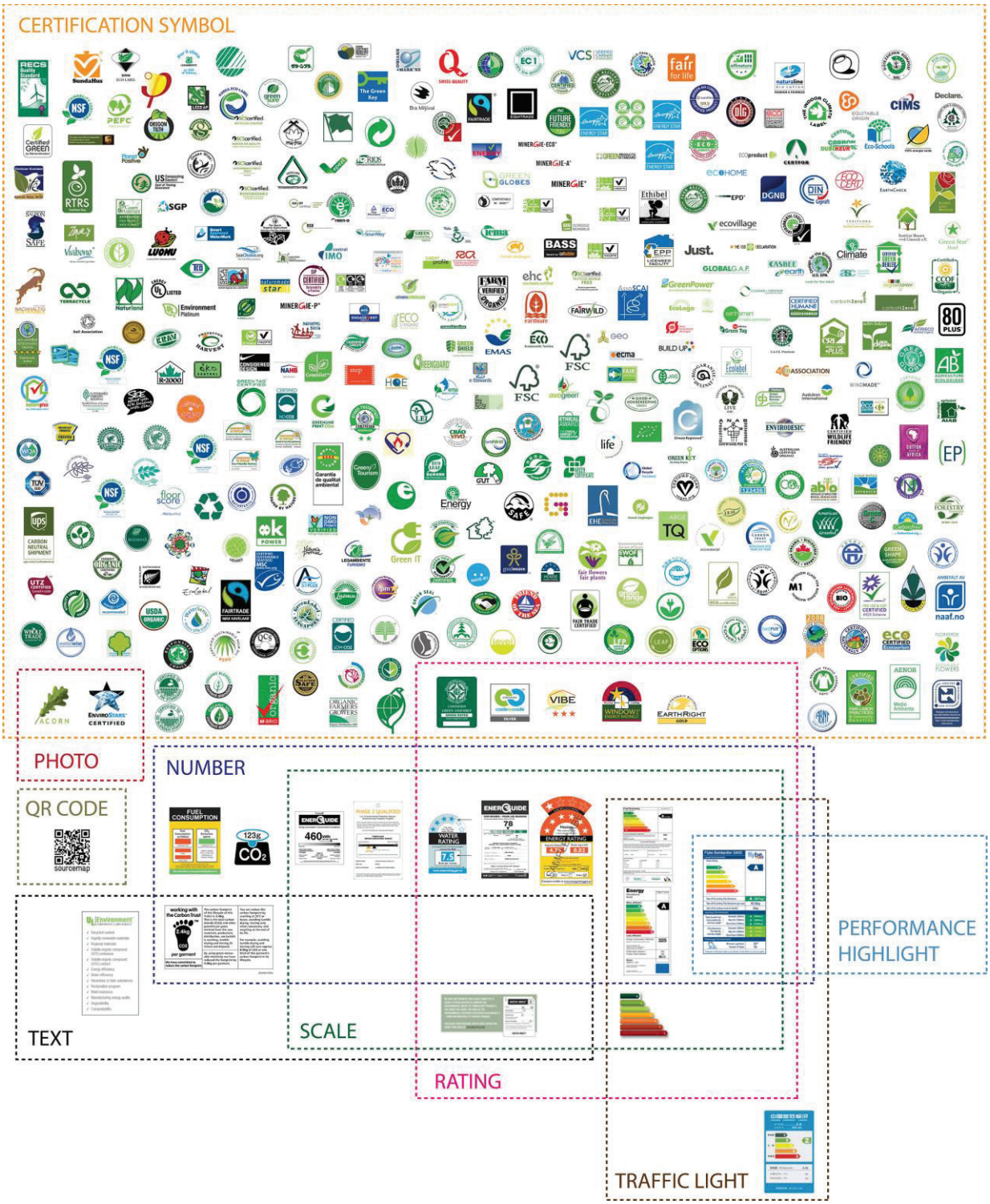


Figure 2.11 Map of existing eco labels

As shown in Table 2.5, most of the existing eco labels belong to the information format category of 'certification symbol'. Out of 405 labels, sixteen labels represent a product's environmental performance in terms of numbers. Fifteen labels use a quantifying tier system such as scale rating or traffic light system to represent product's performance

level. Three labels contain a text based description of environmental attributes. The two labels that embed photographs within their design are *Acorn Scheme*, which uses the photo of a leaf, and *EnviroStars*, which includes an image of the planet earth. There is one interactive label, the QR code label by *Sourcemap*. Yet it is not intuitive, the user cannot understand without a QR code reader and internet connection. It is anticipated that, with the help of technologies, more flexibility in the presentation methods of eco label will be enabled.

Table 2.3 Frequency of eco label information formats

Information formats	Frequency
Certification symbol	389
Number	16
Scale	15
Rating	13
Traffic light symbol	5
Text	3
Photo	2
Performance highlight	1
QR code	1

2.5. OPPORTUNITIES FOR ECO LABELLING ENABLED BY CONTEXTUAL TECHNOLOGIES

2.5.1. Contextual technology

Contextual technology is a collective term for various technologies enabling the 'age of context', as illustrated in the book by Scoble and Israel (2014). The book examines the five forces of contextual technology (i.e. mobile, social media, big data, sensors and location-based technologies) and describes how this technology can unlock new ways for companies to connect with customers.

Although the term 'contextual technology' may be new, the application of contextual technology resembles persuasive technology, and its technology infrastructure is comparable to ubiquitous computing and context-aware systems. Table 2.6 divides the processes of context technology into four stages, and relates them with some particular relevant enabling technologies.

Table 2.4 Stages in contextual technology in relation to enabling technologies

Stage	Enabling technologies
Capturing contextual data	Mobile sensing The Internet-of-Things Wearable technology & lifelogging Location based technology (e.g. GPS) Data mining
Storing contextual information	Cloud computing Ubiquitous computing Database
Presenting contextual information	Information retrieval & visualisation Mobile device Augmented reality Social media
Sending contextual information	Wireless data transmission

2.5.2. Contextual information

Context is a concept that has been discussed in the field of Information Retrieval and Information Systems for decades. Numerous models of context and context-aware frameworks have been proposed (Achilleos, Yang, & Georgalas, 2010; Baldauf, Dustdar, & Rosenberg, 2007; Cheverst, Mitchell, & Davies, 1999; Floch, Hallsteinsen, Lie, & Myrhaug, 2001; Göker, Watt, & Myrhaug, 2004; Henricksen & Indulska, 2006; Ruthven, 2011). These models or frameworks are mainly developed for different technological domains to support the software engineering process. One useful example is the context model developed by Kofod-Petersen and Aamodt (2003), that illustrates the range of contextual factors around users and mobile devices.

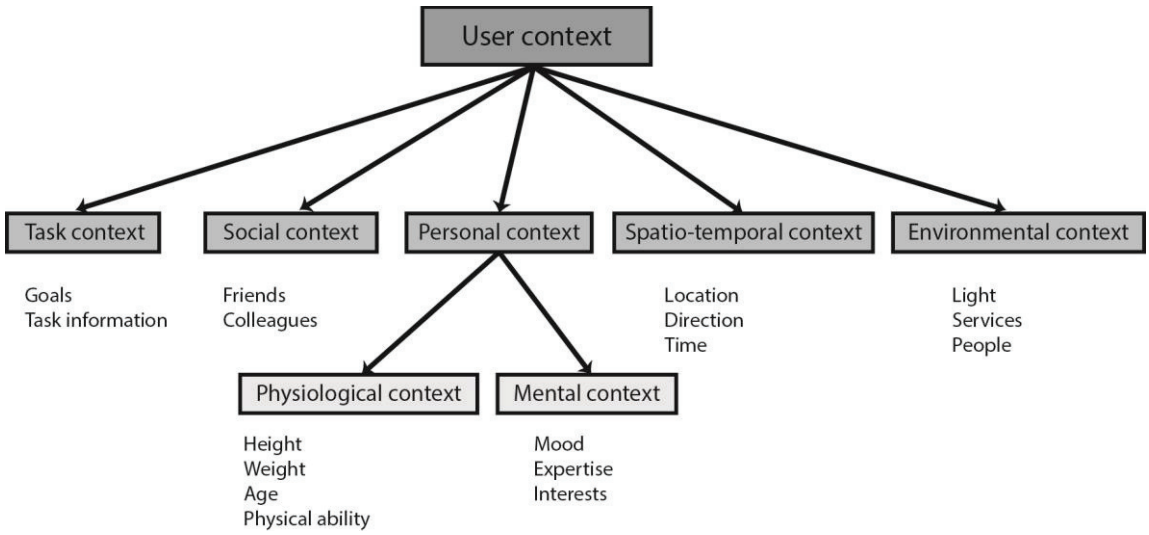


Figure 2.12 Ambisense model of context (Kofod-Petersen & Aamodt, 2003; Ruthven, 2011)

Contextual information has the potential to support the design of different types of systems. To support better interaction design, Ruthven (2011) has further delineated the concept of contextual information by proposing the five axes along which contextual information may differ:

- Objective (e.g. GPS signals) or subjective (e.g. mood, experience)
- Individual (e.g. individual searcher) or group based (e.g. family);
- Meaningful context (directly affects how a task is performed or how the task results are interpreted) or incidental context (does not significantly affect how a task is carried out or evaluated);
- Extrinsic (e.g. popularity of documents) or Intrinsic (e.g. document type);
- Visible or invisible.

While the human computer interaction (HCI) community is aware about the availability of a large amount of consumption-related data (Jon Froehlich, Everitt, & Fogarty, 2009), there seems to be surprisingly little emphasis on human factors research for behaviour change (Lockton, Nicholson, Cain, & Harrison, 2014; Zimmerman, Forlizzi, & Evenson, 2007). It is time to start thinking about interesting and engaging applications, interfaces, and information designs to make use of this data (Jon Froehlich et al., 2009), but the existing models and frameworks are not pertinent enough to support user experience (UX) designers.

2.5.3. Emerging enabling technologies

A number of emerging technologies were believed to be particularly useful in enabling the ubiquitous provision of information, and hence provide opportunities for realising information individualisation.

2.5.3.1. Augmented Reality (AR)

Augmented Reality (AR) is a human-computer-interaction technology that overlays computer-generated information on the real world environment. The advantage of AR over other offline data sources is that the virtual information can be displayed at the same location as the object it relates to. This provides context for the information, often making it more engaging and easier to understand (Nee, Ong, Chryssolouris, & Mourtzis, 2012; Wither, DiVerdi, & Höllerer, 2009).

Born in military and aerospace applications (Fiorentino, Monno, & Uva, 2009), AR is gaining prominence in several other fields, such as education, entertainment, medicine, robotics and engineering (Portalés, Lerma, & Navarro, 2010), and is believed to be a promising paradigm that can offer users with real-time, high-quality visualisation of a wide variety of information (Moussa, Radwan, & Hussain, 2012)

2.5.3.2. Barcode & QR code

A barcode is a machine-readable optical label that contains information about the item to which it is attached. QR or Quick Response Code is a type of matrix barcode. These barcodes can be read by an imaging device, e.g. scanner, smartphone with camera. They can link directly to text, websites, email and URLs for augmented reality contents. Due to its fast readability and considerable information capacity compared to standard barcodes, the QR code system became popular in a broad context, such as product tracking, item identification, marketing and customer service (Denso Wave Inc., 2014).

An interesting example is *'Aestheticodes',* which has evolved from a research project that makes aesthetic decorative patterns interactive. Visual codes that can be recognised by computers are embedded in beautiful images, resulting in the same interactivity as that of the QR code (Meese et al., 2013).

2.5.3.3. RfID & NFC

Radio-frequency identification (RfID) is a form of wireless communication that uses electromagnetic fields to automatically identify and track objects. Near field communication (NFC) is a specialised subset within the family of RfID technology. Both RfID and NFC tags contain electronically stored information that, unlike a barcode, can be scanned without a direct line of sight of the reader.

RfID is a one-way process, and NFC is capable of complex two-way communication between devices. However both RfID and NFC are commonly used for one-way communication between a reader and a passive tag (Jalkanen, 2005; Zhu, Mukhopadhyay, & Kurata, 2012).

2.5.3.4. iBeacon

iBeacon is a technology developed by Apple to extend Location Services. It is a low-cost, wireless one-way transmitter that broadcasts their signals to nearby portable electronic devices, such as smartphone, using Bluetooth low energy (LE) proximity sensing. A specific

app has to be installed on the receiving device to interact with the beacons (the broadcasting devices) to ensure only the installed app can track users as they walk passively around the transmitters. The beacons can be detected within 70m range with no obstructions. They are usually stuck to walls or hidden in other objects (Apple Inc., 2015; Cavallini, 2013).

2.5.3.5. Mobile & Wearable technologies

Today many mobile devices (e.g. smartphone, tablet and Google Glass) come with a growing set of powerful embedded sensors, such as accelerometer, digital compass, gyroscope, GPS, microphone, camera and NFC/ RfID sensors, which enable a wide range of mobile sensing applications (J Froehlich, 2011; Lane et al., 2010). Powerful self-monitoring and personalised information tools can be developed using these sensor-equipped mobile devices.

Lifelogging, the process of tracking personal data generated by the user's behavioural activities for large portions of their lives, is an example enabled by the advancements in wearable technology.

2.5.3.6. The Internet of Things (IoT)

The basic idea of the Internet of Things (IoT) is the pervasive presence around us of a variety of things or objects – such as RfID tags, sensors, mobile phones, vehicles, etc. – which collect data and interact with each other. With this novel advancement in sensor technology, we can have access to a multitude of information about our surroundings and control objects remotely.

The US National Intelligence Council envisages that 'by 2025 internet nodes may reside in everyday things – food packages, furniture, paper documents, and more'. IoT offers great potential for improving the efficiency for many things, such as more efficient energy solutions, smart retail, smart supply chain, etc. (Atzori, Iera, & Morabito, 2010; Jain et al., 2012)

2.5.3.7. Social media

Social media refers to a variety of online channels connecting users interested in specific subjects. Examples include Facebook, twitter, Wikipedia, Linkedin and Pinterest. It has become a platform where people read and share highly personalised information every day. This content gives clues about the context of who people are, what they are doing and what they are likely to do next.

Social media can leverage peer pressure and social norm to promote greener choices by making visible the behaviours within communities (Zapico & Brandt, 2009).

2.5.3.8. Location based services

A location-based service tracks the location of a person of object using real-time geo data from a mobile device if the person has given permission to the service to do it. Some applications allow people to 'check-in' at places like restaurants, stores, attractions or events. This provides opportunities to interact with users at the point of purchase. For example, it helps with pushing suggestions for purchases, discovering the nearest ATM or the location of a friend, or personalising weather reports.

The simple and standard solution for location-based services is to use GPS technology. However GPS does not work very well indoors, in that case alternative techniques such as iBeacon indoor positioning or self-reported positioning can be used(Goodrich, 2013; WebMaps, 2012).

2.5.3.9. Cloud computing

Cloud computing is a type of Internet-based computing. It refers to both the computing services (applications) delivered over the Internet (the 'cloud') and the hardware and systems software in the data centres that process these applications. Some common applications are webmail, online file storage, social networking and games, etc.

Cloud computing provides a shared pool of computing power, memory and storage resources in remote data centres, which could be used to overcome the resource limitation of mobile devices (Armbrust et al., 2010; Naqvi, Preuveneers, & Berbers, 2013).

2.6. SUMMARY

This chapter presents a review of current literature surrounding the areas of sustainable consumption, eco labelling and consumer behaviour, existing eco information/ eco feedback tools, and contextual technology. The findings can be condensed into five statements:

- Eco labelling is one of the information tools developed to facilitate sustainable consumption.
- There exist numerous consumer issues with eco labelling that can potentially be tackled using a design approach.
- Opportunities for improving eco label design are identified.

- Insights are gained from the works of various disciplines on eco information provision.
- Contextual technologies can enable new opportunities in enhancing eco labelling through information tailoring.

Figure 2.13 presents a reference model that summarises the understanding related to the first three statements. It is a graphical representation linking the influencing factors and has to be interpreted as follows.

The nodes represent the influencing factors of the existing situation of eco labelling in relation to consumer behaviour. An influencing factor is an aspect of the existing situation that affects other aspects of this situation, and is formulated as an attribute of an element that can be observed or assessed. These influencing factors come from the literature reviewed in Section 2.2 to Section 2.3 of this thesis. The major significant influencing factors related to consumer behaviour are highlighted in red nodes circled by a thick solid black line, including strength of intention, attitude, level of consumer attention, level of environmental awareness, knowledge of consumer and the difficulty of decision making. The influencing factors related to the design of eco information are highlighted in green nodes circled by a thick grey solid line, including the quality of eco information design, amount of information displayed and the multitude of information. The other nodes circled by thin black solid lines are the related potential consequences. The ultimate goal of reducing the level of environmental impact is listed at the top of the diagram as a result of all linked factors. The nodes in dotted lines are other known related factors that are not considered in this project.

The arrows (→) represent the causal links, pointing from cause to effect. The signs ('+' or ' –') at the ends of a link describe how the value of the attribute of the factor at one end relates to the value of the attribute of the factor at the other end, '+' represents 'high' or 'positive' value, '–' represents 'low' or 'negative' value. Every link is labelled with the source(s) of the statement(s) it represents. The abbreviations within parentheses [ ] indicate the reference(s) of the statement, with [A] meaning that the statement is an assumption. For example, the two centred red nodes in Figure 2.13 illustrate that, according to Thøgersen (2002), consumer's proenvironmental attitude has an positive influence on their attention towards sustainable consumption.

With the aim of having a positive influence on these 'red nodes' through improving these 'green nodes', this thesis proposes the concept of eco information individualisation and describes the development of a tool to educate designers in the design of individualised eco labels.

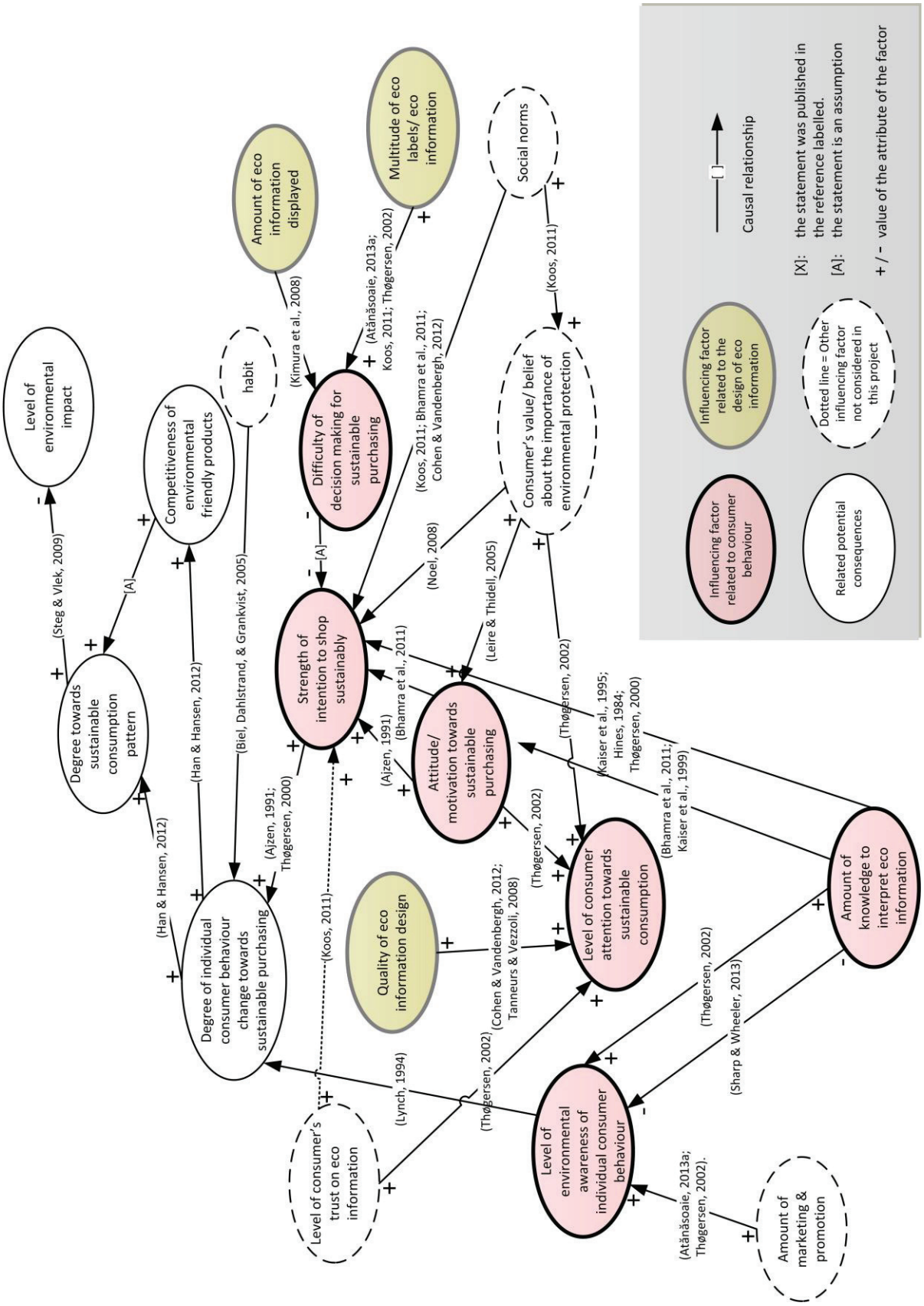


Figure 2.13 Influencing factors of the existing situation of eco labelling in relation to consumer behaviour

1. Eco labelling is one of the information tools developed to facilitate sustainable consumption.

Individual behaviours are accountable for a significant portion of environmental impact caused by consumption. Alongside other traditional practices of environmental regulations, provision of eco information is an appealing tool to increase consumer attention toward environmental risks. Eco labelling is one of the tools that addresses consumer behaviour at the point of purchase most directly.

Despite the proliferation of eco labelling programmes, measuring the effectiveness of eco-labelling is not easy, also efforts in doing so are incomplete. The majority of the evaluation has been done on measuring the *potential effectiveness* of eco labelling. Studies indirectly evaluate the basis of consumers' awareness, knowledge or trust in labels, and consumer demand for labelled products, implicitly or explicitly assuming these factors are fundamental prerequisites for the use of a label in decision making. Anecdotal evidence is also found about the labels' *behavioural effectiveness*, however these findings do not satisfy the standards of rigorous empirical research. Measuring *concrete effectiveness* is extremely difficult and is basically impractical, if not impossible.

However, it appears to be a general view that the market pressure created by 'green' consumers and companies provides reasons for optimism. Under the right conditions, eco labelling can lead to a substantial reduction in pollution and resource use, and it is appropriate to develop eco labelling as part of a portfolio of tools.

2. There exist numerous consumer issues with eco labelling that can potentially be tackled using a design approach.

Consumer concerns are first discussed from a psychological perspective. Generally consumers welcome information product labelling and show a positive *attitude*. Early adopters of a new eco label mostly employ a high effort adoption process, which builds on both motivation and ability. The degree of consumer *motivation* depends on how distinct types of labels (such as hazard warning labels, environmental labels and ethical labels) relate to the consumer's personal relevance and personal values. The trend of sustainable consumption and carbon neutrality are possibly related to *social norms* and are associated with the *'snob'* effect and the *'bandwagon' effect.* The ability of the consumer in perceiving and understanding an eco label is affected by three factors: *understanding*, *awareness* and *attention*. There is still a lack of knowledge of how consumers understand and respond to labels, and why consumers know, notice, and use eco labels. Another essential issue is the

lack of *trust* caused by the increasing distance between consumer and producer, both geographically and mentally. In some cases, consumer behaviours with environmental consequences are possibly *habitual*, behaviour is guided by values in a more reflective process instead of attention paid to information available.

Consumer concerns are also reviewed from the angle of practicality. *Information asymmetry* happens when consumers are handicapped by their deficient knowledge on the quality and pricing of goods in comparison to producers. Eco-labelling is a tool to overcome this asymmetry. *Information overload* occurs when there is too much information to the extent that it becomes very difficult or time consuming to reach a decision. It was found that in an active-search condition a large amount of information can lead to a higher value. For consumers, if value of additional information exceeds the cost of search, they will prefer to have this information for decision making. The risk of the *'rebound effect'* is also considered. The possible environmental gain from a shift to less harmful products may be offset by legitimising continued consumerism. It is believed that existing eco-labelling schemes have not yet provided satisfactory information to diminish the information gap due to various mentioned issues.

A number of theories / models are retrieved from psychology, design and HCI research to provide further information on the psychological factors mentioned.

3. Opportunities for improving eco label design are identified.

In the early stage of the label design process, an important question to be asked is 'what is the level of information detail?' There exists a dilemma in deciding the amount of information to be displayed on the label, on one hand research has found that more detailed environmental labels are more credible, on the other hand research indicates the label design should be simple. A plausible solution is to offer flexibility in information accessibility by changing its presentation style, for example, to encourage an active-search condition which utilises the value of detailed information.

To encourage changes in actual behaviour, it is critical to provide actionable information to consumers, for example provide information that is specific, task-related and based on actual consumer usage. Features that allow comparisons among products and maybe educational are worth considerations.

Credibility and confidence in green claims can be promoted if the source of information is guided by national/ international standard and monitored by third party

organisation. Using open-source databases may also facilitate the widespread availability of accurate information.

Before starting a labelling scheme, a selection of the most promising initial products should be identified. Despite the substantial challenges of life-cycle assessment (LCA) , It is believed that the value of the labels does not come from providing perfect information, but better information than the consumer has at present. New opportunities are brought by new technologies.

4. Insights are gained from the works of various disciplines on eco information provision.

Section 2.4 discusses the techniques and approaches taken by researchers from various disciplines, including design for sustainable behaviour (DfSB) and human computer interaction (HCI), to encourage sustainable behaviour through eco information provision. The state-of-the-art in the development of four major eco information/ eco feedback solutions in everyday life are presented. These solutions are energy monitors, web based eco calculators, mobile based eco calculators and eco labels. The author of this thesis has conducted three surveys on web based eco calculators, mobile based eco calculators and eco labels. It was found that these solutions are deficient in informing individual sustainable behaviour or decision-making, because they do not provide specific feedback in relation to an individual's behaviour change.

5. Contextual technologies can enable new opportunities in enhancing eco labelling through information tailoring.

Lastly, it is argued that the emergence of various contextual technologies and their ability to capture contextual information will open up opportunities for eco information design. The vast amounts of data generated from our daily lives can be viewed as an enabler of possibilities to engage sustainable behaviour. Despite the large number of context-aware frameworks developed for different technological domains, there is a lack of a framework to guide designers in designing systems that employ contextual technologies or contextual information. A number of contextual technologies are then discussed with a focus on their potential in enhancing individualised eco information provision.

Chapter 3
Research methodology

3.1. INTRODUCTION

This chapter considers how to appropriately address the research gaps identified in Chapter 2. During the research design stage, seven key research elements, namely 'theoretical perspective', 'purpose', 'approach', 'data type', 'quality', 'methodology' and 'methods', were considered prior to selecting the methodology and methods that underpinned this research. Figure 3.1 summarises the research elements discussed, and highlights the selected approach in red circles.

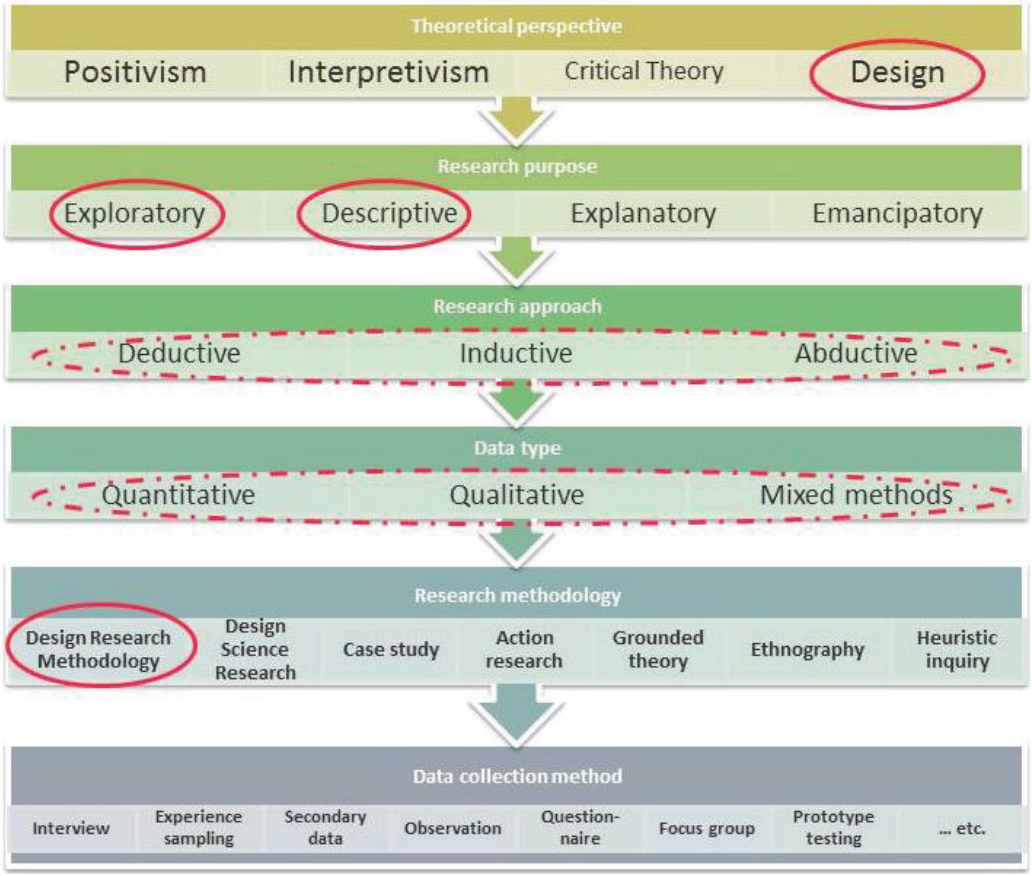


Figure 3.1 The elements of the research process. Adapted from (Gray, 2009; Saunders, Lewis, & Thornhill, 2012)

3.2. RESEARCH PARADIGM

3.2.1. Design research is multi-disciplinary

Design research is complex and multi-disciplinary in nature. A clear representation of such can be seen in the maps of design research created by Liem & Sanders(2013) and Koskinen et al. (2011) (Figure 3.2). The map created by Liem & Sanders (2013) illustrates the landscape of human-centred design research, whereas the map proposed by Koskinen et al. (2011) depicts how Constructive Design Research (i.e. 'research that imagines and builds new things and describes and explains these constructions') is related to other research disciplines .

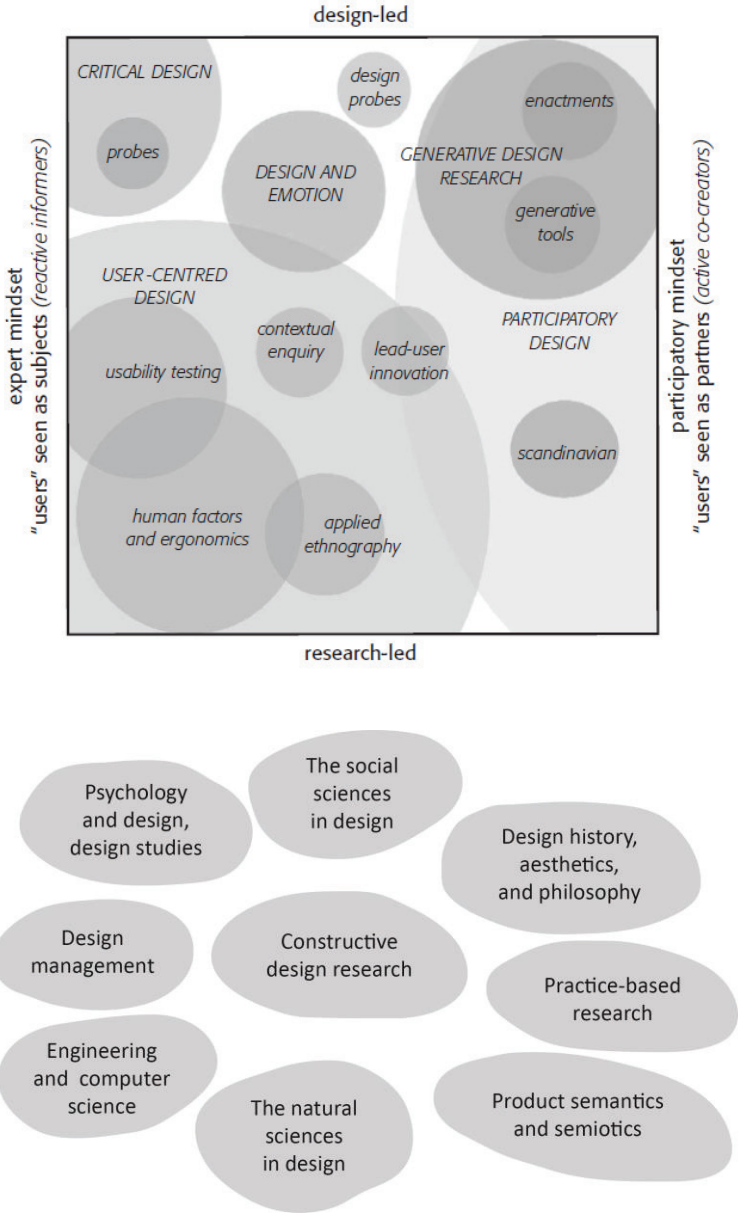


Figure 3.2 Two maps of current design research and practice. Above: (Liem & Sanders, 2013). Below: (Koskinen et al., 2011)

The multifaceted nature of design research (Figure 3.3) leads to the need of blending methodologies from various disciplines, including sociology, engineering, software, philosophy, industrial design, HCI/interaction design (Koskinen et al., 2011). While some disciplines have well-established research methodologies, others (especially in immature sciences) may have evolving, or even conflicting and debatable, approaches. For example, contrasting ontological and epistemological assumptions are used in natural science (positivist) and social science (interpretive) research (Vaishnavi & Kuechler, 2004). Therefore, it is important for a researcher to be aware that:

- 'different schools of thought exist based on underlying paradigms;
- every school has (or should have) a consistent methodology that links the problem to the methods applied and the ways of validation; and
- every methodology has certain premises' (Blessing & Chakrabarti, 2009, p. 240).

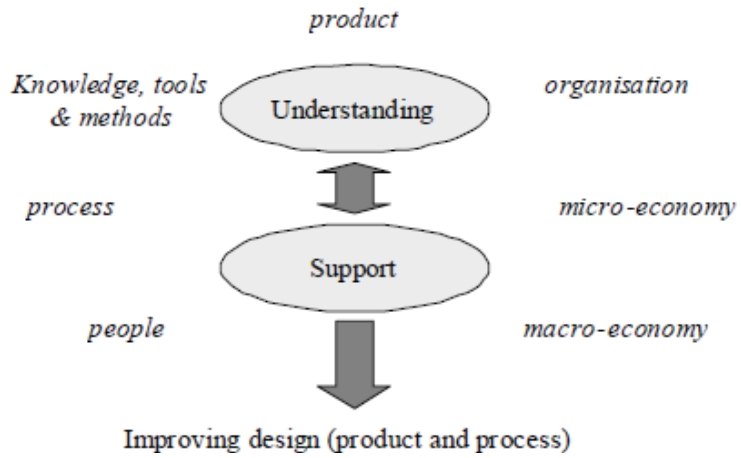


Figure 3.3 The different facets of design research (Blessing & Chakrabarti, 2009, p. 5)

This PhD project was influenced by the belief of Branzi (1988) that design research can be grounded in imagination and should offer alternatives rather than try to alter reality directly, as he writes:

> *'The architectural or design project today is no longer an act intended to alter reality, pushing it in the direction of order and logic. Instead the project is an act of invention that creates something to be added on to existing reality, increasing its depth and multiplying the number of choices available.' (Branzi, 1988, p. 17)*

This research envisioned a future scenario, and investigated the meaning and feasibility of our proposal through a series of exploratory and qualitative studies, to inform

the development of a '*support'* (a term used as in Design Research Methodology (Blessing & Chakrabarti, 2009)) for improving the design of product(s) and process(es). The *support* in this project refers to the means to enhance the display of eco information to consumers.

3.2.2. Theoretical perspective

Theoretical perspective, sometimes called paradigm or theoretical/conceptual lens, refers to the particular views (assumptions) we have about the topic of investigation (Crouch & Pearce, 2012, p. 59). It influences the choice of research methodology and the interpretation of the findings. It is worth noting that theoretical perspectives can change over time, new paradigms emerge and compete with existing views (Blessing & Chakrabarti, 2009; Kuhn, 1962). Table 3.1 summarises the four theoretical perspectives being considered. Positivist, interpretive and critical approaches are the three most well-known theoretical perspectives. The stance taken for this PhD project is the fourth one, the 'design' perspective.

Table 3.1 The four main research perspectives. Adapted from (Gray, 2009; Vaishnavi & Kuechler, 2004; Wiafe, 2012)

	Theoretical perspectives			
Basic beliefs	**Positivist**	**Interpretive**	**Critical**	**Design**
Ontology	A single reality. Knowable, probabilistic	Multiple realities, socially constructed	Reality is historically constructed	Multiple, contextually situated alternative world-states. Socio-technologically enabled
Epistemology	Objective; dispassionate. Detached observer of truth	Subjective, i.e. values and knowledge emerge from the researcher-participant interaction.	Reality is shaped by social context, knowledge is grounded in social and historical practices, facts and values are entwined	Knowing through making: objectively constrained construction within a context. Iterative circumscription reveals meaning.
Methodology	Observation; quantitative, statistical.	Participation; qualitative. Hermeneutical, dialectical.	Assumptions, beliefs, and values shape and shaped by the investigation.	Developmental. Measure artefactual impacts on the composite system.
Axiology: What is of value	Truth: universal and beautiful; predictions	Understanding: situated and description	Descriptive and situated knowledge and understanding of phenomena	Control; creation; progress (i.e. improvement); understanding

The 'design' perspective is proposed by Vaishnavi & Kuechler (2004) for the field of Information Systems. Vaishnavi & Kuechler (ibid) borrow Gregg's (2001) suggestion of a 'Social-technologist/ Developmentist' approach, and rename this way of knowing as 'design' after integrating their combined 40+ years of Design Science research experience.

'Design Science' is a research field that tries to change the state-of-the-world through the introduction of novel artefacts. In their view, multiple and contextually situated alternative world-states can exist; the problem statement is subject to revision as the research proceeds; abductive thinking is used to produce an artefact with problem solving functionality; knowledge is uncovered through an iterative development process. As opposed to more traditional research, the criterion of being a successful project is not the pursuit of complete understanding, instead a practical or functional addition to knowledge, even in the form of partial or incomplete theory, can have value if it provides a basis for further exploration (Vaishnavi & Kuechler, 2004). Although the 'design' perspective is proposed by the Information System researchers typically for the Information Systems discipline, it is believed that the basic beliefs proposed are directly applicable for a range of design research projects. Indeed, the description of this paradigm shares many similarities with the traditions of 'Constructive Design Research' (Koskinen et al., 2011).

This thesis investigates the opportunities in promoting sustainable purchasing by addressing individual's behaviour and needs contextually, imagines new things and proposes an alternative, preferred way of living. In an attempt to tackle the complex problems related to behavioural phenomena and associated environmental impacts, this research envisaged the existence of multiple, contextually situated alternative world-states, as opposed to the positivist's belief of 'one reality'.

This research was centred on constructing a conceptual framework, usage scenarios of the proposed concept (eco information individualisation), a design tool and a working prototype**.** Through an iterative design and development process, a deeper understanding of user perception and user needs, as well as the values of the proposed concept were revealed. The artefacts constructed are expected to bring positive design impact, both functional and theoretical, to the world.

3.2.3. Research purpose

Enquiries can be categorised according to their purpose and the research methods used. Often one purpose would predominate a research study, although a particular study may have more than one purpose. The purpose may change as the research evolves (Robson, 1993). Summarised in Table 3.2 are the characteristics of four research purposes: exploratory, descriptive, explanatory (Robson, 1993) and emancipatory (Letherby, 2006; T Tang, 2010).

Table 3.2 Categories of research purpose. Adapted from (Robson, 1993; T Tang, 2010)

Research Purpose	Description
Exploratory	• To find out what is happening, particularly in little understood situations • To seek new insights • To ask questions • To assess phenomena in a new light • To generate ideas and hypotheses for future research • Usually, but not necessarily, qualitative
Descriptive	• To portray an accurate profile of persons, events or situations • Requires extensive previous knowledge of the situation etc. to be researched or described, so that appropriate aspects on which to gather information can be identified • May be qualitative and/ or quantitative
Explanatory	• Seeks an explanation of a situation or problem, usually in the form of causal relationships • To explain patterns relating to the phenomenon being researched • To identify relationships between aspects of the phenomenon • May be qualitative and/ or quantitative
Emancipatory	• Seeks to empower the subjects of social inquiry • To create opportunities and the will to engage in social action • Usually, but not necessarily, qualitative

It was suggested that certain research methods are more closely related to specific research purpose, for instance surveys are appropriate for descriptive studies. Acknowledging some truth in this assertion, Robson (1993) argues that each research method can used for any or all of the above purposes.

In brief, this research project was exploratory in nature for it was an investigation on an under-explored research area. Some descriptive data were collected to support the proposed ideas. The project began with an investigation into the opportunities provided by ubiquitous technology and augmented reality technology in encouraging sustainable purhcasing behaviour. The research purpose has then evolved and focused on exploring the concept of eco information individualisation via a series of descriptive and presciptive studies using a user centred design approach. The purpose of each study is explained in each related chapter.

3.2.4. Research approach: inductive, deductive, and abductive thinking

Deductive research is based on hypothesis testing. The classical approach is to select a theory or set of theories, formulate a hypothesis, determine the variables to be measured, then test or falsify by corroboration or attempted falsification. The outcomes, usually quantitative, are used to accept or reject the hypothesis, and do not focus on the 'why' and 'how' (Blessing & Chakrabarti, 2009, p. 191; Gray, 2009, p. 14).

Inductive approach is data-driven. It does not start from a theory nor hypothesis, and does not pre-determine variables. Instead, questions are used for data collection, data are then analysed to see whether any patterns emerge. Generalisation, relationships or even theories may then be possibly constructed from the data, which can be either qualitative or quantitative (Blessing & Chakrabarti, 2009, p. 191; Gray, 2009, p. 14).

Additionally Crouch & Pearce (2012) have mentioned a third approach – a transformative way of thinking called '*abductive thinking*'. While deductive thinking proves something must be the case, and inductive thinking shows that something is happening, abductive thinking involves a 'creative leap' (also called 'intuition' (Cross, 2006)) that is essential for problem solving. They claim that 'the solution to a problem emerges during the reflexive process of its resolution, and information gathering and ordering are not enough *by themselves* to provide solutions… Abductive thinking encourages us to think about what *might* happen, or what *might* be the case, or what could happen if things were rearranged'. Preparedness is needed for making abductive decisions, for example, the designers who saw the potential of transforming one set of qualities (e.g. existing objects) into another (e.g. new design) would need knowledge of both sets of information before an imaginative jump can be made.

Deductive reasoning is a classic intellectual tool used in natural science research, inductive research is typically used in social science research, and abductive thinking has its distinct usefulness in design research for framing creativity and generating solutions to a problem. For this research, all three thinking tools were used in different stages of the research process.

3.2.5. Data type: quantitative, qualitative and mixed methods

Quantitative research is about collecting quantitative data in the form of numbers measuring occurrences, and delimiting phenomena into measurable categories. The types of data

collected in *qualitative* research are, however, much more diverse. While qualitative studies usually comprehend data in the form of text (e.g. interview transcripts, diary entries), other media such as drawings, photographs, audio and video recordings can as well be used (Gray, 2009, p. 177). The richness of qualitative data makes it possible to better describe the complexity and depth of social interactions in 'real life'. A problem of evaluating qualitative research is that traditional notions of validity and reliability cannot be applied. On the contrary, quantitative research is regarded as more valid and reliable because it can generate generalisable and replicable data. Table 3.3 further compares the differences between quantitative and qualitative research. The advantages and disadvantages are marked by the '✓' and '×' bullets respectively.

Table 3.3 Some differences between quantitative and qualitative research. Adapted from *(Coolican, 2009; Crouch & Pearce, 2012; Gray, 2009; Langdrige & Hagger-Johnson, 2009; T Tang, 2010).*

Quantitative	Qualitative
Seek the facts/ causes of social phenomena	**Concerned with understanding behaviour from actor's own frames of reference**
✓ Seek to make claims about causation	✓ Generally does not impose a particular way of 'seeing' on the participants
Obtrusive and controlled measurement	**Naturalistic and uncontrolled observation**
✓ Precise (in terms of measurement) ✓ Controlled (in terms of design)	✓ Often produces unexpected insights about human nature through an open-ended approach to research
Objective	**Subjective**
✓ Generate reliable, rigorous and replicable data × May fail to recognise or be explicit about the subjective nature of social science research	✓ Recognises the subjective experience of participants ✓ Generate rich and deep data × Cannot apply traditional notions of validity and reliability on the data; × Lack of replicability
Removed from the data: 'the outsider' perspective **Focuses on 'facts'**	**Close to the data: the 'insider' perspective** **Focuses on 'meanings'**
✓ Eliminating or minimizing subjectivity of judgment	✓ Enables an 'insider' perspective on different social worlds
Generalisable: multiple case studies **Assumes a stable reality**	**Ungeneralisable: single case studies** **Assumes a dynamic reality**
✓ Has predictive power (can generalise to other settings on the basis of some finding in a particular setting) × May grossly oversimplify the complexity of human nature	× It is often not appropriate or even possible to make generalisation or predictions

Quantitative	Qualitative
Particularistic	**Holistic**
✓ Enable researchers to gather data that reflects the perspectives of large groups of people or populations × May fail to recognise the individuality and autonomous nature of human beings	✓ Study personality by gathering meaningful verbal information from people which gives a richer, fuller description of the phenomenon of interest

To support and complement the above seemingly opposite approaches, the *'mixed methods'* approach has been developed. In principle mixed methods research should include at least one quantitative method and one qualitative method, yet the definition of *'mixed methods'* is not straightforward (Gray, 2009). Johnson et al. (2007) examine the definition of *mixed methods* by asking 19 mixed methods research scholars. Amongst the definitions gathered, it is found that three of the definitions supposed that the mixing occurred at the data collection stage, two considered that mixing occurred at both the data collection and data analysis stages, and four supposed that mixing can occur at all stages.

The five broad purposes of mixed method studies are identified as triangulation, complementarity, development, initiation and expansion (Greene, Caracelli, & Graham, 1989). Triangulation enables convergence and corroboration through combining results from different methods studying the same phenomenon, therefore strengthen a study by cross checking and providing validity for the claims (Crouch & Pearce, 2012, p. 129). Mixing methods also provides better information to complement and expand understanding of a particular phenomenon. For example, 'words and narratives can add meaning and richness to numerical data, numbers can add clarity and precision to the qualitative data'(Crouch & Pearce, 2012, p. 129).

This research had adopted both quantitative and qualitative methods. Focus groups (a qualitative method) were used to explore the opportunities in promoting sustainable consumer behaviour in the beginning of the research (DS1), and to evaluate the proposed conceptual framework in DS3. Both quantitative and qualitative data were collected in the card sorting study (DS2) and the data were triangulated in the analysis. The results informed the refinement of the proposed conceptual framework (PS1.2) and the development of the design tool (PS2). The design tool was evaluated with a designer workshop (DS4) using both quantitative and qualitative methods.

3.2.6. Quality criteria of research

The meaning of doing research is to extract reliable knowledge from the world, and to make that knowledge available to others in a reusable form (Cross, 1999). In order to realise the rigour needed to obtain useful statements, research study needs to be carefully designed, and the results need to be verified to ensure the plausibility and credibility of evidence (Blessing & Chakrabarti, 2009).

While both quantitative and qualitative seek reasonable standards of good evidence (quality criteria), there exist many different views towards the conception and operationalisation of these quality criteria (Frambach, Vleuten, & Durning, 2013). Table 3.4 presents an overview of traditional quality criteria in quantitative and qualitative research.

Table 3.4 Traditional criteria for quantitative and qualitative research

Applicable research type	Traditional quality criteria	Definitions
Quantitative research	Validity (Internal validity)	- 'The degree to which the measurements actually reflect the true variation in the outcome of interest. It is the best available approximation to the truth or falsity of the propositions, because we can never know for certain what is true.' (Blessing & Chakrabarti, 2009) - Validity means 'an instrument measures what it is intended to measure' (Gray, 2009, p. 161). - It is 'the extent to which observed effects can be attributed to the independent variable' (Frambach et al., 2013), i.e. the relationship between variables is plausibly causal.
	Reliability	- The reproducibility of measurement (Blessing & Chakrabarti, 2009). - Reliability means an instrument is consistent in this measurement (Gray, 2009, p. 161). - The extent to which the results are consistent if the study would be replicated (Frambach et al., 2013)
	Replicability	- Very similar to *reliability*. *Replicability* means that 'a study should produce the same results if repeated exactly' (Fournier, 2016). - 'The suitability of the methods for others to repeat' (Bryman & Teevan, 2005).
	Generalisability (External validity)	- 'The extent to which the results can be generalized from the research sample to the population' (Frambach et al., 2013), across persons, settings or times (Blessing & Chakrabarti, 2009).

Qualitative research	Credibility	- 'The extent to which the study's findings are trustworthy and believable to others' (Frambach et al., 2013)
	Transferability	- 'The extent to which the findings can be transferred or applied in different settings' (Frambach et al., 2013)
	Dependability	- 'The extent to which the findings are consistent in relation to the contexts in which they were generated' (Frambach et al., 2013)
	Confirmability	- 'The extent to which the findings are based on the study's participants and settings instead of researchers' biases' (Frambach et al., 2013), i.e. the likeliness that another researcher will reach the same conclusion.

Traditional criteria for quantitative research include validity, reliability, replicability and generalisability. It should however be noted that there have been many different views on the attempt to identify quality criteria for qualitative research, in addition to the ones presented in Table 3.4. Some researchers try to apply traditional quantitative criteria, such as validity and reliability, to qualitative research. Some have conceptualised the notions of rigour as *trustworthiness*, and further divide that into four sub-categories - credibility, transferability, dependability, confirmability, as shown in the table above (Annear, Lea, & Robinson, 2014; Bryman, Becker, & Sempik, 2008). Some question the possibility of having a single set of qualitative criteria, or even appear to reject the very possibility of criteria, because they believe qualitative research is divided not only in terms of substantive focus and the use of particular methods, but it also varies according to the theoretical assumptions and the paradigms adopted (Hammersley, 2007). Corbin and Strauss (2008) even think that creativity counts as a criterion or factor of the quality of qualitative research.

Four descriptive studies (DS1 – DS4) have been conducted in this research work. To satisfy the trustworthiness requirement of qualitative research, it is important to ensure the sample size for data collection is adequate. Saturation is the criterion for determining when sampling is enough. According to Morse et al. (2002), 'Saturating data ensures replication in categories; replication verifies, and ensures comprehension and completeness.'

'Theoretical saturation' is a term originally developed within the approach of grounded theory, and has a specific and theory driven meaning. The notion of saturation has evolved and has been transformed for other qualitative methods, where the terms 'data saturation' or 'thematic saturation' are used. Nowadays multiple meanings are associated with the term 'saturation'. There are some debates and confusion about its definition and

when it is applicable. Generally speaking, the need for data/ thematic saturation implies that sampling (and data collection) should continue until no new insights is being added and no more new patterns emerge from the data (O'Reilly & Parker, 2013). However there is an almost complete absence of explicit guidelines for determining saturation (Bowen, 2008).

In reference to the above discourse, Chapter 10 and other releveant chapters have discussed the quality criteria and sampling strategy adopted for different studies, and how the studies have or have not met the criteria.

3.3. GENERAL RESEARCH METHODOLOGIES

A methodology can guide the research process in a manner that is smoother, more rigorous and systematically planned, which in turn increases the prospects of obtaining valid and useful results. As a topic with its own body of knowledge, design research has a relatively shorter history than other topics, and lacks a common view on the aims, objectives and methodology (Blessing & Chakrabarti, 2009, p. 12).

This PhD research is a design research project that involves understanding people's needs, proposing a design concept to solve a real world problem, developing the proposed concept via a user centred approach and prototyping, and evaluation of the proposed concept. In order to define a methodological framework that addresses these specific challenges, a spectrum of methodologies was reviewed.

3.3.1. DRM, a Design Research Methodology

Blessing & Chakrabarti (2009) have proposed a design research methodology called *DRM, Design Research Methodology*. The goal is to support a more rigorous approach to improve the effectiveness and efficiency of design research. The overall objectives of design research are regarded as:

- 'The formulation and validation of models and theories about the phenomenon of design' and
- 'The development and validation of support founded on these models and theories, in order to improve design practice, management, education and their outcomes'. (Blessing & Chakrabarti, 2009, p. 9)

Figure 3.4 illustrates the relationship between design research methodology, design research and design.

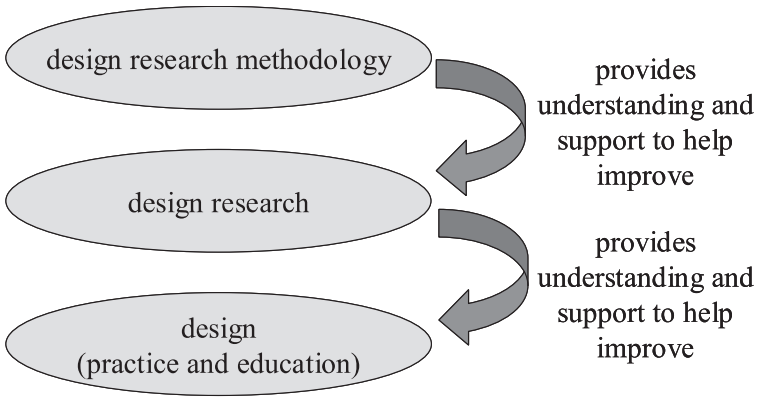


Figure 3.4 Relationships between design, design research and design research methodology (Blessing & Chakrabarti, 2009, p. 9)

DRM consists of four main stages: Research Clarification (RC), Descriptive Study I (DS-I), Prescriptive Study (PS) and Descriptive Study II (DS-II). The bold arrows in Figure 3.5 illustrate the main process flow that links the four stages, and the 'white' arrows indicate the possible iterations.

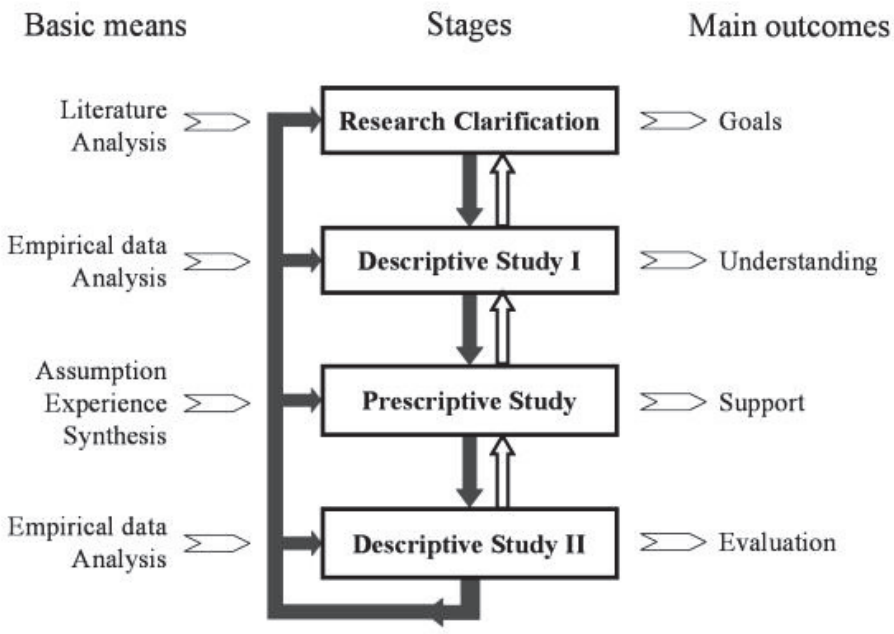


Figure 3.5 DRM Framework. Adapted from (Blessing & Chakrabarti, 2009)

A typical project guided by DRM starts with a research clarification (RC) stage, where literature is reviewed to determine the aim, focus and scope of the research. The criteria of success to be used in design research are identified in the descriptive study-I (DS-I) stage, that is followed by a prescritpive study (PS) stage which suggests how the findings from DS-I

could be used to improve design. A descriptive study-II (DS-II) then evaluates the resulting support developed from the PS stage, and indicates how the support is to be improved.

Parallel execution of these stages can happen in reality, although not explicitly illustrated in the diagram. Also, depending on the nature of enquiry, a project can focus on less than or more than four stages, and the stages can be completed to varying levels of depth (review-based, initial, or comprehensive).

DRM has been adopted in numerous design research projects, for example in the research conducted by Combe(2012), Mcginley(2012) and Nickpour(2012).

3.3.2. Action Research

Action research is defined as a form of enquiry that enables practitioners to investigate and evaluate their own work practice. Unlike traditional forms of social science research, where professional researchers stand outside of a situation, 'spectate' and do research on practitioners, action research is a liberating form of professional enquiry that empowers insider researchers to improve their own learning as well as help the learning of others. An advantage of action research is that everyone can do it, for instance the practitioners can be principals, managers, administrators and students (McNiff & Whitehead, 2006).

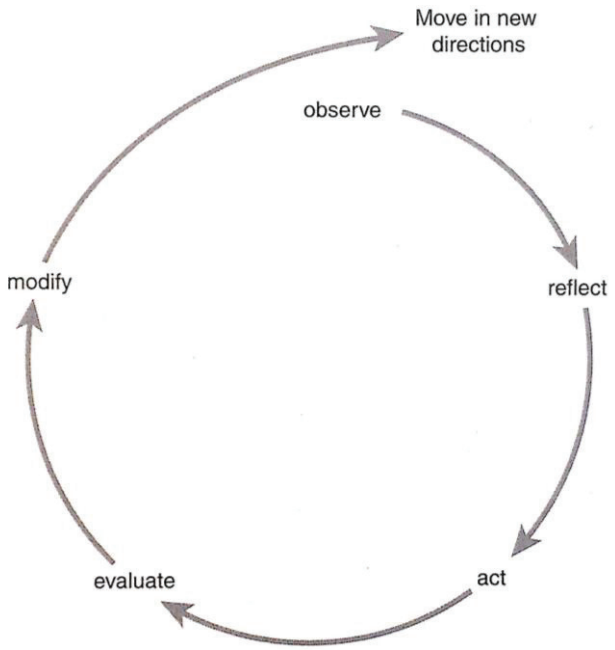


Figure 3.6 An action-reflection cycle (McNiff & Whitehead, 2006)

A typical action research plan goes through the cyclical process of 'observe – reflect – act – evaluate – modify – move in new directions' (generally known as 'action-reflection'

cycle) (Figure 3.6) (McNiff & Whitehead, 2006). Action research is distinct from many other research approaches with its heavy emphasis on the evaluation (critical reflection) stage, in addition to the action (development & implementation) stage. The evaluation is formative, and the research process is mostly qualitative and participative (Blessing & Chakrabarti, 2009).

McNiff & Whitehead (2006) draw a notional action plan as:

- 'Take stock of what is going on
- Identify a concern
- Think of a possible way forward
- Try it out
- Monitor the action by gathering data to show what is happening
- Evaluate progress by establishing procedures for making judgements about what is happening
- Test the validity of accounts of learning
- Modify practice in the light of the evaluation'.

Having gained popularity in many areas, action research has developed particularly well in education. Action research is not the approach to be used when seeking statistical correlations, comparisons, or cause and effect relationship (McNiff & Whitehead, 2006).

3.3.3. Grounded theory

First developed by Glaser and Strauss (1967), grounded theory has become influential in qualitative research for its inductive but systematic approach to gather and interpret data (Charmaz, 2008) (Figure 3.7). Its major strength is the capability to construct theories about social phenomena (Gray, 2009; Gregory, 2011).

The research process can begin with a topic or general research questions. Individual cases, incidents or experiences can be studied inductively before more abstract categories are tentatively created to explain the data. These categories are used for synthesising data and identifying patterned relationships. Then more specific data are gathered to refine and delineate data properties and relationships. After looking at all possible theoretical explanations, the researcher goes on to pursue the most promising theoretical direction (Charmaz, 2008).

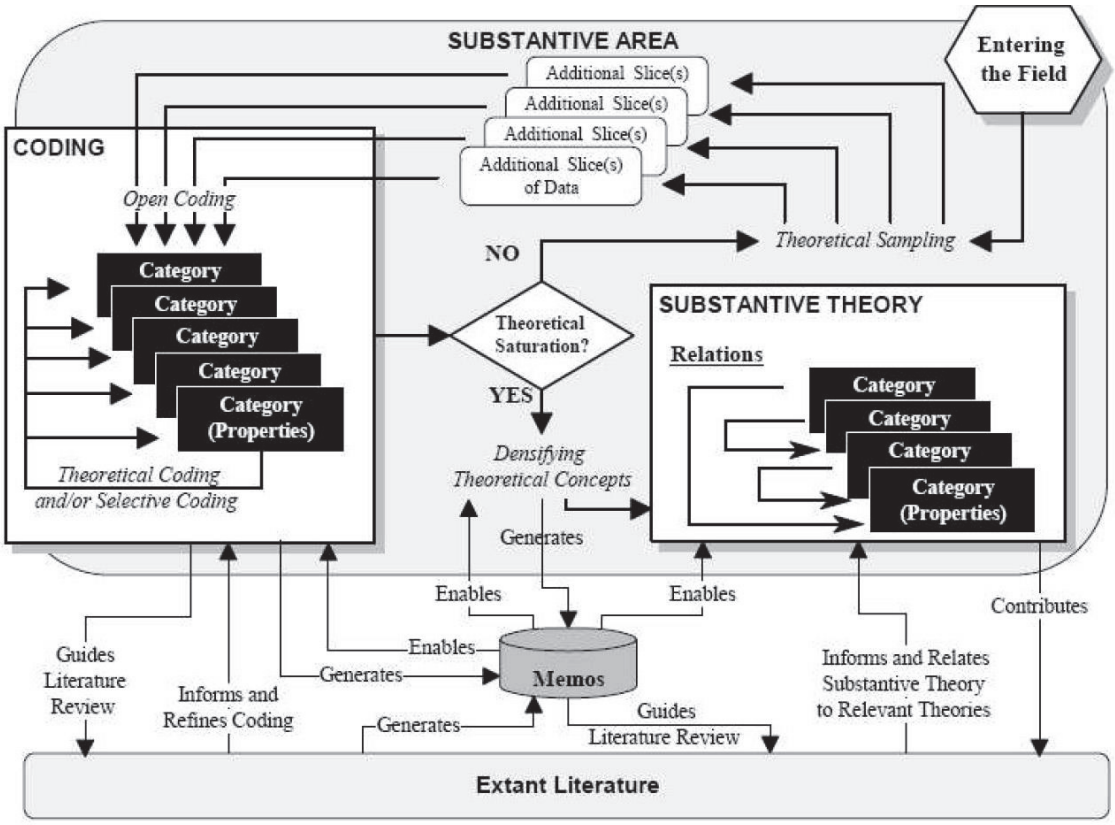


Figure 3.7 Grounded theory research model (Gregory, 2011) Adapted from (Fernández, 2004)

In contrast to quantitative approaches that simplify phenomena by breaking down constructs into variables, grounded theory embraces complexity by including context. Theories are not applied to subjects being studied, but emerge, or are discovered, from the empirical data themselves (Gray, 2009). A 'thick description' is produced to serve as a starting point of the general theory development process. Unlike many other research approaches, the data collection stage and the data analysis stage in grounded theory are not separable (Langdrige & Hagger-Johnson, 2009).

Grounded theory is suitable for studying the action and meaning of social interactions, but not for testing hypotheses (Gregory, 2011). It has been adopted to study diverse processes on an individual and social level. For example, typical psychological topics such as motivation, personal experience, emotions, identity, and interpersonal cooperation and conflict can be studied with this approach (Charmaz, 2008).

3.3.4. Design Science Research

As suggested earlier in Section 3.2.2., Design Science research has a pragmatic nature (Hevner, 2007) and places the focus on the creation of new knowledge through the design of new or innovative artefacts for solving problems or achieving improvements, and on analysis and evaluation of the use of such artefacts (Vaishnavi & Kuechler, 2004). It was developed to improve and understand the behaviour aspects of Information Systems research. The four iterative phases of the design science research methodology are: artefact design, construction, analysis and evaluation (Vaishnavi & Kuechler, 2004).

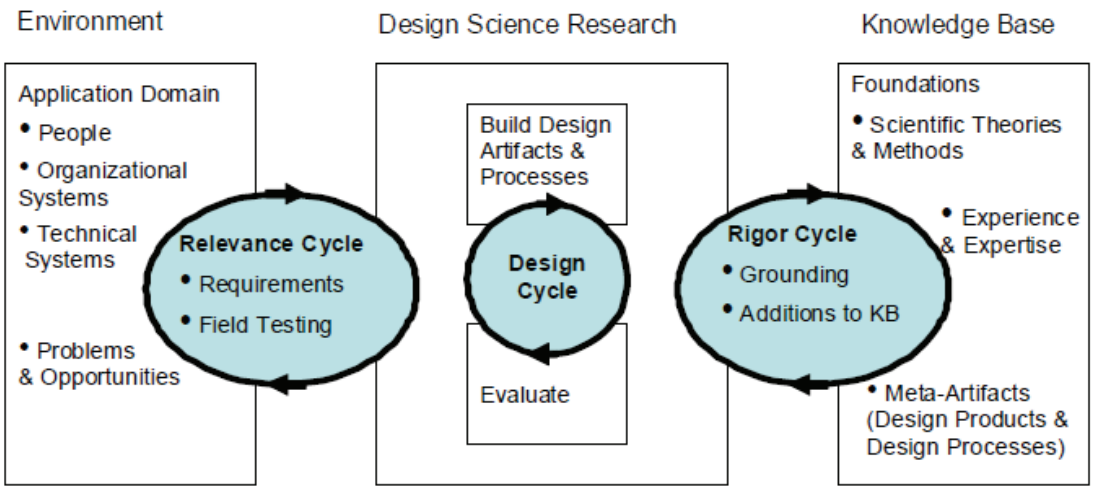


Figure 3.8 Design Science Research Cycles (Hevner, 2007)

Hevner (2007) posits the importance of three cycles in a design science research project, as illustrated in Figure 3.8. The Relevance Cycle takes in requirements from the contextual environment into the project. The Rigor Cycle connects the design science activities with grounding theories, methods and domain experience that inform the project, and relate the new knowledge generated to existing knowledge base. The central Design Cycle iterates between the construction and evaluation of design artefacts and processes of the research (Hevner, 2007).

A variety of approaches, methods and techniques are used in design science research, which has been adopted in many disciplines and fields, notably software engineering and computer science (Vaishnavi & Kuechler, 2004). Some researchers have advocated the use of qualitative methods for evaluating the research outcomes, as well as enhancing problem identification (Livari & Venable, 2009).

Although both Action Research and Design Science Research involve an iterative process of construction of solutions and artefact evaluation, they differ in terms of relationship between researcher and clients/ practitioners. Action Research assumes a joint collaboration between researcher(s) and specific practitioner(s), whereas Design Science Research aims to generalise their research findings for a generalised class of people after addressing specific problems of a specific client (Livari & Venable, 2009).

3.3.5. Reflection on the methodologies

To select the methodology for this research, the above four methodologies were compared in terms of their means to knowledge contribution, whether any artefact is constructed and evaluated, and their domains of use (Table 3.5).

Table 3.5 Comparison of different methodologies

	Contribution to knowledge	***Construction of artefact/ support?***	***Evaluation stage***	***Suitable domain of use***
Design Research Methodology (DRM)	Formulate and validate models/ theories about the phenomenon of design; develop and validate artefacts/ support founded on these models/ theories in the hope to improve design practice, management, education and their outcomes (Blessing & Chakrabarti, 2009)	It is optional. PS stage of the DRM emphasises the development of a vision of a 'support' that is likely to change the existing situation into a desired situation. Types of 'support' Include strategies, methodologies, procedures, methods, techniques, software tools, guidelines, workbooks, etc. (Blessing & Chakrabarti, 2009, p. 142)	Aims at obtaining generic statements about partial implementation (Blessing & Chakrabarti, 2009)	Design
Action Research (AR)	To generate living theories about how learning has improved practice and is informing new practices (McNiff & Whitehead, 2006, p. 13)	Yes (Often a programme or an approach)	Aims to gradually improve the support/ artefact for use in a specific situation until a full, optimised implementation is done (Blessing & Chakrabarti, 2009)	Education, esp. teaching
Grounded Theory (GT)	Generate theories about social phenomena (Gray, 2009; Gregory, 2011).	No	--	Many, including design

	Contribution to knowledge	***Construction of artefact/ support?***	***Evaluation stage***	***Suitable domain of use***
Design Science Research (DSR)	Create new knowledge through design of new artefacts (mostly algorithms, human/computer interfaces, etc.) for solving problems (Vaishnavi & Kuechler, 2004)	Yes (Mostly algorithms, human/computer interfaces)	Aims to generalise their research findings for a generalised class of people, after addressing specific problems of a specific client (Livari & Venable, 2009).	Information systems, computer science

The *Design Research Methodology (DRM)* is selected because it provides a systematic way to link the research questions together, and a range of research activities can be guided by this methodology:

- Understanding of a phenomenon and identifying a problem;
- Generalisation of a framework/ model/ theory;
- Design and development of a *support* that provides a vision of the desired situation;
- Evaluation of the proposed *support*;
- Obtaining generic statements to provide insights for future designs.

3.4. SELECTED RESEARCH METHODOLOGY

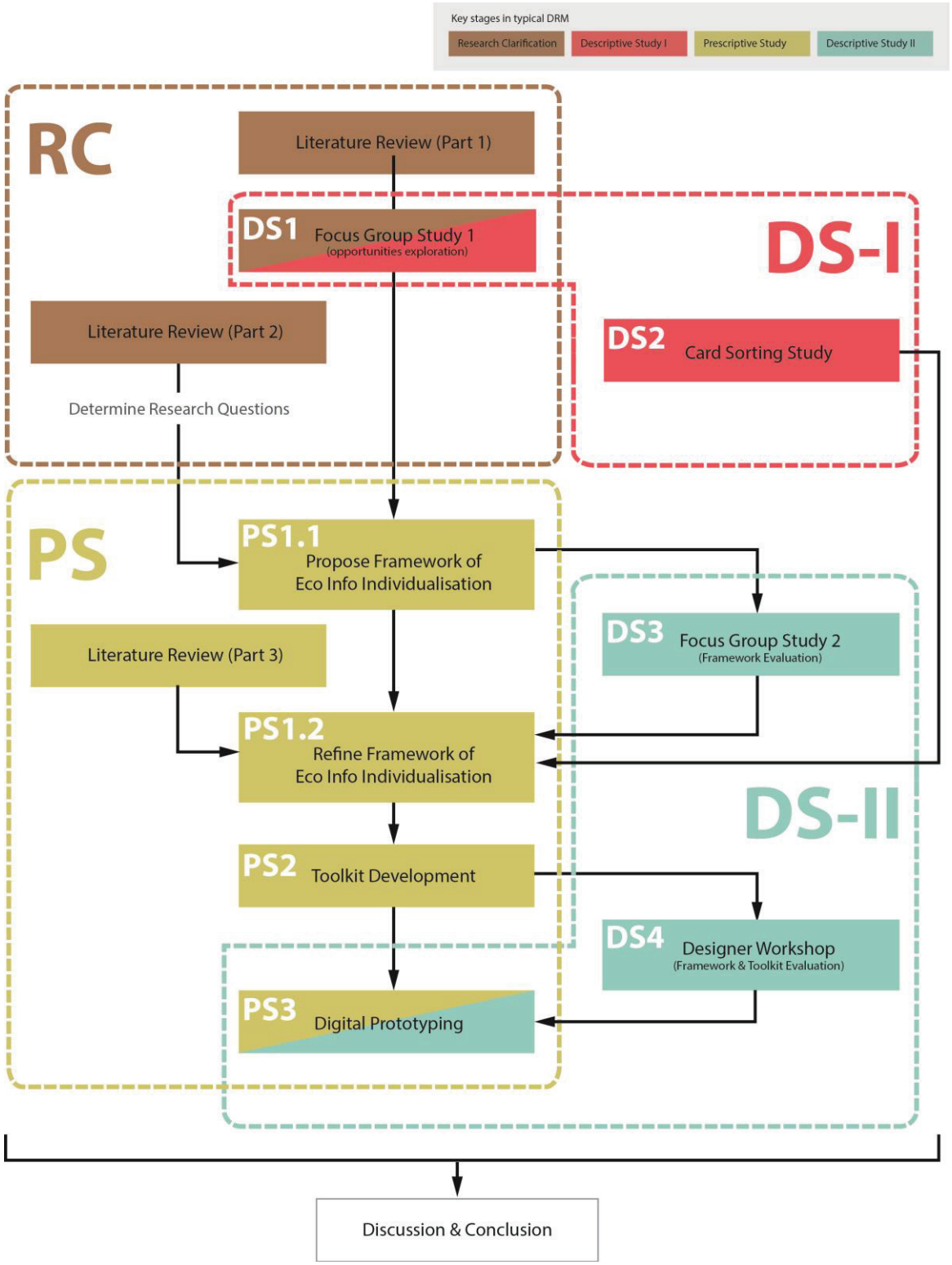


Figure 3.9 Research methodology framework

3.4.1. Research methodology framework

The methodological framework in Figure 3.9 outlines the main studies involved in this research project. Each coloured box represents a study or research activity. Four colours are used to indicate the four key stages in a typical DRM process – brown for Research Clarification (RC), red for DS-I, green for PS, and blue for DS-II. Boxes with two colours imply that they functioned for two stages.

The research clarification (RC) stage of this PhD project encompassed the review of literature, the surveys of existing eco information tools (which are reported in Chapter 2) and a focus group study (DS1) to explore user needs and the opportunities provided by enabling technologies. The focus group study (DS1) also provided descriptive results, together with the insights gained from the card sorting study (DS2), these two studies formed the DS-I stage of this research work. The prescriptive study stage consists of the creation of three outcomes, namely the conceptual framework (PS1), the design tool (PS2) and a digital prototype (PS3). Arrows in Figure 3.9 illustrate the process flow between these studies, but do not represent the chronological order of the studies. To evaluate the outcomes, another focus group study (DS3) was carried out to validate the conceptual framework, a designer workshop (DS4) was conducted to evaluate the design tool. The digital prototype (PS3) was created based on the design outputs generated from the designer workshop (DS4), and the prototyping process was in nature both generative and evaluative (as to evaluate the design process proposed for eco information individualisation).

3.4.2. Research Clarification (RC) stage

According to Blessing & Chakrabarti (2009), there are six steps in the RC stage (Figure 3.10).

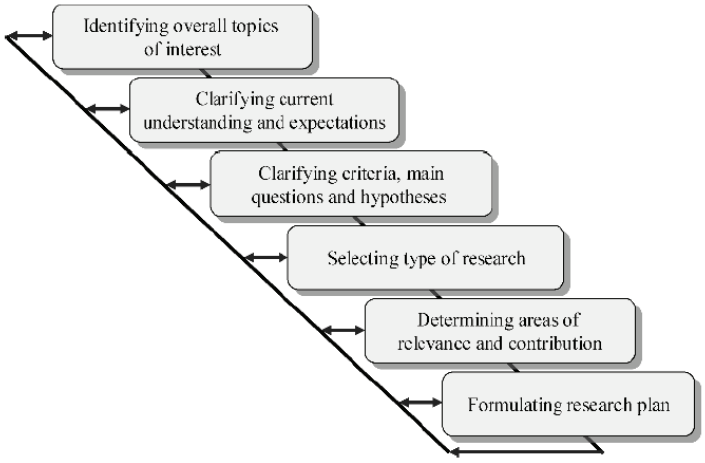


Figure 3.10 Main steps in the Research Clarification (RC) stage

Chapter 1, Chapter 2, Chapter 3 and Chapter 4 of this thesis form the Research Clarification (RC) stage. Chapter 1 identifies the overall topics of interest and determines the areas of relevance and contribution. Chapter 2 identifies gaps in the current literature related to the context of eco labelling, consumer behaviour and emerging contextual technologies. The reference model (Figure 2.13 in Chapter 2) represents the key factors related to consumer behaviour that influence success of the concept proposed in this thesis. Chapter 4 reports on an exploratory study that clarifies the needs for a novel eco information provision tool. This chapter (Chapter 3) explains the research plan formulated to address the main research questions of this research work:

Research question 1: *What are the user requirements for eco information design?*

Research question 2: *How to design eco information individualisation to support sustainable consumer behaviour?*

Research question 3: *How feasible is it to use a tool to support the design of eco information individualisation?*

The research questions will be addressed sequentially in the following chapters with a view to answer the **overarching research question** of this thesis:

How can we encourage sustainable consumer behaviour by providing individualised eco information at the point of purchase?

3.4.3. Descriptive Study I (DS-I) stage

The Descriptive Study-I (DS-I) stage helps to clarify the success criteria and implications for the support to be designed and developed in the PS stage. There are two types of DS-I:

i. A Review-based DS-I which covers Step 1 and Step 5 outlined in Figure 3.11
ii. A comprehensive DS-I which involves the five-step process (Figure 3.11) including literature review and one or more empirical studies. (Blessing & Chakrabarti, 2009):

The DS-I stage of this research consisted of two empirical studies, namely the focus group study 1 (DS1) and the card sorting study (DS2) which are reported in Chapter 4 and Chapter 6 respectively. The goal was to address *Research Question 1* by obtaining a deeper understanding of the user needs for eco information design. DS1 was a small scale study that explored the opportunities for influencing sustainable consumer behaviour with ubiquitous eco information proivision. DS2 intended to uncover a deeper understanding of user's perception towards information presented on existing eco labels.

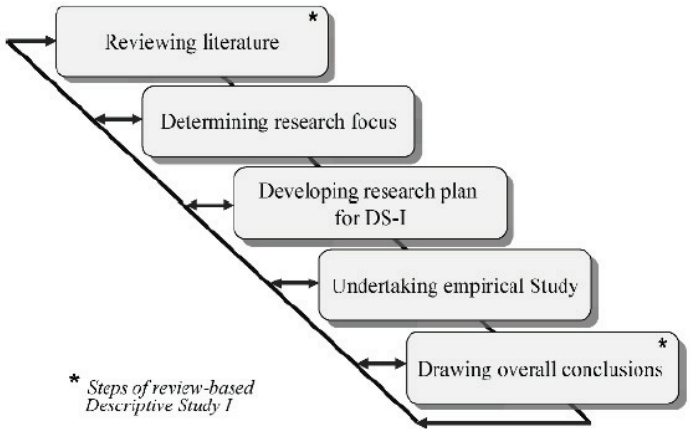


Figure 3.11 Main steps in a Comprehensive DS-I, stars (*) indicating the steps in a Review-based DS-I (Blessing & Chakrabarti, 2009)

3.4.4. Prescriptive Study (PS) stage

Traditional research approaches, such as positivist and interpretive research, are typically concerned with describing, understanding and explaining a phenomenon. Design research however can involve a distinct activity, i.e. the Prescriptive Study (PS) stage that is concerned with the purposeful development of *design support* (or its concept) to improve a situation. Figure 3.12 outlines the main steps involved in the PS stage.

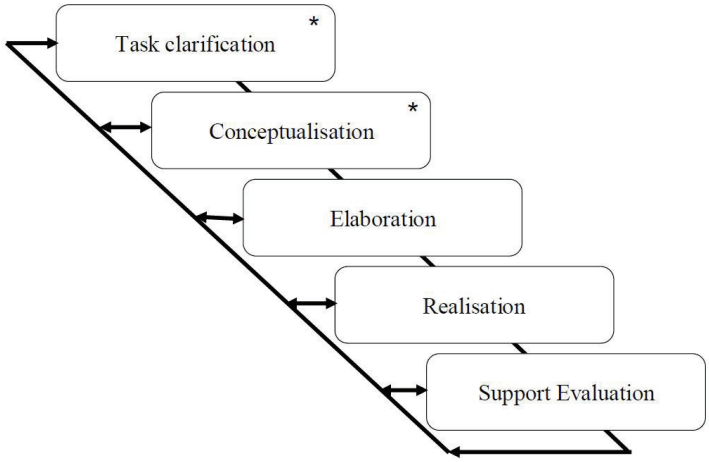


Figure 3.12 Main steps in the PS stage, stars (*) indicating the steps of an Initial PS (Blessing & Chakrabarti, 2009)

There are three prescriptive studies in this research. PS1 proposed a conceptual framework that illustrated the concept of information individualisation with specific emphasis in the context of eco labelling. The conceptual framework can be used to guide the design of eco information provision to individual users. The initial proposal of the conceptual framework (PS1.1) is presented in Chapter 5, and the framework was refined (PS1.2) as

reported in Chapter 7. PS2 developed a design tool that helped communicate the concept of eco information individualisation to designers and support their design process. This tool is an elaboration of the conceptual framework (See Chapter 7). PS3 generated a working digital protype of eco information individualisation in the form of an Android mobile phone application (see Chapter 9). Insights gained from these prescriptive studies correspond to *Research Question 2*.

3.4.5. Descriptive Study II (DS-II) stage

The objectives of the Descriptive Study-II (DS-II) are to evaluate application and impact of the proposed *support*, to identify necessary improvements and to evaluate the assumptions behind the current situation represented in the reference model (Blessing & Chakrabarti, 2009). The main stages of DS-II are described in Figure 3.13. The DS-II of this project has been completed to an initial stage as elucidated in Chapter 5, Chapter 8 and Chapter 9.

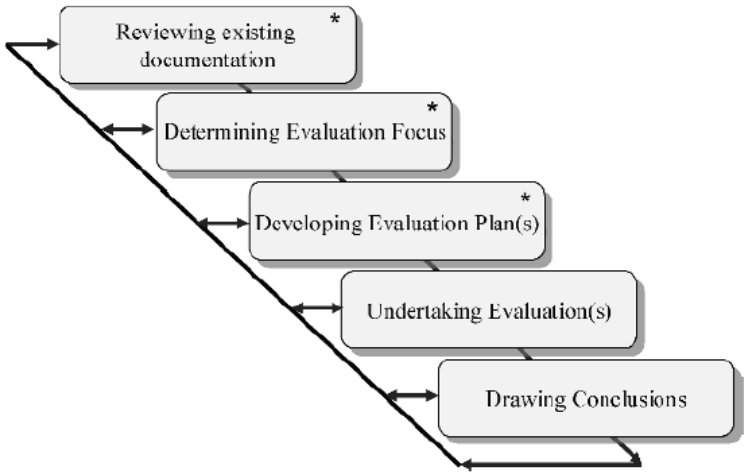


Figure 3.13 Main steps in the DS-II stage, stars (*) indicating the steps that start during PS to develop an Initial Evaluation Plan (Blessing & Chakrabarti, 2009)

Chapter 5 reports on a focus group study (DS3) that evaluated the conceptual framework. Chapter 8 reports on a workshop (DS4) during which the designers generated designs of eco information individualisation with the aid of the tool. The tool was evaluated based on the designers' responses to a questionnaire, and the observation of the design outputs and of the workshop. Chapter 9 reports on a prototyping activity (PS3) that built upon the design outputs generated from the design workshop (DS4). The lessons learnt from the workshop (DS4) and from the prototyping process (PS3) provided insights about the feasibility of supporting the design of eco information individualisation with the design tool. Therefore *Research Question 3* was addressed.

3.5. GENERAL RESEARCH METHODS

To ensure the selection of appropriate research methods, a range of methods used in design and human computer interaction research were reviewed. Some examples are discussed in the following.

3.5.1. Interview & focus group

The use of interviews to collect data has grown with the increasing popularity of qualitative research. It is a flexible method that enables detailed conversational data collection (Langdrige & Hagger-Johnson, 2009). The types of interview can range from structured to unstructured (or 'loose'). In a structured interview, every respondent receives the same set of questions. In an unstructured interview, a more 'conversational', flexible and informal approach is adopted, usually open-ended questions are asked to canvas richer, fuller and perhaps more genuine responses. However the unstructured approach may be challenged by the positivist perspective for lacking reliability and generalisability (Coolican, 2009).

The discussion on structured vs unstructured designs is highly related to the debate of quantitative vs qualitative research. A positivist view uses interviews as a tool to gather facts from respondents and try to discover and describe an objective reality using techniques to avoid sampling and procedural bias. Alternatively, a view which is common to qualitative approaches would consider the interviewer as a human participant and take into account the social interaction between the interviewer and the interviewees, who construct their unique reality in the interview session (Coolican, 2009).

While many interviews focus on one-to-one elicitation of information, focus groups are group interviews on a specific topic. It is especially useful to collect consensus opinion from several, ideally around five, people. Typically one to two moderators are involved to facilitate the discussion.

Focus groups can be used to gather raw data about user needs in the concept development phase of a design, and to clarify issues during the design. Focus groups can also be used to evaluate existing designs (Stanton, 2005). The questions and structure of the focus group should follow the same careful planning as questionnaires. The questions can be closed, open-ended or probing questions (Blessing & Chakrabarti, 2009). The six types of topics that can be questioned in particular in interviews are ‘experience/ behaviour’, ‘opinion/ belief’, ‘feeling’, ‘knowledge’, ‘sensory’ (what you see, etc., used to find out the

stimuli that interviewee is subject to) and 'background & demographic'. (Blessing & Chakrabarti, 2009; Patton, 2002).

Interview/ focus group was used as a data collection technique in various stages of this research. Details of the studies are reported in Chapter 4, Chapter 5, and Chapter 6.

3.5.2. Self-report methods: Experience sampling & Diary studies

Self-report methods such as experience sampling and diary studies provide the means for self-reflection, which is a critical medium for studying patterns of individual behaviours.

Both methods are considered the gold standard of in-situ data collection, which aim at understanding people's intent and behaviours right at the moment when they occur. In experience sampling studies, participants respond to surveys that are signalled by the system either at random or pre-established intervals, while diary studies allow the participants to decide when and what to report (Gouveia & Karapanos, 2013). As opposed to answering predefined questions about events (feedback studies), in another form of diary studies, participants are asked to capture media which are used as prompts to aid interviews later (elicitation studies) (Carter & Mankoff, 2005).

A drawback to these methods is that they are often disruptive to participants' daily activities. They also suffer from a lack of realism, since the researcher often does not know all contextual details of the experiences in question (Gouveia & Karapanos, 2013). Besides, in certain circumstances self-report methods were demonstrated to be biased (A. Doherty, Kelly, & Foster, 2013).

3.5.3. Wearable camera: first person perspective data collection

Studying everyday experiences from a 'first-person perspective' has been made possible with the arrival of wearable technologies for capturing images and videos (A. R. Doherty, Moulin, & Smeaton, 2011; Gouveia & Karapanos, 2013; O'Hara, Tuffield, & Shadbolt, 2009; O'Loughlin et al., 2013). *Autographer* (Hoyle, Templeman, Armes, Anthony, & Crandall, 2014) is an example of a wearable camera that opened up research opportunities to answer questions about individual behaviour. The camera captures images and five sensor data (ambient light, accelerometer, magnetometer, PIR, temperature) automatically when switched on. Such rich media capturing technology could help to avoid retrospection and rationalization biases that are known in self-report methods. It lowers the risk of missing key experiences, and it places reduced burden on participants in terms of recording data about

their own behaviour as the system captures data continuously with minimum intervention from the user (Gouveia & Karapanos, 2013; Kefalidou et al., 2014; Shipp, Skatova, Blum, & Brown, 2014).

During this PhD, a pilot study was designed with the objectives to collect data about people's everyday purchasing behaviour and related environmental attitudes as well as to investigate the feasibility and practicality of extending and/or complimenting existing experience sampling methods with a wearable camera. However, numerous ethical issues and potential risks were uncovered, pointing to the need of considering alternative low risk study designs. Details about this study design and related ethical challenges are published in the position paper titled *'The Ethical Challenges of Experience Sampling Using Wearable Cameras'* (Kwok, Skatova, Shipp, & Crabtree, 2015).

3.5.4. Card sorting

Card sorting is a powerful and flexible participatory design method to understand how people categorise, perceive and describe different groups of information. It has a long history in social research. Nowadays its most common use to explore and generate ideas is for information architecture (AI) projects, and to evaluate categories to maximise the chances of enabling users to seek the information they need (Martin & Hanington, 2012). Despite the generative nature of card sorting, Spencer (2009) stresses that this is more a tool that helps us to understand users than a collaborative method for creating information navigation.

A typical card sort uses 30 to 100 cards, in some cases over 200 cards were used (Martin & Hanington, 2012; Spencer, 2004, 2009). There are several ways to run a card sort, including i) open sort vs closed sort; ii) in-person vs remote and iii) individual vs team sorts. The appropriate number of participants and sorts depends on the study goals as well as the methods of analysis. Both qualitative and quantitative approaches can be used (Spencer, 2009).

For this research work, a card sorting study was carried out to understand how people perceive, describe and categorise existing eco labels. The method of card sorting and the study are discussed in more detail in Chapter 6.

3.5.5. Prototyping: paper prototype and digital prototype

Prototyping is a generative process that creates a representative model or simulation of a system. It has the power to show and explain more complex systems, and provides the

experience that cannot be provided by a requirement document or wireframe. Prototyping also has these other potential benefits:

- Reducing misinterpretation;
- Saving time, effort and money;
- Providing real-world value;
- Exploring what is feasible or marketable (Warfel, 2009).

Table 3.6 shows results of a survey conducted in 2008 on the most common types of prototypes that the user experience (UX) comminity were building (Warfel, 2009).

Table 3.6 Survey results of common types of prototypes built in the UX community (Warfel, 2009)

Paper	81.0%
Hand-coded HTML	58.0%
Auto-generated (Axure, iRise, Visio, Fireworks, or similar)	39.0%
Clickable screenshots using HTML	34.0%
Flash, Flex, AIR, or Blend	27.0%
Keynote or PowerPoint	24.0%
Clickable PDFs	21.0%
Production environments (Rails, Java, .Net, PHP, Xcode)	9.0%
3D models (cardboard, foam core)	2.0%

Warfel (2009) suggests there are eleven top influencers that drive tool choice for prototyping (in order of importance):

i. Familiarity and availability
ii. Time and effort to produce a working prototype
iii. Creating usable prototype for testing
iv. Price
v. Learning curve
vi. Ability to create own GUI (Graphical User Interface) widgets
vii. Available on my platform
viii. Collaborative/ remote design capabilities
ix. Built-in solutions/ patterns for AJAX transitions

x. Built-in GUI widgets

xi. Creating usable source code

Prototypes can vary on the sliding scale from hi-level fidelity to lo-level fidelity. The design outputs created by designers in the design workshop reported in Chapter 8 are closer in resemblance to low-level fidelity prototypes, and the digital prototype reported in Chapter 9 is relatively high in fidelity.

3.5.6. Design workshop

Workshop is a form of more structured, guided meeting (RSSB, 2008, p. 175). Design workshops are a form of participatory design session that generally involve several activities, planned and facilitated by design team facilitators. For instance, a workshop may begin with an introductory presentation, followed by group discussions and creative expressions such as brainstorming, mapping, collages or drawings. The workshop may provide simple design tools to enable participants to create mock-ups, sketches and storyboards, etc. (Martin & Hanington, 2012)

Workshops can be labour intensive to organize and deliver, but they allow collection of a wealth of insights. The design workshop method is commonly used in generative research where participants ideate and verify design direction, individually or in groups, in response to a design problem or brief. Workshops can also be used for evaluatory purpose, where participants are asked to review concepts, offer feedback and contribute insights for design iteration and improvement (Martin & Hanington, 2012)

Chapter 8 of this thesis reports on a design workshop which involved both generative and evaluative activities. The participants were asked to generate individualised eco label designs with the aid of the Eco Information Individualisation design tool , and to evaluate the tool by responding to a questionnaire survey at the end of the session.

3.6. SELECTED RESEARCH METHODS

This chapter discusses a range of research approaches and has outlined the research paradigm, methodology and research methods adopted in this research project. Table 3.7 summarises the methods used at each stage of this project as underpinned by the DRM methodology, the outcomes and where these are evidenced in this thesis.

Table 3.7 Summary of research methods applied

DRM stage	Study/ Method(s)	Outcomes	Related chapter
RC	Literature review	Research questions formulated.	Ch 2
RC	Survey of existing eco information tools	Surveys of web based & mobile eco calculators and map of eco labels.	Ch 2
RC & DS-I	Focus group study 1 (DS1)	Better understanding of user needs for a ubiquitous eco information device.	Ch 4
DS-I	Card sorting (DS2)	Better understanding of user perception towards existing eco labels. Possible eco information classification scheme identified.	Ch 6
PS	Proposal of eco information individualisation (PS1)	Conceptual framework developed.	Ch 5, Ch 7
DS-II	Focus group study 2 (DS3)	Tentative validation of the conceptual framework.	Ch 5
PS	Development of design tool (PS2)	Design tool developed.	Ch 7
PS-II	Designer workshop (DS4)	Tool evaluation. Label designs generated by designers.	Ch 8
PS & DS-II	Digital prototyping (PS3)	Working prototype (mobile app) to demonstrate eco information individualisation.	Ch 9

All studies were approved by the ethics committee of Brunel University. Information sheets about the studies were distributed to all participants before the studies. All participants signed and returned the informed consent forms before any study commenced.

Chapter 4
Exploring the needs for a ubiquitous eco information device

4.1. INTRODUCTION TO FOCUS GROUP STUDY 1

This chapter reports on a focus group study (DS1) that explored the opportunities provided by technologies in encouraging sustainable consumer behaviour at the point of purchase. The aim of the focus group study was to canvas people's views on ubiquitous eco information provision and to understand their needs and expectations for a ubiquitous eco-feedback device. The focus group was conducted in the early phase of this research. The findings from this exploratory study informed the clarification of the research direction that later focused on improving eco information provision via product labels. The results of this study were published in the peer-reviewed conference *Sustainable Innovation 2013* (Kwok et al., 2013).

The discussion was set to revolve around the use of a ubiquitous eco-feedback device that enabled augmented reality (AR) in a clothing store. This particular scenario was chosen to make the discussion more concrete and focused. Clothing purchasing behaviour is an interesting example because it significantly affects environmental quality and is an under-explored area in sustainable behaviour research. In terms of carbon emissions, 'clothing and footwear' is one of the most important categories on high level consumer needs account, causing 9.6% of total emissions on this account (Jackson, Papathanasopoulou, Bradley, & Druckman, 2006). 'Purchasing' and 'end-of-life' are the two stages where consumer behaviour largely determines the environmental impact associated with products, whereas changing purchasing behaviour generally has greater environmental benefit than reusing or recycling available products (Gardner & Stern, 2002). Clothing was also a relatively representative topic because the price and the life span of a typical clothing product lie in the middle of the spectrum of products. It is generally more expensive and longer lasting than groceries (therefore involves more serious consideration of its environmental performance),

but the commitment in buying clothing products is more moderate than purchasing some extreme products such as expensive electronic products or motor vehicles.

4.2. METHOD

4.2.1. Participants

In all, 18 participants (11 male, 7 female) attended the study (including the pilot group). The data were coded and analysed after each focus group. This sample size was deemed enough when thematic saturation occurred, at that point no new data was added and the category was considered adequately explained.

Six of the participants in the first regular focus group were design researchers, who were considered to have a deeper understanding of user needs and information design. The six participants in the second regular focus group were engineers and computer scientists and represent the population with higher technological awareness. A table of participant demographics for this study is included in Appendix 4.

Figure 4.1 Photos of the two regular focus groups

4.2.2. Procedures

Totally three semi-structured focus groups took place in Brunel University London and the University of Nottingham in July and August of 2013. The pilot focus group was used as a pilot test of the script questions. The questions asked were the same in all three groups. Results from the pilot focus group are included in this report.

All discussions featured several open ended questions (Table 4.1) and two rounds of sketching activities. The participants were asked to sketch desirable features for an eco-information device, first on their own, then working in small groups of 3-4 people and then to

present their ideas as a group. Totally there were five small group presentations. Each focus group interview lasted for 90 minutes.

Table 4.1 Questions asked in the focus group study

	Topic /Question
1	Their feelings towards a wearable device, like *Google Glass* or smartphone, which 1. displays eco-information 2. captures data about their interaction at the points of purchase, e.g. i) when they pay, the camera will automatically take a photo of that moment; ii) or the product info (tagged/ sensor/ QR codes) will be saved in their personal history (private, or disclosed in Facebook) Will they feel comfortable wearing it?
2	Their feelings/ perceptions towards different formats of eco information, for example: 1. (Detail) Text, e.g. Description of all environmental properties, e.g. carbon footprint, certificate, breakdown of environmental impact, material… 2. Number, e.g. UK carbon footprint logo 3. Histogram / chart, e.g. Energy labels, traffic light rating labels 4. Image/ Photo, e.g. Photo of raw material origin, or manufacturing environment
3	Their reaction towards this eco-information displayed in real time and in context. Would their behaviour be influenced? If they think their behaviour would be changed, is the decision-making driven by rational or emotional factors?

4.2.3. Analysis

All discussions were recorded by a Dictaphone and transcribed using the software MS Excel. The focus group data were analysed via a qualitative analysis technique called 'constant comparison analysis' (Onwuegbuzie, 2009). The data were chunked into small units and coded. The codes and associated 'texts' were grouped into categories. Emerging themes were identified. One coder (the author of this thesis) was involved. The coding was crosschecked by two independent researchers. The transcripts and code definitions are presented in Appendix 5, and provide a foundation for assessment of credibility and dependability.

4.3. RESULTS

4.3.1. Outcome 1: People's views on wearable AR eco-feedback device

To provide the participants with a background of the research, Google Glass (Google Developers, 2016) was used as an example to illustrate what a ubiquitous augmented reality device looks like.

The participants were asked to comment on how comfortable they would be wearing a ubiquitous augmented reality eco-feedback device ('the device'). Responses to this question varied, some felt comfortable wearing it, some did not.

Their worries are summarised into five types:

- *Privacy*: Much discussion was spent debating whether user privacy can be protected technically and practically. All participants thought it is a critical issue and would only wear the device if their privacy were guaranteed. If the device may capture personal data passively, all participants wanted to have control on how the data is saved, used and shared.
- *Intrusive information*: When assuming the device is a head-mounted visual display (glasses), information constantly displayed in vision is considered to be intrusive. Participants were worried about information overload.
- *Physical burden*: Several participants were concerned about the size and weight of the device. Some were worried that the visual display would stress their eyes and even cause pain.
- *Appearance*: Several participants expressed concern about their appearance when wearing the device, they would not wear the device if it looks ugly.
- *Rules of etiquette*: Participants questioned about hidden rules in using the device in different settings, for example, whether the device is allowed in restaurants, how public would react to the device, would it look awkward talking to the device in public (if that is the way to control it). One participant said his decision about wearing the device or not depends on the reactions of other people. He did not want to attract confrontation nor become unwelcome, but he would wear the device if many people wear it.

A feature of the proposed device was providing personalised eco-information. Participants were asked about their acceptance of a device that captures personal data (e.g.

local detection, photo taking at the point of purchase) automatically. Generally participants accept the idea of automatic data capturing on these conditions:

- They can turn off the data capturing function if they want
- The data will be kept confidential and within control
- The information captured is limited and 'reasonable', for example, recording shopping history is acceptable, but recording body shape of user is not.

Another crucial feature of the proposed device was displaying eco-information using augmented reality. With a few exceptions, all participants responded positively to such function.

4.3.2. Outcome 2: Preferred eco-information and functions

The second topic discussed was to canvas participants' ideas on the device function, features, and information to be displayed. Some visual materials were used to support discussion and aid imagination, such as photos of a clothing shop and examples of eco-information. All five small groups presented their ideas illustrated with sketches (Figure 4.1). Their comments are summarised below.

Three working modes:

i. Whole scene mode. When the user walks into a shop and sees a variety of products in front of him, the device overlays a simple label on multiple products. For example, if the user is looking for clothes made of organic material, small labels will be tagged to these clothes. In other words, the device can provide a 'filter function' to speed up the selection process.
ii. Single item mode. When a single item is picked and looked at by the user, more detailed information is shown.
iii. Comparison mode. The device allows comparison of two or more products, and suggests alternative products upon user defined selection criterion, for example: price, material, carbon footprint.

Two major functions:

i. Simplified indicating labels. This simplified information shown with augmented labels or tags is especially useful in whole scene mode. Comments suggested the labels to be displayed in different colours, acting similarly as a traffic light rating system, and be customisable by users.

ii. Expandable interface. Most participants expressed that detailed information should only become available upon user's request. A small label can be embedded in the product using a QR code or a sensor tag (such as RfID or NFC). The interface can be expanded when the user wants to learn detailed information about a product. An interesting idea was displaying a product timeline showing eco information associated to each stage of its life cycle, from material to the end-of-life.

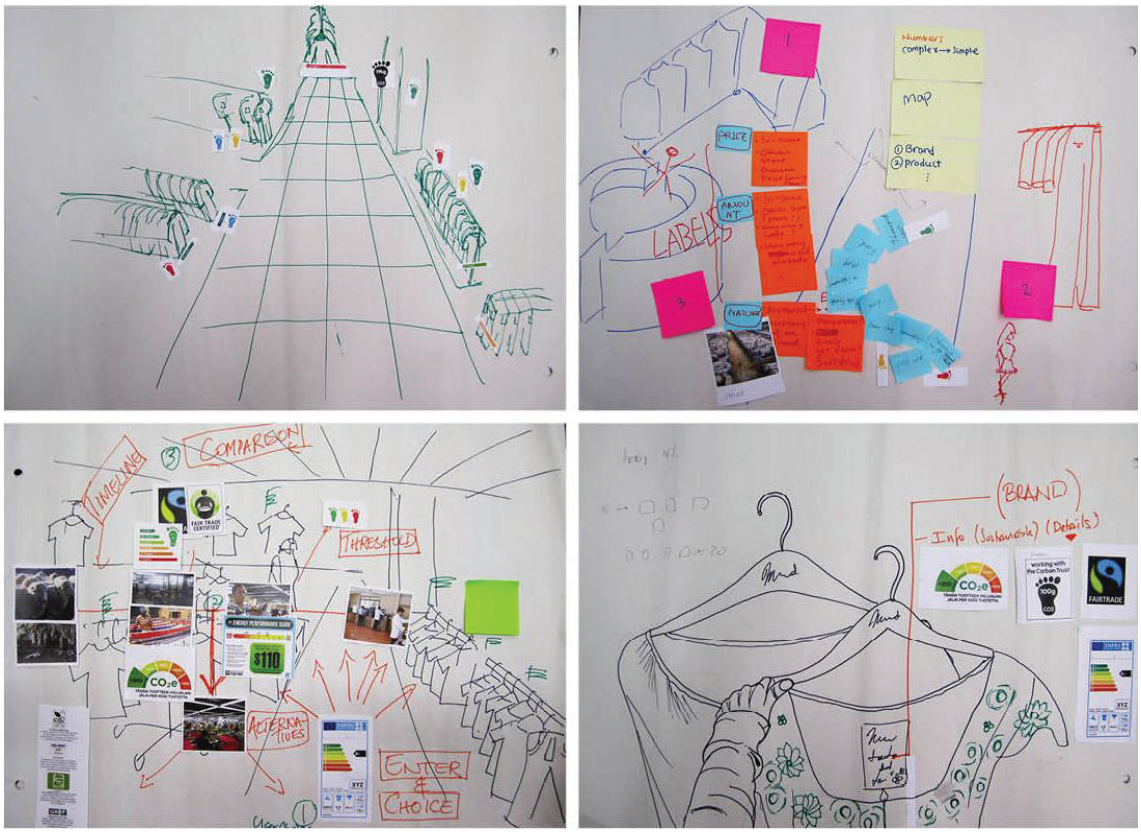


Figure 4.2 A selection of participants' sketches of ideas

Responses about the types of information to be displayed by the device are diverse and creative. The information types suggested include: price, health and safety factors, size, colour, carbon footprint, material, cruelty free, traffic light rating system (level of eco-friendliness), suggestions for product disposal (e.g. recycling method), map of eco friendly store, communication with friends, information about restaurant and transport. Some suggestions are not directly relevant to sustainability, but are listed here, because insights for design of eco-information may be gained from understanding user's needs inclusively.

Different perspectives were revealed from questioning whether one would be interested in learning certain information, such as the ethics of the material production and the manufacturing process. A thought-provoking example was an image showing the living

condition of a sheep whose wool was used to make fabric. Some participants claimed they were not interested in the well-being of animals used for material production. In contrast, some participants showed concerns about ethics in animals and humans behind the product production. One comment states "*the image of endangered species has a strong emotional appeal, after seeing such image people may prefer artificial fabric than leather from endangered species*". Most participants, however, expressed scepticism about the reliability of images, because companies would prevent disclosure of information that discourages sales. Participants expressed worries about having impartial information and being manipulated by companies, especially when images are more prone to bias. For example, a sheep may be badly caged for years and live in a nice farm at other times, but only the best moment of its life would be photographed.

Participants also commented on five formats of information to be displayed by the eco-feedback device, and voted for their favourite format (see Table 4.2). They could vote for more than one choice. Indicating eco-feedback using a traffic light rating system was the most preferred information format.

Table 4.2 Responses towards different formats of eco-information

Type of format	Example	Votes	Responses
Numerical figure	Carbon footprint label (display of numerical figure)	3	*"It is more objective and trust worthy."* *"Number does not work."* *"Traffic light rating system is easier to understand than number. But it depends on the person's level of environmental literacy."*
Colourful traffic light rating system or histogram	Colourful logos and energy label	18	*"Histogram and traffic light rating system are more objective."* *"Graphical information is clearer than text."* *"Information must be simplified."* *"BBC water consumption chart illustrates the data with infographics and icons, which is easier to understand."*
Image	Image of sheep in farm	4	*"Image can be powerful."* *"Image will have a strong emotional appeal."* *"Information may be impartial and misleading."*
Detail text description	Eco label of shoes (display of sustainability facts in texts)	3	*"If it is just text, people will turn the feature off, no one will want to read."* *"It is complicated and too much to read."* *"I can read detail information which will cover 100% of the screen or my vision (if the device is a pair of glasses)."*
Video	Video of production processes	0	*"I don't have time to watch a 10 seconds long video."* *"It depends on the product, if it is an important purchase, such as buying a car, I will spare time to watch the video."*

4.3.3. Outcome 3: Potential of behaviour change

Several participants mentioned sustainability as one factor for consideration when purchasing clothing, although their prime concerns are often price and quality. If it was within budget, they were willing to pay more for eco-friendly products.

It was generally agreed that the availability of more eco-information could change people's perspective and impact decision-making. Nowadays price is usually the main information people have, which largely dominates their decision-making process. If there exists more information, people would consider other factors and perhaps have different purchasing preferences. Once eco-information is available, it may become standard that people always expect to see it.

All participants agreed that the user should have the freedom to choose whether or not to see the eco-information.

4.4. REFLECTIONS

An exploratory focus group study was conducted in the early stage of this PhD project for research clarification (RC). The study explored the opportunities for a new ubiquitous eco-feedback device which aids decision-making for more environmentally beneficial behaviour. The participants discussed their needs, expectations and concerns related to an imagined eco-feedback device at the point of purchase in a clothing shopping scenario. Insights and implications for the design were drawn from the study results, and have informed the development of this PhD research which later focused on improving the practice of eco labelling using contextual technologies.

Chapter 5
Proposing the concept of eco information individualisation

5.1. INTRODUCTION

The previous chapter reports on a focus group study (DS1) that suggests, despite some worries about privacy and other risks, some people felt positive about the idea of an augmented reality display that could provide adaptive eco information at the point of purchase. The device ideas the participants envisioned resembled eco labelling enabled by ubiquitous technology. This finding led to further review of literature covering the topics of:

- The development of eco labelling in relation to consumer behaviour;
- Theoretical and technological development of contextual technology and contextual information.

The findings of this literature review are reported in Section 2.3 and Section 2.5 in Chapter 2. Chapter 5 proposes a conceptual framework of eco information individualisation that was built upon the insights gained from literature, the surveys of existing eco information provision tools (Section 2.4 in Chapter 2) and the findings from the focus group study (DS1) with regard to people's expectations and needs. This conceptual framework aims to guide future designs of a novel contextual individualised information system. Two example application scenarios are included to exemplify the concept.

To evaluate the value of the proposed conceptual framework, a second focus group study (DS4) was conducted to collect opinions from designers, who are the target users of the conceptual framework. The results of this study were published in the peer-reviewed conference, *19th DMI: Academic Design Management Conference* (Kwok, Harrison, & Qin, 2014).

5.2. PROPOSING THE CONCEPTUAL FRAMEWORK

5.2.1. The concept

Considering insights from the Design for Sustainable Behaviour (DfSB) and Human Computer Interaction (HCI) research, it is believed contextual technology can enable a powerful solution for supporting individual behaviour (Kwok et al., 2013). The conceptual framework proposed here aims to provide a systematic methodology that facilitates the design process of an information individualisation system.

In this system, both product and user act as data carriers. Since contextual technology permits the ubiquitous capture, storage and retrieval of a large amount of contextual data, not only can a person keep a personal profile, history, status, preference and social life ('personal data'), a product can also have a traceable record and a 'life record' ('product data') that can be comprehended.

Using enabling technologies, such as mobile computing, the Internet-of-Things and augmented reality, with appropriate information software, pervasive interaction between product and user can be realised. The product data library can be seen as a matrix containing tremendous amounts of product related information. The personal data can be seen as a vector, which extracts a row of values from the matrix after multiplication. The extracted values equal to information individualised to the user's interests. As such, a product can be intelligent enough to approach and appeal to a user in need, and provide tailored assistance.

On a 'product-user interaction' level, the availability of the 'personal data' can enable calculations based on actual user behaviour, so the user can get information that is more accurate and more actionable. On a network level, the 'Internet-of-Things-and-People' can empower a wide range of opportunities for collective decision-making and collective planned action (Figure 5.1).

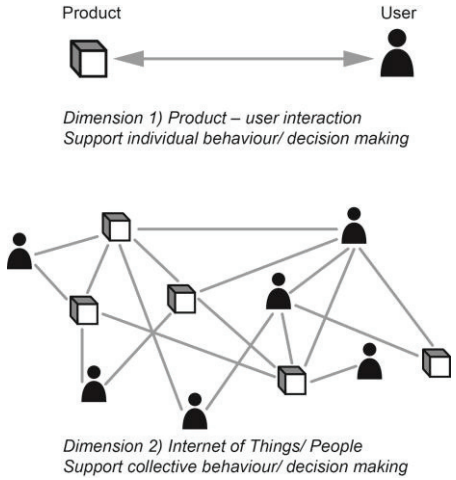


Figure 5.1 System concept (above) Product and user interaction. (below) Multiplying the dimension of interaction constructs an Internet of Things and People.

5.2.2. The initial conceptual framework

The conceptual framework presented in Figure 5.2 describes the five components required for the proposed system. Using eco labelling as an example application, Table 5.1 describes suggestions for the information architecture for personal data and product data, as well as giving a list of technology choices to be employed. Different technologies are suitable for different applications; the actual system design thereby varies.

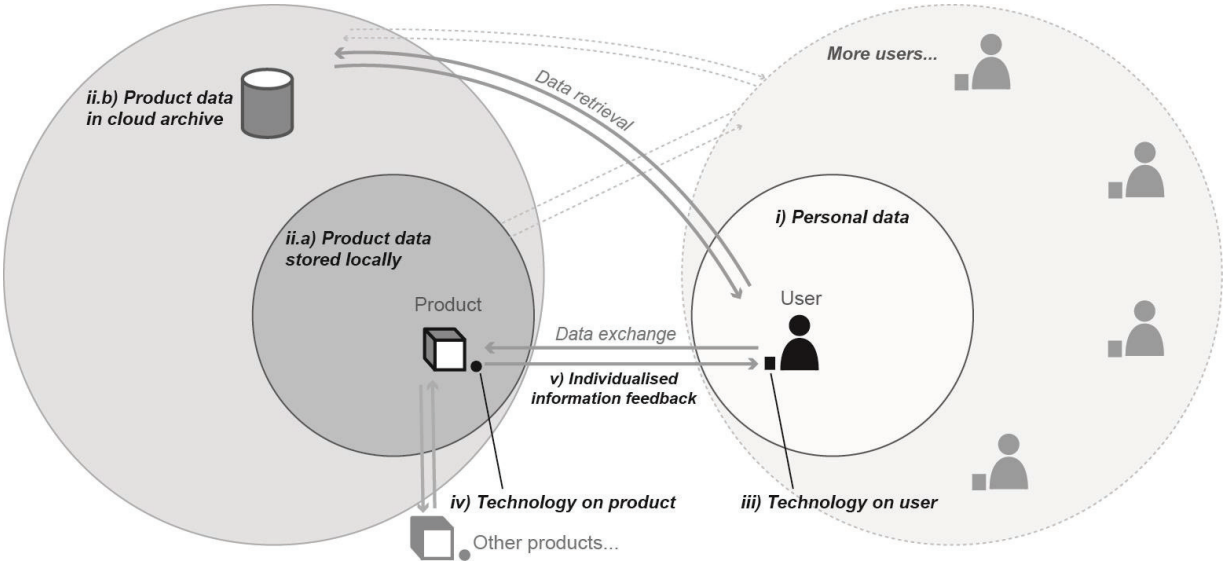


Figure 5.2 Components of individualised information system

Table 5.1 Description of components for an individualised eco labelling system

Components	Information/ technology
1) Personal data	User profile: age, gender, size… History and habit: shopping record, frequency of laundry, frequency of grocery shopping… Status: location, time, weather, task to do, budget… Preference and need: motivation for environmental behaviour, information presentation preference, personal goal… Social: social circle (family, friends…), activities record with social circle…
2) Product data	Can be stored a) locally and b) in cloud archive. Archive: database storing all information about products Product type: storing information for each product type (e.g. Brand A Fresh Milk 2 Pint) Product life: storing record of each individual batch/ piece of product (e.g. a specific bottle of milk produced on a specific date from a specific producer) Information can be categorised in terms of content and format/medium. Content can be divided into four groups: i) Life cycle assessment (LCA) (e.g. material, manufacturing, transport, usage, disposal) and corresponding footprint (e.g. carbon footprint, energy efficiency, embedded energy, water footprint) ii) Certificates (e.g. fairtrade, organic, cruelty free) iii) Instructions (e.g. recyclability, care instruction, suggested usage) iv) Other purchasing considerations (e.g. price, colour, size, quantity, material, place of production, material sources) v) Traceable record of actual product (e.g. location of specific product, history of usage, interaction history with other product or user) Format/ medium can be number, text, chart, infographic, photo, video… or a combination of the above.
3) Technology on user	Choices include ubiquitous computing, GPS, sensors (e.g. camera, accelerometer, proximity, touch, light...etc.), display (e.g. screen, head mounted display, projector), wireless signal transmission (e.g. Bluetooth, Wifi, infrared).
4) Technology on product	Choices include GPS, tags (e.g. QR code, RfID, NFC), digital memory, wireless signal transmission (e.g. Bluetooth, Wifi, infrared), tag sensor and tag writer (e.g. RfID writer).
5) Individualised information feedback	Tailored label based on user's preferred content and format.

5.2.3. Example scenarios of application

Two application scenarios are described below to illustrate how an individualised eco labelling system works in relation to the proposed conceptual framework. Scenario 1 shows an example where two users see different individualised labels when looking at the same shirt (Figure 5.3), and Scenario 2 illustrates an Internet-of-Things example (Figure 5.4). Table 5.2 and Table 5.3 provide descriptions of the components needed for generating individualised eco labels in the two example scenarios respectively.

Scenario 1: Clothing purchasing

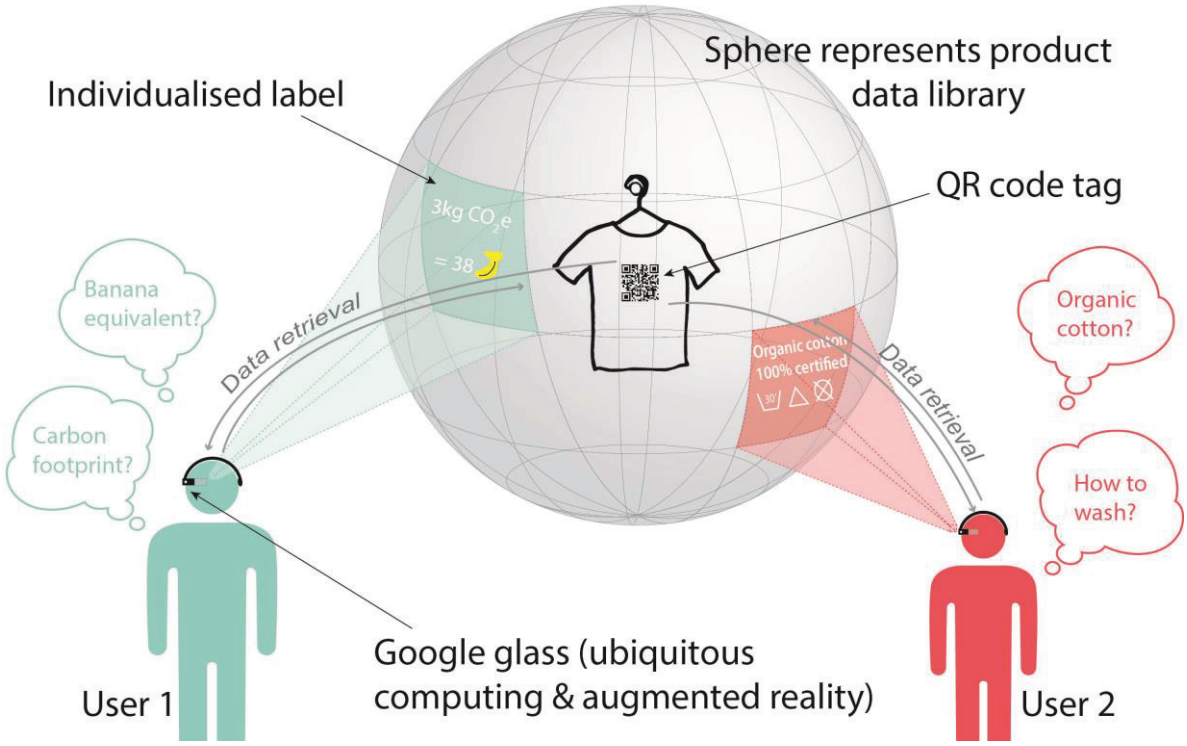


Figure 5.3 Individualised eco labelling in a clothing purchasing scenario

Table 5.2 Components of an eco-labelling system for the clothing shopping scenario

Components	Information/ technology
1) Personal data	Personal preference of information content and formats. For example, user1 wants to learn about the carbon footprint value of the t-shirt, and wants to see the information displayed in the format of infographic in relation to bananas, a unit which he is familiar with; user2 cares about the material used (whether it is made of organic cotton) and how to wash the t-shirt.
2) Product data	All information about this type of t-shirt (product type) and this specific piece of t-shirt (product life) is stored remotely on a cloud archive, which the QR code links to.
3) Technology on user	Google Glass (ubiquitous computing + augmented reality display), internet connection
4) Technology on product	QR code printed on a tag
5) Individualised information feedback	Two users see different labels according to their needs and preference. User 1 sees the carbon footprint of producing a t-shirt, and the representation of that in terms of 'number of banana' (infographic format). User 2 sees an organic cotton label (certificate information) and clothing care tips (instruction information).

Scenario 2: Bottled milk shopping

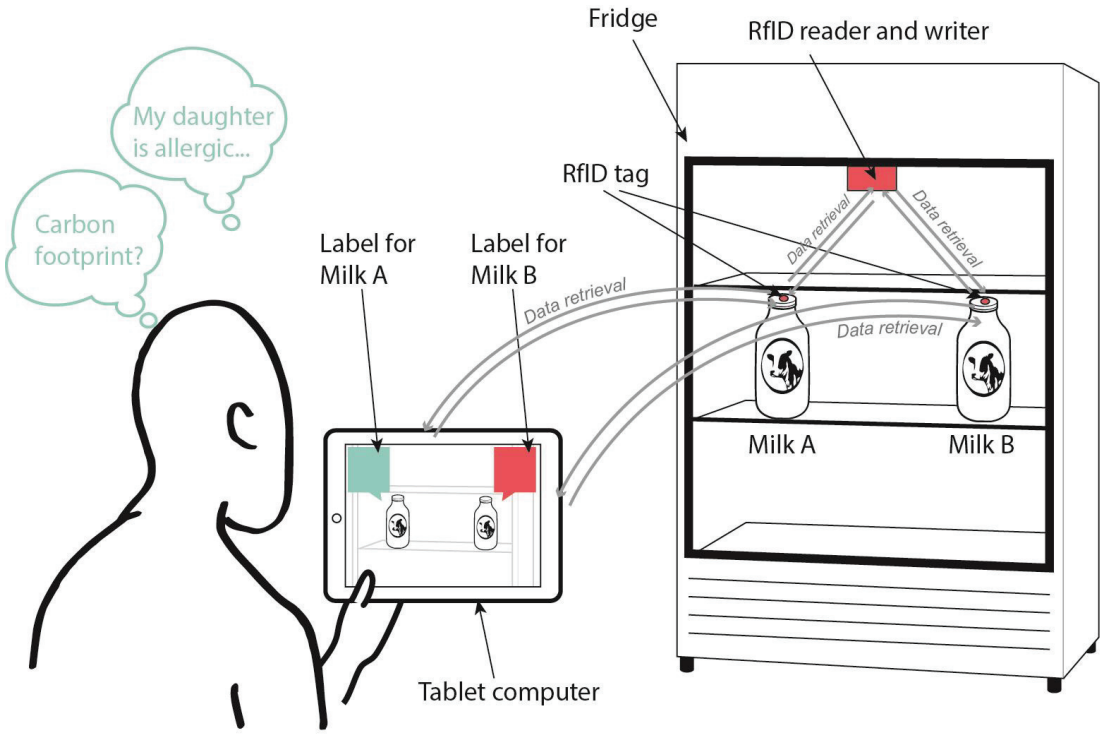


Figure 5.4 Individualised eco labelling in an Internet-of-Things

Table 5.3 Components of an eco labelling system for the milk shopping scenario

Components	Information/ technology
1) Personal data	User location, user preference on information content & format. For example, the user's daughter who would drink the milk suffers from allergies, and he needs to check if there is any allergenic substance in her food (social context); this user is concerned about carbon footprint (LCA information) and prefers to read numerical figure (information format).
2) Product data	Milk A & B: general product information (e.g. ingredients, volume), life cycle information (e.g. producers location, transportation history, storage record). Fridge: energy efficiency, storage record (what and when is the product stored in the fridge).
3) Technology on user	Tablet computer (mobile computing) with RfID reader embedded, internet and augmented reality function
4) Technology on product	Milk bottles: RfID tags Fridge: timer, RfID sensor and writer These three products form an Internet-of-Things.
5) Individualised information feedback	Although the two bottles of milk look identical, their product data can be different. For example, they may have different carbon footprint values because they are transported differently, and cooled in the fridge for different length of period. The two individualised labels then show different carbon footprint labels based on the user and product location (LCA and location information), and show whether the ingredients are allergy-provoking for the consumer's daughter (social information).

5.3. FRAMEWORK EVALUATION: FOCUS GROUP STUDY 2

5.3.1. Method

To collect insights for evaluating and refining the framework, a focus group study (DS3) took place in May 2014 in Brunel University. Two semi-structured focus group interviews were conducted with a total of ten participants. All participants were design students at postgraduate level and had a good understanding in user centred design (UCD) and information design. All discussions featured a briefing session and several open-ended questions. Knowledge about eco labelling, individualised information system, stages of contextual technology, the conceptual framework and the two user scenarios were explained to all participants before the discussions began.

All discussions were recorded with a Dictaphone. The data was transcribed and coded using the software NVivo 10, and was analysed using thematic analysis. The transcripts and code definitions are presented in Appendix 13.

5.3.2. Outcome 1: Designer's opinion on the conceptual framework

The participants were asked to comment on how useful they think the proposed conceptual framework is in inspiring future designs of individualised eco information system. The feedback was generally positive.

PA2 *The framework is easy to understand.*

PA1 *[The framework] is useful.*

PB5 *The framework is good.*

PB7 *It makes sense as a framework. Certainly there are elements designer can use in designing the system.*

PB2 *The framework itself it works as a framework. It would work, by just looking at the diagram.*

One participant gave a suggestion on how to improve the framework:

PA1 *I think on this diagram (the framework), it would be good to have annotations explaining the technology options, so it would be easier to understand. Because now I have to spend time wondering what technologies are these.*

This participant said the above because he had overlooked the second part of the framework which was a table that provided descriptions of the components in the diagram (Table 5.1). He appeared to be satisfied after the researcher showed him the table. Still this comment hinted the need for more detailed information with regard to the framework.

When asked about the potential applications to be designed based on the proposed framework, the participants quickly came up with a variety of ideas. In addition to eco information display, some suggested the designs of information system for health and medical care, such as supporting exercise, diet control and medication. The participants also thought the conceptual framework can be used in designing smart home solutions, product marking system and educational device. One participant raised the concern of economic viability of the proposed system, but another participant believed that the individualised information system was economically viable. The participants generally believed that it opens up many possibilities for information and product design.

PB7 *The only worry that I have is the economic viability of these systems. You are talking about eco system, which has a lot of agents are in play. You talk about RfID chips, you cannot put that in a milk bottle. It is too expensive.*

PB5 *I think it is possible economically and [sensors] prices are dropping and dropping.*

PB7 *I think the biggest challenge and also biggest asset of this system is to individualise information feedback and the data exchange. You know that data is so valuable that Google uses that to basically be a multi-billion pound company.*

PB7 *There are possibilities for [information and product] designers... This is like an automatic feedback system that designers can interpret. If it is done properly then it could be a quite powerful tool for designers, or even engineers for that matter, who actually do new product development.*

PB2 *It is useful. If like for example, when you buy a milk you got your tailored experience. You use it constantly. You are going to use it again, on the same sort of thing that you already got the information. And gradually you want to have that continuous embedment… it is worth the difficulty of incorporating into something using the different types of agents…*

It was observed that the system concept diagram (Figure 5.1) was useful in clarifying application ideas that involve the Internet-of-Things-and-People. The participants circled the

involved data carriers and their relationships on the printed copies of the diagram when they explained their system concepts.

5.3.3. Outcome 2: Role of User Centred Design (UCD) in designing individualised eco information system

Although it is generally agreed that user centred design (UCD) is important in design and evaluation of information system, its role in designing an *individualised* eco information system is yet to be fully explored. In the focus group study, the participants had discussed about the role of UCD in designing an individualised eco information system, and described the potential contributions of UCD in informing, designing and evaluating the system development processes.

All participants strongly acknowledged that UCD methods are useful in informing the design of this kind of system, because designers are good at understanding users and empathising with users' needs.

PA2 *We designers can make the system more human centred. Designers understand user needs better, for example designers would understand different stages of a consumer's shopping behaviour. Designers can understand the key stages and design accordingly.*

PB1 *UCD methods such as field study and observation are important for deciding the function of the system, timing to intervene and the information to be displayed.*

PB2 *The stakeholder analysis is used [in marketing and business discipline] to identify groups of end user... [UCD methods] will be useful in understanding the needs of an individual user... This understanding will better benefit the design of the individualised information system.*

PB7 *The strength of designer is about empathising with customers.*

Some pointed out the individualised information system acts like an automatic feedback system which generates a lot of data, and design profession is especially strong at interpreting and visualising data.

PB4 *From the point of view of information architecture, data is already there. But designers are needed to organise and give meanings to them.*

Building this kind of system is complicated; the participants thought the conceptual framework would be useful in supporting communication among various teams, such as designers, engineers, marketing department and behaviour scientists.

PB1 *It is the engineers who are responsible for the technological part and they would not concentrate so much on the user. Designers can put the user needs together and decide what kind of technology to be used.*

PB6 *Designer can be the mediator between teams... such as marketing and psychologist.*

Lastly, all agreed that designers are good at evaluating product/ systems, especially before the product/ system is implemented or launched.

5.4. DISCUSSION

5.4.1. Implications of the proposed concept

A common problem with many information systems is that human factors advice and user involvement come very late in the design process. Usability and potential benefits of the system are thus reduced (Kontogiannis & Embrey, 1997). Responses from the focus group study indicate the proposed conceptual framework can support designer's involvement in an early stage of the design process of the individualized information system. The benefits brought by UCD approach are also discussed.

An individualized information system is believed to have a big potential for impact on consumer behaviour, and can be made an effective tool to encourage sustainable consumption. The application scenarios picture how the proposed system concept can potentially change people's perception and understanding towards everyday products, and impact decision-making processes.

In the context of eco labelling, information individualization can potentially benefit the consumers by reducing information overload, reducing information asymmetry and increasing consumer receptiveness. It can also benefit businesses by providing a way to direct highly motivated consumers to navigate niche markets in the long tail. The conceptual framework can also provide design implications for other application areas such as marketing, health care, education and smart home.

5.4.2. Differentiating 'individualisation' from 'personalisation'

The term 'individualisation' was used purposefully to differentiate from 'personalisation', a term commonly used in marketing, design and information system. To the authors' knowledge, there are no clear-cut definitions to set apart these two terms in these contexts. This thesis takes the stance that individualised design and personalised design fall in different positions on the spectrum of tailoring. A design can claim to be personalised with minor tailoring to the user's preference, for instance some mobile phones from the 1990s could be 'personalised' with changeable colourful cases; while individualised design has a much higher degree of tailoring, for instance a smartphone possesses tremendous flexibility in its features depending on the apps installed - the same smartphone model could serve completely different functions (e.g. document editing, music player, video production) when used by different people.

Figure 5.5 Difference between individualised design and personalised design

5.4.3. Novelty of the proposed conceptual framework

The novelty of the proposed conceptual framework can be further elucidated with a comparison of eco information individualisation and existing personalised news feed system.

Nowadays it is not uncommon for people to read news from personalised news feed aggregators such as *Google News* and *Facebook*. These aggregators try to engage users by selecting the most relevant stories from thousands of potential stories and show that on an individual's news feed reader. The algorithms used to choose the content vary from one to another, in many instances these companies build profiles of users to learn and predict the their interests and preferences. It could be created manually by asking the users to choose topics or news sources that they would like to see; or be constructed automatically by tracking the user activities such as search or browsing history, or stories that the users had 'liked' (using web rating button) or commented on. Sometimes demographic data is also used for targeted news feed or advertisement. It is anticipated that the concept of information individualisation proposed in this thesis would make use of similar information

filtering techniques as well. Yet eco information individualisation involves a higher degree of tailoring and is different from existing personalised news aggregators in four ways:

1. **Profiles are built for both the user and the product in information individualisation.**

Personalised news aggregators only build profiles for human users in order to tailor news feed for them. However the concept of eco information individualisation emphasises also tracking the life history of products and building profiles for the products. Profiles of both the user and the product are compared when information individualisation occur.

Technologies for activity logging are attached not only to human users but also to products. This makes the products 'smart' and enables them to sense their use and act upon their surroundings. Social contexts can be embedded on the products' 'memories' so that the products can develop and maintain relationships with other objects/ people. Potentially this can change how people see objects and affect how people interact and consume everyday products.

2. **Information are tailored upon more dimensions in eco information individualisation.**

The degree of information tailoring is much higher in information individualisation. The number of dimensions (i.e. variables) to be tailored upon would be many times more than what are used in existing personalised news feed aggregators.

Eco information individualisation is expected to consider more contextual factors about the user, such as physiological conditions, cognitive styles, mood, behaviour history, interests, location, personal goal, social connections, etc. The data library storing product data for eco information individualisation would also be more massive than digital news archives, and would demand a more complex and well-designed information architecture for efficient information retrieval.

As a result of complicated information visualisation process, individualised eco labels may appear very different to different users in terms of visual design. While in personalised news feed systems, although different users may see different news stories, the layouts of what they read (the interface) usually do not differ significantly from one another.

3. **Eco information individualisation targets at supporting behaviour change.**

Existing information personalisation practices, such as personalised news feed and targeted advertisement, are mostly business oriented. But information individualisation emphasises

the active roles of the users as individuals and intends to support their plans for behaviour change.

Information displayed in personalised news feed or targeted advertisement are usually tailored based on relatively simple data association. The information can be scattered and the scope can be unrestrained. Eco information individualisation however aims to encourage sustainable consumer behaviour. The information tailored should be the result of a rational reasoning process that revolves around this specific goal, if this aligns with what the user sets out to do. Besides, in addition to product recommendation, information individualisation might benefit the user by helping self-monitoring (e.g. personal carbon footprint calculator).

4. **Information individualisation involves the processing of greater amount of data.**

It is envisioned that, in the likely future scenario, eco information individualisation will create a new consumer experience and it will involve continuous capturing of contextual data and seamless embedment of eco information in everyday life, perhaps using sensors and augmented reality technology. Its complexity will require the computation of enormous amount of data, presumably in a much larger scale than existing personalised news feed systems.

5.5. REFLECTIONS

By conceptualising both user and product as data carriers and reducing purchasing environments into components and analytical elements, we are better able to work towards product label design through a user centred design (UCD) approach.

This chapter proposes a conceptual framework of a novel individualised eco information system. To the author's best knowledge, it is the first framework on individualised information system proposed by designer and for designer. The components, data and technologies required are described. Two application scenarios are included to explain the concept of eco information individualisation and demontrate the use of the framework. A focus group study was conducted to evaluate the framework. All relevant comments on the framework, both positive and negative, are reported, followed by a discussion on the implications and the novelty of the framework.

Results of the focus groups suggest that the proposed framework for such a system is useful to guide future design of eco labelling systems. Implications can be drawn for

designing other information systems for behaviour change. It would be a good idea to aid the understanding of the proposed framework by providing more detailed information about the various components listed in the framework.

The focus group method is a flexible tool to uncover opinions, to contextualise perceptions and to test the reality of assumptions. It is particularly useful for exploratory purposes or preliminary analysis. While this qualitative method can be used to extend and deepen understanding, it is not a tool to validate nor quantify design characteristics (Adams & Cox, 2008; Stewart, Shamdasani, & Rook, 2007; Wilson, Lilley, & Bhamra, 2013).

Only design students were recruited for this focus group study due to time and resource constraints. The use of students as participants has been a common practice in psychology research and design research because they are accessible and convenient to recruit. Concerns however have been raised about student participation. The major worry is that student samples are not representative of the adult population, and may limit generalisability of the results. It is not the intention of this study to claim generalisability of the results. One of the valuable outcomes was the opinions canvassed from the potential users of this framework (i.e. designers with an interest in designing eco information). These were used to inform refinement of the framework and the development of a design tool (see Chapter 7).

Random sampling method was not adopted because the participants were required to have knowledge in environmentally sensitive design, user centred design (UCD) and information design for the discussion. The purpose of this preliminary evaluation was to uncover opinions. Ten participants in two focus groups were considered a reasonable amount, although there was no evidence of data saturation when choosing this sampling strategy.

It should be noted that the conceptual framework was proposed to present an idea for improving eco information design. The framework was not created to explain behaviour nor to guide the construction of hypothesis or theories.

Chapter 6
Understanding user perception of existing eco labels

6.1. INTRODUCTION TO CARD SORTING STUDY

Most of the published studies about eco labelling focus on consumer's awareness of, knowledge about or attentiveness to eco labels, or their trust in them. However these studies are principally descriptive and scarcely answer the questions of *why* consumers know or notice a label, and *how* they perceive and/ or understand eco labels (Thøgersen et al., 2010; Thøgersen, 2000, 2002; M. Vandenbergh et al., 2011).

To find out the requirements for the product data context referred to in the conceptual framework introduced in the previous chapter, a card sorting study (DS2) was carried out. This card sorting study aimed to uncover how users make sense of existing eco labels and had these objectives:

- To explore how people categorise eco labels;
- To identify indicative examples from each category;
- To understand how people perceive the information displayed on eco labels and learn about how people think about eco labels;
- To gain insights to inform the design of an eco information architecture for the proposed device.

6.2. METHOD

6.2.1. What is card sorting?

Card sorting is a user centred design technique to:

- Explore how people group information into categories;

- Understand how people perceive groups of content and relate concepts to one another;
- Gather terminologies that people use to describe groups of information, and identify words that are likely to be misunderstood.
- Learn about what goes together and what does not (Martin & Hanington, 2012; Spencer, 2009).

It has a long history in social research, and is now a commonly used method in information architecture (IA) projects which often focus on organising, grouping and labelling items (often content) (Spencer, 2009). It can identify different schemas for digital interface design (e.g. structuring online help) as well as table of contents (e.g. menu, book), or any projects where user comprehension and meaningful categorisation is critical. This method helps in developing frameworks that maximise the efficiency of users finding the information they want (Martin & Hanington, 2012).

While card sorts are relatively simple to moderate, their rigour lies in the analysis. Both quantitative and qualitative data can be collected from card sorting. Depending on the study purpose, card sorting can be exploratory for understanding how people group and perceive information, or generative for canvassing possible ideas, or evaluative for making sure the categories in a product/ service reflect the mental model of its users (Martin & Hanington, 2012).

Although card sorting is commonly used to generate options for structuring information, as Spencer (2009) points out, 'card sorting is best understood not as a collaborative method for creating navigation, but rather as a tool that helps us understand the people we are designing for.' Rich insights gained from card sorting should be considered as one input in a user-centred design process and is best to be used in combination with other complementary user research techniques such as surveys, interview etc (Spencer, 2009).

6.2.1.1. Open sort vs closed sort

The procedures of card sorting are simple. Participants are given cards with printed content, terms, or features on them, and are asked to sort them in one of these two primary ways:

- *Open sort:* participants group the cards in whatever ways that make sense to them;
- *Closed sort:* participants are given cards plus a set of predetermined categories, and are asked to place the cards under these categories (Martin & Hanington, 2012);

These methods can be extended, for example by allowing participants to query terms or provide their own terms (Hudson, 2013b). A typical card sort uses 30 to 100 cards. Some successful studies used over 200 cards where the participants knew the content well (Martin & Hanington, 2012; Spencer, 2004, 2009).

6.2.1.1. In-person vs remote

Card sorting can be conducted face-to-face using physical cards, or can be done remotely using online tools such as *OptimalSort* (Optimal Workshop, 2015). The advantage of in-person card sorts is that the moderator/ researcher can observe the participant's behaviour and capture qualitative insights into their thought processes by asking participants to think aloud when sorting (Righi, James, Beasley, & Day, 2013). On the other hand, online card sorting allows researchers to collect data from a much larger participant sample more easily and more quickly which, in turns provides a measure of statistical validity not provided by small sample size. Often online tools also include data analysis functions that create tables and diagrams (Righi et al., 2013).

Printed cards can be time-consuming to prepare, and data entry can be tedious. There exists processing software that helps speed up preparation and data capture using bar code scanning, and provide a means to analyse data. An example is *SynCaps* (Hudson, 2013a).

6.2.1.2. Individual vs team sorts

Card sorting can be conducted individually or in small teams of 3-5 participants (Martin & Hanington, 2012). Individual card sorts have the advantage of resulting in more sorts with fewer participants. The disadvantage of individual card sorts is that this does not provide rich insights into the participant's thought process as a team sort can do. Although 'think aloud' protocol can be prompted, this extra information captured in an individual card sort is typically less rich than what can be observed from the discussion and debate in a team sort (Spencer, 2009), which also is an efficient way of collecting consensus opinion. A team also has the ability to handle larger set of cards, and has a tendency to talk through their decisions, resulting in rich data set with more insights into their mental model (Spencer, 2004). The drawback of a team sort comes from potential negative group behaviour, for example a dominant member may force his or her ideas on the group (Spencer, 2009).

6.2.2. Participants

The appropriate sample size for card sorting depends on the purpose of the study, the number of cards to be sorted, and the confidence intervals (if statistical significance is

required). If a study only intends to gather some broad ideas or to check whether the ideas are on track, a small number of card sorts, say 5-6 team or individual sorts, is enough. In this case, other complementary user research methods should be used. If the research aims to explore an idea in depth, the sample size needs to be large enough for identifying areas where responses are consistent and where they differ. If the research compares the results of different groups, for example in terms of age, level of experience or audience, the study has to involve enough participants in each group for identifying consistent patterns for the group and for between-groups comparison (Spencer, 2009). Generally speaking, the amount of insights that can be collected reaches the point of diminishing returns after 15 sorts (Martin & Hanington, 2012; Sauro, 2013). The 'statistical significance' of card sorting results is not particularly relevant for information architecture projects (Spencer, 2009), which use card sorting as a technique to identify 'the types of groups people create, what they put into groups, and how they describe those groups'. In addition to the card sorting results, other inputs, such as the overall project goals or the understanding of the content, are usually used in designing information architecture.

This study (DS2) involved 9 participants in 6 card sorts, which included 5 individual sorts (with participants P1 – P5) and one team sort with 4 participants (G1). They were postgraduate students or teaching staff from Brunel University (Table 6.1). Both individual and team card sorts were conducted, for the advantages of collecting rich insights from discussion in a team sort and collecting more data from fewer participants.

The eligibility criteria used for participants selection were rather simple:

- They had to be end users of eco labels, who basically could be anyone with everyday shopping experience;
- They were required to have a good command of English, so that their use of vocabularies made sense.

As this card sorting study only intended to gather some broad ideas of how people categorise eco labels and how people perceive the information displayed on eco labels, and a complementary user research method (interview) was used, this sample size was considered adequate. The concept of data saturation was not taken strictly when choosing this sampling strategy, because although meanings were extracted from the patterns identified, more interesting insights were obtained from the inconsistency of the categories formed and from the participants' comments.

Due to the exploratory and generative nature of this study, as well as time and cost constraints, convenience sampling method was used. The researcher (the author of this thesis) invited people whom she encountered during the participant recruitment period as long as they met the above criteria. Extra caution was given to form the group for the team sort. Participants of the same age range with no foreseeable conflicts of interest were put together as a team to migitate difficult group behaviours such as monopolising or withdrawal. Each participant received a £10 Amazon voucher as a compensation for his or her participation.

Table 6.1 Demographics for individual participants

Participant number	**P1**	**P2**	**P3**	**P4**	**P5**	**G1**
Profession	Design	Marketing	Design	Marketing	Design	Design
Nationality	British	Taiwan	Columbia	Taiwan	British	Italian, Korean X 2, British,
Time needed	1 hour 20 min	1 hour 25 min	1 hour 20 min	1 hour 35 min	1 hour 35 min	40mins (sorting) + 1.5 hours discussion
Age	26-35	26-35	26-35	26-35	46-55	All 26-35
Gender	Male	Female	Male	Male	Male	All male

6.2.3. Card sets

The *'Ecolabel index'* is the largest global directory of eco labels. At the time of this study, it was tracking 458 ecolabels in 197 countries and 25 industry sectors (Ecolabel Index, 2014). Excluding some duplicates or labels without images, 403 labels from the Ecolabel Index database were used in this study.

The participants were asked to categorise 403 cards (Figure 6.1). Each card was numbered and printed with an eco label retrieved from the Ecolabel Index database (Ecolabel Index, 2014). Although this amount of cards was larger than what typical card sorts would use, it was believed that these image-based cards would be less cognitively demanding than typical text-based cards.

Figure 6.1 Cards used in the card sorting study

6.2.4. Procedures

This study adopted an open sort, face-to-face approach, because this would help explore both the thought process and the behaviour of the participants. In each sort there was one facilitator (i.e. the author of this thesis) to work iteratively with the participants. The study followed the procedures below:

- Briefing session to collect written informed consent and participants' demographics.
- The participants were asked to categorise the cards and create a name for each category according to their natural association. They could group in whatever ways that make sense to them, and could create as many categories as they wished. It was suggested that if there were cards that they thought did not go with any category, they could place them into a category called 'Odd'.
- Think aloud protocol was prompted to canvas participants' comments and dilemma during the activity.
- Participants were asked to pick an indicative example from each category.
- The participants were shown a list of words related to eco labels, and were asked to map the category names they created to one of these words. This step was done to standardise the terminologies used by different participants. Figure 6.3 and Figure 6.4 show the data before and after standardisation.
- In the debriefing interview, the participants were asked to explain their categorisation and naming, and the rationale of selecting the indicative examples.

Also, to validate one of the outcomes from this study, another evaluative card sorting activity was conducted, as explained at the bottom of Section 6.2.5.2.

6.2.5. Analysis

6.2.5.1. Choices of analysis method

Spencer (2009) divides card sorting data analysis into two types: exploratory and statistical. Both approaches can be used to spot key patterns in data, derive useful insights and learn broad ideas.

Exploratory analysis can be used to investigate:

- What categories are created;
- Where cards are placed;
- What words people use to describe categories;
- What classification scheme people used;
- Whether people created accurate or inaccurate categories (Spencer, 2009).

And *statistical analysis* is particularly strong for:

- Determining if there are consistent patterns in data;
- Identifying consistent patterns;
- Comparing differences between different groups of participants (Spencer, 2009).

There is a long list of statistical methods that can be used, such as K-means cluster analysis, hierarchical cluster analysis (HCA) and multidimensional scaling (MDA). *Hierarchical cluster analysis (HCA)* can be used to create a hierarchy that best fits the data relationships. It begins with a calculation of the distance between each pair of objects, in this case, the eco label cards. Pairs of cards placed in a category with many participants are closer together (low distance score), while cards placed in a category infrequently are farther apart (high distance score). Hierarchical Cluster Analysis (HCA) has these advantages:

- It gives one single outcome under same settings (while K-means clustering may give different results depending on the initial assignment of items which is random);
- It doesn't pre-determine how many clusters to be formed;

Researchers should however be aware of the limitations when using statistical analysis:

- The idea behind statistical clustering is to find a single best fit, but card sorting is not a means to obtain one true answer of classification. Card sorting is a method to collect insights and ideas, therefore in this case, statistical significance is not really important;
- Statistical methods can help to identify patterns, but they do not explain why a pattern exists;
- Statistical analysis looks at consistent patterns, yet for an information architecture project, some of the most useful insights come from the inconsistencies;
- Results from all participants are combined in statistical analysis, and is unlikely to reflect what groups an individual participant creates, thus does not represent the real-world result;
- Statistical clustering is not the final word on an optimal information structure (Spencer, 2009).

6.2.5.2. Adopted analysis methods

The study had collected several types of data, including names created for the categories, card placements, indicative examples for each category created, and interview data on how people perceived and described these eco labels. To derive insights from the data, both qualitative analysis and statistical clustering were conducted.

Section 6.3 below reports on the exploration of what categories were created, the analyses on card placements and their levels of agreement. This exploratory analysis was done using the software *Microsoft Excel 2010.* The *Excel* spreadsheets used were adapted from a template created by Spencer (2015). Figure 6.3, Figure 6.4 and Figure 6.5 show parts of the multiple-sheet *Excel* document.

In parallel with the exploratory analysis, a hierarchical cluster analysis (HCA) was conducted to identify consistent patterns from the card placements. The software *SPSS Statistics 20* was used for this cluster analysis, based upon the card placement correlation spreadsheet created in *Excel*. A proximity matrix and a dendrogram (Appendix 9) were drawn using (between groups) average linkage for 'Euclidean distance'. The grouping of thirteen clusters was chosen for further interpretation for it had a relatively even and dispersed distribution. Then a word frequency test was carried out for the label names within each cluster using the software *NVivo 10*. For each cluster, the six most frequently used words in the label names were identified, which were then generalised into a theme based on the

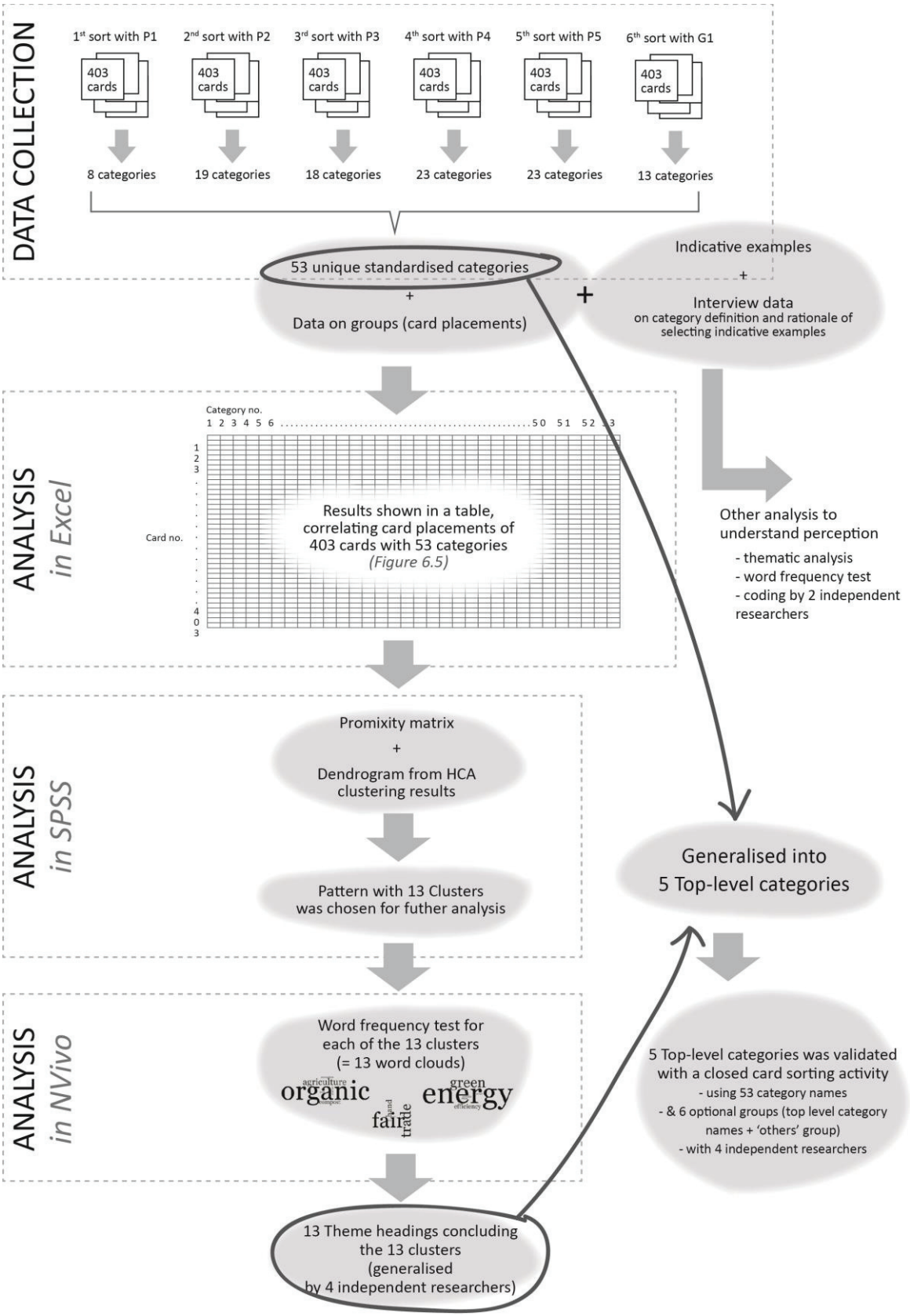


Figure 6.2 Flow diagram of the card sorting study (DS2)

interpretation of four independent researchers. As a result thirteen themes emerged. The clustering results were triangulated with the results from the exploratory analysis on card categories.

Furthermore, to understand how people perceived eco labels, thematic analysis and word frequency test were conducted to examine the interview data about how people defined those categories and their rationale of selecting the indicative examples. The transcribed interview data were coded by both the author of this thesis and another independent researcher to increase the dependability/ reliability of the analysis.

Five top-level categories were then created to encapsulate all the 53 categories generated by the participants. Another evaluative card sorting activity was carried out with four independent researchers to validate this set of top-level categories. This evaluative card sort was a closed sort that involved the sorting of 53 cards, each printed with one category name. The sorters were asked to group these cards under six optional groups, which equaled to the five top-level categories and a group called 'others'.

1	Card no	Card name	Sort1	Sort2	Sort3	Sort4	Sort5	Sort6
2	1	4C Association	Logos	Countries/ associations	Not understand	Coffee	Eco farming/ agricultural business & food product	Food
3	2	80 PLUS	Logos	Odd	Logo	Entertainment	Nothing to suggest econess	Odd
4	3	100% Green Electricity - 100% Energia Verde	Logos	Carbon/ energy	Logo	Difficult identify	Energy	Energy – renewable
5	4	AB (Agriculture Biologique)	Logos	Food organic	Agriculture	Food	Eco farming/ agricultural business & food product	Food
6	5	ABIO	Logos	Food organic	Agriculture	Food	Eco farming/ agricultural business & food product	Food
7	6	ABNT Ecolabel	Approval / Certified	Company	Certificates	Certified	Nothing to suggest econess	Odd
8	7	Acorn Scheme	Logos	Green label	Brands	Agriculture	Forestry stewardship	Odd
9	8	AENOR Medio Ambiente	Logos	Global label	Environment	Go Green Products	Generic eco endorsement various sectors, authority etc – Something eco but not clear what	Odd
10	9	Afrisco Certified Organic	Approval / Certified	Food organic	Certificates	Certified	Eco farming/ agricultural business & food product	Material
11	10	AIAB (Italian Association for Organic Agriculture)	Logos	Food organic	Environment	Certified	Eco farming/ agricultural business & food product	Land
12	11	AMA Biozeichen	Logos	Countries/ associations	Not understand	Bio	Generic eco marks with national co-	Land
13	12	American Grassfed	Approval / Certified	Countries/ associations	Logo	Go Green Products	Eco farming/ agricultural business & food product	Material
14	13	ANAB - Architettura Naturale	Logos	Carbon/ energy	Certificates	Home	Eco building	Odd
15	14	Anbefalt	Logos	Carbon/ energy	Not understand	Difficult identify	Water & the environment	Sustainable labour
16	15	Animal Welfare Approved	Approval / Certified	Gentle reminder	Not understand	Bio	Preserving wild life (animals)	Sustainable behaviour
				Countries/	Environment		Marine	

Figure 6.3 Part of the results: the original category names created by the participants

	A	B	C	D	E	F	G	H
1	**Card no**	**Card name**	**Sort1**	**Sort2**	**Sort3**	**Sort4**	**Sort5**	**Sort6**
2	1	4C Association	Logo	National Standard	Difficult	Coffee	Food	Food
3	2	80 PLUS	Logo	Odd	Logo	Entertainment	Difficult	Odd
4	3	100% Green Electricity - 100% Energia Verde	Logo	Global warming	Logo	Difficult	Energy	Renewable energy
5	4	AB (Agriculture Biologique)	Logo	Organic	Agriculture	Food	Food	Food
6	5	ABIO	Logo	Organic	Agriculture	Food	Food	Food
7	6	ABNT Ecolabel	Certification symbol	Private companies	Certification symbol	Certification symbol	Difficult	Odd
8	7	Acorn Scheme	Logo	Green	Brands	Agriculture	Forest products / Paper	Odd
9	8	AENOR Medio Ambiente	Logo	Planet	Environment	Green	Eco label content	Odd
10	9	Afrisco Certified Organic	Certification symbol	Organic	Certification symbol	Certification symbol	Food	Raw material
11	10	AIAB (Italian Association for Organic Agriculture)	Logo	Organic	Environment	Certification symbol	Food	Earth
12	11	AMA Biozeichen	Logo	National Standard	Difficult	Biological	National standard	Earth
13	12	American Grassfed	Certification symbol	National Standard	Logo	Green	Food	Raw material
14	13	ANAB - Architettura Naturale	Logo	Global warming	Certification symbol	Building	Building	Odd
15	14	Anbefalt	Logo	Global warming	Difficult	Difficult	Water	Ethics
16	15	Animal Welfare Approved	Certification symbol	Animal friendly	Difficult	Biological	Animal friendly	Use phase
17	16	Aquaculture Stewardship Council	Logo	National Standard	National standard	Food	Ocean friendly	Water
18	17	Arge TQ	Logo	Private companies	Difficult	Difficult	B to B	Odd
19	18	AsureQuality Organic Standard	Certification symbol	Organic	Certification symbol	Certification symbol	Food	Food
20	19	IBU Type III Environmental Declaration (IBU Environmental Product Declaration)	Logo	Green	Difficult	Environment	Building	Odd
21	20	Audubon International	Logo	Odd	Difficult	Odd	Difficult	Earth
22	21	Australian Certified Organic	Certification symbol	Organic	Certification symbol	Certification symbol	Agriculture	Food
		Australian Forest Certification	Certification				Forest products /	

Figure 6.4 Part of the results: the category names standardised by participants after Step 5

6.3. RESULTS

6.3.1. Card categories

The results of the exploratory analysis are shown in Table 6.2. 53 categories were identified from the six card sorts, each carried out with 403 cards. To supplement this table, Appendix 7 shows an overview of all categories created in each sort, and the corresponding indicative examples for each category.

The number of categories created by different participants varied. Participant P1 had created 8 categories, the least among all participants. Participant P4 and P5 had created 23 categories, the most among all.

Since the moderator had suggested the participants place cards in a category named 'Odd' if they found the card that did not go with any of the groups, the 'Odd' category existed in all 6 sorts. In addition to the 'Odd' category, three participants had created a similar category called 'Difficult' for other cards that they found confusing.

No instruction was given to the participants on how many hierarchical levels of category to be formed. All individual participants grouped the cards into a flat structure, i.e. they did not form any sub-category within a category. However in the team sort, two levels of categories were created. The team came up with 9 main categories, two of which (i.e. 'energy' and 'environment') contain subcategories.

Table 6.2 Standardised categories, number of sorters who used the standardised names and card counts (in descending order of the number of sorters)

No.	Standardised category	Sorters who used this	Total cards in this category	Weighing of all cards	Unique cards	Agreement
1	Odd	6	162	6.70%	128	0.21
2	Building	4	70	2.89%	46	0.38
3	Carbon footprint	4	50	2.07%	31	0.40
4	Certification symbol	4	325	13.44%	185	0.44
5	Ocean friendly	4	39	1.61%	20	0.49
6	Agriculture	3	28	1.16%	25	0.37
7	Difficult	3	141	5.83%	101	0.47
8	Eco label content	3	190	7.86%	133	0.48
9	Energy	3	44	1.82%	31	0.47
10	Environment	3	102	4.22%	88	0.39
11	Ethics	3	48	1.99%	39	0.41
12	Fair trade	3	23	0.95%	12	0.64
13	Food	3	118	4.88%	83	0.47
14	Green	3	125	5.17%	92	0.45
15	National Standard	3	74	3.06%	63	0.39
16	Product Info	3	49	2.03%	44	0.37
17	Recycling	3	36	1.49%	22	0.55
18	Water	3	24	0.99%	17	0.47
19	Animal friendly	2	14	0.58%	12	0.58
20	B to B	2	17	0.70%	17	0.50
21	**Cosmetics / Personal care**	**2**	**7**	**0.29%**	**5**	**0.70**
22	Global warming	2	60	2.48%	55	0.55
23	Logo	2	265	10.96%	216	0.61
24	Rating	2	35	1.45%	35	0.50
25	**Textiles**	**2**	**21**	**0.87%**	**16**	**0.66**
26	**Tourism**	**2**	**17**	**0.70%**	**11**	**0.77**
27	Biological	1	4	0.17%	4	1.00
28	Brands	1	10	0.41%	10	1.00
29	Chart	1	7	0.29%	7	1.00
30	Cleaning products	1	7	0.29%	7	1.00
31	Coffee	1	2	0.08%	2	1.00
32	Considered design	1	6	0.25%	6	1.00
33	Digital	1	3	0.12%	3	1.00
34	Earth	1	10	0.41%	10	1.00
35	Efficiency	1	13	0.54%	13	1.00

No.	Standardised category	Sorters who used this	Total cards in this category	Weighing of all cards	Unique cards	Agreement
36	Energy efficiency	1	29	1.20%	29	1.00
37	Entertainment	1	9	0.37%	9	1.00
38	Fashion	1	6	0.25%	6	1.00
39	Financial services	1	7	0.29%	7	1.00
40	Forest products / Paper	1	14	0.58%	14	1.00
41	I.T.	1	2	0.08%	2	1.00
42	Logistics	1	3	0.12%	3	1.00
43	Organic	1	32	1.32%	32	1.00
44	Planet	1	34	1.41%	34	1.00
45	Plants	1	21	0.87%	21	1.00
46	Private companies	1	21	0.87%	21	1.00
47	Producers associations	1	19	0.79%	19	1.00
48	Raw material	1	39	1.61%	39	1.00
49	Renewable energy	1	7	0.29%	7	1.00
50	Resource consumption	1	12	0.50%	12	1.00
51	Soil	1	3	0.12%	3	1.00
52	Transportation	1	5	0.21%	5	1.00
53	Use phase	1	9	0.37%	9	1.00

6.3.2. Low level of agreements on card categories

The weighing of and the level of agreement on category can be derived from the card counts and the number of sorters.

The weighing of a category among all cards sorted was defined as:

$$Weighing\ of\ all\ cards\ = \frac{Total\ cards\ in\ this\ category}{Number\ of\ all\ cards}$$

The total number of cards sorted was 6 X 403 = 2418. The two categories with the most cards are 'Certification symbol' and 'Logo', both have a weighing of all cards larger than 10%.

The level of agreement on card category was defined as:

$$Agreement\ of\ category = \frac{Total\ cards\ in\ this\ category}{No.\ of\ sorters\ who\ used\ this\ category\ \times\ No.of\ unique\ cards}$$

Here 'unique cards' refers to the number of unique cards that were placed within that category at least for once, if the same card was placed within that category twice, only one occurrence was counted.

As shown in Table 6.2, the levels of agreement of the categories were low. Out of 53 categories, excluding categories which were used by only one sorter, only 3 categories had cards with relatively high agreement level (larger than or equal to 66%). (The categories from no.27 to no.53 have an agreement level of 1.00 because there was only one sorter that had used these categories.)

6.3.3. Low level of agreements on card placements

To assess the level of participant agreement on the card placements, every card was correlated to every standardised category, as illustrated in Figure 6.5. Each single row represents a card and shows the percentages of the different placements of each card in each standardised category. Higher percentage means that more participants placed that card in that category. For the ease of reading, the cells are coloured with different shades of blues for different conditions. The higher the card placement percentage, the deeper the colour blue. For example, out of 6 sorts, card no.255 was grouped within 'Certification symbol' in three sorts out of the total of six, thus resulted in a 50% card placement in a blue cell. The actual spreadsheet contains over 20,000 cells and is too long to be included in this thesis.

	A	B	C	D	E	F	G	H	I	J	K	L
1	Card no	Card name	Agriculture	Animal friendly	B to B	Biological	Brands	Building	Carbon footprint	Certification symbol	Chart	Cleaning products
245	244	Krav										
246	245	Label STEP										
247	246	Lao Organic								33%		
248	247	LEAF										
249	248	LEAF Marque	17%									
250	249	Leaping Bunny										
251	250	LEED Professional Credentials										
252	251	LEED Green Building Rating Systems						17%		33%		
253	252	Legambiente Turismo										
254	253	SFC Member Seal								17%		
255	254	level										
256	255	LFP Certified	17%							50%		
257	256	LIFE Certification						33%				
258	257	Water Lily: Lithuania										
259	258	LIVE (Low Input Viticulture and Enology)								50%		
260	259	LowCO2 Certification							50%	17%		
261	260	Luomuliitto - The Ladybird label		17%								
262	261	Luomu Sun Sign								17%		
263	262	M1 Emission Classification of Building Materials						17%	17%	17%		
264	263	MADE-BY										
265	264	Marine Aquarium Council (MAC) Certification								17%		
266	265	Marine Stewardship Council								50%		
267	266	MAS Certified Green						17%		33%		
268	267	Max Havelaar								17%		
269	268	M-BRIO Organic and Food Labeling								17%		
270	269	Migros ECO										
271	270	Milieukeur: the Dutch environmental quality la										
272	271	Minergie										
273	272	Minergie-A										
274	273	Minergie-ECO										

Figure 6.5 Part of the results about the card placements

Table 6.3 summarises the levels of agreement on card placements according to each category. 'Unique cards in this category' refers to the number of unique cards that have been placed within that category at least for once, for example if the same card has been placed within this category twice, only one occurrence is counted.

The results show that the levels of agreement on card placements were generally low. As shown in the table, totally there are 1861 unique (non-duplicate) card placements distributing in all 53 categories, while the maximum possible value of total unique card placements was 2418 (number of cards multiplied by the number of sorts). Also, out of 403 cards, there were only 8 cards with relatively high agreement level (i.e. larger than or equal to 66%). There was no card placement with an agreement level higher than 75%, whereas 1506 card placements have a medium agreement level (25%-66%), and 355 card placements have a low agreement level (<25%).

Table 6.3 Summary of levels of agreement on card placements

	Category name	Unique cards in this category	Cards with high agreement (>75%)	Cards with relatively high agreement (>66%)	Cards with medium agreement	Cards with low agreement (<25%)
1	Agriculture	25	0	0	21	4
2	Animal friendly	12	0	0	10	2
3	B to B	17	0	0	13	4
4	Biological	4	0	0	0	4
5	Brands	10	0	0	7	3
6	Building	46	0	4	39	7
7	Carbon footprint	31	0	1	26	5
8	Certification symbol	185	0	0	165	20
9	Chart	7	0	0	6	1
10	Cleaning products	7	0	0	4	3
11	Coffee	2	0	0	0	2
12	Considered design	6	0	0	5	1
13	Cosmetics / Personal care	5	0	0	5	0
14	Difficult	101	0	0	81	20
15	Digital	3	0	0	2	1
16	Earth	10	0	0	3	7
17	Eco label content	133	0	0	113	20
18	Efficiency	13	0	0	12	1

19	Energy	31	0	0	29	2
20	Energy efficiency	29	0	0	25	4
21	Entertainment	9	0	0	7	2
22	Environment	88	0	0	68	20
23	Ethics	39	0	0	33	6
24	Fair trade	12	0	0	11	1
25	Fashion	6	0	0	4	2
26	Financial services	7	0	0	4	3
27	Food	83	0	0	64	19
28	Forest products / Paper	14	0	0	10	4
29	Global warming	55	0	0	39	16
30	Green	92	0	0	78	14
31	I.T.	2	0	0	2	0
32	Logistics	3	0	0	3	0
33	Logo	216	0	0	171	45
34	National Standard	63	0	0	51	12
35	Ocean friendly	20	0	3	18	2
36	Odd	128	0	0	103	25
37	Organic	32	0	0	20	12
38	Planet	34	0	0	26	8
39	Plants	21	0	0	14	7
40	Private companies	21	0	0	12	9
41	Producers associations	19	0	0	16	3
42	Product Info	44	0	0	35	9
43	Rating	35	0	0	31	4
44	Raw material	39	0	0	32	7
45	Recycling	22	0	0	19	3
46	Renewable energy	7	0	0	5	2
47	Resource consumption	12	0	0	11	1
48	Soil	3	0	0	3	0
49	Textiles	16	0	0	14	2
50	Tourism	11	0	0	9	2
51	Transportation	5	0	0	5	0
52	Use phase	9	0	0	7	2
53	Water	17	0	0	15	2
	Total	**1861**	**0**	**8**	**1506**	**355**

6.3.4. HCA clustering and themes emerged based on card placements

A hierarchical cluster analysis (HCA) was conducted to calculate a range of clustering solutions (See Section 6.2.5.2. for details). The minimum number of clusters created was ten, and the maximum number of clusters created was fifteen (see Appendix 10).

The grouping of thirteen clusters was chosen for further interpretation, because it had a relatively even and dispersed distribution. To identify patterns from the clusters, a word frequency test was conducted for the card names within each cluster using *NVivo 10*. The six most frequently used words (with minimum length of 3 characters) in the eco label names within each cluster are shown in Table 6.4.

Table 6.4 Keywords emerge from 13 clusters

Cluster	Word	Count	Weighted Percentage (%)	Similar Words
1	organic	21	8.82	organic
	agriculture	10	4.20	agricultural, agriculture, farm, usda
	compost	8	3.36	compost, compostable, composting
	association	6	2.52	association
	food	6	2.52	food
	practice	6	2.52	good, practice, practices
2	eco	24	4.12	eco
	green	23	3.95	green
	environmental	17	2.92	environmental, environmentally
	certification	10	1.72	certificate, certification, credentials
	certified	10	1.63	certifie, certified, endorsement
	quality	10	1.54	choice, quality
3	energy	10	12.05	energy
	green	6	7.23	green
	efficiency	4	4.82	efficiency, efficient
	australia	3	3.61	australia
	china	3	3.61	china, taiwan
	power	3	3.61	index, power
4	certified	31	8.76	certified
	green	18	5.08	green
	certification	14	3.95	certificate, certification
	organic	11	2.97	organic, organically, systems
	sustainable	9	2.54	sustainability, sustainable
	product	8	2.26	product, products
5	indoor	3	8.82	indoor
	energy	2	5.88	energy

Cluster	Word	Count	Weighted Percentage (%)	Similar Words
	home	2	5.88	home, house
	rating	2	5.88	rating
	scheme	2	5.88	scheme
	scs	2	5.88	scs
6	green	3	12.50	green
	chlorine	2	8.33	chlorine
	free	2	8.33	free
	avogreen	1	4.17	avogreen
	certified	1	4.17	certified
	degree	1	4.17	degree
7	carbon	4	12.50	carbon
	climate	3	9.38	climate
	standard	3	9.38	measurement, standard
	reduction	2	6.25	reduction
	action	1	3.12	action
	carboncare	1	3.12	carboncare
8	safe	3	8.82	safe
	sea	3	8.82	ocean, sea
	dolphin	2	5.88	dolphin
	friend	2	5.88	friend, friendly
	marine	2	5.88	marine
	program	2	5.88	program
9	standard	2	13.33	standard
	textile	2	13.33	textile
	100	1	6.67	100
	africa	1	6.67	africa
	coop	1	6.67	coop
	cotton	1	6.67	cotton
10	fair	4	14.81	fair
	trade	3	11.11	trade
	hand	2	7.41	hand
	award	1	3.70	award
	benefits	1	3.70	benefits
	certified	1	3.70	certified
11	recycle	3	17.65	recycle, recycled, recycling
	punkt	2	11.76	punkt
	biobased	1	5.88	biobased
	content	1	5.88	content
	der	1	5.88	der

Cluster	Word	Count	Weighted Percentage (%)	Similar Words
	dot	1	5.88	dot
12	green	2	16.67	green
	tourism	2	16.67	tourism
	business	1	8.33	business
	certification	1	8.33	certification
	hotel	1	8.33	hotel
	legambiente	1	8.33	legambiente
13	water	3	17.65	water
	wqa	2	11.76	wqa
	efficiency	1	5.88	efficiency
	gold	1	5.88	gold
	mark	1	5.88	mark
	marque	1	5.88	marque

The meaning of the keywords within each cluster were often related to each other. For example, in the first cluster, the words 'organic', 'agriculture', 'compost', 'food' and 'practice' potentially hint about sustainable 'agriculture & food'. Four independent researchers were involved in generalising the cluster themes, the results generated by the researchers were highly similar, and are combined and concluded in Table 6.5, which suggests thirteen themes that encapsulate these keywords for each cluster.

Table 6.5 Themes emerge from 13 clusters

Cluster	Word	Theme Heading
1	organic	Agriculture & food
	agriculture	
	compost	
	association	
	food	
	practice	
2	eco	Environmental friendliness
	green	
	environmental	
	certification	
	certified	
	quality	
3	energy	Energy efficiency
	green	
	efficiency	
	australia	
	china	
	power	
4	certified	Certification
	green	
	certification	

Cluster	Word	Theme Heading
	organic	
	sustainable	
	product	
5	indoor	Indoor energy rating
	energy	
	home	
	rating	
	scheme	
	scs	
6	green	Toxicity
	chlorine	
	free	
	avogreen	
	certified	
	degree	
7	carbon	Carbon footprint
	climate	
	standard	
	reduction	
	action	
	carboncare	
8	safe	Ocean friendliness
	sea	
	dolphin	
	friend	
	marine	
	program	
9	standard	Textile
	textile	
	100	
	africa	
	coop	
	cotton	
10	fair	Fair trade
	trade	
	hand	
	award	
	benefits	
	certified	
11	recycle	Recycling
	punkt	
	biobased	
	content	
	der	
	dot	
12	green	Tourism & hotel
	tourism	
	business	
	certification	
	hotel	
	legambiente	

Cluster	Word	Theme Heading
13	water	Water footprint
	wqa	
	efficiency	
	gold	
	mark	
	marque	

6.3.5. Word frequency query on participants' comments

One objective of the card sort was hearing the participants' comments on the label design, for this, a word frequency test was conducted. The test took all participants' responses from the interview session into account.

When 'finding matches', this query included synonyms and only included words with a minimum length of 3 characters. Figure 6.6 is a visual representation of the fifty most frequently used words by all participants when they explained their definitions of the categories and their rationale of choosing the indicative examples. The image shows an emphasis on the word 'word' and 'picture' in the context of 'eco' 'green' 'sustainable' 'labels'. Details of the word frequency query can be found in Appendix 12.

Figure 6.6 Fifty most frequently used words by all participants from 6 sorts

6.3.6. Indicative examples: selection and perception

6.3.6.1. Chosen indicative examples

Seventy-six labels were selected as indicative of the categories they belonged to, out of which six indicative examples appeared for three times, and eight indicative examples

appeared twice. Figure 6.7 shows the fourteen most popular indicative examples that had appeared more than once. (See Appendix 8 for the full list of the seventy-six selected indicative examples.)

Figure 6.7 The most popular indicative examples

The indicative examples selected by multiple participants were sometimes used to represent different categories. For example, Card No.151 (the EU organic products label) was chosen to represent the categories 'Environment', 'Green' and 'Logo'; Card No.90 (dolphin safe /dolphin friendly label) was seen as indicative for the categories ‘Ocean friendly’ and ‘Food’. Besides, a good range of information formats can be observed from these fourteen most popular examples, such as certification symbol, numerical rating, company logos, colourful rating chart, QR code.

6.3.6.2. Rationale of the selecting indicative examples

To understand the rationale of the selection of these indicative examples, the participants were asked to explain why the chosen indicative examples could represent the associated category. The verbal responses were transcribed. Two researchers coded the transcripts separately, then the codes were compared and combined. Table 6.6 shows the definitions of the codes (i.e. the reasons of indicative example selection), the number of sorters who mentioned that, and its number of occurrences (i.e. number of references in the speech).

Table 6.6 ***Codes used for the analysis of the indicative example selection***

Theme/ code	Definition	No. of sorter(s)	No. of references
Wording	An expression in words or phrasing	5	34
Picture	A visual representation or visible image	4	27
Recognisable	Participant has previously seen or known the label.	4	15
Clear	Distinctly perceptible, without obscurity	1	7
Brand	A trademark of a company	3	6
Informative	Giving information	1	5
Famous	Having a widespread reputation	3	3
Colour	Related to the use of colour in the design	2	2
Simple	Not complicated, easy to understand	1	1
Relevant	Connected with the person or the matter in hand	1	1
Beautiful	Aesthetically pleasing	1	1

The most popular hints perceived when selecting an indicative eco label example were the verbal ('word') and visual ('picture') shown on the eco label. Some example quotes to illustrate the importance of verbal (word) and/ or visual (picture) description are shown below:

P2 *Because it has got the word 'ocean wise recommended' and it has a fish (picture) on it. So I think people would think of ocean issues when they see this.*

P3 *It has the word 'organic' 'farmer' and grower'.*

P4 *Because there is a picture of a green power cord, and there is the word 'I.T.'*

P5 *I would say, no.49, it says certified natural cosmetics. They are using the word 'certify' trying to give it more authority.*

P5 *Indicative one is 76, it has picture of a house and carpet. And it writes 'green plus'.*

P5 *57, I thought it is a good one because it is the most descriptive. It has got a picture of the blue planet and it has got things associated with cleaning, washing, glass.. professionally laundered tee shirt and a brush and it says 'sustainable cleaning.com'.*

G1 *Because it is 100% clear what they want to claim. Both pictorial and word way.*

The number of sorters and number of references for 'wording' is larger than that of 'picture', which possibly implies that verbal hints have a higher importance in eco label interpretation. As a participant in the team sort put it, *"Without text, graphic itself can be misleading."*

Another major reason for selecting an indicative example is that the participants could recognise the labels.

G1 *Fair trade. It is an obvious one about labour and everyone knows it is labour.*

G1 *It is a well-known company, so we know what they do...*

P2 *361 is chosen because I have seen it.*

P2 *Carbon footprint. 38. This family is about carbon and energy. It is chosen because I think everyone is familiar with this symbol.*

P3 *395. Water wise. I know it is set up for making sure you are aware of the water consumption in your house. I have done research on it before that's why I know the brand*

P5 *This one, 330, got a bit more authority because it is easily recognisable.*

P5 *It is the most recognisable.*

Other factors mentioned are whether the label was 'clear', 'informative', 'famous', 'simple' and 'beautiful'.

G1 *38 is informative and clear.*

G1 *We chose 311 for similar reasons. It is clear and detail, so it is easy to understand.*

G1 *EU energy label. It is informative, clear and it has got the flag. And it is simple enough.*

P4 *30. Because I think this one is the most beautifully design.*

P5 *157, fair trade, is probably one of the most well-known.*

Some participants selected an eco-label because it reminded them of a 'brand', or was 'relevant' to their life.

P4 *I chose this one because Starbucks is a well-known coffee brand all over the world.*

P2 *62. School is more relevant in my career because I am a student. School is a representative example of an industry.*

Colour was sometimes a factor which affected their choice too.

P3 *207. 'Green.com'. Because of its word and the colour.*

P4 *240. The reason is the picture is very colourful and we can see the picture of star and the word of star on the label.*

6.3.7. ‘Odd’ and ‘Difficult’ cards

There were a lot of cards that the participants found difficult to group or name. 162 cards were placed in the ‘Odd’ category, and 141 cards were placed in the ‘Difficult’ category. The comments towards these cards can provide insights for improving eco label design.

The participants gave similar definitions to the category ‘Odd’, for example:

P2 *Odd. I cannot recognise them. Some of the labels are blur, I cannot see the word on it. Like this one I did not know the language on it so I ignored it.*

P4 *Odd. Some pictures are strange... Odd, to me, means strange. I cannot even make guesses.*

While ‘Difficult’ was defined as:

P3 *I don't understand those ones. I don't know what they are. I cannot correlate them to anything, to any group of ideas.*

P4 *Maybe for this one [‘Difficult’ group], I can guess the picture. There is a bird, pigeon. I could try to guess the meaning of the labels from the 'difficult' group.*

P5 *Ambiguous. Nothing to suggest eco-ness.*

Table 6.7 shows card examples from these two groups. All examples had a 50% of agreement level on card placement, which was the highest percentage in both categories. Some common features were shared by these label examples:

- There was a lack of clear verbal description;
- Many of them did not have a meaningful picture;
- Some of the labels were written in non-English languages which caused difficulty in understanding and grouping.

Table 6.7 Examples of ‘Odd’ and ‘Difficult’ cards

Category	Card no.	Label image	Card name	Level of agreement
Odd	107		Ecomark: India	50%
	121	 121.	Emblem of Guarantee of Environmental Quality: Catalonia	50%

Category	Card no.	Label image	Card name	Level of agreement
	168		Fly-360-Green	50%
	257		Water Lily: Lithuania	50%
	307		ÖkoControl	50%
	351		Sourcemap	50%
Difficult	25		BASS (Product inventory for the construction industry)	50%
	82		Declare	50%
	145		Estonian Ecotourism Quality Label	50%
	242		Just	50%
	390		VIBE-label	50%

6.4. DISCUSSIONS

6.4.1. Card categories and themes emerged from clustering

Two lists of terms were generated from this study (Table 6.8). The first list contains the 53 category names created by the participants. The second list contains the 13 themes emerged from the 13 clusters derived from the HCA based on the card placements. These lists provided ideas for possible eco information organisational schemes.

Most of these categories and themes can be classified into five top-level concepts, with some exceptions placed under the column 'Others'. The top-level categories were 'Information format', 'Type of eco attribute', 'Product category', 'Issuing organisation' and 'Stage of life cycle' (Table 6.8). These top-level categories were validated with an additional series of evaluative card sorts that involved four closed sorts with four researchers.

Table 6.8 Five top-level categories encapsulating most category names and cluster themes

Five top-level concepts	Category names	Theme headings emerged from HCA
Information format	Certification symbol	Certification
	Logo	
	Rating	
	Chart	
	Digital	
Type of eco attribute	Eco label content	Environmental friendliness
	Environment	Toxicity
	Global warming	Carbon footprint
	Carbon footprint	Ocean friendliness
	Product Info	Fair trade
	Ethics	Water footprint
	Energy	
	Ocean friendly	
	Organic	
	Energy efficiency	
	Fair trade	
	Animal friendly	
	Efficiency	
	Renewable energy	
	Biological	
Product category	Food	Energy efficiency
	Building	Agriculture & food
	Agriculture	Indoor energy rating
	Water	Textile
	Textiles	Tourism & hotel
	Tourism	
	Forest products / Paper	
	Entertainment	
	Cleaning products	
	Financial services	
	Cosmetics / Personal care	
	Fashion	
	Logistics	
	Soil	
	I.T.	
	Coffee	

Five top-level concepts	Category names	Theme headings emerged from HCA
Issuing organisation	National Standard	
	Private companies	
	Producers associations	
	B to B	
	Brands	
Stage of life cycle	Raw material	Recycling
	Recycling	
	Resource consumption	
	Use phase	
	Transportation	
Others	Odd	
	Difficult	
	Green	
	Planet	
	Plants	
	Earth	
	Considered design	

6.4.2. Level of agreements on categories and on card placements

The low level of agreements on categories and that on card placements may indicate that participants have different perceptions or understandings towards these 403 eco labels. It could be because an eco-label can have different attributes and can be grouped into different categories. The small participant sample size might also have an effect on the level of agreements on categories and on card placements.

6.4.3. Indicative examples

This argument about the existence of multiple perspectives to look at one eco label is supported by the results of the indicative example selections, where the same label was being 'favoured' for different reasons, e.g. the label No.151 (the EU organic products label) is considered to be indicative because it is associated with 'green' (for its colour), 'environment' (for its leaf shape element) or 'logo' (for the information format of the label).

The 14 most popular examples represent a good range of information formats, including certification symbol, numerical rating, company logos, colourful rating chart, QR code. It may imply that the effectiveness of an information format is contingent upon the context of use and the target audience.

6.4.4. Perception towards existing eco labels

It was found that, to interpret an eco-label, users mainly relied on verbal ('word') and visual ('picture') hints, where verbal hints had a higher importance for accurate interpretation of an eco-label. Some factors that affect the indicative-ness of an eco label were whether it is recognisable, clear, informative, famous, simple, beautiful and relevant to the user's interest. The participants also claimed the use of colour and the association with brands have an impact on them.

Generally the participants showed a relatively poor understanding of existing eco labels. Their interpretations of the label meanings were frequently inaccurate. The participants found it difficult to place a number of labels in any category. These labels tend to share one or more of these characteristics:

- Lack of clear verbal (word) description;
- Lack of clear visual (pictorial) description;
- Written in language that users could not understand.

6.5. CONCLUSIONS OF CARD SORTING STUDY

Card sorting was used as a technique to understand user perception towards existing eco labels, and to generate a good set of categories for classifying eco information for the proposed device. The results have informed these three outcomes:

1. A set of categories based on user perception

One of the characteristics of a good set of categories is to have labels that clearly describe the content and match how users think (Spencer, 2009). The hierarchical cluster analysis identified a strong clustering in the results, suggesting common underlying views about information on eco labels do exist. This card sorting study provided insights on how people categorise and perceive information on eco labels, and suggested a possible organisational scheme which groups eco information under five top-level categories, namely 'Information format', 'Type of eco attribute', 'Product category', 'Issuing organisation' and 'Stage of life cycle'. While the first top-category is about information presentation, the later four are about the contents of the information.

2. More than one 'appropriate' classification scheme

Considering the low level of agreement for most categories and card placements, it is believed that there exist multiple ways to view an eco-label. This belief is supported by the indicative examples where the same labels were often chosen to represent different categories, and the wide diversity of the categories created. A range of information formats are present in the most indicative examples. A possible implication is that the effectiveness of an information format is contingent upon the context of use and the target audience. Therefore it would be appropriate to consider multiple classification schemes for structuring eco information, instead of one main classification scheme. An interactive system that displays information in multiple layers may be a desired solution.

3. Perception towards existing eco labels

An understanding about how people see an eco label was gained. It was observed that the participants had a relatively poor understanding of eco labels (this is consistent with the finding from the literature review). To interpret an eco label, the participants mainly relied on the verbal and visual cues on it. Identified from the results were also a number of factors which determined the indicative-ness of an eco label, and a number of factors which hinder the comprehension of eco labels.

6.6. REFLECTIONS

Through a card sorting study on user perception towards existing eco labels, this chapter further explored the user requirements for the structuring of product eco information when designing eco information individualisation.

It is worth noting that designers should be flexible in adapting the above findings when designing information architecture. Card sorting is only a technique to provide insights, but it is the designer's thinking that puts it all together to create great solutions. Also, the card sort outcomes are not to be used to find one true way, but rather many possible ways to group contents. As Spencer (Spencer, 2009) states, 'Classification is ultimately an imperfect and messy undertaking", getting it "right" sometimes could be a false goal.'

Chapter 7
Framework refinement & development of the design tool

7.1. INTRODUCTION

In his review on the discipline of design research, Cross (1999) expresses, 'The whole point of doing research is to extract reliable knowledge from either the natural or artificial world, and to make that knowledge available to others in re-usable form.' A consistent view is shared by the book *DRM, a Design Research Methodology* (Blessing & Chakrabarti, 2009), which suggests that design research should aim at not only understanding but also improving design, and this requires a vision of the '*support*' that is likely to change the existing situation into the desired situation. The '*support*' here refers to the possible means, aids or measures that can be used to improve the design of product and/ or process.

The proposal of 'Eco Information Individualisation', in this case, is the proposal of such a '*support*'. It is a complex concept that involves knowledge from multi disciplines. In the focus group study (DS3) reported in Chapter 5, some participants expressed interests in obtaining more details of the framework. This led to the idea of developing a design tool that helps communicate the concept to designers and aids their design process by supporting problem framing and stimulating design ideas.

This chapter extends the conceptual framework by introducing a more structured way of considering the personal data and product data requirements, and reports on the development of the design tool.

7.2. REFINING THE CONCEPTUAL FRAMEWORK

As part of refining the conceptual framework, the fifth component (the 'individualised information feedback') in the original framework diagram (Figure 5.2 on p.100) has had its numbering removed, because the individualised feedback is considered an output resulting

from the designing of the other four components. The refined framework therefore has four numbered components (Figure 7.1), namely ‘personal data’, ‘product data’, ‘technology on user’ and ‘technology on product’.

Supplementary information with regard to the structuring of the ‘personal data’ and the ‘product data’ are provided in the followings sections (Section 7.2.1 and Section 7.2.2). This addition encompasses the insights gained from an additional review of literature on user context and context-sensitive system, as well as the findings from the card sorting study described in Chapter 6.

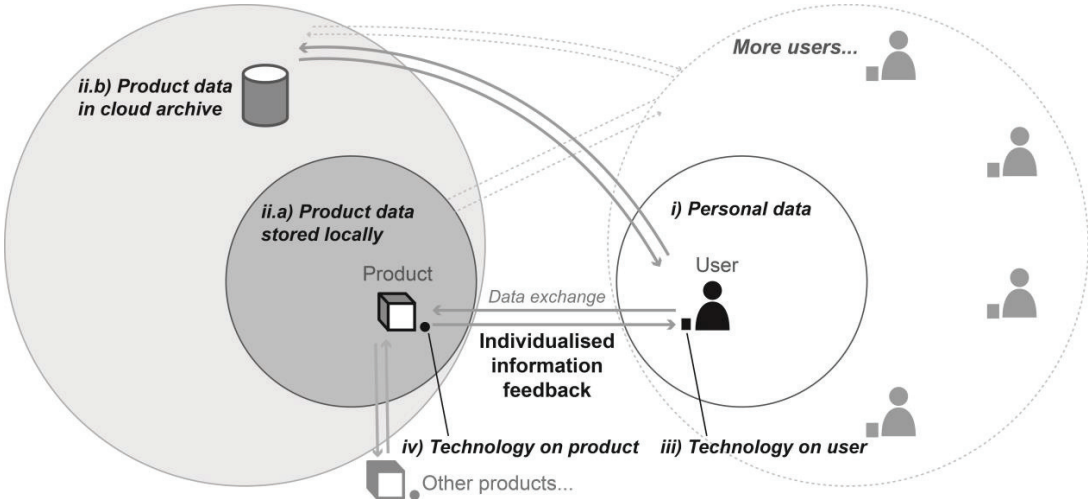


Figure 7.1 The refined conceptual framework of Eco Information Individualisation. Personal data can be stored with technology on the user. Product data can be either stored locally or remotely in cloud archive and be accessed by technology on product. Contextual technologies can enable digital interaction between product and user, and result in individualised eco information feedback.

7.2.1. User context model

To structure the ‘personal data’ element, the user context model of Kofod-Petersen & Aamodt (2003) was extended to provide a model for personal data aspects of eco information individualisation. There were five key aspects to this personal context model, namely personal profile, task context, spatio-temporal context, past history and social context. The personal profile was further divided into mental context and physiological context. Examples of these contexts related to tailoring eco information are illustrated in Figure 7.2.

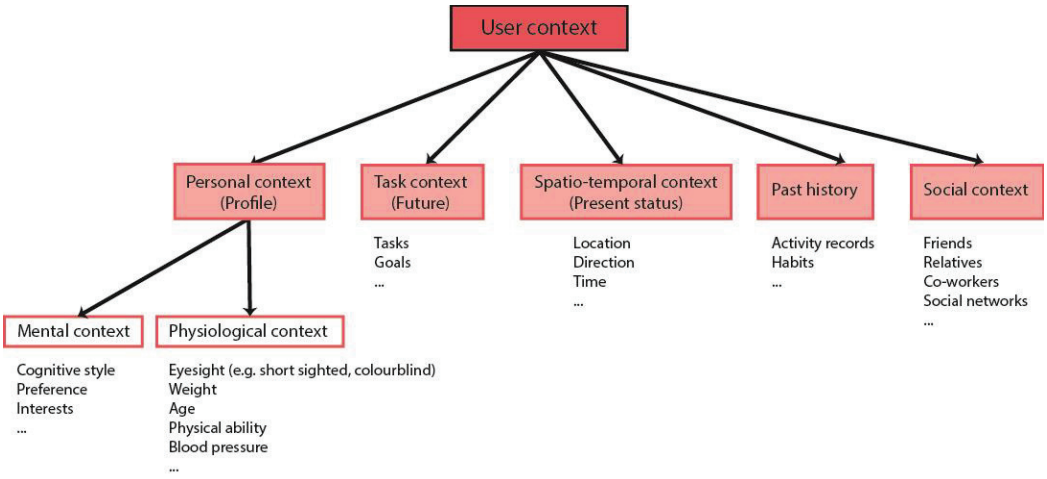


Figure 7.2 Personal context model for eco information individualisation. (Extended from the user context model of Kofod-Petersen & Aamodt (2003))

7.2.2. Classification of eco information

As reported in Chapter 6, a card sorting study was conducted to uncover how users make sense of existing eco labels. The results provided insights on how people categorise and perceive information on eco labels, and suggested a possible organisational scheme which groups eco information by information formats and by eco information content. The later can further be divided into 4 categories: product categories, life cycle stages, eco attributes and issuing organisation (Kwok, Harrison, & Malizia, 2016).

7.3. STRUCTURE OF THE DESIGN TOOL

Card-based tools have previously been used as a presentation format to put together knowledge from diverse areas into a re-usable form to stimulate designers' thinking. Relevant examples include *the Design with Intent Tool* (Lockton, Harrison, & Stanton, 2010), *IDEO Method Cards* (IDEO, 2003), the *Human-Centred Design Toolkit* (IDEO, 2015), *the CoLab Design Tool* (Pei, 2009) and *Drivers of Change* card sets (Arup, 2009).

The four major components needed to produce an individualised eco label were personal data, product data, technology on user and technology on product. This information was used to drive the content structure of the tool. The tool consisted of a short guidebook that introduces the concept of eco information individualisation (Appendix 15), 2 design templates that assist with structuring label design and picturing the use of technology (Appendix 16), and 25 cards that provide structured information on user context, product

context and technologies in relation to eco information individualisation (Appendix 14). Table 7.1 lists all cards in the tool.

Table 7.1 Summary of design tool card structure and card names

Type of cards	Person Cards	Product Cards	Technology Cards
Title of card	1. Verbaliser vs Imager (VI)	9. Product Category	17. Barcode & QR code
	2. Wholist vs Analytic (WA)	10. Issuing organisation	18. Augmented Reality (AR)
	3. Preference & Interest	11. Life Cycle Analysis (LCA)	19. iBeacon
	4. Physiological factors	12. Eco attribute	20. RfID & NFC
	5. Time & Location	13. Colour	21. Mobile & Wearables
	6. Task Related	14. Data visualisation	22. Social Media
	7. History & habit	15. Level of detail	23. Internet of Things (IoT)
	8. Social factors	16. Richer medium	24. Location-based service (LBS)
			25. Cloud computing

7.3.1. Person cards

Building on the personal context model shown in Figure 7.2 and the insights gained from earlier studies (i.e. DS1- focus group study 1 and DS3-card sorting study), eight person cards were designed to provide information about potential dimensions of individualisation around people's data, with respect to their cognitive styles ('verbaliser vs imager' and 'wholist vs analytic'), 'preference & interest', 'physiological factors', 'time & location', 'task related behaviour', 'history & habit' and 'social factors'. Table 7.2 briefly describes the key ideas of the person cards.

Table 7.2 Brief descriptions of the person cards

Card No. & Title	Sub-title	Key Idea(s)
1. Verbaliser vs Imager (VI)	Cognitive styles	The habitual way in which a person tend to process information and knowledge, in words (verbal) or mental pictures (images) [4]..
2. Wholist vs Analytic (WA)	Cognitive styles	The habitual way in which people view, process and structure information in wholes or parts[5]
3. Preference & Interest	What attributes are valued?	Ways to elicit user's preference and interests to increase effectiveness of an eco label.
4. Physiological	Physical ability varies among individuals	Context of a person's physical conditions, e.g. age, gender, eyesight, weight, physical ability, glucose level.
5. Time & Location	Essential for an adaptive system	Contextual information that is useful for understanding user behaviours and enabling a

		wide range of tailored functions.
6. Task Related	Task-specific information motivates behaviour change	Drawing a close link between specific actions and their effects helps activate various motives that appeal to different consumers [11,12].
7. History & habit	Self-tracking for behaviour change	Shopping record gives an account of actual environmental impact consumed and helps self-understanding.
8. Social factor	What do others like?	Social contexts for consideration of the needs of others and of social norms.

7.3.2. Product cards

Informed by the organisational scheme identified in the card sorting study (Table 6.8) and the insights gained from a review of literature on information formats/ presentations, eight product cards were designed. Four of these cards describe relevant product eco information content: i) 'product category' that determines the shopping context; ii) 'issuing organisation' which affects consumer's trust and confidence; iii) 'life cycle analysis' that results in an inventory of environmental impact throughout various product life cycle stages; and iv) the wide variety of 'eco attributes' that represents various product qualities. The other four cards provide insights about presentation formats of eco information on products, namely i) using 'colour' to convey meaning; ii) tips on 'data visualisation'; iii) considerations on the 'level of detail'; and iv) using 'richer medium' to provoke engagement.

7.3.3. Technology cards

The design of the 'technology' card deck was informed by findings from literature review (Section 2.5.3). This card deck reflects two components of the conceptual framework, which are the technology on user and the technology on product. This deck contains nine technology cards to provide information about useful technologies that enable eco information individualisation. Topics covered include 'barcode & QR code', 'augmented reality', 'iBeacon', 'RfID & NFC', 'mobile & wearables', 'social media', 'the Internet of Things', 'location-based service' and 'cloud computing'.

7.4. DETAILS OF THE DESIGN TOOL

All cards are in A6 size with contents printed on both sides. On the front is a big image which acts as a visual aid to illustrate the overall concept of the card concisely and clearly. The images were chosen to serve one or more of the following purposes: i) reinforce the messages of the card with emotive and playful visual elements; ii) present the concepts

through metaphor; iii) depict explicitly the scenarios/ examples suggested by the card contents. On the back are 4 items - title, sub title, main text and an interesting fact supplemented with an explanatory image. Figure 7.3 shows an example of the person card. The complete set of 25 cards in actual size is presented in Appendix 14.

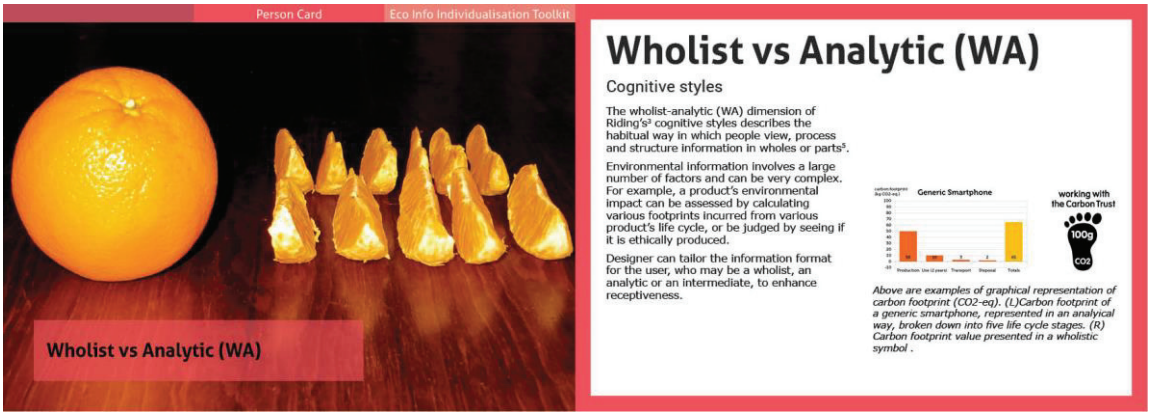


Figure 7.3 An example of person card

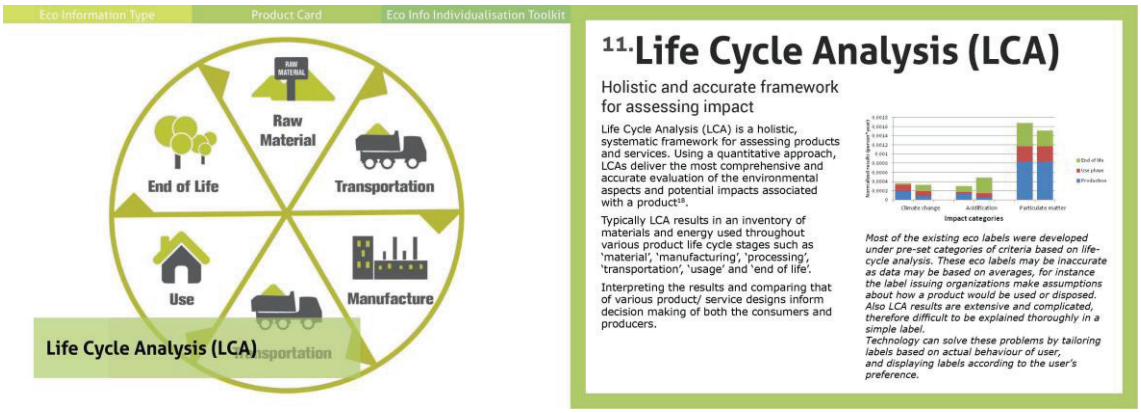


Figure 7.4 An example of product card

Figure 7.5 An example of technology card

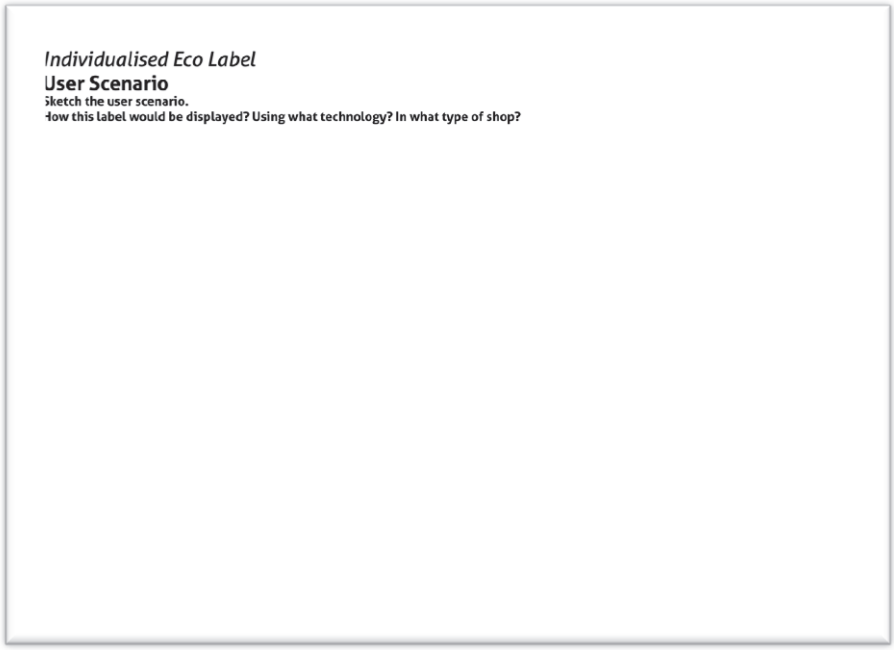


Figure 7.6 Image of 'user scenario' worksheet

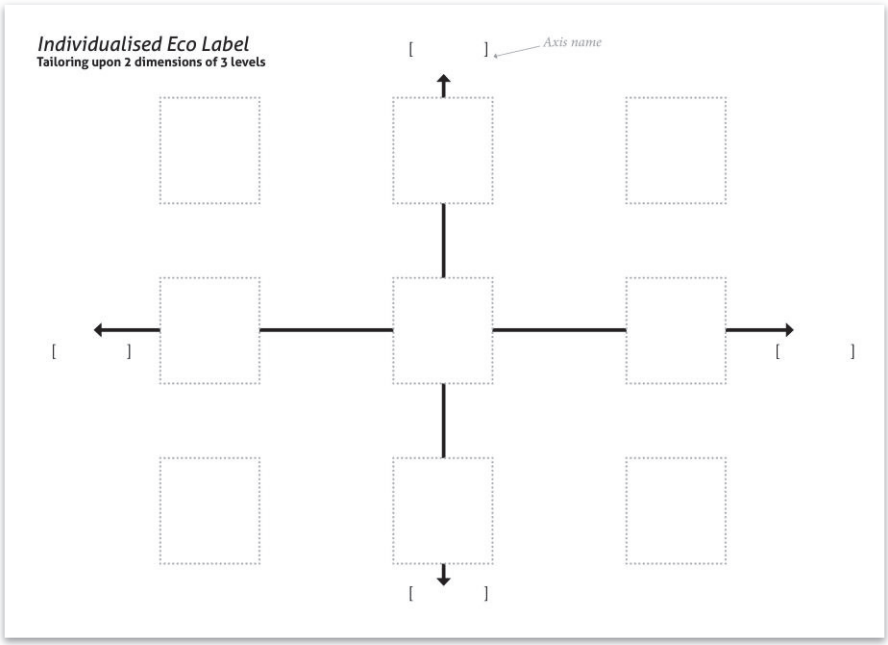


Figure 7.7 Image of 3X3 matrix label design template

The idea of information individualisation is rooted in the fact that the context around the user and product can be very complex and the amount of contextual data captured can be enormous. When visualising these data in the form of an eco label, there may exist many possible dimensions for tailoring - cognitive styles, time, location, social parameters,

parameters of environmental impact, and size of fonts to name a few. Each dimension consists of a continuum of label designs, so that individuals with different needs would see different labels accordingly. For example, when tailoring upon the dimension of 'level of detail', designers should create a continuum of labels with different levels of detail in order to satisfy different individuals (Figure 7.8). Figure 7.9 illustrates an example of 2-dimension tailoring with 5 variations on the axis of 'product life cycle stages' and 3 variations on the axis of 'wholistic-analytic' cognitive styles. In essence the number of dimensions for information tailoring can be unlimited where a wide range of contextual factors can be involved (Figure 7.10).

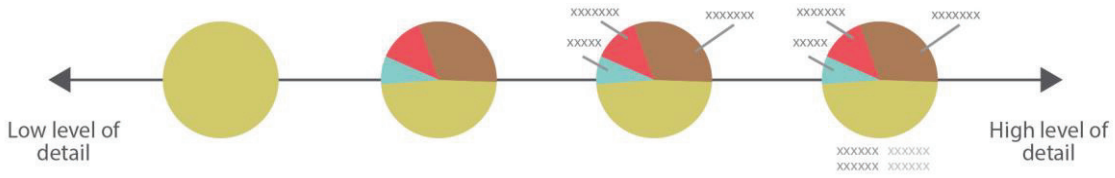


Figure 7.8 Example of 1-dimension individualisation of eco information

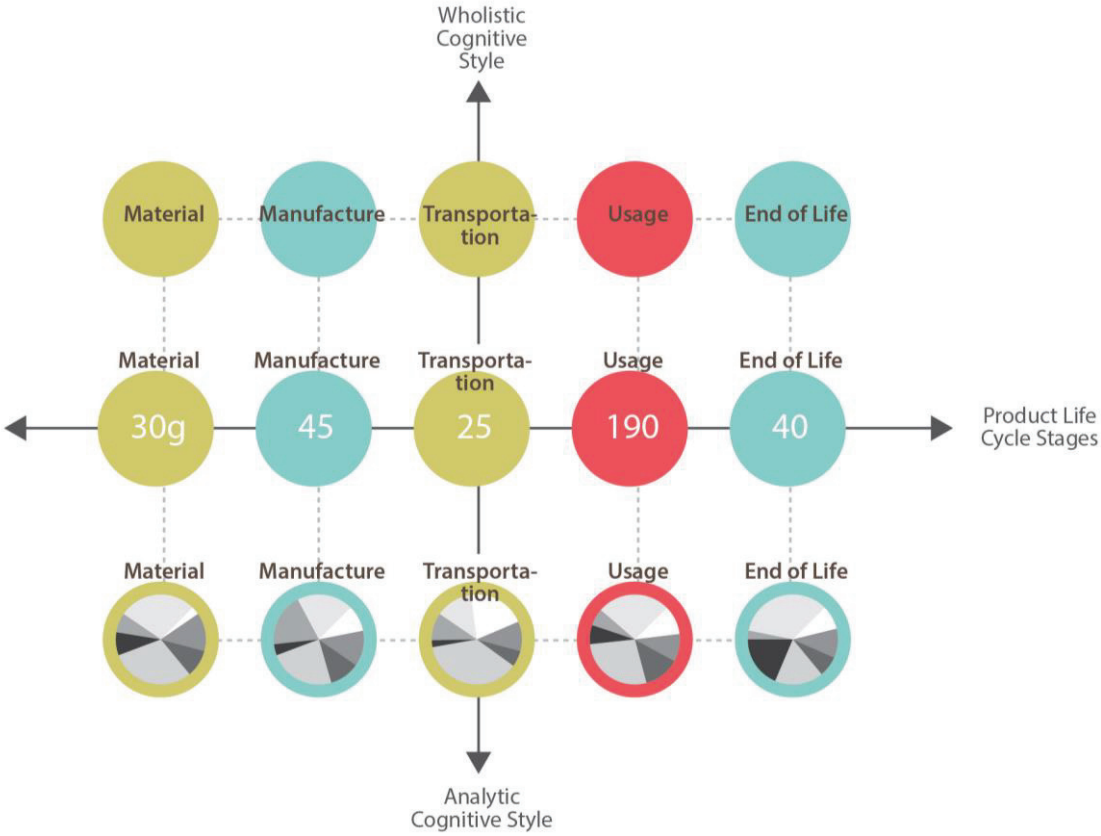


Figure 7.9 Example of 2-dimension individualisation of eco information

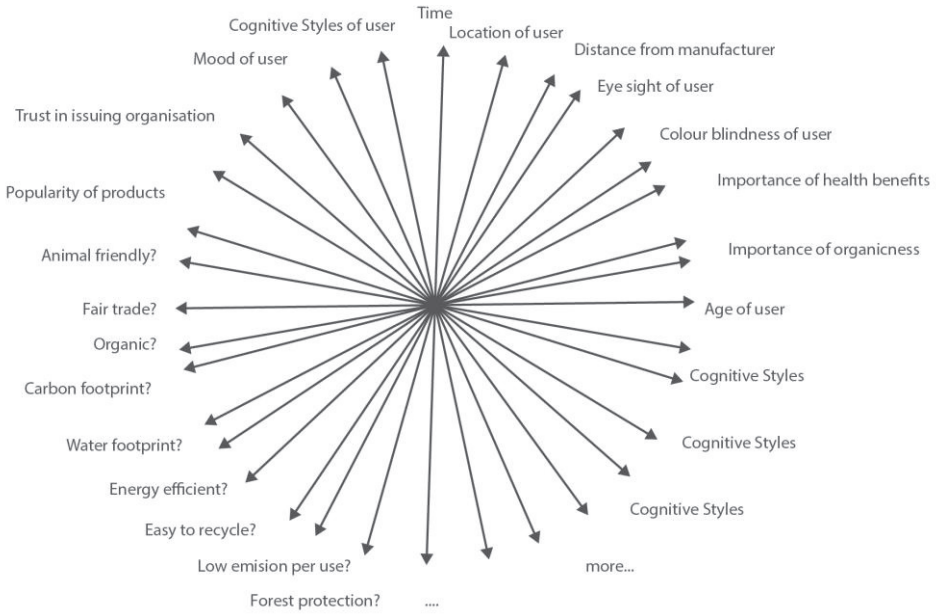


Figure 7.10 The number of dimensions for information tailoring can be unlimited

Figure 7.7 shows a design template created to help position 9 design variations in the form of a 3X3 matrix. This template provides a basic structure for 2-dimensional eco information individualisation, with 3-levels of variation on each dimension. Examples of the template usage can be seen in Figure 8.5 and Figure 8.7.

7.5. REFLECTIONS

This chapter updates the conceptual framework of eco information individualisation by re-labelling the components and adding more details relating to structuring personal data and product data. A design tool was developed to extend the conceptual framework with the aim of providing more support to designers in terms of problem framing and encouraging creativity during the design process for eco information individualisation.

The tool contains three sets of cards that delineate contexts related to user, product and relevant technologies, as it was believed that the attempts to create solutions evolve in parallel with the understanding of the problem. These sets of cards are not exhaustive. More cards can be added or renewed, especially over time when technologies continue to advance.

Chapter 8
Design workshop day: design tool evaluation

8.1. INTRODUCTION TO DESIGN WORKSHOP

This chapter reports on a design workshop carried out to introduce the concept of eco information individualisation and the design tool to designers. The session also served as an evaluation of the usability and usefulness of the design tool.

Three main research questions were asked:

i. Is it possible for a designer to understand the idea of eco information individualisation in the workshop with the aid of the design tool?
ii. Could feasible concepts for individualised eco labels be generated?
iii. How did the designers feel about the tool in terms of usability and usefulness?

Figure 8.1 Photo of the workshop

8.2. METHOD

8.2.1. Participants

Workshops typically tend to involve 8 to 20 people working on carefully planned activities to generate specified outputs (RSSB, 2008). The workshop reported in this paper involved two facilitators and eleven designer participants. All designers satisfied the recruitment criteria which required them to have knowledge of eco design, graphic design and an understanding of life cycle analysis. Nine of them had industrial experience ranging from 1 year to 15 years long. This sample size was considered enough to answer the three research questions since patterns were identified from the results.

8.2.2. Procedures

The workshop lasted for three hours. At the beginning of the workshop, the designers were introduced to the background of Eco Information Individualisation, then they were asked to work on four 40 minutes long design activities. A 5-minute break was given after every task, while the facilitator distributed materials and explained the next task. The researcher was aware that fatigue might potentially happen after 3 hours long of work. This might have a negative impact on the performance of the designers. However the results seem encouraging as the designs were generally better in the later stages and did not appear to suffer after three hours. Also 3-hour long design sessions are acceptable in design practice.

The four activities were named ‘Task 1’, ‘Task 2.1’, ‘Task 2.2’ and ‘Task 3' and were all individual activities. The designers were asked to design for the same brief throughout the workshop. The brief included a product specification, which contained eco information of various aspects for a bottle of milk, and four personas (Figure 8.2), which described individuals with different backgrounds, cognitive styles, values, personal goals, and shopping habits.

Task 1 was an unguided activity. The designers were not shown the design tool cards. Each designer had to choose to design for at least two of the personas and to design individualised eco labels for them. The reason for having to choose at least two personas was to inspire the designers to consider the needs of more than one individual, and so to encourage the generation of a range of designs.

Task 2.1 required the designers to design individualised eco labels for the same personas they chose previously with considerations of the personas' cognitive styles.

Cognitive styles are the ways in which different people characteristically approach different cognitive tasks. Riding (1991) proposes there are two dimensions of cognitive styles, namely the Verbal-Imagery (VI) dimension and the Wholist-Analytic (WA) dimension. Before the task began, the designers were introduced to the two cards about cognitive styles from the 'person card' deck. For Task 2.2, the designers were asked to move their design ideas onto the 3X3 matrix design template and structure their ideas on the axes representing the two dimensions of cognitive styles. This template was similar to the one shown Figure 7.7, but with the axes labeled with the two dimensions of cognitive styles.

Figure 8.2 The four personas used during the workshop. See Appendix 17 for a larger version.

For Task 3, all cards from the tool were given to the designers. They were also given another 3X3 matrix design template (Figure 7.7), but this time the axes on the template were not labelled. The designers had the freedom to design for any user needs, and make their own choice of axes. They were also asked to mark which cards from the tool inspired their design ideas.

At the end of the workshop, the designers answered a post-task questionnaire that consisted of 17 questions related to the usability and usefulness of the design tool and two open-ended questions about their opinions.

8.2.3. Role of the facilitators

The job of facilitator is to help a people to gain knowledge and skills in a workshop. Although sometimes top-down 'teacher-like' methods can be effective (for example, starting the workshop with a presentation or demonstration), workshop facilitation is often about creating an environment that enables people to learn from each other and draw on their own experiences (Seeds for change, 2012).

Two facilitators were involved in the workshop. The main facilitator (the author of this thesis) was responsible for briefing the participating designers, controlling length of time for each activity, as well as interacting with the designers throughout the workshop. The second faciltator was responsible for distributing and collecting materials (such as papers, stationeries and the design tools) used during the workshop.

A presentation was given by the main facilitaor in the beginning of the workshop to introduce the concept of eco information individualisation to the designers. The main facilitator also introduced the four personas (Figure 8.2) and relevant part of the design tool (cards or worksheets) to the designers before each design activity began. The content of the presentation was the same as the content shown on the guidebook (Appendix 15) and the cards (Appendix 14) of the design tool and the personas in Figure 8.2. During the design tasks, the main facilitater had spent most of the time listening to and observing each designer to understand their ideas.

To create a friendly and creative atmosphere in the workshop, as well as to avoid influencing the results, the facilitators were cautious not to 'drive' the activity rigidly. Sometimes the main facilitator asked open questions to encourage the designers to explain their drawings and design concepts, but it was made clear that there was no 'right' or 'wrong' answer and all design directions could be explored. The facilitator would respond to queries from the designers when needed, but did not 'feed' them with any design ideas. The faciltator did not comment on the qualities of their design outputs either.

8.3. RESULTS

To address the research questions, we analysed three types of data collected from the workshop, which were i) observations during workshop, ii) design outputs from workshop, and iii) responses from the questionnaire.

8.3.1. Task 1 - Unguided design task

We have observed the following from the unguided activity and the design outputs from the session:

- The design processes of the participating designers were diverse and messy;
- Before starting to sketch the labels, many designers ideated the context, for instance, considering the personas' core values, styles, personalities, desired functions;
- Most designers came up with two label designs in the shape of a symbol, one for each persona they chose;
- They presented on their label designs the information that the personas were interested in, for example the labels showed carbon footprint for Ben, and showed animal welfare for Lucy;
- Other common features in the design outputs include comparison of environmental performance between people or products, and integration of several eco attributes in one label.

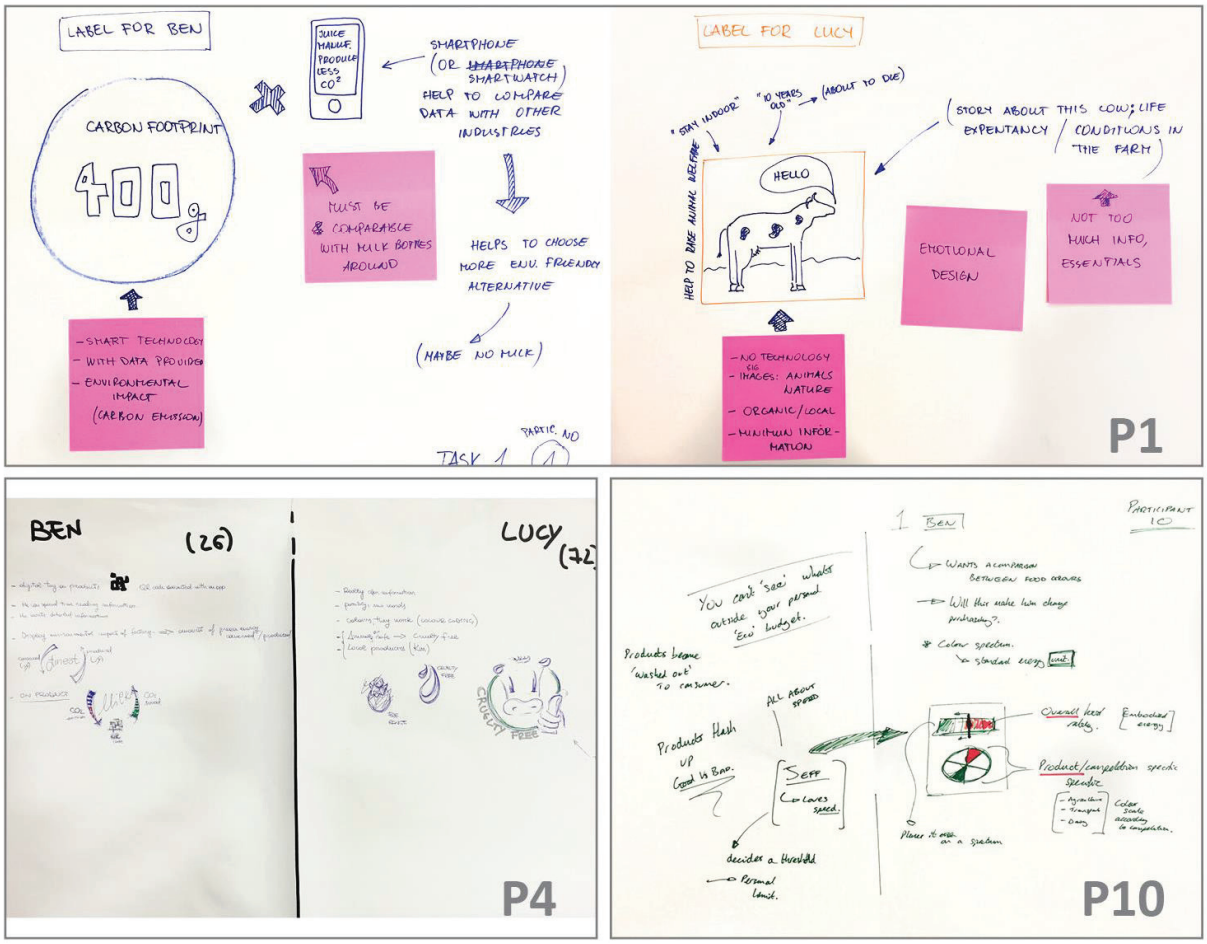


Figure 8.3 Selected design outcomes from Task 1

Figure 8.3 shows a selection of sketches from Task 1. These were produced by the participants P1, P4 and P10. Both P1 and P4 were designing around the personas *Ben* and *Lucy*; while P10 worked around the personas *Ben* and *Jeff*.

8.3.2. Task 2 - Designing for cognitive styles

Two cards from the tool were introduced to the designers before the design activity began. Design outputs from Task 2 showed that most of the designers have gained a deeper understanding of the concept of eco information individualisation by integrating spectrums of design. They were able to individualise eco labels according to the personas' cognitive styles, and they showed considerations about the technologies used.

Figure 8.4 shows the selected design outputs for Task 2.1 created by the participants P1, P4 and P10, who were all designing for the personas Ben and Lucy. As defined in the brief, Ben was a verbaliser and analytic. He was strong on numerical thinking, was concerned about carbon emission and was tech savvy. Lucy was an imager and wholist. She was fond of nature and animals, and she kept the use of technology to minimum.

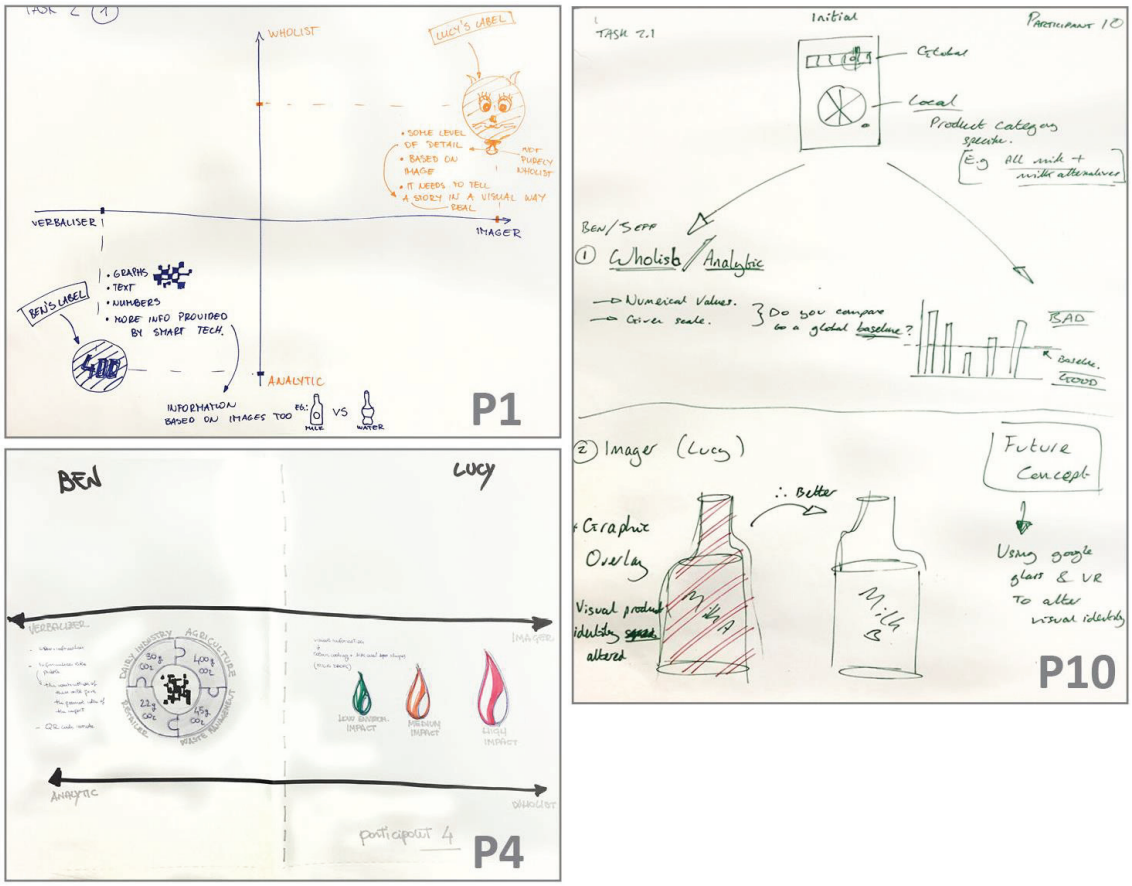


Figure 8.4 Selected design outcomes from Task 2.1

To illustrate the two spectrums of cognitive styles, P1 and P4 aligned their label designs to two axes. P10 created separate designs for Ben and Lucy, but these were not design variations that can be aligned on a spectrum. Both P1 and P4 made use of QR code in their designs, while P10's design idea used augmented reality technology to overlay graphics on product packages (Figure 8.4).

Compared to Task 2.1, in Task 2.2 the designers better structured their design concepts using the given template (Figure 7.7). Most designers had created two continuums of label design that accorded to the two dimensions of cognitive styles. On their design outputs, we could see a horizontal transformation from text-oriented designs to image-based designs, as well as a vertical transformation from holistic to analytic information presentation.

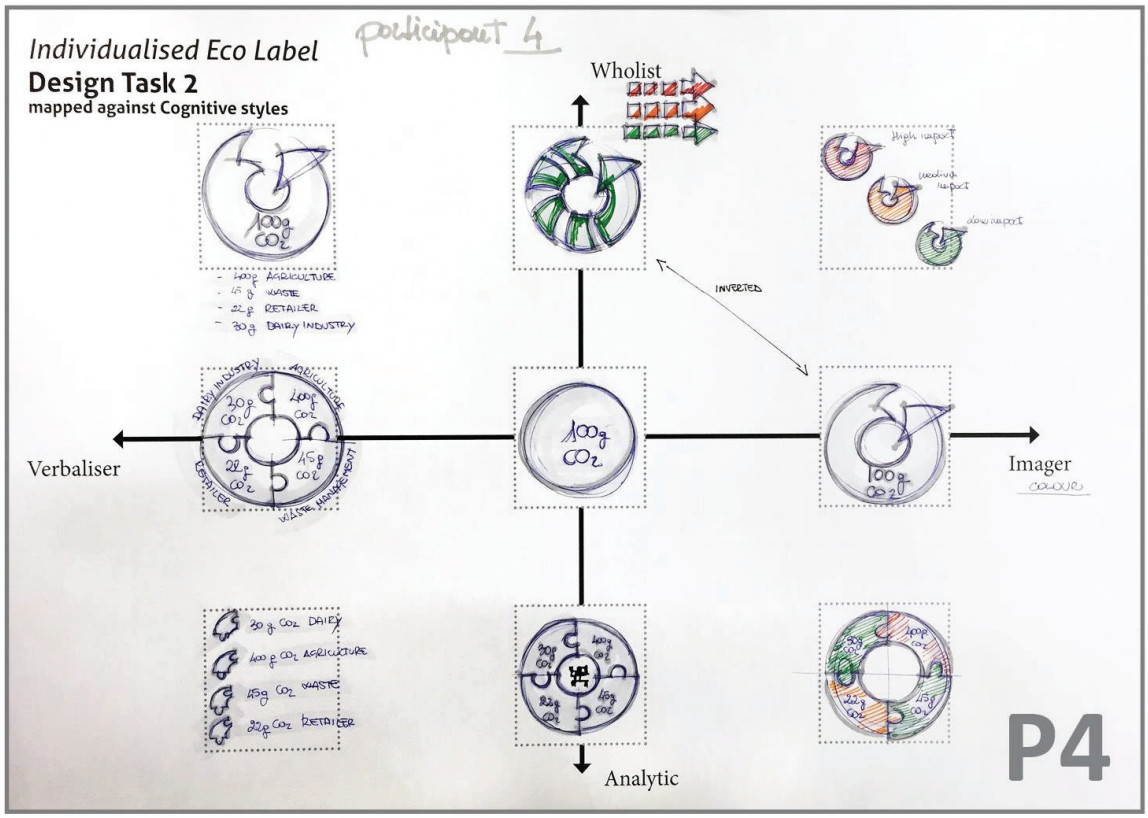


Figure 8.5 Selected design outcome from Task 2.2

In Figure 8.5 we saw an example design generated by P4, who had designed 9 labels that morphed into one another across the spectrums. (Please note, as indicated by P4 on the sketch, the label in the middle of the top row should be swapped with the label on the right in the middle row.) On the top row were labels showing eco information holistically. On the top left was one label design with a number presenting the overall carbon emission of the product; on the top right was one label design that differentiated environmental

performance of product using different colours, with green indicating more desired performance and red indicating less desired performance. In the bottom row were three designs that contained a more detailed breakdown of eco information, again on the left the design was relatively text based, to suit the need of verbaliser, and on the right the presentation was more graphical, differentiating meanings using colours. The designs in the middle balanced the characteristics of both ends.

Apart from drawing the graphical labels, the designers also considered user scenarios. On the provided 'user scenario' worksheet (Figure 7.6), they illustrated the technologies to be used to display the labels (Figure 8.6).

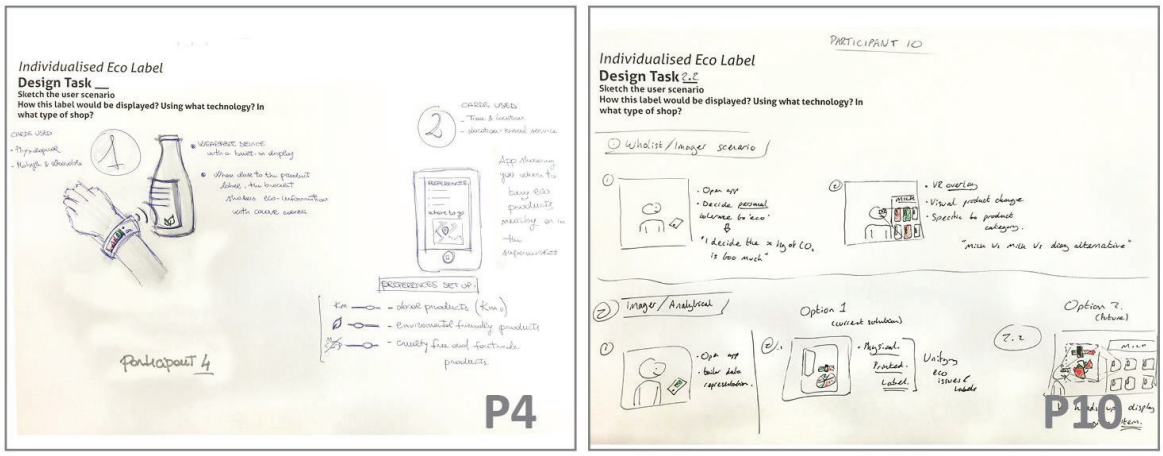


Figure 8.6 Selected sketches of user scenario

8.3.3. Task 3 - Designing for any chosen dimensions

Provided with all cards from the design tool, the designers were able to think of many new ideas of eco information individualisation around various types of user and product contexts.

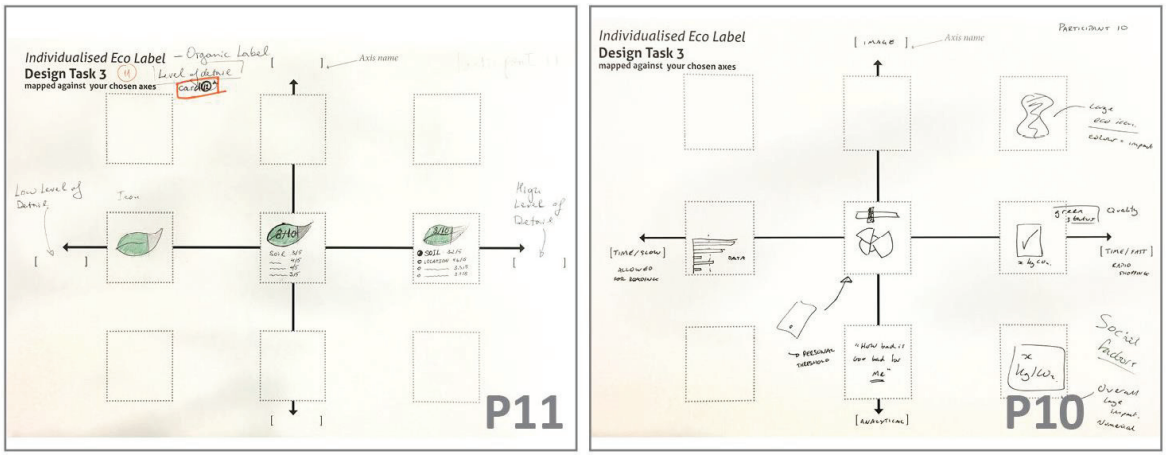


Figure 8.7 Selected design outcomes from Task 3

Figure 8.7 shows two examples created by P11 and P10 from Task 3. P11 was designing eco information with various levels of detail. The label on the left represented environmental performance by the amount of green colour filled on a leaf symbol. The label on the right, in addition to colouring the leaf symbol, showed detailed factors related to product environmental performance. P10 designed an individualised label that varied along two dimensions. The horizontal axis was related to how much time (how fast) the user had for reading the label. The vertical axis was related to how graphical the label was.

The designers were also asked to mark the cards that triggered ideas from their own thinking, the results are summarised in Figure 8.8. Twenty three cards, out of a total of twenty five, were tagged on the design outputs Task3. The most popular card was 'level of detail' which appeared five times. This confirmed that the tool was able to enhance brainstorming and trigger new ideas.

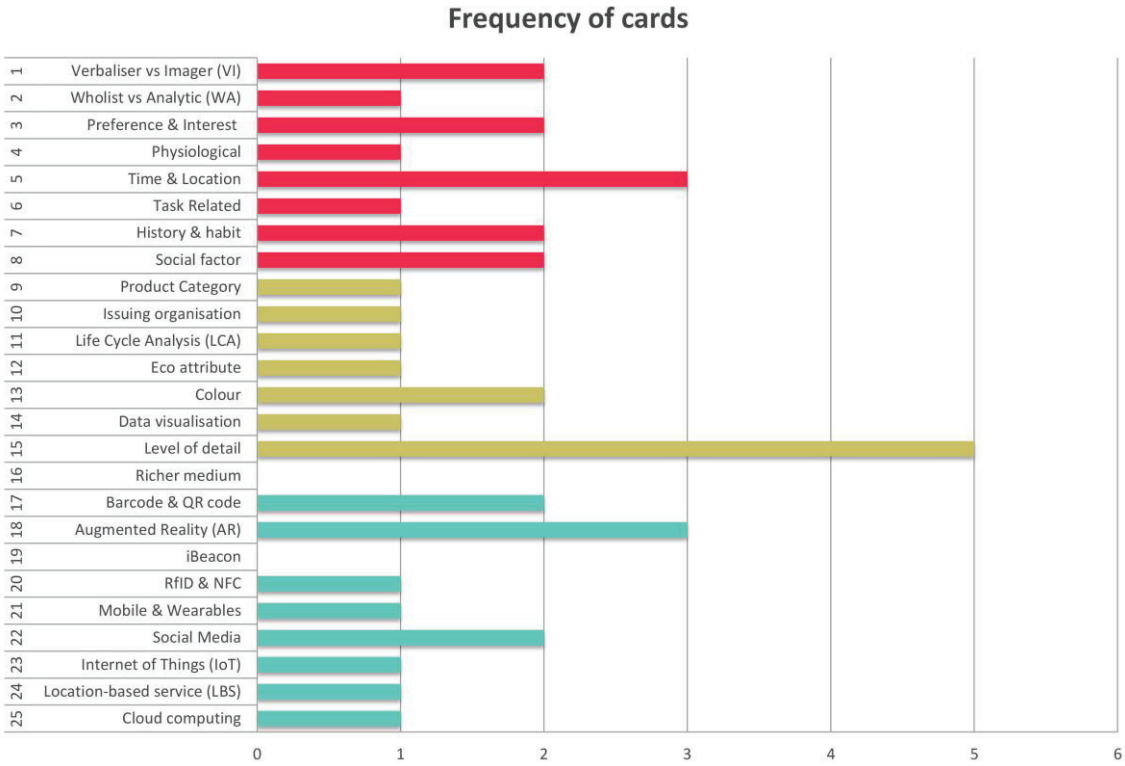


Figure 8.8 Summary of frequency of cards marked useful in triggering ideas

8.3.4. Feedback from participating designers

All designers appeared to be enthusiastic during the workshop, working quickly and giving positive verbal comments as they worked. It was observed that some designers were more able to pick up the framework than others. In particular there was one undergraduate

designer who did not understand the framework and design task until the last exercise (Task 3). More experienced designers (with more working experience/ more senior level students) understood the framework in shorter time and created more 'thoughtful' designs. Their designs were more developed, detailed and logically sound.

In the post-task questionnaire, the participants were asked to rate their agreement with seventeen 5-point rating scale questions related to the usefulness and the usability of the tool and the workshop, with 1 indicating the most negative feedback and 5 indicating the most positive feedback. The 'usability' part of the questionnaire design was inspired by the System Usability Scale (SUS) (Brooke, 1996). Also there were two open-ended questions asking for the participants' comments on the tool design and the workshop. Details of the questionnaire and the responses are presented in Appendix 18 and Appendix 19.

Table 8.1 shows the key concepts of the seventeen questions and the corresponding ratings. The usefulness of the tool was positively rated. Averaging the responses for all questions on usefulness (Q1 - Q8), the tool scored a mean of 3.61. The responses related to the usability of the tool were very positive. The mean value for all questions on usability of the tool and the workshop (Q9 - Q17) was 3.90.

Table 8.1 Feedback on the usability and the usefulness of the tool and workshop

Aspect	Mean		Key concept of the question	N	Mean	Median	Mode	Range
Useful-ness	3.61	Q1	Text on cards is informative	11	4.27	4	4	2
		Q2	Images on cards are informative	11	3.91	4	5	1
		Q3	Cards provide information needed	11	3.68	4	4	3
		Q4	Understanding of eco info individualisation	10	3.40	4	4	3
		Q5	Tool supports problem framing	11	3.73	4	4	3
		Q6	Worksheets trigger ideas	10	3.10	3	3	3
		Q7	Cards trigger ideas	11	3.27	3	3	3
		Q8	Tool is useful in guiding design	11	3.55	4	4	2
Usabilit y	3.90	Q9	Card info is well structured	11	3.73	4	3	2
		Q10	Text on card is clear	10	4.10	5	5	3
		Q11	Card layout	11	3.73	4	4	3
		Q12	Worksheet layout	11	3.55	4	4	3

Q13	Colour of cards	10	4.40	5	5	2
Q14	Readability of cards	11	3.64	4	4	3
Q15	Size of cards	11	4.27	4	5	2
Q16	Experience using the design tool	11	3.64	4	4	2
Q17	Experience attending workshop	11	4.09	4	4	1

Other opinions from the participants were canvased from observation during the workshop and the responses to the open-ended questions. Comments that emerged were clustered into two themes.

Firstly, designing eco information individualisation was a complex concept. Both positive and negative comments were received on the effectiveness of the tool and the workshop to communicate this idea. It was observed that more experienced designers understood the concept more quickly and their design outputs were more developed compared to junior designers. Specific comments included:

P1 *'...the complexity of the topic is massive and you made a good clarification and categorisation of all elements.'*

P2 *'It has helped to give more insights into how the design process goes. [It] gives me new possibilities of using this in my design.'*

P4 *'I enjoyed the workshop and found it thought provoking.'*

P6 *'I like the diagram [the 3X3 matrix template].'*

P2 *'I wished I understood the content much better.'*

Secondly, more time was needed for some participants to understand the concept and digest the content of the design tool. Many participants expressed that they were confused during Task 1 (which was indeed purposefully set as an unguided activity), and would have preferred the tool to be introduced earlier.

P7 *'Make the workshop more clear, explain better, and have less information. Too many information was displayed, and is not really clear the objective of the workshop.'*

P11 *'I think more time needs to be provided for the first exercise because there is a lot of information to take in and to start ideating.'*

P9 *'[The tool was] introduced too late in the process.'*

8.4. DISCUSSIONS ON WORKSHOP

8.4.1. Answering the research questions

Through applying the tool in a design workshop and observing designers' performance in designing individualised labels, the three research questions set out at the beginning were addressed.

1. Can designers learn to design eco information individualisation in a short time?

The design outputs from the workshop suggest that, with the aid of the design tool, it is possible for designers to learn the idea of eco information individualisation in a short time. The designers were able to generate a variety of ideas in the workshop, and demonstrated progression on their design development after the design tool was introduced to them, although some individuals took longer to fully understand the framework and the design task than others. It should also be noted that in the beginning of the workshop, a presentation about eco information individualisation was given by the facilitator, and this could have had a positive effect in facilitating the learning process.

2. Feasibility of design outputs.

Most of the design concepts generated were considered feasible by the workshop facilitator and have the potential to be developed into digital prototypes. To be suitable for digital prototype development, the design output should consist of a range of varied layouts in accordance to different user profiles. The label design should also indicate one or more eco attributes of the product (milk in this case). All examples shown in Figure 8.5 and Figure 8.7 satisfied these criteria.

3. How did the designers feel using the design tool?

Generally positive responses were received with regard to the usefulness and usability of the tool, despite some variability in the positiveness of the responses. The high ratio of cards that were marked as inspiring in Task 3 is a positive indication of the relevance of the card content. From observation during the workshop and the responses to the questionnaire, lessons were learnt for further improvement of the workshop and tool design.

8.4.2. Limitations of the study

This study was of a qualitative and explorative nature. A workshop can be used as a generative and an evaluative method. It has the strength of eliciting a rich picture of the

experiences of the participants, but the reliability and validity of the data can be questionable. To increase the credibility of the outcomes, triangulation was done through using multiple data collection methods (observation, design outputs and questionnaire) as well as multiple data analysis methods (both quantitative and qualitative analysis of the questionnaire responses and the ideas generated). To increase transferability, this workshop had recruited both design students and designers with industrial experience.

Although improvements were observed in the design outputs generated after the tool was introduced, this could be due to a practice effect - the designers may have become more experienced and skilful over time. Other constraints of the study include the skills and interests of the participants, time constraints, and the artificial nature of the session.

Besides, it is not the intention of this chapter to evaluate the quality of the contents of the tool and the quality of the design ouputs from the workshop.

8.5. REFLECTIONS

This chapter reports on the evaluation of the tool which was applied in a design workshop with designers. Positive responses were received with regard to its usefulness and usability. The design outputs generated were considered largely feasible by the workshop facilitator and have the potential to be developed into digital prototypes. These indicate that it is possible for designers to learn to design eco information individualisation in a short time.

The focus of this chapter has been on the development and the usage of the tool and the workshop experiences.

Chapter 9
Digital prototyping

9.1. INTRODUCTION

As shown in the previous chapter, a number of individualised label designs were created by the designers who took part in the design workshop. This chapter introduces the making of a digital prototype that was developed with the following goals:

- To gauge the technological feasibility of eco information individualisation through building a relatively high level fidelity prototype based on one of the design outputs generated in the workshop;
- To help communicate the concept of designing eco information individualisation through the generative process of prototyping;
- To create a working prototype which can be used for further testing.

9.2. GRAPHICAL LABELS FOR THE PROTOTYPE

The design created by participant P11 in the workshop was chosen for development into a digital prototype because it is a simple example that demonstrates the essence of eco information individualisation. The key concept of this label design is to tailor information along the dimension of 'level of detail'. Figure 9.1 shows the sketch created by the designer and the digital graphics developed based on the sketch.

As explained by the designer during the workshop, this label design encompasses multi eco attributes including the quality of soil, the degree of environmental impacts caused by the use of water, carbon emission and transportation (which is partly determined by the location of the product and the user). All environmental impacts of the product are integrated into a single indicator, i.e. a score out of ten. The leaf shaped symbol with varied degrees of green colour filled is also an graphical indication of the environmental performance.

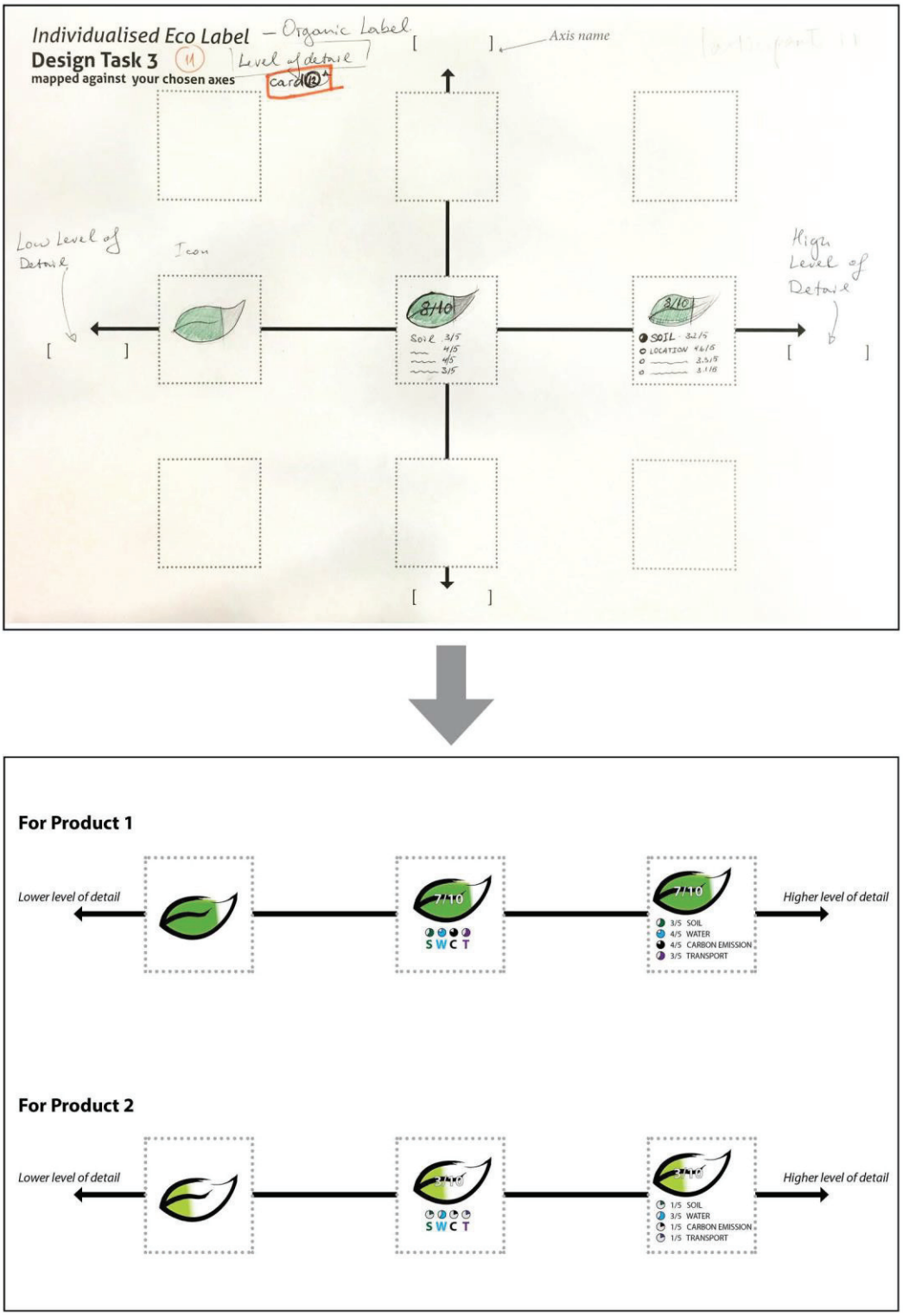


Figure 9.1 The design sketch from the workshop (above) was converted into graphics (below) for the prototype.

For the digital prototyping, two rows of graphical labels were created to represent the environmental performance of two products (see bottom image in Figure 9.1). On each

row are three labels, the one on the left has the lowest level of detail while the one on the right contains information of the highest level of detail.

9.3. THE PROTOTYPING ENVIRONMENT

Prototype is a vehicle to convey the intent of a design and stimulate multiple states of that design (Warfel, 2009). Prototypes can vary in terms of fidelity and functionality, and the tool choices for prototyping differ accordingly. Figure 9.2 illustrates the choices of hardware device, detection method and programming tools considered for this PhD project. The tools chosen are highlighted in the blue boxes.

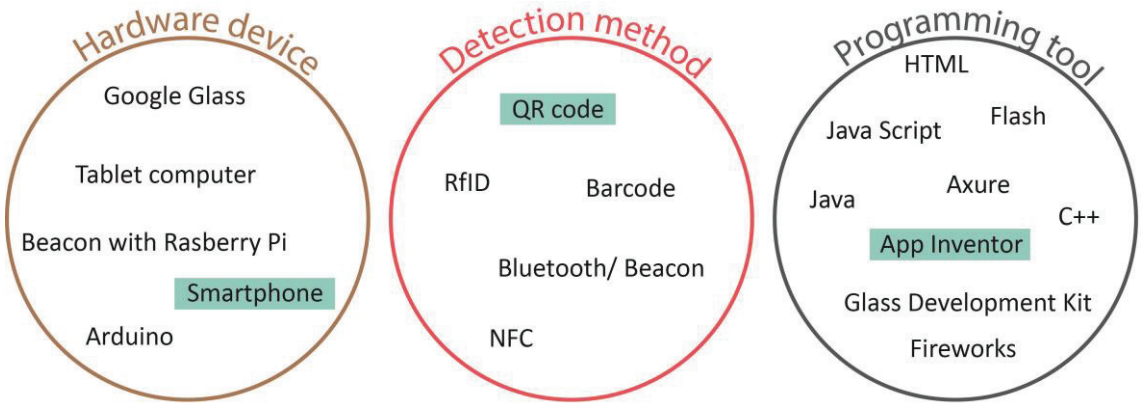


Figure 9.2 Choices of hardware device, detection method and programming tools

Warfel (2009) suggests there are 11 top influencers that drive the selection of tool choice for (software or website) prototyping (See Section 3.5.5 for detail). Adapting the list of top influencers suggested by Warfel (2009), below is the list of factors considered when selecting the prototyping tool choice for this project:

i. Familiarity and availability
ii. Time and effort to produce a working prototype
iii. Creating usable prototype for testing
iv. Price
v. Learning curve
vi. Built-in GUI widgets
vii. Creating usable source code

The hardware used for the prototype described in this chapter was a smartphone with Android OS. The smartphone had a built-in camera, and the prototype detects a product's eco information by reading QR code labels as suggested by the design brief created by the designer (participant P11). *App Inventor 2* (new version of *App Inventor)* was chosen as the programming tool to create the Android application (app), i.e. the prototype.

App Inventor is an open-source web application that enables beginners to computer programming to create basic, fully functional app. It was originally provided by Google and is now maintained by MIT. It has a graphical interface that allows users to drag-and-drop visual objects to build an application. The interface consists of two major views, namely the 'designer window' and 'blocks editor'. The 'designer window' is where users lay out the look of their app and specify the functional components that the app has. The 'blocks editor' allows users to program the app's behaviour by arranging blocks of code (Massachusetts Institute of Technology, 2015).

9.4. DEVELOPMENT OF THE PROTOTYPE

9.4.1. Program procedure flow

The digital prototype was designed to run five major procedures:

viii. Detect user profile by reading an external file.

In this case the profile is simplified into a number between 1 to 3, representing the preference for 3 levels of detail. The external file is a pre-saved text file storing a number.

ix. (Optional) Allow user to enter his/ her profile number.

This function is optional, and the user entry will override the user profile number read from the pre-saved text file.

x. Scan/ detect product identity.

xi. Map product identity and user preference based on the user profile and retrieve eco information from the database accordingly.

xii. Display individualised eco label.

The flowchart in Figure 9.3 explains the procedures and functions of the app.

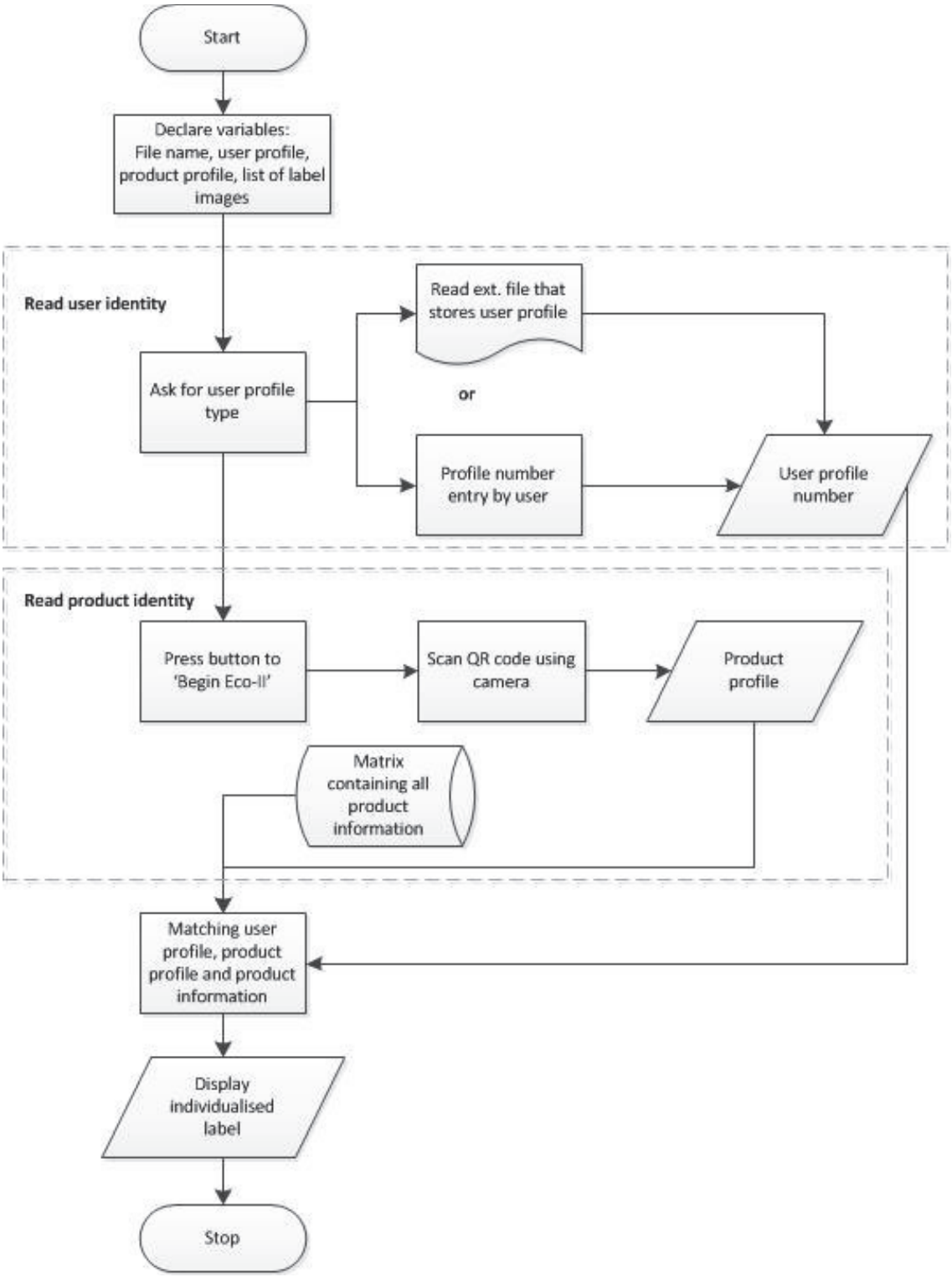


Figure 9.3 Procedure flowchart of the app prototype

9.4.2. Program design and source code

An application screen is the highest-level container for designing application user interface (UI). It typically contains the content and UI components of the application, such as images

and buttons. To implement the above-mentioned procedures and functions (Figure 9.3), three screens were used to program the user interface of this prototype. Figure 9.4 shows the design of all three screens in the 'designer window' view of *App Inventor 2*. The components and programming codes ('blocks') used for these three screens are explained below.

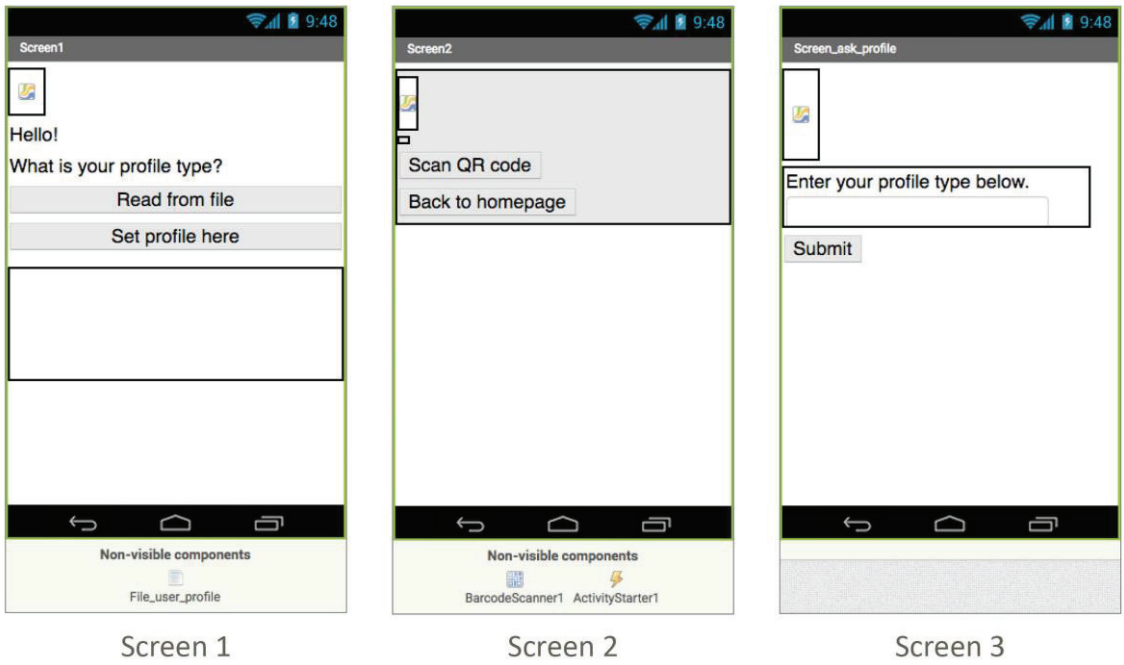


Figure 9.4 Three application screens of the prototype.

9.4.2.1. Screen 1: home screen

Screen 1 is the home screen that appears first when the application starts. This screen greets the user and allows the user read his/ her profile from an external file (*'eco_II_profile.txt')* by pressing the button *BtnReadFile*, or choose to enter his/ her profile by pressing another button *BtnEnterProfile* (that opens Screen 3). Figure 9.4 shows the screen in a programmable state, some of the components shown here are not visible to the user when the app is running. After the user profile is obtained (from a file or from user input), another button named *StartButton* (not visible in Figure 9.4) would appear at the bottom of the screen. If the user presses on *StartButton*, Screen 2 will be opened.

The components contained in Screen 1 are canvas, buttons, labels, table-arrangement and file storage, as listed in Table 9.1. The names of the components are used in the source code ('blocks') to initialise functions or store variable values. Figure 9.5 shows the source code for Screen 1 in the 'blocks' view of *App Inventor 2.*

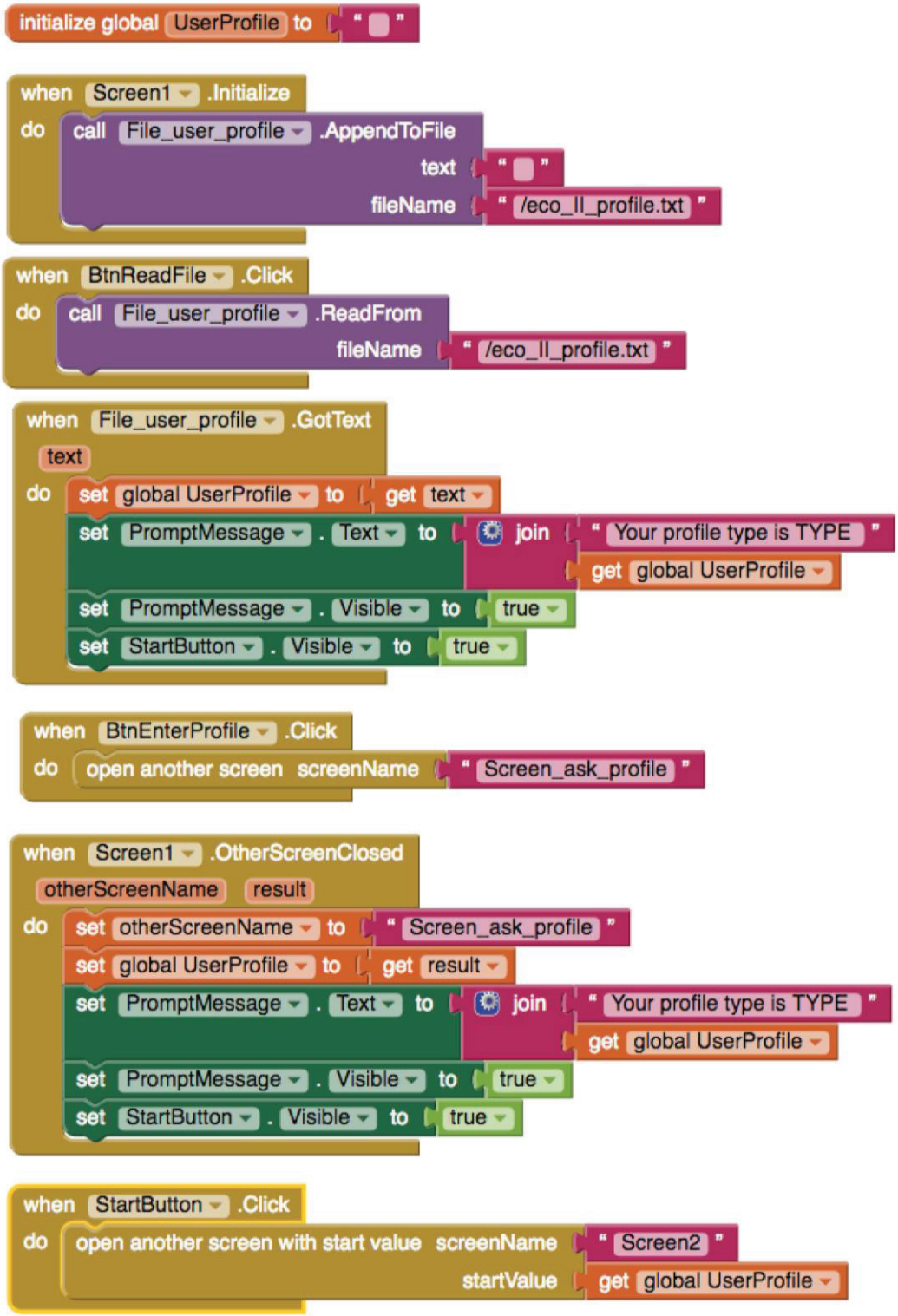


Figure 9.5 Source code of Screen 1

Table 9.1 The components in Screen 1

Type of components	Names of components
Canvas	*Canvas1*
Button	*BtnReadFile, BtnEnterProfile, StartButton*
Label	*Welcome_message, What_profile, PromptMessage*
Table-arrangement	*TableArrangement 1*
File	*File_user_profile*

9.4.2.2. Screen 2: tailoring label for individual user

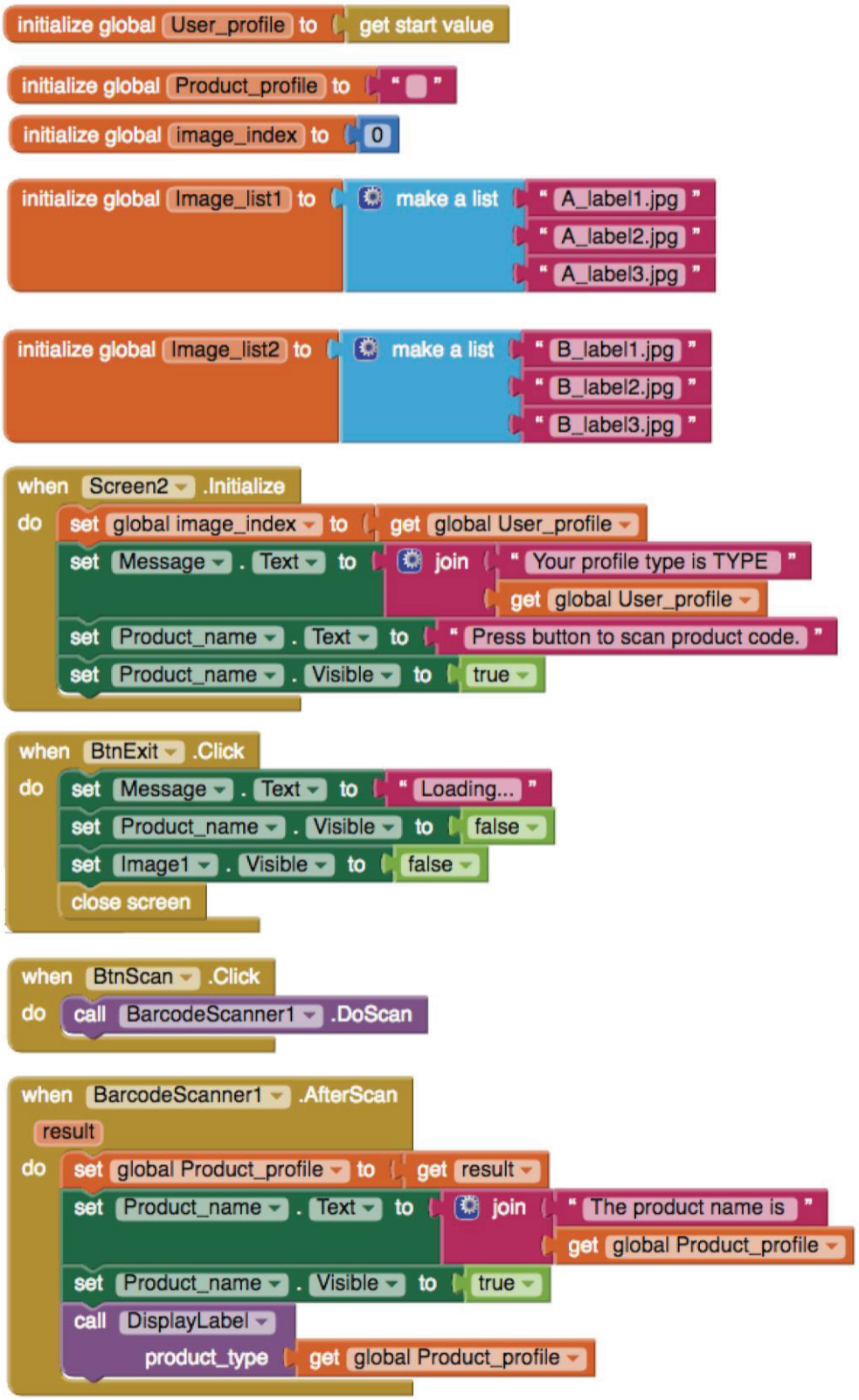
Screen 2 allows activation of the product scanning process and displays the individualised label after scanning. This prototype contains a simplified version of an eco information database that stores product data for eco information individualisation. The ''database' contains six eco label images embedded in the program. In the 'block editor', two lists were created to store the file names of these label images. Table 9.2 lists the components used in Screen 2. Figure 9.6 shows the source code for Screen 2.

Table 9.2 The components in Screen 2

Type of components	Names of components
Canvas	*Canvas2*
Button	*BtnScan, BtnExit*
Label	*Product_name, Message*
Image	*Image1*
Table-arrangement	*VerticalArrangement1, HorizontalArrangement1*
BarcodeScanner	*BarcodeScanner1*
ActivityStarter	*ActivityStarter1*

Upon intiialisation, five global variables were set. *Image_index* refers to which label to be displayed in the lists, in this case equals to *User_profile* number, which is passed to Screen 2 from Screen 1. When the button *BtnScan* is clicked, the program calls an external barcode scanner application *BarcodeScanner1* to scan QR code, and returns the result to the variable *Product_name*. The procedue named *DisplayLabel* calls for an algorithm to look up the label image list and the desired image according to *Product_name* and *Image_index.*

Then the chosen label image is set to be the image of *Image1.Picture* and is made visible (it is hidden in the beginning).



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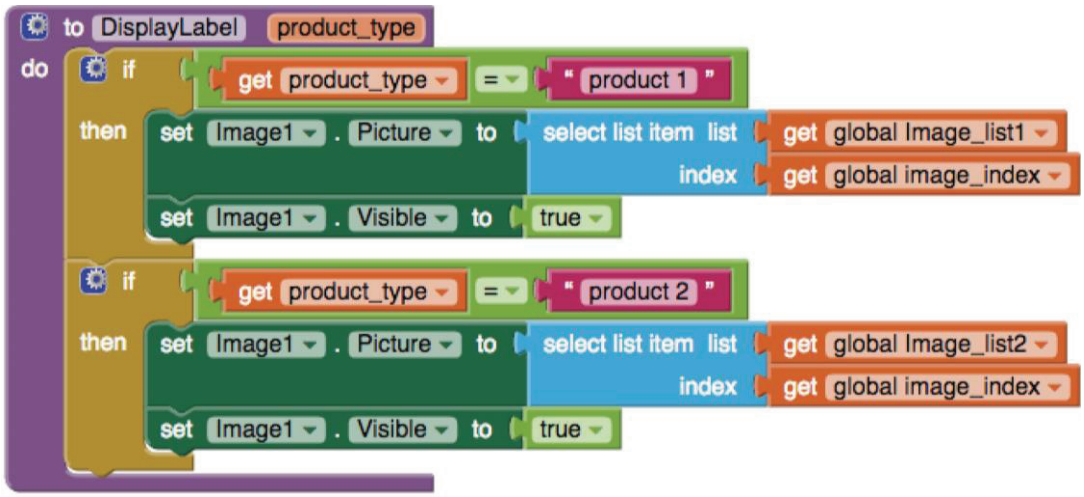


Figure 9.6 (Previous page and above) Source code of Screen 2

9.4.2.3. Screen 3: asking for user profile

Screen 3 enables an optional function that allows the user to enter his or her profile type into a text box. User can activate this screen from Screen 1 by pressing the button *BtnEnterProfile.* After user entry, the result is passed back to Screen 1.

Table 9.3 The components in Screen 3

Type of components	Names of components
Canvas	*Canvas1*
Button	*Enter_button*
Label	*Message*
TextBox	*TextBox_profile*
Table-arrangement	*TableArrangement1*

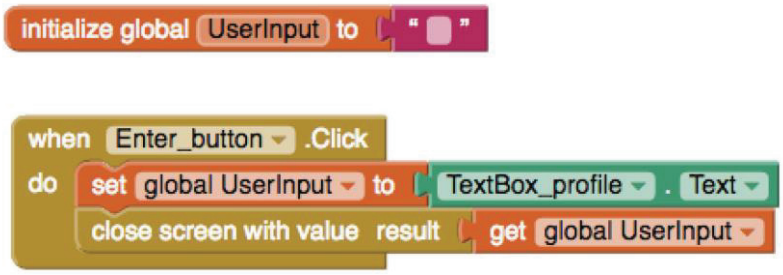


Figure 9.7 Source code of Screen 3

9.4.3. Final prototype

The prototype app could be used with an Android smartphone, the series of images in Figure 9.8 explain the steps of its use.

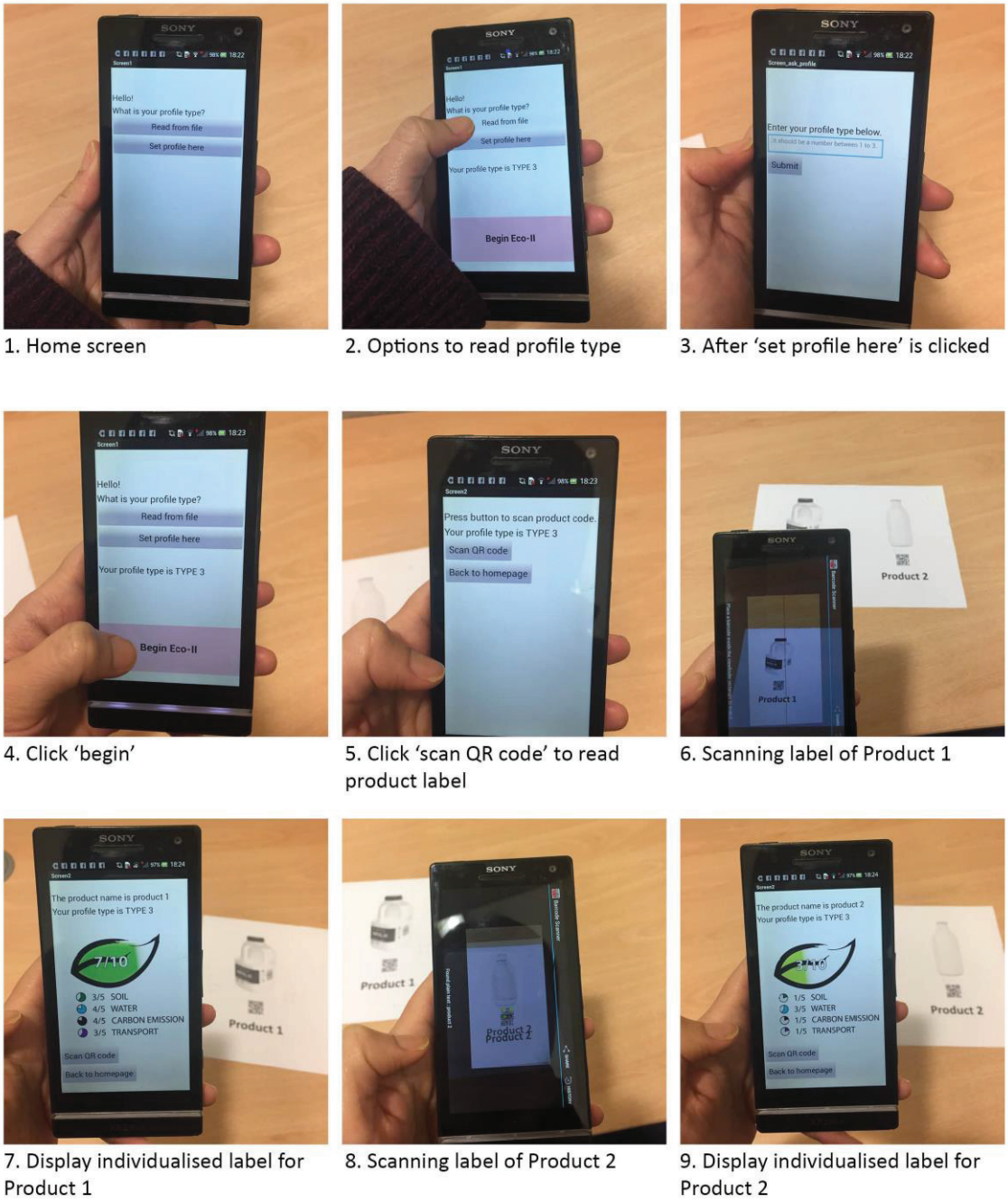


Figure 9.8 Demonstration of the use of the prototype

Image 1 shows the app when it was initialised. There were two optional methods to read the user profile, the user could click 'Read from file' to read his or her profile type stored in an external text file, or click 'Set profile here' to enter a new value (Image 2). If 'Set

profile here' button was clicked, the app would direct the user to Screen 3 (Image 3) where the user was advised to enter a number between 1 to 3. Image 4 shows what happened after the user profile was read - the app would display the user profile type (as a form of feedback to confirm entry) and a pink button labeled 'Begin Eco Information Individualisation'. After this 'Begin' button was clicked, Screen 2 appeared (Image 5). When the 'Scan QR code' button was clicked, the camera and QR scanner function would be called.

In this demonstration, as a mock up of the products, photos of two bottles of milk were printed on paper. Two QR codes was printed next to the photos of the milk to represent the corresponding product labels. Image 6 shows how the label of Product 1 was scanned, an individualised label of Product 1 was then displayed (Image 7). Similarly, the label of Product 2 was scanned (Image 8) and another individualised label was displayed (Image 9). The labels displayed were different, and were tailored according to the product identities and the user profile.

9.5. DISCUSSIONS

Through the development of the prototype, these three goals defined in the beginning of this chapter were addressed.

1. To gauge the technological feasibility of eco information individualisation

A high level fidelity prototype was built based on one of the design outputs generated in the design workshop reported in Chapter 8. The prototype itself demonstrates a simplified example of eco information individualisation, and exhibits the technological feasibility of the design outputs from the workshop.

2. To help communicate the concept of designing eco information individualisation

Through the generative process of prototyping a working smartphone application, the main steps and key elements to be constructed when programming eco information individualisation were identified (Figure 9.3). It should be noted that this prototype was only a basic proof-of-concept, therefore did not include features such as:

- Mistake proofing. Code modules can be added to error proof input from users or from QR code scanning, for example by checking the format of input before accepting the input.

- Advanced method to detect user identity (and associated needs). In this prototype, individual users were simply differentiated by a number between 1 to 3, that represents three different needs for the levels of information detail. In an ideal case of eco information individualisation, user needs would be more finely divided (e.g. in terms of their positions on the two spectrums of cognitive styles), and it is possible to programme functions that detect user's needs (e.g. cognitive styles) from a record of their behaviour (e.g. shopping history). This detection may be manual (e.g. by asking the user to answer a questionnaire related to their cognitive styles) or automatic (e.g. using machine learning algorithm to track and analyse user behaviours).

3. To create a working prototype for further testing

The prototype provides a basis for further testing of eco information individualisation. However, usability testing of the app is out of the scope of this thesis.

Chapter 10
Conclusion

10.1. INTRODUCTION

The aim of this research is to encourage sustainable individual consumer behaviour at the point of purchase by proposing the designing of eco information individualisation. This chapter reviews the outcomes of the research in relation to the research questions, together with a discussion on the contributions to knowledge and the limitations of this research, and then presents recommendations to further works related to this research.

10.2. ANSWERING THE RESEARCH QUESTIONS

The *overarching research question* of this research is:

> ***How can we encourage sustainable individual consumer behaviour by providing individualised eco information at the point of purchase?***

To answer this question (hence to meet the research aim), this thesis has presented an in-depth exploration of eco information individualisation. Through a series of exploratory and descriptive studies, this thesis has sought to answer the three *detailed* research questions as follows.

Research Question 1: What are the user requirements for eco information design?
This question is answered by insights obtained from three research activities which depict the user requirements for eco information design.

To enhance knowledge of the user requirements for eco information at the point of purchase, a focus group study (DS1) with a total 18 participants was conducted to investigate people's views on an imagined ubiquitous eco information device featuring augmented reality, as reported in Chapter 4. The study found out the worries that people may have, and the device functions that people desire. The study also provided a rich description of the

types of information that people would like to see in an eco information provision device, and their views on a range of information formats.

A review of literature adds to the answering of this research question by identifying the consumer issues in eco labelling practice and the opportunities for improving the design of eco labels (Chapter 2). The identified consumer issues include i) psychological challenges related to attitude, social norm, consumer's perception (understanding, awareness and attention) of eco labels, their trust in eco labels and their purchasing habits, as well as ii) practical problems such as information asymmetry, information overload and rebound effect. The reference model in Figure 2.13 illusrates how these psychological factors are related to each other, and gives a perspective on how different attributes of eco information design can be used to address these psychological factors.

The literature review also points out that there is a lack of knowledge of how consumers understand and notice eco labels. To fill this knowledge gap, a card sorting study (DS2) was conducted to understand how people categorise, perceive and think about existing eco labels. As reported in Chapter 6, a thick description of people's perception resulted from the study. This included a list of 53 categories created by the participants (N=9) when they were sorting 403 existing eco labels, the names and definitions of the categories, indicative examples of the categories, as well as the rationale behind the categorisation and the selection of indicative eco labels. A user centred eco information organisational scheme was derived from the data by triangulating the results of an exploratory analysis and a hierarchical cluster analysis (HCA). This organisational scheme classifies eco information under five top-level categories, namely 'Information format', 'Type of eco attribute', 'Product category', 'Issuing organisation' and 'Stage of life cycle'. Another conclusion from the card sorting study is that, it would be appropriate to consider the use of multiple layers for structuring eco information, instead of one main classification scheme. Also, a deeper understanding of how people see an eco label was obtained. It was found that people mainly rely on the verbal and visual cues on an eco label to interpret its meaning. The study also identified a list of factors that determine the indicative-ness of an eco label and a list of factors which hinder the comprehension of eco labels.

Research Question 2: How to design eco information individualisation to support sustainable consumer behaviour?

This research has delivered three outcomes to address *Research Question 2*, namely the conceptual framework of eco information individualisation (PS1), the design tool (PS2) and

the digital prototype (PS3). Results from the literature review and four primary studies (DS1-focus group study 1, DS2-card sorting study, DS3-focus group study 2 and DS4-design workshop) were woven together to inform the abductive process of developing these three deliverables.

The framework of eco information individualisation conceptualises both user and product as data carriers and reducing purchasing environments into components and analytical elements. The framework aims to provide a systematic methodology that facilitates the design process of an eco information individualisation system, a system that tailors the displaying of eco information in accordance to specific user needs and contexts. Chapter 5 reports on the proposal of the conceptual framework and the validation of the framework through focus group study 2 (DS3). Findings from the focus groups and the card sorting study (DS2) have been used for the refinement of the framework (See Chapter 7). The conceptual framework is presented again below (Figure 10.1), followed by a table summarising details about the framework's components (Table 10.1). The 'personal data' component of eco information individualisation is broken down into five types of contexts as specified by the personal context model. The 'product data' component of eco information individualisation is divided into two major groups, 'formats' and 'contents'; the 'contents' of eco information can be further divided into four sub-groups 'Type of eco attribute', 'Product category', 'Issuing organisation' and 'Stage of life cycle'. The table also suggests a list of enabling technologies, divided according to the stage of contextual technological function.

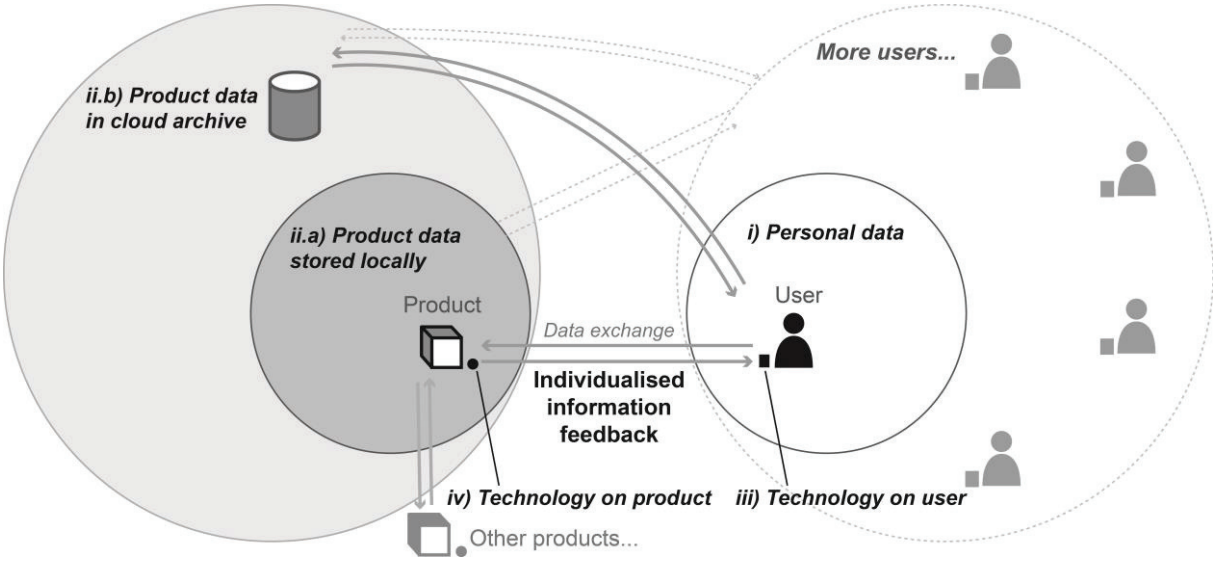
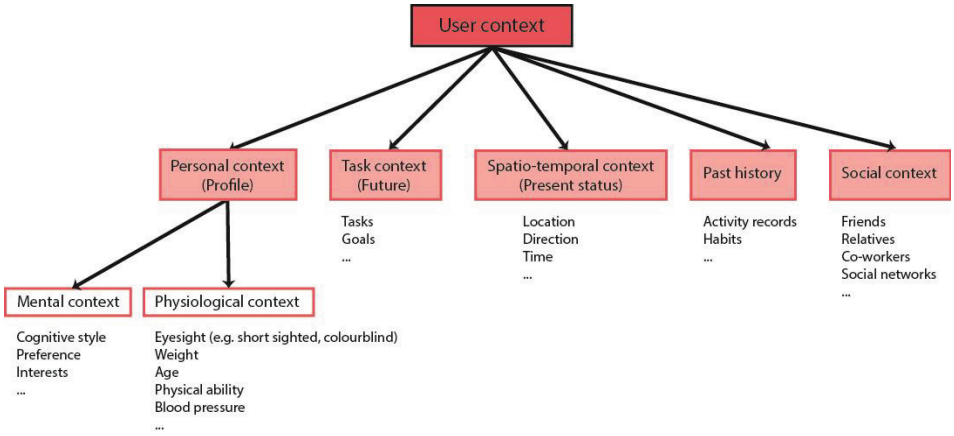


Figure 10.1 The proposed conceptual framework of Eco Information Individualisation.

Table 10.1 Components in the conceptual framework of eco information individualisation

<table>
<tr><th>Components</th><th>Information structure/ Technology choice(s)</th></tr>
<tr><td>i) Personal data</td><td>Personal context model for eco information individualisation (Extended from the user context model of Kofod-Petersen & Aamodt (2003))
 
</td></tr>
<tr><td>ii) Product data</td><td>
<table>
<tr><th>Eco information organisational structure</th><th></th><th>Examples</th></tr>
<tr><td>Formats</td><td></td><td>Certification symbol, Logo, Rating, Chart, Photo…</td></tr>
<tr><td>Contents</td><td>Type of eco attribute</td><td>Carbon footprint, Ocean friendly, Organic, Energy efficiency, Fair trade, Animal friendly…</td></tr>
<tr><td></td><td>Product category</td><td>Food, Building, Agriculture, Water, Textiles, Tourism, Forest products / Paper, Cosmetics / Personal care</td></tr>
<tr><td></td><td>Issuing organisation</td><td>National Standard, Private companies, Producers associations, Brands</td></tr>
<tr><td></td><td>Stage of life cycle</td><td>Raw material, Recycling, Resource consumption, Use phase, Transportation…</td></tr>
</table>
</td></tr>
<tr><td>iii) Technology on user

&

iv) Technology on product</td><td>
<table>
<tr><th>Stage of function</th><th>Example technologies</th></tr>
<tr><td>Capturing contextual data</td><td>Mobile sensing
The Internet-of-Things
Wearable technology & lifelogging
Location based technology (e.g. GPS)
Data mining</td></tr>
<tr><td>Storing contextual information</td><td>Cloud computing
Ubiquitous computing
Database</td></tr>
<tr><td>Presenting contextual information</td><td>Information retrieval & visualisation
Mobile device
Augmented reality
Social media</td></tr>
<tr><td>Sending contextual information</td><td>Wireless data transmission</td></tr>
</table>
</td></tr>
</table>

As described in Chapter 7, a design tool was created (PS2) to elaborate the conceptual framework. The tool consists of a short guidebook, 25 cards and 2 worksheets (Appendix 14 – 16). Structured information on user context, product context and technology was provided with the aim to support designers in designing individualised eco information. A design workshop (DS4) was carried out to verify the usability and usefulness of the tool.

The generative process of prototyping a smartphone app (PS3) was presented in Chapter 9 to further convey the concept of eco information individualisation by providing a step-by-step description of the elements needed to create a technological prototype.

Research Question 3: How feasible is it to use a design tool to support the design of eco information individualisation?

Results from the design workshop (DS4) and the digital prototype (PS3) developed subsequently indicate that it is largely feasible to use a design tool to support the design of eco information individualisation.

As reported in Chapter 8, the 3-hour long design workshop involved 11 designers. These participating designers all had knowledge of eco design, graphic design and an understanding of life cycle analysis, but had not learnt about eco information individualisation before they attended the workshop. The workshop involved design tasks both without the aid of the design tool and with the aid of the design tool. It was found that it was possible for designers to learn the idea of eco information individualisation in a short time. The designers were able to generate a variety of ideas in the workshop, and demonstrated progression on their design development after the design tool was introduced to them. The design outputs generated were largely feasible and have the potential to be developed into digital prototypes.

A working digital prototype (PS3) was built based on a design selected from the outputs from the workshop, providing further evidence of the feasibility of the design outputs.

10.3. CONTRIBUTIONS TO KNOWLEDGE

This research was undertaken to explore the opportunities unlocked by contextual technologies for encouraging sustainable consumer behaviour. This is multi-disciplinary and inter-disciplinary research, drawing knowledge from various domains including design for sustainable behaviour (DfSB), user centred design (UCD), environmental psychology and

human computer interaction (HCI). This thesis specifically centres on the concept of 'eco information individualisation' and on providing a new perspective by envisioning its usage in an imagined world. The contributions to knowledge made by this thesis are:

- The synthesis of a novel conceptual framework of eco information individualisation for design;
    - Despite the increasing popularity of research on personalisation in the disciplines of computer science and information systems, the topic of tailoring information is still an underexplored area in design research. This project is the first in-depth investigation on information individualisation (or personalisation) using a user centred design approach. This thesis has proposed the first conceptual framework of eco information individualisation.
- The creation of a design tool to support designers in designing eco information individualisation
    - The tool has been shown to be useful to designers through its application in a design workshop from which feasible design outputs were generated and later prototyped.
- A deeper understanding of i) the user requirements for eco information design at the point of purchase and ii) user's perception of existing eco labels
    - This is the first in-depth qualitative research into the user requirements for eco information design. The understanding of user's perceptions of eco labels contributes to the knowledge gap of '*why* consumers understand and notice eco labels'. The user centred eco information organisational scheme proposed in this thesis appears to be the first of its kind.
- The creation of a working digital prototype
    - The prototype mobile application is an evidence of the technological feasibility of eco information individualisation and provides a basis for further testing of eco information individualisation.

10.4. LIMITATIONS OF THIS RESEARCH

As Koskinen et al. (2011) state, 'Constructive design research probes an imagined world, not the real world of a social scientist.' Although validity and reliability are often seen as the cornerstones of traditional research, the author of this thesis believes these criteria are more appropriate for quantitative approach, and are not applicable for this qualitative research

project. There is still an ongoing debate on the definition of quality criteria for qualitative research (see Chapter 3). To facilitate the discussion on the limitations and quality of this research work, this thesis applies the set of quality criteria defined for qualitative research as shown in Table 3.4. The rigour of this qualitative research work is hence determined by its trustworthiness, which can be divided into four sub-qualities - credibility, transferability, dependability and confirmability.

This research project consists of i) four *descriptive* studies that explored and described, mostly qualitatively, the user needs and opportunities for sustainable behaviour change; and ii) three *prescriptive* studies that produced three deliverables to communicate the proposed concept. The limitations and quality of this research are discussed in the following in relation to these two types of activities.

10.4.1. Quality of the four descriptive studies

The four descriptive studies were set out to meet both exploratory purpose and descriptive purpose. To 'explore', the studies aimed to seek new insights, to ask questions, to generate ideas, and to assess phenomena in a new light; to 'describe', these studies were used to portray an accurate profile of events or situations. In order to fulfil these purposes, a range of research quality considerations were taken to mitigate threats to their quality.

The techniques of data triangulation and methodological triangulation were employed in three studies (DS1-focus group study 1, DS2-card sorting and DS4-workshop) to increase credibility of the results. Code validation by more than one researcher has also been performed repeatedly in studies that involved interview and thematic analysis, to enhance dependability. To increase transferability, this thesis has provided a thick description to all qualitative studies. Some sections of this thesis also have compared study results to findings from literature, to confirm the researcher's interpretation and strengthen confirmability. Table 10.2 presents an overview of the four descriptive studies and associated quality considerations.

Table 10.2 Four descriptive studies and associated quality considerations

Descriptive study	Method/ data	Quality consideration
DS1- Focus group study 1	3 focus groups (semi-structured interviews, and group tasks of sketching & presentation)	• To increase transferability, participants were recruited i) from two universities; ii) from technological and non-technological backgrounds to represent people with different levels of technological awareness; iii) from both genders (11 male, 7 female).

	(18 participants in total)	• A thick description is provided in Chapter 4 and in Appendix 4, 5, 6 to facilitate transferability decisions. • To increase dependability, discussions were recorded, transcribed, then analysed using standard thematic analysis procedures and code validation (codes reviewed by two additional researchers) • Sample size was deemed enough when thematic saturation occurred.
DS2- Card sorting study	5 individual sorts and 1 team sort with 4 people (9 participants in total)	• To increase credibility, triangulation was done to verify findings through i) Using multiple methods of data collection (interview and card sorting, which consists of both individual sort and team sort) ii) Using multiple methods of data analysis (exploratory analysis, thematic analysis, hierarchical cluster analysis, word frequency test) iii) Validating the 5 top level categories with another round of evaluative closed card sorting with 4 independent researchers • A thick description is provided in Chapter 6 and from Appendix 7 to Appendix 12 to facilitate transferability decisions. • To increase dependability i) All interviews/ discussions were recorded, transcribed, then analysed using standard thematic analysis procedures. Codes for various activities were developed/ reviewed by at least two (or more) independent researchers; ii) The logic used for selecting participants and eco labels (cards for sorting), and the study procedures are clearly presented in this thesis • References to literature were identified to confirm the researcher's interpretation and strengthen confirmability • Sample size was deemed adequate to inform the proposal of the information architecture. Emergent patterns were observed from the data although saturation was not considered to be a priority because rich insights could also be obtained from the inconsistencies spotted in the categories and from the participants' comments.
DS3- Focus group study 2	2 focus groups (10 participants in total)	• To increase dependability i) All interviews/ discussions were recorded, transcribed, then analysed using standard thematic analysis procedures. Code definitions are presented in Appendix 14 for review. ii) The logic used for selecting participants and the study procedures are clearly presented in this thesis • A thick description is provided in Chapter 5 and in Appendix 14 to facilitate transferability decisions. • The participants were required to have specific knowledge therefore the sample size was small. There was no evidence of data saturation and this has largely limited the generalisability of the results.

DS4- Workshop	Briefing, 4 design tasks without and with the tool (11 participants in total)	• To increase credibility, triangulation was done to verify findings through i) Using multiple methods of data collection (observation, design outputs, and questionnaire that collects both qualitative comments and quantitative ratings) ii) Using multiple methods of data analysis (both quantitative and qualitative analysis of the questionnaire responses) iii) Further verification of the design outputs by prototyping • To increase transferability, i) Both design students (N=2) and designers (who had working experiences in industry, N=9) were recruited ii) A thick description is provided in Chapter 8 to facilitate transferability decisions. • Sampling adequacy i) Patterns were identified in various areas, including the designers' performance, their design outputs, usage of the cards of the design tool, the designers' level of satisfaction and their comments. So the sample size was considered enough for answering the research questions set out.

The studies were however limited by their participant sampling methods. Apart from the workshop, which involved an open recruitment via multiple channels, all other studies' participants were recruited using convenient sampling method. This is a type of non-probability sampling method that is prone to bias and has limitation in generalisation and inference making. This method was preferred due to the time and resources available to this PhD project, and because the participants were required to possess specific skills/ knowledge to be eligible for certain studies. The method used was believed to be acceptable since the studies were mostly qualitative and did not aim for statistical significance nor generalisation.

10.4.2. Limitations relating to the three research deliverables

Limitations are recognised with regard to the three research deliverables, including the conceptual framework (PS1), the design tool (PS2) and the digital prototype (PS3).

10.4.2.1. The conceptual framework

The conceptual framework was formulated to outline possible courses of action and to present a preferred approach to an idea. It was not the author's intention to explain behaviour, nor to guide the construction of hypothesis or theories.

A number of concepts (the four components) were identified, and the conceptual definition for these concepts (such as the user context model, the eco information

organisational scheme and the table of enabling technologies) were provided. However, this thesis has not provided any operational definition of these concepts, i.e. this thesis did not delineate the procedures or operations required to measure the concept, although the design tool has provided more support for designing eco information individualisation.

Also, the framework was only initially evaluated by a focus group study, which is subject to limitations as discussed previously.

10.4.2.2. The design tool

There are three aspects that are particularly relevant to the quality of a design tool, namely usability, usefulness and the quality of content.

This thesis has only addressed the 'usability' and 'usefulness' aspects of the tool through a design workshop. In addition to the observation during the workshop and an assessment of the design outputs, a questionnaire was used to collect responses related to the usability and usefulness of the tool. Since the sample size of the questinnaire survey was small (N=11), the positive responses received should only be viewed as an indicator with no statistical significance. Although the 'usability' part of the questionnaire design was inspired by the System Usability Scale (SUS) (a validated questionaire design) (Brooke, 1996), the questionnaire used was designed by the author of this thesis and was not a validated questionnaire design. These two factors have limited the validity of the questionnaire results.

The quality of the card contents was not sufficiently evaluated. The comments from the participating designers were not considered as an assessment of the content quality, because expert knowledge of various aspects are required to assess the contents of different set of cards, for example:

- Knowledge in cognitive psychology is required to assess the 'person' cards (such as cards about cognitive styles);
- Knowledge in eco labelling / sustainable development is required to assess the four cards related to eco information content;
- Knowledge in information design is required to assess the four cards related to eco information formats;
- Knowledge in computer science and information system is required to assess the content about emerging technologies.

Due to time and resource constraints, the evaluation of the tool had ended as it was reported in this thesis. An expert interview study might though be a reasonable approach to

validate the accuracy of the card contents, and to gather comments for improving the card contents. However it should be noted that design is an iterative process that always comes with room for improvement. Just as any prescriptive activity that involves abductive thinking, although insights can be gained from the comments of various stakeholders, the final design decision still depends on the judgement of the designer.

10.4.2.3. The prototype app

Time and limitation of the researcher's knowledge in programming mobile applications has limited the functions of the prototype. Moreover, the limited time available for the research made it impossible to test the usability or effectiveness of prototype.

10.5. RECOMMENDATIONS FOR FUTURE WORK

This thesis brings forward a number of opportunities for further research. A number of which are listed below.

1. **Iterations to the design tool and the workshop plan**

This thesis has proposed the first design tool on eco information individualisation. The tool was tried in a workshop with some designers as reported in Chapter 8. The feedback received from them could be used to drive the development of the next iteration of this design tool, and provide insights for improving the planning of the workshop.

Summarising the feedback from the participating designers, there are two things about the design tool that can be improved:

i. Readability & visual design. A number of designers suggested the need to improve the readability of the cards. Some possible methods include simplifying the texts, redesigning the graphic elements such as font sizes and space, using icons to highlight the natures of some information, increasing the card size, etc.
ii. Number of cards. One designer thought the 'person card' collection could be expanded to cover more factors related to user context.

Besides, the workshop can potentially be improved if these considerations are taken into account:

i. Allow more time. Most designers found that the concept of eco information individualisation was complex, and there was a lot to digest in the three-hour workshop. It is believed the workshop experience will be enhanced if it is expanded

into a long workshop of one full day or two days long. It might also be helpful if more time is given to the designers to get familiarised with the contexts of the task and the design tool. The unguided task (Task 1 as reported in Chapter 8) can be skipped to save time.

ii. Set more focused task and stricter boundaries. Some designers expressed that they were confused about the requirement of the task because they were given too many options. Perhaps future workshops can start with two personas only, instead of four optional personas. The workshop could begin with simpler design tasks that come with less variables, for example by introducing less contextual factors in the personas, before the designers gain confidence in understanding the concept of eco information individualisation. It is advised to keep the practice of introducing fewer cards in earlier task(s), just as what happened in Task 2 (as reported in Chapter 8), only two cards were used for that activity.

iii. Encourage team work. Future workshops can try to let the designers work in teams, so to provide more chances of collaboration and knowledge exchange amongst designers.

iv. Include a final showing of the design outputs. If time allows, future workshops can end with a final showing of the design outputs. This will give the designers a chance to present their ideas formally. They may benefit from learning others' design ideas as well as hearing comments from other designers.

2. Further prototyping and testing of eco information individualisation

The prototype created in Chapter 9 can provide a basis for testing of eco information individualisation. Experiments can be conducted to test its usability, its effectiveness in promoting environmental benign attitude and its impact on attention.

This thesis also provides the theoretical underpinnings for prototyping other forms of eco information individualisation. The author of this thesis has published a position paper describing a prototyping concept based on social media (Kwok & Harrison, 2015). For future works, a wider range of prototypes can be also designed and tested, for example, for different usage scenarios (product categories), different technologies, or addressing different aspects of user needs (as suggested by the 'person' cards in the design tool).

3. Quantitative investigation on information individualisation

A more complex version of eco information individualisation can be realised with a quantitative approach. It is possible to create user preference model for an individual user in

a laboratory environment. Through experiment that involves numerous purchasing decisions, the relationship between user preference and product attributes can be determined statistically, for example with the help of existing choice modelling software.

The user preference model of an individual user can enable the development of a prototype that displays individualised eco information in real time. That will provide the foundation for experimenting the measurable effects of eco information individualisation on users, for instance, about their attention, motivation or observable behavioural change, etc.

4. Investigating ethical issues around information individualisation

Chapter 4 of this thesis has reported on an initial discussion on issues related to information individualisation, such as privacy and autonomy of user, physical burden and etiquette. Further research is recommended to study the ethical implications of eco information individualisation, which presumably will be realised with the use of a ubiquitous technological device. There is a foreseeable trade-off between the intelligence of the device and the privacy of the user, where should we draw the line? What measures should be taken to minimise the risks of information leakage and harm to people? How to provide information that is supportive but not intrusive? Space limitation has prevented this thesis from an in-depth discussion of these ethical issues, and future works on this can certainly be a significant additional contribution and a step forward in the underexplored area of information individualisation in design.

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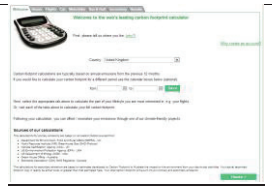
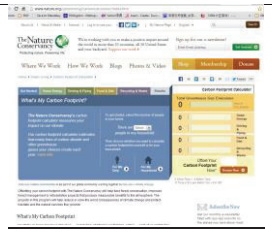
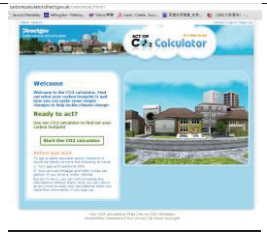
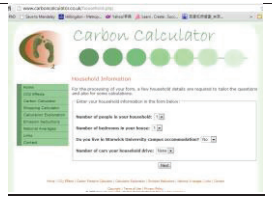
APPENDICES

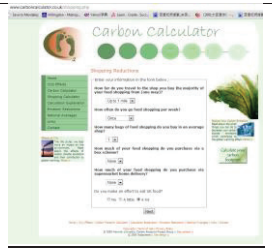
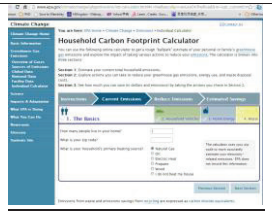
Appendix 1 Functions of existing mobile app eco-calculators

App name	Operational level	Application area	Functions						Mobile platform	
	Personal = P Household = H Business = B		Indicate carbon footprint (CO_2e) / money saving ($) / others as specified	Input method: User estimation / Automatic	Show educational information	Export results to external community/ social network			iOS	Android
Zero carbon	P, H	Transportation, household energy & water consumption	CO_2e	User	*	*			*	
CarbonTrack	B	Transportation, business energy consumption, waste	CO_2e, $	User	*				*	
CO2 Emis Calculator	P	Transportation	CO_2e	User					*	*
Vpod Calc.	B	International business meeting	CO_2e	User					*	
UNEP Calc	P	Transportation	Habitat area needed to bind used carbon	User	*				*	
Eco-Bulbz	P, H, B	Lighting	$	User						*
Green Calculator Lite	P, H	Transportation, household energy consumption	CO_2e, $	User	*				*	*
ElectroCost	P, H	Household energy consumption	$, energy consumption	User						*
eFuel - Fuel Efficiency Tracker	P	Transportation	$, fuel consumption	User					*	
Eco Charger	P	Battery charging	Notify users when battery is charged to save	Auto						*

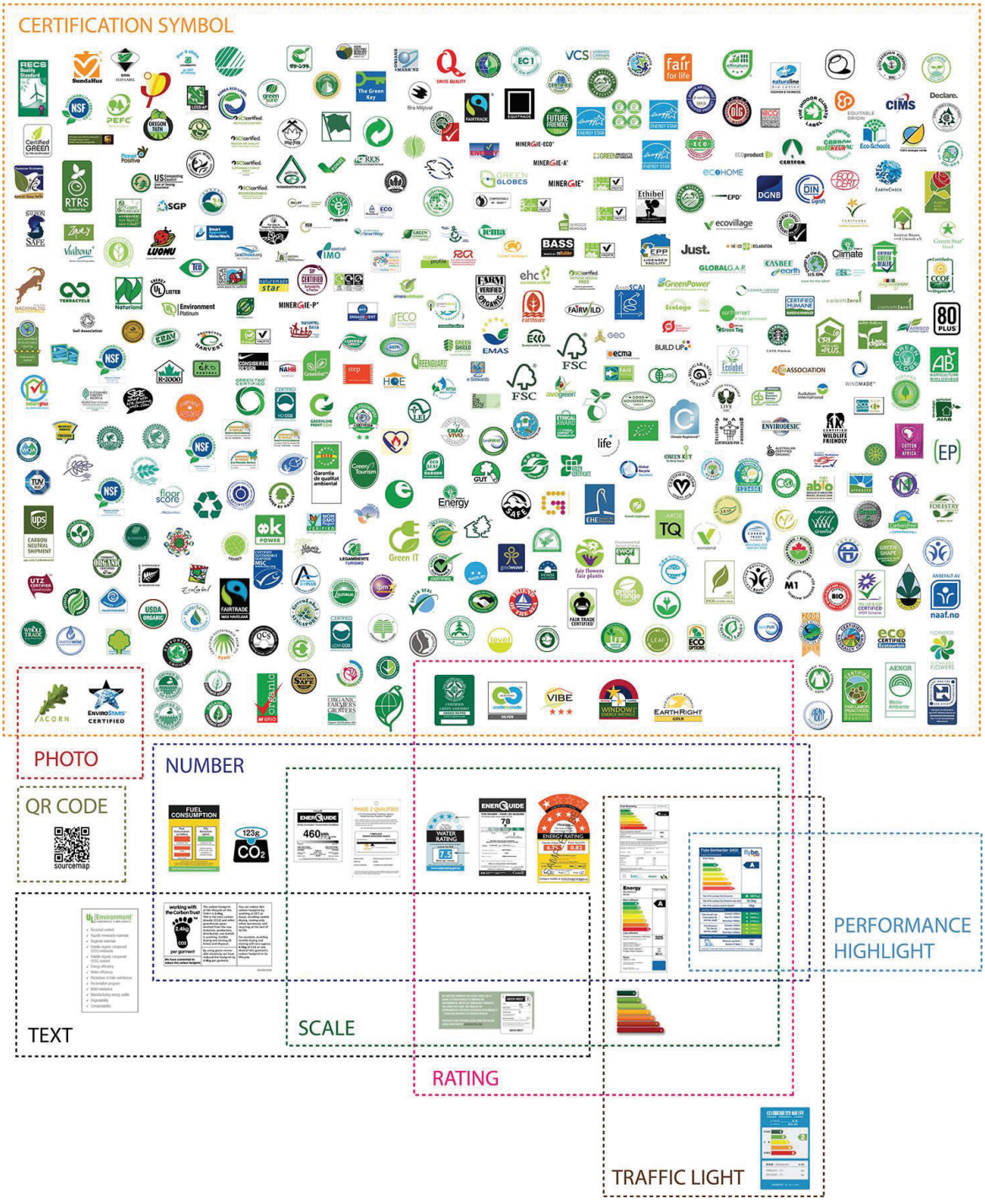
			energy					
Green Savings Calculator	H	For zero emission home building or renovation	CO_2e, $, energy consumption	User			*	*
JCB Efficiency Calculator	B	Machine operation	CO_2e, $, fuel consumption	User			*	*
The Eco-activist	P, H	Transportation, household energy consumption	CO_2e	User	*		*	*
Carbon Footprint Calculator	P	Transportation	CO_2e	User		*		*
AGT Carbon Calculator	P, H, B	Transportation, household/ business energy consumption	CO_2e	User				*
EcoCalculator	P	Transportation	CO_2e, NOx emission	User			*	*
Neenah Paper Eco-Calculator	P, H, B	Paper consumption	Environmental savings measured in wood, water, energy, emissions and solid waste.	User	*	*	*	
eco:Drive Fiat Group Automobiles S.p.A.	P	Transportation	CO_2e, $, fuel consumption	Auto	*	*	*	*
Sprite Bandits Eco Drive	P	Transportation	$, fuel consumption	User	*		*	

Appendix 2 Survey of existing web-based eco-calculators

Name of Calculator	Interface design	Country of developer	Name of developer	Applicable country	Factors considered						
					Shopping	Home energy	Driving & Flying	Food & Diet	Recycling & Waste	Indirect emission	Living environment
Carbon Footprint Calculator		UK	Carbon footprint TM	All countries	Yes	Yes	Yes	Yes	Yes	Little (bank service)	No
Nature Conservancy My Carbon Footprint		USA	The Nature Conservancy	USA	No	Yes	Yes	Yes	Yes	No	No
Act on CO2 calculator		UK resident	GOV.UK	UK	No	Yes	Yes	No	No	No	No
Carbon calculator		UK	Warwick University	UK (for student)	No	Yes	Yes	No	No	No	No

Name of Calculator	Interface design	Country of developer	Name of developer	Applicable country	Factors considered						
					Shopping	Home energy	Driving & Flying	Food & Diet	Recycling & Waste	Indirect emission	Living environment
Shopping calculator		UK	Warwick University	UK (for student)	Yes	No	Yes (for shopping trip)	No	No	No	No
The Guardian's quick carbon calculator		UK	Guardian	UK	Yes	Yes	Yes	Yes	No	Yes	No
EPA Victoria Ecological Footprint		Australia	State Government of Victoria	Australia	No	Yes	Yes	Yes	No	No	Yes (city weather)
Household Carbon Footprint Calculator		USA	United States Environmental Protection Agency	USA	No	Yes	Yes	No	Yes	No	Yes (zip code required)

Appendix 3 Map of existing eco labels



Appendix 4 DS1 – Focus Group Study 1 participant demographics

Focus group	Participant No.	Nationality	Gender	Age	Profession	Profession / occupation	*Level of technological awareness	*Level of sustainable behaviour commitment
A	A1	British	Male	26-35	Design researcher	Designer	5	3
A	A2	Chinese	Female	26-35	Design researcher	Designer	2	3
A	A3	Malaysian	Male	36-45	Engineer	User	5	5
A	A4	Malaysian	Male	26-35	Economics/ business	User	3	4
B	B1	British	Male	26-35	Design researcher	Designer	2	3
B	B2	British	Male	26-35	Design researcher	Designer	4	2
B	B3	Columbian	Male	26-35	Design researcher	Designer	5	3
B	B4	Chinese	Female	26-35	Design researcher	Designer	3	4
B	B5	Chinese	Female	26-35	Engineer	Engineer	4	4
B	B6	Korean	Female	26-35	Design researcher	Designer	2	3
B	B7	Taiwanese	Female	26-35	Design researcher	Designer	4	4
C	C1	Burmese	Male	Under or equal to 25	Computer engineer	Computer engineer	5	4
C	C2	German	Female	26-35	Information science	Computer scientist	4	4
C	C3	British	Male	Under or equal to 25	Geospatial engineer	Geospatial engineer	5	4
C	C4	French	Male	Under or equal to 25	Geoscience engineer	Geospatial engineer	5	5
C	C5	British	Male	36-45	Software developer	Research engineer	4	3
C	C6	Indian	Female	26-35	Social scientist	Computer scientist	5	4
C	C7	Polish	Male	26-35	Geospatial engineer	Geospatial engineer	5	4

**Questions asked to obtain the participants' rating about their 'level of technological awareness and 'level of sustainable behaviour commitment' were shown below.*

Please rate your level of agreement on a scale of 1-5, with 1 meaning that you strongly disagree and 5 meaning that you strongly agree.

	1 - Strongly Disagree	2	3 - Neutral	4	5 - Strongly Agree
I am a technological aware person. *Examples of technological awareness: Has much interest in finding out about technology, willing to learn new technology*	○	○	○	○	○
I am committed to sustainable behaviour. *Examples of sustainable behaviour: recycling, low carbon living, buying eco products, conserve electricity…*	○	○	○	○	○

Appendix 5 DS1 – Code definitions of Focus Group Study 1

Code		Meaning/ theme
AR		Acceptance on AR
	AR1	Do they feel comfortable using google glass/ AR device?
	AR2	Background data capturing function
	AR3	Information display
	AR4	Privacy, and other concerns
EC		Eco information
	EC1	Suggested functions / desired information
	EC2	Whole shop scenario
	EC3	One item scenario
	EC4	Info format preference
CB		Change of behaviour
	CB1	Personal attitude/ behaviour
	CB2	Potential change of behaviour

Appendix 6 DS1 – Transcripts of Focus Group Study 1

The following transcript is a record of all three focus group discussions. Coding was done manually, based on the voice recording of each discussion, using the software *MS Excel*. The definitions of the codes are provided in Appendix 5. The numbers of the questions asked (listed in the first column) correspond to Table 4.1 in Chapter 4. The responses are grouped according to its code (theme), instead of being arranged in chronical order.

Question no.	Category code	Participant ID	Responses
1	AR1	A1	"Google glass is interesting, but I won't use it."
1	AR1	A1	He would rather access to information via smartphone, because it is uncomfortable to see display on glasses.
1	AR1	A1	But it is not suitable for everyday use.
1	AR1	A3	It is not convenient to use. It will cause physical stress for example make his eyes painful.
1	AR1	B1	He does not feel comfortable about wearing an AR device.
1	AR1	B6	She feels more comfortable if the AR device looks like a smartphone, instead of a pair of glasses.
1	AR1	B4	She likes an AR device that can free her hands for other tasks (versus holding a phone).
1	AR1	C5	Regarding how comfortable he feels when wearing an AR device which will capture information behind the scene, he says it depends on the assumption/ condition, if the device takes photos automatically at the point of purchase and synchronise

Question no.	Category code	Participant ID	Responses
			to the cloud, but does not get shared without the user permission, then it is okay.
1	AR1	C6	She does not like it [AR device like Google Glass]. She thinks people are too enchanted with technologies. She prefers interaction with people.
1	AR1	C6	She does not like the medium, in terms of the system and the device itself, as a pair of glasses. She feels like it blocks people from interaction.
1	AR1	C2	She does not like this technology and will not wear it.
1	AR1, AR4	C1, C4, C7	If privacy problem is in control, he feels comfortable wearing it.
1	AR2	A2	She is comfortable about the automatic data capturing, if the data can be kept confidentially and within control. Girls like photo taking.
1	AR2	A1	Photo taking at the point of purchase can help by remembering a product and placing it on the wish list.
1	AR2	B6	The idea of capturing personal information (e.g. photo taking, location detection and recording) automatically is scary.
1	AR2	B6	She has turned off all the location service on her smartphone.
1	AR2	B6	For the idea of capturing (and recording) personal relationship with a product, she is concerned whether the information flow is within control.
1	AR2	B1	Data capturing by AR device behind the scene, is something like 'Real World Cookies'. 'Cookies' refer to the computer internet 'cookies' which track people's information, interest and preference.
1	AR2	B1	He does not like 'real world cookies'.
1	AR2	B3	He is concern whether he can turn off 'cookies'.
1	AR2, AR3	B1	He feels uncomfortable for both the data capturing function and the information display on glasses.
1	AR2, AR3	C7	He wants the data flow to be in control. If he can turn off the uploading (of personal information) function, and turn on only the downloading function, making the information flow one way (only receive of information he needs), then he feels fine with the AR device.
2	AR2, AR4	A2	It depends on what kind of information is recorded online. For example, 3D model of a person's body shape may be more private than shopping history.
1	AR2, EC1	A1	The AR can have a feature to recommend items, just like what Amazon does. When he first began to use Amazon, he did not like the idea of private information being recorded online. But now, after a few years, he is numb with privacy concern and he appreciates the convenience it brings.
1	AR3	A1	It will bring some benefits in some scenarios, for example navigation in driving.
1	AR3	A3	He prefers augmented information projected on the scene (reality objects).
1	AR3	A3	He prefers physical signboard or standalone display, and the AR device can be used supplementarily.

Question no.	Category code	Participant ID	Responses
1	AR3	A2	The mental and physical stress exerted by the AR device depends on how much information is shown.
1	AR3	A1	NFC technology and custom settings can act as a filter to suit a person's taste. Wearable technology (AR device) is good at displaying tailored information.
1	AR3	B2	He thinks AR device can be useful in displaying eco information. It functions similarly as information printed on package.
1	AR3	B6	In Korea she has seen an app, if someone scans a QR code, the app will show the cheapest price.
1	AR3	B2	He thinks, perhaps the information display can be adjusted according to the user's vision. For example, if the user is staring at a product for 5 seconds, then it will trigger the display of certain information. [scene scenario]
1	AR3	C2	She would feel uncomfortable wearing it. Although eco information display sounds okay, she is afraid that the device will be more intrusive, over time, inappropriate information may be available through the AR device, for example background search of the person sitting in front of her can be done immediately with the AR device.
1	AR3	C5	He feels devices that can give information about what he wants would be useful.
1	AR4	A1	Privacy is an issue. He feels insecure if the device record daily activities like CCTV, and saved the data online.
2	AR4	A1	If the privacy issue is addressed properly, maybe people will change and feel okay about having a device recording their behaviour.
1	AR4	B1	But information displayed on AR device (like Google Glass, constantly in vision) is intrusive.
1	AR4	B1	AR device that looks like a smartphone instead of glasses (Google Glass) will be better, because there will not be information constantly displayed in this vision.
1	AR4	B6	She is concerned about her appearance when wearing AR device like Google Glass. Will she look okay with it?
1	AR4	B6	"Does the AR device (Google Glass) talk to the user?"
1	AR4	B6	She does not want to talk to a pair of glasses, especially in public. It is awkward.
1	AR4	B7	She is wearing spectacles, and wonders if using AR device like Google Glass means she needs to wear two pair of glasses in the same time.
1	AR4	C7	He queries the data safety and privacy, he does not trust the user will have total control of the data, the data might leak out.
1	AR4	C3	He thinks data safety and privacy is bound by conditions, terms and regulations.
1	AR4	C3	Personal information (that C2 is worried about) is already on the internet.
1	AR4	C3	His concern is the AR device is too bulky, which may make him look weird. It may intrude his physical appearance.
1	AR4	C7	Size of the AR device is a concern.
1	AR4	C3	He is concerned about how other people thought about him. He is worried that wearing the Google Glasses (or AR device in the form of a pair of glasses) will make him unwelcome by others,

Question no.	Category code	Participant ID	Responses
			and may attract confrontation.
1	AR4	C3	If the device is popular, everybody is wearing it, then he feels comfortable wearing it.
1	AR4, EC1	B1	Too much information displayed constantly on your (his) vision is annoying.
1	EC1	A1	An advantage of using AR device is that it can helps to filter information (versus standalone signboard).
1	EC1	A2	Agree [An advantage of using AR device is that it can helps to filter information (versus standalone signboard).]
1	EC1	A2	The filtering function (of AR device) can tell me the sizes and materials of clothes at a glance, and save my time in selection.
1	EC1	A1	It may also have the function of price comparison between different shops.
2	EC1	A2	She is concern about the clothing material, and its health and safety issues (whether the fabric contains toxin).
2	EC1	A2	She does not care much about the condition of the sheep which provide the wool (raw material). Instead she is interested in learning more about recycling.
2	EC1	A1	"I do not think of recycling of clothes. I donate it after end of use, recycling is not a concern to me." [Donation is actually a way to recycle clothes.]
2	EC1	A2	"I want to know whether it is easy to recycle."
2	EC1	A2	Fabric / material can be used as a criterion for the filtering function. But she is more interested in selection criterion such as size and colours.
2	EC1	A1	He is worried that image may be biased and misleading.
2	EC1	A2	She agrees that image can be biased and misleading if the image is provided by manufacturer.
2	EC1	A4	Manufacturers or companies may manipulate with the images they provide. Number is more objective.
2	EC1	A1, A2, A3, A4	All agree image may not be trust worthy.
2	EC1	A1	He would trust figure given by Carbon Trust.
1	EC1	B2	He has drawn an 'information' icon (small thing) on the product, so it is only visible and expandable for people who are really interested in eco information. He does not think it is good, but people will want this.
2	EC1	B1	When the user looks at specific thing, a light flashes to tell whether it is sustainable or not. For example green light means 'okay'.
2	EC1	B1	Limited information displayed at a time.
2	EC1	B1	While holding only one product, more detail information will be displayed. If look at the label, it triggers the AR information display
2	EC1	B3	We should always give the option of simplified and detail information. The information should be expandable according to the user's preference.
2	EC1	B2	If depends on what kind of information the device wants to show. For example, size is an important piece of information. It

Question no.	Category code	Participant ID	Responses
			is more important to make sure if the clothes fit than knowing whether it is environmentally friendly.
2	EC1	B6	The device should not display too much information.
2	EC1	B6	They suggest rating different brands/ shops on their level of sustainability.
2	EC1	B6	Before the user enters one shop, perhaps a map of eco-friendly stores can be displayed.
2	EC1	B5	She wants information about sizes of clothes. She prefers a map showing the direction to a shop which has clothes of her size.
2	EC1	B5	She wants to be able to talk to her friends with the AR device.
2	EC1	B5	She wants information about restaurants and transport on the AR device too.
2	EC1	B4	She wants the AR device to provide information on price comparison, stock/ quantity, material (whether it is recyclable, and the ingredients), and image of the origin of the material.
2	EC1	B4, B6	They are interested in the material, origin of material, manufacturing… the whole life cycle of a product actually.
2	EC1	All	They query the trustworthy of the message which is conveyed by an image.
2	EC1	B1	Maybe can use the concept of displaying information for the whole product life cycle on a website.
2	EC1	B3	For example, for the image of a caged sheep, it may be just a moment of its life. Sometimes it is caged (ready for shave), sometimes it is 'free range'. It is tricky to decide which image to be used (for the company) and how to judge from an image (for the customer).
2	EC1	B7	I do not care about whether the sheep is 'free range' or 'caged'. Only if it is food, I might care. Who cares?
2	EC1	B6	I care (about how the sheep is kept).
2	EC1	B3	Information about what to do after end of use, for example recycling and disposal are more important than the origin of material.
2	EC1	B5	I do not mind the material either, because it is unlike food which I need to swallow.
2	EC1	B6	[Are you interested in the transportation cost (in terms of environmental impact) for the product?] Yes I am very interested in learning that.
2	EC1	B3	He strongly against the display of complicated information or lengthy text description.
2	EC1	B7	If an image is shown, she is more interested in knowing the designer, than the worker who is making it (the manufacturing environment).
2	EC1	B1	The company will not disclose the image of suffering and 'ripped off' workers.
2	EC1	C5,C6,C7	Step3. Comparison function to compare two products.
2	EC1	C1,C2,C3,C4	They do not want too much information on their device.
2	EC1	C7	I can read detail information which will cover all 100% of my view.
3	EC1		What is the difference between existing eco-label and the proposed AR eco info?

Question no.	Category code	Participant ID	Responses
3	EC1	C3	He questions what if the information is given impartial and mis-leading. Companies may lie a bit and twisting the figure.
3	EC1	C3	Assuming the eco-information provided by the AR-device comes from one reliable source, while eco-labels can given by different sources (difference companies), he possibly prefer AR device over eco label because the information will be more reliable.
3	EC1	C7	Sharing of information can help overcoming the issue of reliability of the information.
3	EC1	C3	Or if the information all comes from one authoritative source, the information may be more reliable.
3	EC1	C7	If the information is open, everybody can monitor it and censor it.
3	EC1	C4	We have to make the test to assure figures is certified, for example by Carbon Trust. Regulations can monitor the information.
3	EC1	C7	Certification process increases the costs of production. Small company's competence will be affected.
3	EC1	C7	Cloud computing and sharing of information can solve the problem (of trustworthy of information) without increasing the costs of the production.
3	EC1	C5	People should have the rights to choose whether they can read the information.
3	EC1	C7	(Rights to choose) Therefore the expandable dynamic interface is good, because people can choose to turn on/ off the information, and determine how much detail to see.
3	EC1	C2, C7	A very small logo is always expected. Detail information are optional.
3	EC1, CB	A2	She suggests providing guidelines on reuse and recycling of products.
3	EC1, CB	A4	Suggesting information on recycling can fulfil people's need of feeling satisfaction [similar to self-achievement].
2	EC1, EC2	C1,C2,C3,C4	When entering into a shop and viewing a lot of products, an 'eco traffic system' will label each product with a colourful symbol (red, yellow, green) to indicate how environmental friendly that product is.
2	EC1, EC3	C5,C6,C7	Step1. A dynamic and expandable interface can be used to show a timeline [x-axis] of the products, moving along the timeline the user can view environmental information for difference stages of the product (like a product life cycle and associated impacts). [show image, the matrix of 2 axes]
2	EC1, EC3	C5,C6,C7	Step2. Along the y-axis, alternative solutions (suggesting other similar products) can be shown according to the user selection criteria, for example similar product but using more sustainable fabric.
2	EC1, EC4	A3	Regarding the idea of seeing an image showing the origin of materials, he said he does not care about information of wool (an example of material).
2	EC1, EC4	A1	Regarding the idea of seeing an image showing the origin of materials, he is interested to learn about whether the wool, an example of material, comes from a happy sheep in a well maintained farm (no animal cruelty).

Question no.	Category code	Participant ID	Responses
2	EC1, EC4	A4	Image of endangered species may have emotional appeal too. He might prefer artificial fabric than endangered species fur, for example tiger.
2	EC1, EC4	A2	She says image can be powerful.
2	EC1, EC4	B1, B2, B3 (group)	They are interested in simplified information such as charts or traffic light system.
2	EC1, EC4	B3	The device can display a video of how the product is produced. But the video should not be displayed at the point of purchase. Perhaps it can give a web address which links to a 10 seconds video, so user can view it later.
1	EC2	A3	Providing information on products may help speeding up the shopping decisions.
1	EC2	A2	Shopping is enjoyable and I do not mind about speed.
2	EC2	B1, B2, B3 (group)	When user walks into a shop, information will be displayed according to the viewer's vision and point of focus.
2	EC2	C5,C6,C7	They suggest a filtering function. User can define the filtering criteria, and when the user walks into a shop, the products will be filtered and labelled, so the user can reach the products/ categories he want quickly and easily. The filter indicator will look like energy certificates (colourful symbols look like traffic light system).
2	EC3	C1,C2,C3,C4	When viewing individual product (cloth), more detail information will be shown. The default setting is the information will occupy half-the-screen (user vision), and information displayed will be an eco-overview of the product (product specification with eco info) which includes a traffic light system to indicate environmental friendliness, carbon footprint, eco certificate, guideline to use the product (e.g. how to wash it, how to dispose it).
2	EC3	C1,C2,C3,C4	The information can be turned on/ triggered by a small label, for example QR code or sensor.
2	EC4	A4	He prefers 2. 4 is too complicated.
2	EC4	A1	Prefers2, 3 is okay.
2	EC4	A3	Prefers2, 4 is too much
2	EC4	A3	Seasonal feeling, 3 (image) may be useful [image of wool has an emotional appeal in winter time.]
2	EC4	A2	2 is more objective [even after the focus group facilitator pointed out 1 is also objective, she still prefers 2.]
2	EC4	A4	2 is better than 1, because it is easier to understand. It depends on the person's level of understanding.
2	EC4	B3	Information format is traffic light system.
2	EC4	B1	Graphical information is clearer than text.
2	EC4	B3	Number (as an information format) does not work.
2	EC4	B3	For example BBC water consumption chart illustrates the number with infographics and icons. E.g. converting water usage for one bath to number of loaf of bread.
2	EC4	B1	In animal kingdom they work on the warning system of colour. Symbolic representation using different colour will be more effectively. People respond to colour.

Question no.	Category code	Participant ID	Responses
2	EC4	B2	If it is just text, people will turn the feature off, no one will want to read.
2	EC4	B1	If there is only one kind of information format to be displayed, it should only display symbols that have meaning. (instead of merely numerical carbon footprint)
2	EC4	B6	Their group prefers analysed information, e.g. number.
2	EC4	B4	Image will have an appeal to the customer's preference.
2	EC4	B6	Can be image, can be text. (for the origin of material/ manufacturing)
2	EC4	B1, B2	"I don't have time to watch a 10 seconds long video."
2	EC4	B4	(For the 10 seconds video) it depends on the product, if it is an important purchase, e.g. buying a car, than I will spare time to watch the video.
2	EC4	C5	1 and 2
2	EC4	all people	chose 2 (and maybe other)
2	EC4	C3, C7	2,3
2	EC4	C1	2,4
2	EC4	All	3 text too much to read
3	BC	B6	Money is a concern to me because I am under financial stress. So although I am interested in learning these information, these might not change my shopping decision which is largely determined by price.
3	BC	B6	"If within my budget, I am willing to pay more for eco-friendly products. Especially if I have more money in the future."
3	BC	B7	She considers about quality more than the eco factor.
3	BC	B4, B3	Agree. They consider more about price and quality.
3	BC	C7	I want to know information about which material is good or bad, it will change my perspective.
3	BC	C7	Information will change my perspective, if I see there is profit for me, I will change and behave more sustainably.
3	BC	C5	"I foresee in 7 years, when I walk into a supermarket, this AR device can tell me which food is organic which food is not. Most of the time, my decision will largely affected by the price of products. But if there is not much price difference, I would take the more organic or sustainable food. For example, similar things happened to me when I chose sustainable source tuna and free-range eggs. "
3	BC	C5	Costs come first, but eco factor matters. Same for my clothing shopping decision.
3	BC	C7	More information might change decision.
3	BC	C2	Eco information has an impact on her decision.
3	BC	C2	If someone only knows the costs, then he has no other 'option' (to choose based on other criteria).
3	BC	C2	If someone knows more information, he can have different preference. "For example, if I knew an animal is treated bad (to produce this product), or the conditions when the meats (product) are bad, then I will choose another product."

Question no.	Category code	Participant ID	Responses
3	BC	C2	In our current situation, usually the major information (if not 'only') we know is cost, which largely dominate our decision making process. If there exists more information, she will consider and may even have a different preference when she shops.
3	BC	C2	After people get this (eco) information for the first time, they will always want to have that information.
3	BC	C5	Once the (eco) information is provided, it will become a standard as people expect they should know about those.
3	BC	C6	Once the (eco) information is available, we expect it always.
3	BC	C1	"I think the same." (my preference will change if I know more information, and after I learn the eco information once, I will always expect that information will be provided to me whenever I shopped.)
3	BC	C5	People do not read food labels, which is a good comparison to the eco information in discussion. Even with the availability of that information, people do not use it.
3	BC	C2	We have to inform and teach people the meaning of the eco information. Only then people will have an interest in reading the eco information.
3	BC	C2, C7	There should always be freedom to choose what to see.
3	BC	A1, A2, A3	They would buy product that I like, eco friendliness is less of a concern.
3	BC	A4	He would buy eco-friendly product, it is one of my major concern.

Appendix 7 DS2 – Categories and indicative examples identified by participants

The table below shows an overview of all categories created in each sort, and the corresponding indicative example for each category. The table is listed in descending order of the number of sorters who used the same (standardised) category name.

Sorter	Original category name	Standardised category name	Indicative example card no.
P1	Approval / Certified	Certification symbol	101
P1	Efficiency	Efficiency	150
P1	Product Info	Product Info	74
P1	Environmental Data	Carbon footprint	38
P1	Trade ethics	Ethics	157
P1	End of life	Recycling	330
P1	Odd	Odd	
P1	Logos	Logo	389
P2	Green label	Green	151

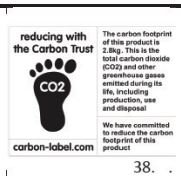
Sorter	Original category name	Standardised category name	Indicative example card no.
P2	Countries/ associations	National Standard	361
P2	Green product	Product info	76
P2	Gentle reminder	Animal friendly	53
P2	Carbon/ energy	Global warming	38
P2	House	Building	275
P2	Fair trade	Fair trade	267
P2	Company	Private companies	80
P2	Plant	Plants	328
P2	Green industry	Producers associations	62
P2	Food organic	Organic	5
P2	Global label	Planet	108
P2	Recycling	Recycling	330
P2	Ranking	Rating	360
P2	Odd	Odd	
P2	Diagram	Chart	169
P2	Ocean	Ocean friendly	298
P2	Considered design	Considered design	351
P2	Ethic	Ethics	185
P3	Agriculture	Agriculture	
P3	Environment	Environment	131
P3	Eco label content	Eco label content	102
P3	Web movement	Digital	320
P3	Not understand	Difficult	
P3	House label	Building	395
P3	Logo	Logo	151
P3	Certificates	Certification symbol	196
P3	Energy consumption	Energy	212
P3	Unknown	Odd	
P3	Textile	Textiles	74
P3	Resource consumption	Resource consumption	59
P3	Carbon	Carbon footprint	39
P3	Environment council	National standard	382
P3	Sea label	Ocean friendly	90
P3	Odd	Odd	351
P3	Word Green	Green	207
P3	Brands	Brands	27

Sorter	Original category name	Standardised category name	Indicative example card no.
P4	Eco	Eco label content	330
P4	Energy	Energy	203
P4	Certified	Certification symbol	50
P4	Food	Food	215
P4	Shipment	Logistics	381
P4	Hotel Travel	Tourism	219
P4	Go Green Products	Green	61
P4	Sea	Ocean friendly	90
P4	Climate	Global warming	65
P4	Beauty	Cosmetics / Personal care	167
P4	Environment	Environment	329
P4	Home	Building	233
P4	Entertainment	Entertainment	240
P4	Soil	Soil	350
P4	Trade	Fair trade	159
P4	Business	B to B	147
P4	Bio	Biological	30
P4	Water	Water	393
P4	Coffee	Coffee	27
P4	Agriculture	Agriculture	7
P4	Fashion	Fashion	179
P4	Odd	Odd	
P4	Difficult identify	Difficult	
P5	Nothing to suggest econess	Difficult	87
P5	Water & the environment	Water	395
P5	Green transport / logistics	Transportation	380
P5	Forestry stewardship	Forest products / Paper	328
P5	B to B & specialist materials based marks	B to B	137
P5	Marine stewardship	Ocean friendly	310
P5	I.T.	I.T.	109
P5	Energy	Energy	196
P5	Non harmful ‘eco’ detergents	Cleaning products	57
P5	Eco building	Building	251
P5	Eco textiles	Textiles	347
P5	Eco farming/ agricultural business & food product	Food	391

Sorter	Original category name	Standardised category name	Indicative example card no.
P5	Fair trade as ethical dimension	Fair trade	157
P5	Eco tourism	Tourism	285
P5	Preserving wild life (animals)	Animal friendly	81
P5	Eco cosmetics	Cosmetics / Personal care	49
P5	Eco farming/ agricultural business with place branding	Agriculture	388
P5	Carbon marks	Carbon footprint	386
P5	Eco/ green ratings	Rating	375
P5	Generic eco marks with national co-branding	National standard	243
P5	Eco/ sustainable finance	Financial services	98
P5	Eco certification	Certification symbol	372
P5	Generic eco endorsement various sectors, authority etc – Something eco but not clear what	Eco label content	105
G1	Recycling	Recycling	311
G1	Energy – renewable energy	Renewable energy	196
G1	Odd	Odd	
G1	Green product	Product info	381
G1	Energy - consumption	Energy efficiency	150
G1	Food	Food	90
G1	Material	Raw material	323
G1	Sustainable behaviour	Use phase	355
G1	Sustainable labour	Ethics	157
G1	Water/ Sea	Water	392
G1	Land	Earth	350
G1	Environment - general	Environment	151
G1	Air	Carbon footprint	38

Appendix 8 DS2 – Frequency of selected indicative examples

The table below summarises the indicative examples selected by the participants, in descending order of their frequency. Frequency here refers to the number of sorters that have chosen the label as an indicative example. For the convenience of reading, this table only includes the images and standardised category names for these 14 (6+8) indicative examples that appear more than once.

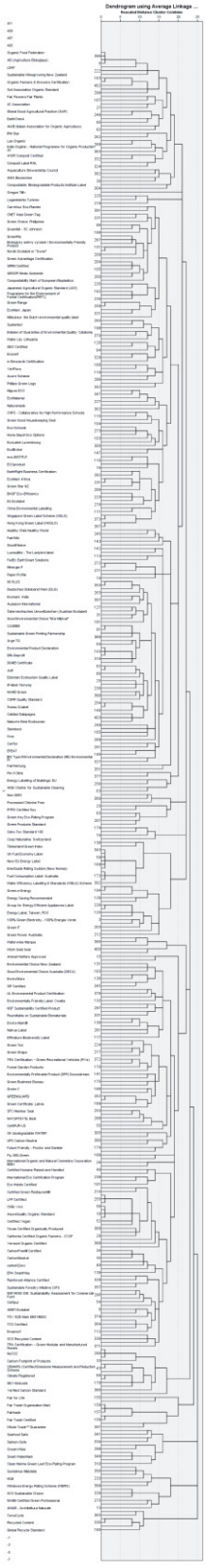
Indicative example	card no.	Frequency	Associated categories	Frequency of categories
 38.	**38**	**3**	Carbon footprint	2
			Global warming	1
 90.	90	3	Ocean friendly	2
			Food	1
 151.	151	3	Environment	1
			Green	1
			Logo	1
 157.	157	3	Ethics	2
			Fair trade	1
 196.	196	3	Renewable energy	1
			Certification symbol	1
			Energy	1
 330.	330	3	Recycling	2
			Eco label content	1
 27.	27	2	Coffee	1
			Brands	1
 74.	74	2	Product Info	1
			Textiles	1
 150.	150	2	Energy efficiency	1
			Efficiency	1

Indicative example	card no.	Frequency	Associated categories	Frequency of categories
 328.	328	2	Plants	1
			Forest products / Paper	1
 350.	350	2	Earth	1
			Soil	1
 351.	351	2	Considered design	1
			Odd	1
	381	2	Logistics	1
			Product info	1
 395.	395	2	Building	1
			Water	1
	5	1		
	7	1		
	30	1		
	39	1		
	49	1		
	50	1		
	53	1		
	57	1		
	59	1		
	61	1		
	62	1		
	65	1		
	76	1		
	80	1		
	81	1		
	87	1		
	98	1		

Indicative example	card no.	Frequency	Associated categories	Frequency of categories
	101	1		
	102	1		
	105	1		
	108	1		
	109	1		
	131	1		
	137	1		
	147	1		
	159	1		
	167	1		
	169	1		
	179	1		
	185	1		
	203	1		
	207	1		
	212	1		
	215	1		
	219	1		
	233	1		
	240	1		
	243	1		
	251	1		
	267	1		
	275	1		
	285	1		
	298	1		
	310	1		
	311	1		
	320	1		
	323	1		
	329	1		
	347	1		
	355	1		
	360	1		
	361	1		

Indicative example	card no.	Frequency	Associated categories	Frequency of categories
	372	1		
	375	1		
	380	1		
	382	1		
	386	1		
	388	1		
	389	1		
	391	1		
	392	1		
	393	1		

Appendix 9 DS2 – Dendrogram of Hierarchical cluster analysis (HCA)



Dendrogram using average linkage (between groups)

Appendix 10 DS2 – Results of Hierarchical cluster analysis (HCA)

Card	15 Clusters	14 Clusters	13 Clusters	12 Clusters	11 Clusters	10 Clusters
1:4C Association	1	1	1	1	1	1
4:AB (Agriculture Biologique)	1	1	1	1	1	1
5:ABIO	1	1	1	1	1	1
10:AIAB (Italian Association for Organic Agriculture)	1	1	1	1	1	1
11:AMA Biozeichen	1	1	1	1	1	1
16:Aquaculture Stewardship Council	1	1	1	1	1	1
27:C.A.F.E. Practices	1	1	1	1	1	1
30:Canada Organic	1	1	1	1	1	1
70:Compostable: Biodegradable Products Institute Label	1	1	1	1	1	1
71:AfOR Compost Certified	1	1	1	1	1	1
72:Compost Label RAL	1	1	1	1	1	1
92:Earth Advantage	1	1	1	1	1	1
93:EarthCheck	1	1	1	1	1	1
95:Earthsure	1	1	1	1	1	1
154:Fair Flowers Fair Plants	1	1	1	1	1	1
163:Farm Verified Organic	1	1	1	1	1	1
167:Flower Label Program (FLP)	1	1	1	1	1	1
182:Global Good Agricultural Practice (GAP)	1	1	1	1	1	1
222:Green Table	1	1	1	1	1	1
237:India Organic - National Programme for Organic Production (N	1	1	1	1	1	1
240:IPM Star	1	1	1	1	1	1
246:Lao Organic	1	1	1	1	1	1
247:LEAF	1	1	1	1	1	1
248:LEAF Marque	1	1	1	1	1	1
262:M1 Emission Classification of Building Materials	1	1	1	1	1	1
268: M-BRIO Organic and Food Labeling	1	1	1	1	1	1
299:Organic Content Standard (OCS)	1	1	1	1	1	1
304:OK biodegradable SOIL	1	1	1	1	1	1
313:Organic Farmers & Growers Certification	1	1	1	1	1	1
314:Organic Food Federation	1	1	1	1	1	1
324:Protected Harvest	1	1	1	1	1	1
332:RSPO Certified Sustainable Palm Oil	1	1	1	1	1	1
350:Soil Association Organic Standard	1	1	1	1	1	1
361:Sustainable Winegrowing New Zealand	1	1	1	1	1	1
382:US Composting Council Seal of Testing Assurance	1	1	1	1	1	1
383:USDA Organic	1	1	1	1	1	1
396:Wholesome Food Association	1	1	1	1	1	1
402:WSDA Organic	1	1	1	1	1	1
2:80 PLUS	2	2	2	2	1	1
7:Acorn Scheme	2	2	2	2	1	1
8:AENOR Medio Ambiente	2	2	2	2	1	1

Card	15 Clusters	14 Clusters	13 Clusters	12 Clusters	11 Clusters	10 Clusters
14:Anbefalt	2	2	2	2	1	1
17:Arge TQ	2	2	2	2	1	1
19:IBU Type III Environmental Declaration (IBU Environmental Pr	2	2	2	2	1	1
20:Audubon International	2	2	2	2	1	1
24:BASF Eco-Efficiency	2	2	2	2	1	1
25:BASS (Product inventory for the construction industry)	2	2	2	2	1	1
28:Calidad Galapagos	2	2	2	2	1	1
31:Canadian Certified Environmental Professional	2	2	2	2	1	1
41:Carrefour Eco-Planete	2	2	2	2	1	1
42:CASBEE	2	2	2	2	1	1
44:Certfor	2	2	2	2	1	1
57:AISE Charter for Sustainable Cleaning	2	2	2	2	1	1
60:China Environmental Labelling	2	2	2	2	1	1
62:CHPS - Collaborative for High Performance Schools	2	2	2	2	1	1
63:Cleaner and Greener Certification	2	2	2	2	1	1
64:Cleaning Industry Management Standard (CIMS)	2	2	2	2	1	1
68:CNET Asia Green Tag	2	2	2	2	1	1
69:Compostability Mark of European Bioplastics	2	2	2	2	1	1
76:CRI Green Label	2	2	2	2	1	1
78:CSRR Quality Standard	2	2	2	2	1	1
80:Danish Ø-mark	2	2	2	2	1	1
82:Declare	2	2	2	2	1	1
84:Delinat Bio Garantie	2	2	2	2	1	1
87:Deutsches Güteband Wein (DLG)	2	2	2	2	1	1
88:DGNB Certificate	2	2	2	2	1	1
89:DIN-Geprüft	2	2	2	2	1	1
91:DUBOkeur	2	2	2	2	1	1
94:EarthRight Business Certification	2	2	2	2	1	1
96:ECMA-370 - The Eco Declaration	2	2	2	2	1	1
98:EcoBroker	2	2	2	2	1	1
99:Ecocert	2	2	2	2	1	1
102:eco-INSTITUT	2	2	2	2	1	1
103:Eco-Leaf	2	2	2	2	1	1
104:Eco-Living seal	2	2	2	2	1	1
105:EcoLogo	2	2	2	2	1	1
106:EcoMark Africa	2	2	2	2	1	1
107:Ecomark: India	2	2	2	2	1	1
108:EcoMark: Japan	2	2	2	2	1	1
109:EcoMaterial	2	2	2	2	1	1
110:ECOproduct	2	2	2	2	1	1
111:EcoStandard EcoProduct South Africa	2	2	2	2	1	1
113:Eco-Rail Mark	2	2	2	2	1	1

Card	15 Clusters	14 Clusters	13 Clusters	12 Clusters	11 Clusters	10 Clusters
114:Eco-Schools	2	2	2	2	1	1
115:EcoVillage	2	2	2	2	1	1
116:Eco Warranty	2	2	2	2	1	1
119:Ekolabel: Indonesia	2	2	2	2	1	1
120:EMAS: European Eco-Management and Audit Scheme	2	2	2	2	1	1
121:Emblem of Guarantee of Environmental Quality: Catalonia	2	2	2	2	1	1
124:Energy Labelling of Buildings: EU	2	2	2	2	1	1
127:Energy Saving Labeling Program: Japan	2	2	2	2	1	1
133:Ekologicky setrny vyrobek / Environmentally Friendly Product	2	2	2	2	1	1
134:Environmental Product Declaration	2	2	2	2	1	1
140:EPEAT	2	2	2	2	1	1
142:Equitable Origin Certified	2	2	2	2	1	1
143:EQUITRADE	2	2	2	2	1	1
144:e-Stewards Certification	2	2	2	2	1	1
145:Estonian Ecotourism Quality Label	2	2	2	2	1	1
146:Estonian Organic Farming	2	2	2	2	1	1
147:Ethibel	2	2	2	2	1	1
148:Etichetta ambientale	2	2	2	2	1	1
149:EU Ecolabel	2	2	2	2	1	1
151:EU organic products label	2	2	2	2	1	1
153:European Computer Manufacturers Association ECMA: TR/70	2	2	2	2	1	1
160:FairWertung	2	2	2	2	1	1
161:FairWild	2	2	2	2	1	1
164:FedEx EarthSmart Solutions	2	2	2	2	1	1
165:Florimark	2	2	2	2	1	1
166:Florverde Sustainable Flowers	2	2	2	2	1	1
177:GEO Certified	2	2	2	2	1	1
181:Gold Standard	2	2	2	2	1	1
184:Good Environmental Choice "Bra Miljöval"	2	2	2	2	1	1
186:GoodWeave	2	2	2	2	1	1
187:Green Advantage Certification	2	2	2	2	1	1
191:Green Choice: Phillipines	2	2	2	2	1	1
192:Green Crane: Ukraine	2	2	2	2	1	1
198:Green Flag Program	2	2	2	2	1	1
199:Green Globe Certification	2	2	2	2	1	1
200:Green Globes	2	2	2	2	1	1
201:Green Good Housekeeping Seal	2	2	2	2	1	1
204:Green Key	2	2	2	2	1	1
206:Green Label: Israel	2	2	2	2	1	1
208:Greenlist - SC Johnson	2	2	2	2	1	1
209:Green Mark	2	2	2	2	1	1
211:GreenPla	2	2	2	2	1	1

Card	15 Clusters	14 Clusters	13 Clusters	12 Clusters	11 Clusters	10 Clusters
214:Green Range	2	2	2	2	1	1
220:Green Star NZ	2	2	2	2	1	1
221:GreenSure - Sherwin Williams	2	2	2	2	1	1
223:Global Green Tag Certified	2	2	2	2	1	1
227:GUT	2	2	2	2	1	1
229:Healthy Child Healthy World	2	2	2	2	1	1
230:Home Depot Eco Options	2	2	2	2	1	1
231:Hong Kong Eco-label	2	2	2	2	1	1
232:Hong Kong Green Label (HKGLS)	2	2	2	2	1	1
234:Hungarian Ecolabel / Környezetbarát Termék Védjegy	2	2	2	2	1	1
235:ICMA Eco Label Standard Program	2	2	2	2	1	1
236:IMO Certified	2	2	2	2	1	1
241:Japanese Agricultural Organic Standard (JAS)	2	2	2	2	1	1
242:Just	2	2	2	2	1	1
244:Krav	2	2	2	2	1	1
245:Label STEP	2	2	2	2	1	1
249:Leaping Bunny	2	2	2	2	1	1
250:LEED Professional Credentials	2	2	2	2	1	1
254:level	2	2	2	2	1	1
256:LIFE Certification	2	2	2	2	1	1
257:Water Lily: Lithuania	2	2	2	2	1	1
260:Luomuliitto - The Ladybird label	2	2	2	2	1	1
261:Luomu Sun Sign	2	2	2	2	1	1
263:MADE-BY	2	2	2	2	1	1
269:Migros ECO	2	2	2	2	1	1
270:Milieukeur: the Dutch environmental quality label	2	2	2	2	1	1
271:Minergie	2	2	2	2	1	1
272:Minergie-A	2	2	2	2	1	1
273:Minergie-ECO	2	2	2	2	1	1
274:Minergie-P	2	2	2	2	1	1
276:NAHB Green	2	2	2	2	1	1
278:National Green Pages™ Seal of Approval	2	2	2	2	1	1
282:Naturally Sephora	2	2	2	2	1	1
283:Naturemade	2	2	2	2	1	1
285:Nature's Best Ecotourism	2	2	2	2	1	1
286:Nature's Promise	2	2	2	2	1	1
287:Naturland e.V.	2	2	2	2	1	1
289:Nike Considered Design	2	2	2	2	1	1
292:Nordic Ecolabel or "Swan"	2	2	2	2	1	1
293:SIRIM Certified	2	2	2	2	1	1
302:Oeko-Tex Standard 1000	2	2	2	2	1	1
306:OK Compost	2	2	2	2	1	1
307:ÖkoControl	2	2	2	2	1	1

Card	15 Clusters	14 Clusters	13 Clusters	12 Clusters	11 Clusters	10 Clusters
309:Ø-label: Norway	2	2	2	2	1	1
315:Österreichisches Umweltzeichen (Austrian Ecolabel)	2	2	2	2	1	1
317:Paper Profile	2	2	2	2	1	1
318:Passivhaus	2	2	2	2	1	1
319:Per il Clima	2	2	2	2	1	1
320:Phillips Green Logo	2	2	2	2	1	1
321:Planet Positive	2	2	2	2	1	1
323:Programme for the Endorsement of Forest Certification(PEFC)	2	2	2	2	1	1
327:R-2000 Certificate	2	2	2	2	1	1
329:RECS International Quality Standard	2	2	2	2	1	1
342:SEE What You Are Buying Into	2	2	2	2	1	1
344:Singapore Green Label Scheme (SGLS)	2	2	2	2	1	1
346:SIRIM Certified	2	2	2	2	1	1
347:Skal Eko Symbol	2	2	2	2	1	1
351:Sourcemap	2	2	2	2	1	1
353:Spiel Gut	2	2	2	2	1	1
354:Steinbock	2	2	2	2	1	1
359:Sustainable Green Printing Partnership	2	2	2	2	1	1
362:SustentaX	2	2	2	2	1	1
363:Swiss Q-label	2	2	2	2	1	1
367:Thai Green Label	2	2	2	2	1	1
370:EcoLabel Luxembourg	2	2	2	2	1	1
373:Tunisia Ecolabel	2	2	2	2	1	1
377:UL Environmental Claim Validation	2	2	2	2	1	1
379:Umweltbaum (The Environment Tree)	2	2	2	2	1	1
387:VeriFlora	2	2	2	2	1	1
389:Viabono	2	2	2	2	1	1
390:VIBE-label	2	2	2	2	1	1
391:Vitality Leaf	2	2	2	2	1	1
403:Zque	2	2	2	2	1	1
3:100% Green Electricity - 100% Energia Verde	3	3	3	3	2	2
58:China Energy Conservation Program (CECP)	3	3	3	3	2	2
59:China Energy Label	3	3	3	3	2	2
118:EKOenergy	3	3	3	3	2	2
122:EnerGuide for Appliances	3	3	3	3	2	2
123:EnerGuide Rating System (New Homes)	3	3	3	3	2	2
125:Energy Label, Taiwan, ROC	3	3	3	3	2	2
126:Energy Rating Programme: Australia	3	3	3	3	2	2
128:Energy Saving Recommended	3	3	3	3	2	2
129:ENERGY STAR	3	3	3	3	2	2
138:Burn Wise EPA	3	3	3	3	2	2
150:New EU Energy Label	3	3	3	3	2	2
169:Flybe Aircraft Ecolabel	3	3	3	3	2	2

Card	15 Clusters	14 Clusters	13 Clusters	12 Clusters	11 Clusters	10 Clusters
173:Fuel Consumption Label: Australia	3	3	3	3	2	2
194:Green-e Energy	3	3	3	3	2	2
196:Green-e Marketplace	3	3	3	3	2	2
203:Green IT	3	3	3	3	2	2
212:Green Power Australia	3	3	3	3	2	2
226:Group for Energy Efficient Appliances Label	3	3	3	3	2	2
308:OK Power	3	3	3	3	2	2
343:Shipping Efficiency - A to G GHG Emission Rating	3	3	3	3	2	2
368:Timberland Green Index	3	3	3	3	2	2
375:UK Fuel Economy Label	3	3	3	3	2	2
376:UL Energy Efficiency Verified	3	3	3	3	2	2
392:Water Efficiency Labelling & Standards (WELS) Scheme	3	3	3	3	2	2
398:WindMade	3	3	3	3	2	2
6:ABNT Ecolabel	4	4	4	4	3	3
9:Afrisco Certified Organic	4	4	4	4	3	3
12:American Grassfed	4	4	4	4	3	3
15:Animal Welfare Approved	4	4	4	4	3	3
18:AsureQuality Organic Standard	4	4	4	4	3	3
21:Australian Certified Organic	4	4	4	4	3	3
22:Australian Forest Certification Scheme	4	4	4	4	3	3
26:International Organic and Natural Cosmetics Corporation BDIH	4	4	4	4	3	3
29:California Certified Organic Farmers - CCOF	4	4	4	4	3	3
34:CarbonFree® Certified	4	4	4	4	3	3
35:CarbonNeutral	4	4	4	4	3	3
36:Carbon Neutral Certification	4	4	4	4	3	3
37:Carbon Neutral Product Certification	4	4	4	4	3	3
40:carboNZero	4	4	4	4	3	3
46:Certified Envirodesic	4	4	4	4	3	3
47:Certified Green Dealer	4	4	4	4	3	3
48:Certified Humane Raised and Handled	4	4	4	4	3	3
49:Certified Natural Cosmetics	4	4	4	4	3	3
50:Certified Naturally Grown	4	4	4	4	3	3
51:Certified Pesticide Residue Free	4	4	4	4	3	3
52:Certified Vegan	4	4	4	4	3	3
53:Certified Wildlife Friendly®	4	4	4	4	3	3
54:Certipur	4	4	4	4	3	3
55:CertiPUR-US	4	4	4	4	3	3
56:Chão Vivo	4	4	4	4	3	3
61:China Organic Food Certification	4	4	4	4	3	3
75:Cradle to Cradle Certified(CM) Products Program	4	4	4	4	3	3
77:CSA Sustainable Forest Management	4	4	4	4	3	3
81:David Bellamy Conservation Award	4	4	4	4	3	3
85:Demeter Biodynamic®	4	4	4	4	3	3

Card	15 Clusters	14 Clusters	13 Clusters	12 Clusters	11 Clusters	10 Clusters
86:Design for the Environment (DFE)	4	4	4	4	3	3
100:ECO certification	4	4	4	4	3	3
101:Eco Hotels Certified	4	4	4	4	3	3
112:Ecoproof	4	4	4	4	3	3
117:Effinature Biodiversity Label	4	4	4	4	3	3
130:Enviro-Mark®	4	4	4	4	3	3
131:Environmental Choice New Zealand	4	4	4	4	3	3
132:Environmentally Friendly Label: Croatia	4	4	4	4	3	3
135:Environmental Warrant of Fitness	4	4	4	4	3	3
136:EnviroStars	4	4	4	4	3	3
137:EPA Lead-Safe Certification	4	4	4	4	3	3
139:EPA SmartWay	4	4	4	4	3	3
141:Environmentally Preferable Product (EPP) Downstream	4	4	4	4	3	3
162:Farm and Ranch Certification Program	4	4	4	4	3	3
168:Fly-360-Green	4	4	4	4	3	3
170:Forest Garden Products	4	4	4	4	3	3
171:Vermont Organic Certified	4	4	4	4	3	3
174:Future Friendly - Proctor and Gamble	4	4	4	4	3	3
175:Green Business Bureau	4	4	4	4	3	3
176:Green Business League Certification	4	4	4	4	3	3
183:Good Environmental Choice Australia (GECA)	4	4	4	4	3	3
188:Green C	4	4	4	4	3	3
189:Green Certificate: Latvia	4	4	4	4	3	3
190:Green Certified Site	4	4	4	4	3	3
195:Green-e Climate	4	4	4	4	3	3
197:Greener Product Certification Seal	4	4	4	4	3	3
202:GREENGUARD	4	4	4	4	3	3
210:Green Office Champions: Seal of Good Practice	4	4	4	4	3	3
215:Certified Green Restaurant®	4	4	4	4	3	3
216:Green Seal	4	4	4	4	3	3
217:Green Shape	4	4	4	4	3	3
218:Green Shield Certified	4	4	4	4	3	3
224:Green Tick	4	4	4	4	3	3
239:International Eco Certification Program	4	4	4	4	3	3
243:Korean Ecolabel	4	4	4	4	3	3
251:LEED Green Building Rating Systems	4	4	4	4	3	3
253:SFC Member Seal	4	4	4	4	3	3
255:LFP Certified	4	4	4	4	3	3
258:LIVE (Low Input Viticulture and Ecology)	4	4	4	4	3	3
265:Marine Stewardship Council	4	4	4	4	3	3
266:MAS Certified Green	4	4	4	4	3	3
277:National Carbon Offset Standard	4	4	4	4	3	3
279:National Programme of Environmental Assessment and Ecolabel	4	4	4	4	3	3

Card	15 Clusters	14 Clusters	13 Clusters	12 Clusters	11 Clusters	10 Clusters
281:Natrue-Label	4	4	4	4	3	3
288:NATURTEXTIL Best	4	4	4	4	3	3
294:NSF/ANSI 140 Sustainability Assessment for Carpet	4	4	4	4	3	3
295:NSF/ANSI 332 Sustainability Assessment for Resilient Floor C	4	4	4	4	3	3
296:NSF/ANSI 336: Sustainability Assessment for Commercial Furni	4	4	4	4	3	3
297:NSF Sustainability Certified Product	4	4	4	4	3	3
300:OE-100 & OE-Blended	4	4	4	4	3	3
305:OK biodegradable WATER	4	4	4	4	3	3
316:Paper by Nature	4	4	4	4	3	3
325:QCS Organic	4	4	4	4	3	3
326:R2/RIOS Certified Electronics Recycler	4	4	4	4	3	3
328:Rainforest Alliance Certified	4	4	4	4	3	3
331:Roundtable on Sustainable Biomaterials	4	4	4	4	3	3
335:SCS Certified Biodegradable	4	4	4	4	3	3
336:SCS FloorScore®	4	4	4	4	3	3
338:SCS Recycled Content	4	4	4	4	3	3
345:SIP Certified	4	4	4	4	3	3
348:SMaRT Consensus Sustainable Product Standards	4	4	4	4	3	3
352:SPCA Certified	4	4	4	4	3	3
355:Stemilt Responsible Choice	4	4	4	4	3	3
357:Sustainable Forestry Initiative (SFI)	4	4	4	4	3	3
358:SFC Member Seal	4	4	4	4	3	3
360:Sustainable Tourism Education Program (STEP)	4	4	4	4	3	3
364:TCO Certified	4	4	4	4	3	3
366:Texas Certified Organically Produced	4	4	4	4	3	3
371:TRA Certification – Green Modular and Manufactured Homes	4	4	4	4	3	3
372:TRA Certification – Green Recreational Vehicles (RVs)	4	4	4	4	3	3
374:TÜV SÜD Mark EE01/EE02	4	4	4	4	3	3
378:UL Environmental Product Certification	4	4	4	4	3	3
380:UPS Carbon Neutral	4	4	4	4	3	3
381:UPS Eco Responsible Packaging Program	4	4	4	4	3	3
384:USDA Certified BioBased	4	4	4	4	3	3
385:UTZ Certified	4	4	4	4	3	3
388:Vermont Organic Certified	4	4	4	4	3	3
13:ANAB - Architettura Naturale	5	5	5	5	4	4
97:Eco3Home	5	5	5	5	4	4
152:Indoor Air Comfort	5	5	5	5	4	4
233:HQE	5	5	5	5	4	4
238:Indoor airPLUS	5	5	5	5	4	4
275:NAHB Certified Green Professional	5	5	5	5	4	4
280:Nationwide House Energy Rating Scheme	5	5	5	5	4	4

Card	15 Clusters	14 Clusters	13 Clusters	12 Clusters	11 Clusters	10 Clusters
284:natureplus	5	5	5	5	4	4
337:SCS Indoor Advantage	5	5	5	5	4	4
339:SCS Sustainable Choice	5	5	5	5	4	4
356:SundaHus Miljödata	5	5	5	5	4	4
399:Windows Energy Rating Scheme (WERS)	5	5	5	5	4	4
23:AvoGreen®	6	6	6	6	5	5
83:Degree of Green®	6	6	6	6	5	5
205:Green Key Eco-Rating Program	6	6	6	6	5	5
207:Greenline Print	6	6	6	6	5	5
213:Green Products Standard	6	6	6	6	5	5
291:Non-GMO	6	6	6	6	5	5
322:Processed Chlorine Free	6	6	6	6	5	5
333:RTRS Certified Soy	6	6	6	6	5	5
369:Totally Chlorine Free	6	6	6	6	5	5
32:CarbonCare	7	7	7	7	6	6
33:Carbon Footprint of Products	7	7	7	7	6	6
38:Carbon Reduction Label	7	7	7	7	6	6
39:Carbon Trust Standard	7	7	7	7	6	6
43:CEMARS (Certified Emissions Measurement and Reduction Scheme	7	7	7	7	6	6
65:Climate Change Action	7	7	7	7	6	6
66:Climate Registered	7	7	7	7	6	6
67:Climatop	7	7	7	7	6	6
79:Danish Indoor Climate Label	7	7	7	7	6	6
178:GEV-Emicode	7	7	7	7	6	6
259:LowCO2 Certification	7	7	7	7	6	6
290:NoCO2	7	7	7	7	6	6
386:Verified Carbon Standard	7	7	7	7	6	6
45:Certified Australian Southern Rocklobster "CleanGreen" Progr	8	8	8	8	7	7
90:Dolphin Safe / Dolphin Friendly	8	8	8	8	7	7
172:Friend of the Sea	8	8	8	8	7	7
264:Marine Aquarium Council (MAC) Certification	8	8	8	8	7	7
298:Ocean Wise	8	8	8	8	7	7
310:Clean Marine Green Leaf Eco-Rating Program	8	8	8	8	7	7
334:Salmon-Safe	8	8	8	8	7	7
340:SeaChoice	8	8	8	8	7	7
341:Seafood Safe	8	8	8	8	7	7
349:Smart WaterMark	8	8	8	8	7	7
73:Coop Naturaline: Switzerland	9	9	9	9	8	2
74:Cotton Made in Africa	9	9	9	9	8	2
179:Global Organic Textile Standard	9	9	9	9	8	2
301:Oeko-Tex Standard 100	9	9	9	9	8	2
155:Fair for Life	10	10	10	10	9	8
185:Good Shopping Guide Ethical Award	10	10	10	10	9	8

Card	15 Clusters	14 Clusters	13 Clusters	12 Clusters	11 Clusters	10 Clusters
156:Fair Labor Practices and Community Benefits	11	10	10	10	9	8
157:Fairtrade	11	10	10	10	9	8
158:Fair Trade Certified	11	10	10	10	9	8
159:Fair Trade Organization Mark	11	10	10	10	9	8
228:HAND IN HAND	11	10	10	10	9	8
267:Max Havelaar	11	10	10	10	9	8
397:Whole Trade™ Guarantee	11	10	10	10	9	8
180:Global Recycle Standard	12	11	11	11	10	9
193:Green Dot / Der Grüner Punkt / Grønt Punkt	12	11	11	11	10	9
303:OK biobased	12	11	11	11	10	9
311:On-Pack Recycling Label	12	11	11	11	10	9
330:Recycled Content	12	11	11	11	10	9
365:TerraCycle	12	11	11	11	10	9
219:Green Star Hotel Certification Programme	13	12	12	2	1	1
225:Green Tourism Business Scheme	13	12	12	2	1	1
252:Legambiente Turismo	13	12	12	2	1	1
312:Oregon Tilth	14	13	1	1	1	1
393:Water Efficiency Product Labelling Scheme	15	14	13	12	11	10
394:WaterSense	15	14	13	12	11	10
395:Waterwise Marque	15	14	13	12	11	10
400:WQA Gold Seal	15	14	13	12	11	10
401:WQA Sustainability Mark	15	14	13	12	11	10

Appendix 11 DS2 – Card sorting transcript about category definitions

This appendix provides the interview transcript made in reference to the 53 categories created by all participants. The text references (in bullet points) are the comments made by different participants, and are grouped below according to the 53 category names created.

Name: Agriculture

- Agriculture. It is related to agriculture products, if the farmer are rightfully treated and the soil and the earth is rightfully used.
- 313. It has the word 'organic' 'farmer' and grower'.
- Agriculture. Because the word 'farm' and we can see some words like 'farmers', 'grower'.
- 7. It looks like vegetable.
- Eco Farming/ Agriculture Business. It is like national co-branding but it could be place branding.
- For example, 388, VERMONT Organic Certified. Because it has got the place branding, and appeal, actually this one is interesting, it has got also the endorsement.

Name: Animal friendly

- Or like this one, 53, wildlife friendly. So like the ethical consideration towards the environmental ... the actual traders they are involved with.
- The family is 'gentle reminder', no.53 is the example. 'Gentle reminder' got 'wildlife friendly', most of them got the wording 'friendly' on the labels. On the picture is a man holding an elephant. It feels like a gentle reminder that you have to care about environmental issues.
- Insect welfare. 151. Pesticide residue free. This is about not using chemical to harm the environment. That could be merged with 'preserving welfare', animal welfare... That one I particularly like, again, because it is about how graphic designers use all the techniques to get the message across. 81(indicative one). David Bellamy is a well known conservationist, it is an award scheme which gives it extra authority. It is a gold one. These graphics and words strengthen the message. I can merge them and call them 'preserving wildlife'.

Name: B to B

- Economic/ finance. Because of the word 'fair', 'fair deal', so I think it is 'economic'. The word 'fair' sounds like trading products with money... something like B-to-B, business. Because the word shows 'investment', and we can see some words on the labels show market ecology. The whole group is related to business... maybe I should rename it so 'banking', 'investment', etc. Or may I should keep the word 'finance'.
- Okay, what the difference between this 'fair' and that 'fair'... I just guess because here are some words that I cannot understand. Here is clearly mentioned 'fair trade', so I think it is 'trade'. This is a B-to-C, but I guess this 'fair' is like stock market to money... or a kind of investment... wait, now I change my mind. I would like to put these two into the group 'difficult'. Then this whole group will be called 'business', including all business behaviours such as investment and marketing.
- Business-to-business (B-to-B) and specialised materials based marks.
- 137. A lead safe certified firm, it is businesses talking to other businesses, it is about specific material or eco issue.

Name: Biological

- Bio, because I see the word 'bio.

Name: Brands

- Brands. They are just brands.
- 27. Starbucks. It is a brand.

Name: Building

- House. I do not really get the actual meanings. But they all have a picture of house on the labels. And there is a big sector [category] of it, amongst 400 labels there are about 20, so I made them a group.
- House. They are companies or organisations who are in charge to make sure you understand how much is your consumption for housing. How you have been using your consumption. Most of the labels are for houses, it has the word and the picture of houses.
- 395. Water wise. I know it is set up for making sure you are aware of the water consumption in your house. I have done research on it before that's why I know the brand.
- Home. I see the picture of house, 'cleaning'... which reminds me of cleaning a house... they write 'home', 'your life', 'house keeping'. So I think these labels are talking about home.
- 233. I chose this because the picture of a house, and it is written 'HOE'... I thought it is home... oh is it 'HQE'? then it is not home... but the picture looks like a home...
- There is an awareness of environmental damage because of this sort of activity, it is a reaction to that to try to establish some eco credentials.
- Eco Air Quality/ Conditioning. People are aware that air conditioning is wasteful to the environment.
- 202. Green Guard Indoor... Certificate, because it is the most descriptive of this category.
- Eco building. Any aspects of built environment, I supposed. It has a range, this is about eco living, water saving, green office, eco village, housing...
- US green build council. 251. They are using their US, country of origin endorsement.

Name: Carbon footprint

- I think with all the big categories that we have chosen, we can separate them by 'conservation' and 'protection' and 'responsibl use'... I guess in a way we didn't want to complicate too much. So environment wise, in term of environmental category, we have chosen where they are trying to either protect or either use responsibly. So all these ones are land, water, air categories. And general ones are the sort of protecting the earth or conserving the greenness of the earth. That is how we separate them.
- Air is the air quality. Again it is the conservation of the air quality, so reducing the carbon... etc.
- Responsible use of air... it doesn't make sense... but that again is related to not harming the air quality.
- The next group is 'environmental data'.
- [38]. This one just shows the effects of manufacturing of the product of the affects or impact of the product on the environment.
- Carbon. It is carbon usage. Similar like water and energy, companies are trying to tell you how much CO2 is produced. It tells you they are more environmental aware than others.

- 39. Carbon trust is standard.
- Carbon marks, it is similar to eco certification but specifically in relation to CO2.
- 386 says 'global benchmark for carbon'. Because it has got the strap line and it tells you 'verified carbon standard'.

Name: Certification symbol

- Basically when the label only shows just basic information of the product, so this one is 'cotton made in Africa', and that's about it. It doesn't show more like the other ones that show much more than that.
- So basically the product has been approved or the standard of the product has been met or assessed by a certain organisation. Some of them are like 'lead free products', 'eco-friendly'.
- Certifications. It is like ISO, or anything... They are the approval from the board, or countries, to actually sell a product or run a business or whatever. You see what I mean. Like, before you start a business that can have certain environmental impact, you need to fulfill certain requirements from your government. So I think this kind of certifications is the one to guarantee the people that they are working on the agreements that the government propose, or the regulatory body propose.
- Certified. It is very interesting because I saw the word 'certify' shown on the label.
- 50. Certify. Because of the word 'certified'.
- Maybe the product is certified by the government or professional association.
- Eco certification, it tries to have more authority than generic eco endorsement.
- 372. Certified green by TRA certification. It is repeating [the word] 'certify' to give it more... it is definitely green.

Name: Chart

- Diagram. Most people will ignore that because it has got a lot of words and we cannot really get the meaning when we see it.
- 169. Because it has too many words.
- Because it's the point of view of consumers.

Name: Cleaning products

- Non harmful eco detergents. Detergents that don't put nasty chemical into the environment.
- 57, I thought it is a good one because it is the most descriptive. It has got a picture of the blue planet and it has got things associated with cleaning, washing, glass.. professionally laundered tee shirt and a brush and it says 'sustainable cleaning.com'.

Name: Coffee

- Coffee. Because I saw the word 'coffee' on the label.

- I chose this one because Starbucks is a well-known coffee brand all over the world.

Name: Considered design

- 'Considered design'. E.g. this is a recycling label.
- Because in the sector, it could be 'easy option' or 'design of green'. But if they got this, a QR code, it is easier to find the information. So it is considered design.

Name: Cosmetics Personal care

- Beauty. From the label we can see the word 'cosmetics', and there is a picture of a beautiful woman's profile.
- 167. We can see a beautiful woman with a rose. So I guess it is 'beauty'.
- Eco cosmetics. Just two in this category. I am sure if you look for it you could find lots of eco cosmetic labels.
- Because it has got (the word) 'cosmetics' on it. Natural cosmetics.
- International organic and natural cosmetics.
- I would say, no.49, it says certified natural cosmetics. They are using the word 'certify' trying to give it more authority.

Name: Difficult

- Not Understand. I don't understand those ones. I don't know what they are. I cannot correlate them to anything, to any group of ideas.
- Maybe for this one (from the group difficult), i can guess the picture. There is a bird, pigeon. I could try to guess the meaning of the labels from the 'difficult' group.
- Ambiguous. Nothing to suggest eco-ness.

Name: Digital

- Web movement. They are movements that encourage people to be better or save the planet. They are not particular labels either, just like organisations that encourage people to do things in a better way.
- The example is 320, it's the 'dot com'.

Name: Earth

- I think with all the big categories that we have chosen, we can separate them by 'conservation' and 'protection' and 'responsible use'... I guess in a way we didn't want to complicate too much. So environment wise, in term of environmental category, we have chosen where they are trying to either protect or either use responsibly. So all these ones are land, water, air categories. And general ones are the sort of protecting the earth or conserving the greenness of the earth. That is how we separate them.

- Land. We have chosen 'Soil Association' logo that is 350. We chose it because it is most well-known. And it says 'soil', obviously land.
- Forest. Protecting the forest.

Name: Eco label content

- Eco labels. This is the kind of things that should appear on a product saying that what kind of benefits to the environment it brings, or the product shows what it is trying to be good at.
- 102. It says eco. It writes product tested, at least we know the product is tested, I guess.
- Eco. It is for the same reason because it has a very 'eco' sign. It has 'green range', 'go green', or... the word 'eco'. It is because of the wording.
- 330. It shows a recycling sign.
- 105. That is extremely generic because it just says 'eco logo', almost like a joke.
- Generic eco endorsements
- Generic eco endorsement... 'generic' means it is not saying anything specific about the nature of sustainability or environmental behaviour. It could be lots of things. It could be not polluting, it could be using less resources. That's what I mean by generic.
- And the eco endorsement basically means all of these are brand marks which represent that certain environmental condition or standard. If you meet the eco standard you can have this mark on your product.
- But in this other category, some of these don't have that additional authority, so for example, 105, eco logo, that's very very generic. Eco schools, is a bit more specific because it says school but it is still quite generic.
- There are interesting things in there. Like the idea of an award, 185, is a different way of giving authority, because by saying award, it has got more authority than just saying eco logo.
- This one is still generic, it can be applied to lots of things. This one, 330, got a bit more authority because it is easily recognisable.
- There is a big stack of generic eco endorsement.
- Something eco, but not clear what.
- ‘Eco?', if using one word to describe.
- 286. Natural Promise, it doesn't tell what it is.

Name: Efficiency

- This group shows how efficient a product is, fuel consumption, water rating and energy efficiency. All the details of why this product is efficient.

Name: Energy efficiency

- Energy consumption. It is about reducing energy use.
- 150. EU energy label. It is informative, clear and it has got the flag. And it is simple enough.

Name: Energy

- Only 'energy' and 'environment' have got subgroups, and the others only got main groups, right?
- Energy consumption, they are like energy awareness company. They tell the public about the amount of energy they are using or they are saving or their products are using energy.
- Energy. Because the text mentions it is energy. And there is a picture of power cord.
- 203. Because there is a picture of a green power cord, and there is the word 'I.T.'

Name: Entertainment

- Entertainment. One of the reasons is the picture... it shows the star... just like celebrity. And I think this picture design is very young and vivid.
- 240. The reason is the picture is very colourful and we can see the picture of star and the word of star on the label.

Name: Environment

- I think with all the big categories that we have chosen, we can separate them by 'conservation' and 'protection' and 'responsible use'... I guess in a way we didn't want to complicate too much. So environment wise, in term of environmental category, we have chosen where they are trying to either protect or either use responsibly. So all these ones are land, water, air categories. And general ones are the sort of protecting the earth or conserving the greenness of the earth. That is how we separate them.
- It is 151. The European...
- Environment Care. These companies... or labels... or brands... I don't know how to describe it... Logos that tell you a product... something similar to the word green, it just represents that it is environment concerned. It is different from the group 'green' because the word is different, this one is environment. I did not mix them because the word 'green' is different from the word 'environment'.
- 131. It got the word 'environment' on it.
- Environment. Because I saw this pictures are all about CO2 or the earth and tree, flowers... So I think this is called 'environment'.
- 329, environment. I chose this one because we can see the picture is just like an environment, it has the sun, trees, grass. So I think it is an environment.

Name: Ethics

- Sustainable labour.
- 157. Fair trade. It is an obvious one about labour and everyone knows it is labour.
- Sustainable labour means respect, not just the environment, but the people working in related field.

- Basically the ethical consideration of how they do business with people, maybe with the farmer or the part of organisation they are involved with.
- Name of the group is 'ethic'. 185. It is chosen because it clearly says 'ethics', it is like a promise to the customers. These labels promise that these are natural products.

Name: Fair trade

- Fair trade. 267. I choose this because everyone knows that.
- By fair trade ... I mean... fair trade... all these labels are related to fair trade, all labels mention the words 'fair trade'.
- Trade. For the same reason, the word 'trade' is mentioned on the label. All is regarding trade activity.
- I choose 159 because I think trade activity is 'whole world', and this label has a picture of the earth. For me, trading an activity that involves the whole world.
- Fair trade. I thought this is rather interesting because fair trade is slightly different to all of the others. Fair trade is more than just eco credential. The ethical part of fair trade is bigger than eco aspect.
- 157, fair trade, is probably one of the most well-known. It also got the ethical dimension that none of the others have.

Name: Fashion

- Fashion. Because we can see the words like 'textile', 'clothes', 'cotton' and 'weave'.
- I chose 179 because it shows the picture of 'clothes' on the label.
- This one says 'see what you are buying into.com'. You can buy anything, you can buy fashion anything.

Name: Financial services

- Eco or sustainable finance. If you invest money, and you want to invest in a green fund.
- This is a broker rather than fund. But the whole category is about eco and sustainable finance.
- 98. Eco broker certified. It is not very nice visually but it is the most descriptive for that group.

Name: Food

- Even for 'food', we have adopted the same principle, trying to understand if the source of food is sustainable or not.
- So we keep this logo as the most representative. The dolphin safe. 90. Because it is 100% clear what they want to claim. Both pictorial and word way.
- Food. The food includes different kinds of food, like salmon, green food, green table or seafood, vegetables... something like that. And there are words shown on the label.

- 215 is chosen because it shows the words 'green restaurant' and we can see the picture of a plate and a fork. And there are Michelin stars...
- Eco Food Agricultural Business with an emphasis on organic.
- This is also business to consumer, B-to-C. This one, 366, has got a number of features, it has got the place branding, the consumer appeal and the endorsement 'certified'.
- Eco Farming Agricultural Business and Food Products
- 391. Vitality Leaf Green Choice, has a consumer appeal.

Name: Forest products Paper

- Sustainable Paper. 316, because it says (the word) 'paper by nature'.
- Sustainable paper has various aspects, e.g. chlorine free, it talks about more specific aspects of eco paper or sustainable paper. This one is about recycled content... that one says green print, they are all about paper.
- Forestry steward. It is a bit like marine stewardship.
- It is interesting that there is national branding going in there as well. It is interesting, I think like forest, I think it belongs to the country.
- 328. Rainforest alliance certified. Because it has got rainforest to identify it to a particular place rather than very generic, which gives it brand power if it is related to a place. [the word] 'Certified' gives it some authority.

Name: Global warming

- Carbon footprint. 38. This family is about carbon and energy. It is chosen because I think everyone is familiar with this symbol.
- Energy... because of global warming... carbon is a big issue on the environment. Energy is kind of a producer of carbon footprint, so I place these terms together. Production of energy is highly related to carbon emission.
- Climate. Because there is the word 'climate' on the labels.
- 65. There is the word 'climate' and the picture shows something like the earth. I think earth is closely associated with climate.

Name: Green

- There is a piece of leaf and I have seen the term 'green label' on the products.
- I call them 'green label' because we usually see there is a leaf on these labels, and usually it's written 'green label' on it.
- Green. I just correlate them to the word 'Green'. Just the word 'green'. I don't think they are eco labels either... some of them may, there is a chance that some of them may be. It's just like green is also representative of environmental friendly, or at least in products and services. It can be the word, it can be the colour.

- 207. Green.com. Because of its word and the colour.
- Go Green Products. Because we know the environment ... we have the know eco issues. Nowadays we all focus on eco issues, so I think some businesses to extend to eco products or go green products... all of these labels are about green products.
- 61. Because I think why we need 'go green' food or something like this? It's because of eco issues. Food is an important type of products. I think 'organic food' is a very representative example of 'go green products'.

Name: IT

- Eco IT is another category which I thought could be much bigger. Because I am thinking there are lots of aspects to ... electronics and computers and stuffs that have environmental impact.
- 190, because of all of these words, 'green', 'certified' and 'verified'. But I am not sure what that means, I guess it is about I.T. because there is the word 'site'. Maybe a green website.

Name: Logistics

- Shipment. It is easy, because I know UPS is something like DHL, FeDex... shipment office, or courier. Logistics.
- Shipment. 381. Because I saw the logo of UPS is a shipment office.

Name: Logo

- Next family ... this one... the logos... they just simply look like logos. Maybe some of them do not even have any information, like this one... this is just a logo and you do not really get any more information from that.
- Logo. 209. They are graphical representation of a company.

Name: National Standard

- 361 is chosen because I have seen it. It has the word 'New Zealand' so I relate this to 'association' because it mentions a country name, although I do not know what it means really. Maybe I should change the family name to 'association/ country'.
- Councils. 382. These ones represent the ones who care about the environment. There is the body who empowers it to do. They are the organisations that make the labels, that are in charge of the labels.
- Well I brought this over because this is related to that. It also... I think I would want to divide this pile into another pile probably. This one is similar because I have also put generic eco marks... but these generic eco marks also... I said with national co-branding.
- Korea Eco Label. 243.
- That was eco endorsement with national co-branding.

- I kept this one separately because, as we were discussing earlier, one of the factors is authority, what authority does the mark have. And all of these ones are using the country of origin, American, Australia, Korea, Singapore... they are using the country of origin as additional authority. And that seems important.

Name: Ocean friendly

- Ocean. Because all picture of these are related to fish, sea life, sea animals and ocean issues.
- Sea label. They are just labels to make sure that marine life is exploited in a self-sustainable way.
- 90. Because I know it is dolphin safe, very common.
- Sea. Ocean. I think the reason is the same, it is because of the picture, we can see the blue ocean, and... there is a fish, also we can see the words about the sea or ocean on the label.
- 90. Sea. Because it has the picture of ocean.
- Marine Stewardship. Agriculture stewardship council.
- 310. Clean Marine. It looks at specific marine environment.
- Marine Stewardship means looking after the marine environment, like a steward of ocean.
- Water based food with eco credential. [words written on label:]Seafood safe, lab tested for mercury and PCBs... these are sort of endorsement certification area.

Name: Odd

- Odd... a lot of odds.
- Odd. I cannot recognise them. Some of the labels are blur, I cannot see the word on it. Like this one I did not know the language on it so I ignored it.
- Odd. That is nothing, that is just a barcode. I think it is odd, it is a barcode.
- Odd. Some pictures are strange. G... yellow.. Odd, to me, means strange. I cannot even make guesses.

Name: Organic

- (no.5) Often the label mentions 'organic' and on most of the labels there is picture of food, like carrots.
- For 'food organic', often the label mentions the term organic. Most of these have picture related to food.

Name: Planet

- Global label. 108. All labels got the picture of the earth on it. I chose 108 because I have seen it in Japan.

Name: Plants

- Plants. 328. When we have chocolate, we will see this label on it. Because of cocoa, which is from rainforest. So I chose it. I have seen this on Magnum ice-cream too.
- [Plant] Because forest is kind of... plantation. In this sector it is related to organic cotton, and coffee beans... flowers... these are all plants.

Name: Private companies

- Company. 80. I do not really know what companies are these. Most of the labels show company names, I guess they are company names. So I think in their countries maybe they are effective to use their names on eco labels.
- No no no... influence.
- I mean to be influential in their countries about environmental issues.
- You say you don't know about these companies but you guess these are all names of companies that claim to be influential about environmental issues. Do you mean that these are the names of companies that claim to be green?
- Not really... oh... claim to be green? YES!

Name: Producers associations

- 'Green industry'... I mean it a sector because there are different industries but they claim to be green.
- The 'association' mostly shows country names on the labels, if it is on the package they will show they are member of some associations.
- Association is defined because they are countries of members of some associations.

Name: Product info

- 'Green Products' means that are produced or manufactured in a sustainable way. Products or services.
- 381. UPS. In this case, it is because there is a clear explanation, and there is record of a website where the user can understand the criteria adopted.
- It is a well-known company, so we know what they do... if we trust them.
- Green product. 76. It is called 'green product' because they show that using green materials, e.g. green paper, recycled paper, to make the products.

Name: Rating

- Ranking. 306. Like 306, it has 5 stars to show its rating.
- Eco or green ratings. I don't know how to call those things, but you see that a lot. It has got a lot of recognisable, authority and they are quite univerally used. Could be called traffic light ratings.
- 375. It is the most recognisable.

Name: Raw material

- Material. We picked this one 323.
- For us 'material' is ... verifying the source, origin of materials, if it is sustainable or not.
- We picked 323 because it is a well-known logo. There is a clear indication of protection of biodiversity... There is conservation of the sources of material.

Name: Recycling

- Recycling. The logo is recyclable product, whether we can recycle them or not.
- We chose 311 for similar reasons. It is clear and detail, so it is easy to understand.
- The answer is recycling? hahaha.
- The next group is 'end of life'. [330]. It's like what the user can do with the product after they finished using it. Like combustible, biodegradable, just recyclable...
- Recycling. 330. This example is the most commonly seen, I saw it on bottles that could be recycled.
- Most of them (recycling) mention that they are recycled products, because I see the arrows.

Name: Renewable energy

- Only 'energy' and 'environment' have got subgroups, and the others only got main groups, right?
- Renewable energy. The green energy.
- It is more about the source, I think, other than the usage.
- 196. The reason is ... we couldn't find anything better.
- 196. The message is pretty clear.
- Green Energy. 196. It's indicative of that. Since, green is in the title, 'renewable energy' in words, it has got 'certified'. It has got a graphical combination of plant, a sun or lightbulb. Again that is aiming to appeal.
- Green Energy ... this one is renewable, it has the idea that energy from renewable sources that is good. Some of these don't specify it is green energy, it is assuming that you make the connection.
- Some of these has got slightly different meaning but I put them in green energy, like 'energy star' is quite well know. But in this case it is not so much about renewable sources but conserving energy.

Name: Resource consumption

- 'Resources Indicators For Consumption'. It tells you how much resources you are consuming during a certain period of time.
- 59. The example is the energy label.

Name: Soil

- Soil. Because of the words 'soil' and 'compost'.
- 350. The words 'soil association' are clearly shown on the label.

Name: Textiles

- Textile. They are representative of the fair exploitation of resources for textile.
- 74. It tells where the textile is coming from.
- Eco Textile. 347. Sustainable furnishing.
- Eco Textile is all about textile, there is a general understanding that cotton production can be environmentally unfriendly, especially in the processing, people talk about jeans requiring huge quantity of water in their production. So people know about environmental issues know that textile can be bad about the environment.
- 347. It is a generic one, Sustainable Textile.
- Eco Flooring. Same sort of idea. People know that flooring, particularly carpets are not good for the environment. Therefore companies want to respond to that.
- Indicative one is 76, it has picture of a house and carpet. And it writes 'green plus'.

Name: Tourism

- Hotel and travel. For the same reason: I see the word 'hotel' on the label. And the picture shows some houses.
- I chose 219. Because it is straight a way, it writes 'hotel'.
- First I wrote down 'travel', I remember... later I wrote hotel.
- Eco tourism. People are aware of the environmental damage caused by tourism. That might be about wanting to preserve the nature at a particular place, or it could be more general... green star hotel... that got a bit of nature in it but you also got the thing in hotel. It says don't put your towel to wash every day.
- I think the one that is particular indicative is 285 because I like the spelling of 'EKOTURISM''. Graphically I quite like that, they have not used 'green' but with the word 'ekoturism' it is making point about natural. People are making this connection between natural and eco as a positive thing. So eco tourism is a positive thing.
- That's eco credential as a positive thing, which is different from eco credential as an endorsement.

Name: Transportation

- Green Transport/ logistics. It must be a big environmental impact sector, like airplanes. They are underrepresented here. They are all related to transport and they all say something about eco credential.

- 380. UPS. It is a global delivery company and it says 'carbon natural shipment'.

Name: Use phase

- Sustainable behaviour.
- It is not active action... but it suggests people to increase their awareness of sustainable concepts.
- 355. Because it is more general than the others. The others are more industry specific.

Name: Water

- I think with all the big categories that we have chosen, we can separate them by 'conservation' and 'protection' and 'responsible use'... I guess in a way we didn't want to complicate too much. So environment wise, in term of environmental category, we have chosen where they are trying to either protect or either use responsibly. So all these ones are land, water, air categories. And general ones are the sort of protecting the earth or conserving the greenness of the earth. That is how we separate them.
- Water is for water consumption and conservating the water, the sea mainly, that is sort of obvious environment.
- Water. The labels show the word 'water' and we can see the picture of 'water'.
- 393, because it clearly shows the text and picture of water.
- Water and the environment, but may not be eco. These look like water related, and I suppose subconsciously we make some connection between water and environmental credential. E.g. we know that saving water is good for environment.
- They are organisations that try to use brand mark to identify some conformity to environmental standard of water use.
- 395. Water wise, award winning water saver, it is the most specific about saving water. It used the word 'wise', and is an award, it has got all those messages of being good.

Appendix 12 DS2 – Word frequency query results

The following diagrams show the word frequency diagrams for responses related to category definitions and indicative examples respectively. The table on next page shows the summary of word frequency of all participants' responses from 6 sorts.

Fifty most frequently used words when explaining category definitions

Fifty most frequently used words when explaining the indicative examples

Summary of word frequency of all participants' responses from 6 sorts:

Word	Count	Weighted Percentage (%)	Similar Words
picture	91	2.39	image, pictorial, picture, pictures, project, see, 'see, show, shows, visually
think	78	2.04	considered, 'considered, guess, guesses, mean, meaning, meanings, means, reason, reasons, remember, suppose, supposed, think, thinking, thought
word	77	2.82	discussing, language, logo, logo', logos, word, wording, words
make	74	1.24	brand, branding, brands, build, building, caused, clear, clearly, establish, fashion, forming, get, give, gives, giving, holding, make, making, name, names, produced, producer, working
labels	68	2.27	label, label', labels, mark, marks
eco	65	2.38	eco, 'eco, 'eco'
green	60	2.15	common, commonly, green, 'green, green', 'green', greenness
like	60	2.00	care, like, likely, probably, similar
see	53	0.91	considered, 'considered, find, look, looking, looks, meet, regarding, see, 'see, understand, understanding, view
one	52	1.90	one, ones
just	51	1.31	fair, 'fair, 'fair', good, just, rightfully, simply
shows	47	0.78	appear, design, 'design, design', designed, designers, establish, indication, indicative, indicators, point, record, show, shows, view
place	46	1.01	aiming, home, 'home', identify, invest, investment, 'investment', office, place, point, positive, put, range, range', ranking, rating, ratings, set, 'site'
authority	43	0.84	authority, clear, clearly, empowers, government, office, source, sources, sure
product	41	1.50	product, product', production, products, products'
related	40	1.04	associated, association, 'association, association', 'association', associations, concerned, connection, deal', relate, related, relation, tell, tells
using	39	1.32	applied, consumption, consumption', exploitation, exploited, usage, use, use', used, using
fair	36	0.55	clean, cleaning, 'cleaning', coming, fair, 'fair, 'fair', pretty, reason, reasons
know	35	1.16	know, knows, living, recognisable, recognise, wise, 'wise'
mean	32	0.57	based, closely, important, mean, meaning, meanings, means, way
endorsement	30	1.10	certified, 'certified', certify, 'certify', endorsement, endorsements
got	30	1.10	got
energy	30	1.08	energy, 'energy, energy', vitality
house	30	0.78	family, firm, home, 'home', house, 'house, houses, housing, sign
environment	28	1.03	environment, 'environment'
example	28	0.86	case, example, represent, representative, represents

Word	Count	Weighted Percentage (%)	Similar Words
sustainable	27	0.74	get, holding, keep, keeping', sustainability, sustainable, 'sustainable
brand	27	0.46	brand, branding, brands, mark, marks, steel
water	25	0.92	water, 'water'
saving	25	0.50	delivery, economic, 'economic', keep, keeping', preserve, 'preserving, protect, protecting, protection, 'protection', save, saving, write, writes
trade	23	0.79	deal', sell, trade, 'trade, trade', 'trade', trading
called	21	0.51	call, called, career, claim, name, names, promise
group	20	0.61	group, sort
environmental	19	0.70	environmental, 'environmental, environmentally
business	19	0.64	business, 'business', businesses, concerned, line
organic	19	0.56	establish, forming, government, organic, 'organic, organic', 'organic', organisation, organisations
country	19	0.53	area, countries, country, country', land, national
well	19	0.48	consideration, easily, good, well
certification	18	0.63	certificate, certification, certifications, credential, credentials, security
textile	18	0.49	'clothes', material, 'material', materials, textile, 'textile'
much	17	0.48	lot, lots, much, often
food	16	0.59	food, 'food, food', 'food'
ocean	16	0.59	ocean, 'ocean, sea
carbon	14	0.51	carbon, 'carbon, carbon'
company	14	0.51	companies, company
generic	14	0.51	generic, 'generic'
people	14	0.51	people
recycling	14	0.51	recyclable, recycle, recycled, recycling
also	13	0.48	also
things	13	0.48	thing, things

Appendix 13 DS3 – Transcripts and coded used in Focus Group Study 2

A list of nodes was used to code the transcripts in NVivo, namely:

1. Conceptual framework function in discussion clarification
2. Ethical issues with information individualisation
3. Features of information individualisation system
4. Possibility of information individualised system
5. Role of UCD
6. Tailored experience
7. Technology used for information individualisation system
8. Usefulness of proposed conceptual framework
9. Issues for labeling

Below are the transcripts of the two focus group discussions held for DS3.

1. Transcript of first focus group in DS3

Content	Speaker
[focus group background introduction]	Researcher
My question is... the first question I want you guys to discuss is, 'Do you think the conceptual framework is useful in inspiring design of eco information system or information system?'	Researcher
What is benefit of these scenarios?	PA1
The benefit for these scenarios is that, without the information system we just described, what you can see on a bottle of milk is that they would look the same just like they would have the same carbon label, they would have the same carbon footprint, you can't tell the difference. You cannot make more informed choice. And the benefit of this one is also the benefit of this one, it's that... I think when we buy a new product, many people would not read the carbon label or eco label on it. But if it is personalised, perhaps it can increase people's interests and attention to it. It is also easier to understand.	Researcher
For example people might not care about the environment, but when you show photo of the daughter and say how the impact of environment is related to your daughter, someone that you care about, then maybe it will provoke a high emotional linkage and motivate people in a higher degree.	Researcher
It [the framework] is easy to understand.	PA2
I think on this diagram (the framework), it would be good to have annotations explaining the technology options, so it would be easier to understand. Because now I have to spend time wondering what technologies are these.	PA1
Actually the technologies are already listed here [show the captions on the other half page of the diagram].	Researcher
I see.	PA1

The framework is useful.	PA1
For example, user might have specific requirement for some important products, such as medicine. Or milk, in China there are a lot of fake milk. This kind of information system is especially useful for specific products and specific users.	PA1
How would this be especially useful?	Researcher
For example normal users might not be especially concerned whether the milk product is fake. But for mothers, it is very important. If the system can tailor information according to the person's identity, it would be good.	PA1
So if the system can distinguish whether the user is concerned about the authenticity of a product, the system can then display information to...	Researcher
... to satisfy individual's needs.	PA1
Because it can automatically detect user's profile, it can respond to individual's preference and distribute information. There are too much information available, this kind of tailoring system is more efficient.	PA1
It is a good example of potential application of information system.	Researcher
What do you think about the value of this framework for designers?	Researcher
What does that mean? For designers?	PA2
Will this framework help designers to design eco individualised information system?	Researcher
I still do not understand.	PA2
Do you understand? [looking at other participants]	Researcher
Yes I understand.	PA1
If you are a designer, when you look at this framework, will this be useful for you?	PA1
Yes. It would be useful.	PA2
This look similar to my previous project from the course Professional Design Studio.	PA3
Just that my previous project was designed for office workers. They will be given an Office ID card that can enable file exchange. It can calculate time difference for difference time zone, and recommend appropriate international video conference time.	PA3
Another function is file exchange. For example, if you work with a Japanese team and need to exchange file, the Office ID can help to transmit file and automatically translate the document into Chinese. This can save time in file transmission and translation.	PA3
Why do you think this project is similar to the information individualisation that we can talking about?	Researcher
Because both of them rely on the interaction between two products.	PA3

When you said 'product', are you referring to the Office ID card?	Researcher
You mean the Office ID card will help you to translate? Where is the display then?	Researcher
The Office ID card will have a small display interface.	Researcher
How does the Office ID card know who you like to meet in your meeting?	Researcher
You can set it by yourself. For example you usually have meetings in several places in different countries, you can set these places in default.	PA3
What about the personalisation?	Researcher
I think these two [Office ID card project and information individualisation] are quite different.	PA1
Because one works in a shopping environment, and a personal device would scan different products. But the Office ID card itself is a product that helps people in communication. But the information individualisation helps consumers to make informed purchasing decisions. So they are different.	PA1
Maybe what PA3 talked is like... [drawing on the diagram of Internet of Things/ People]... This is your customer, this is the product, this is you... so in your idea there are two users and one product, and forms a network as such... [sketching on the diagram].	Researcher
Right.	PA3
What do you think about Human Centred Design (HCD) in relation to this framework?	Researcher
How do you think Human Centred Design (HCD) methods can help in informing and evaluation this system or this framework? What is the role of UCD? If you want to know what I mean by HCD, you can have a look of this sheet. Here are a list of UCD methods and steps. Some examples are card sorting, participatory evaluation, interview, paper prototype.	Researcher
Methods such as paper prototype let you test your idea without complicated and lengthy prototyping process.	PA1
So you think paper prototype is useful in evaluating individualised information system?	Researcher
What is designer's role in designing this kind of system? Maybe compared to engineers?	Researcher
We designers can make the system more human centred.	PA2
Designers understand user needs better, for example designers would understand different stages of a consumer's shopping behaviour. Designers can understand the key stages and design accordingly.	PA2
Designers understand the process of consumer behaviour...?	Researcher
Designers have their own methods to investigate.	PA2
Yes, for example methods to gather qualitative data. Any more ideas?	Researcher

What is software prototyping?	PA1
Software prototyping... is similar to what you can create with Axure.	Researcher
I think software prototyping is useful. Because this can show the majority of the effects of the final product. It can provide a more intuitive experience than paper prototyping.	PA1
It allows interaction function visualisation. This would be help for designers when designing interactive features.	PA1
It is quite good.	PA2
I think designers can guide...	PA2
For example, some male consumers do not like shopping. Information individualisation can provide tailored information and recommendation, then the male consumers can save time and effort.	PA3
So you think the information individualisation system can providing information that appeal the users, then save his time and effort?	Researcher
Yes.	PA3
Your example is, the system can tell the consumer about seasonal trend...	Researcher
Yes, the system can give simplified information, maybe advices on how to mix and match. Say the consumer needs to attend a banquet at night, the system can assist in clothing selection.	PA3
Any more ideas related to UCD methods or this framework? Any questions?	Researcher
Medical functions are important. Health care topic is a popular. I think application in this area is of more importance. For example milk.	PA1
Regarding general grocery products, e.g. vegetables, maybe consumers would not pay much attention to this kind of product. But if this is medicine, consumers may be concerned to a higher degree.	PA1
What about clothing product labelling?	Researcher
I think I would like to have a simplified and convenient shopping experience. Often there is time constraints.	PA2
For example... for food. There are some kinds of food that you cannot eat at the same time with other food. This kind of information would be vital for consumers. And this kind of system can detect whether there is food combination that might cause poisoning.	PA3
It sounds like an Internet of Things, isn't it?	Researcher
Yes. If two products are placed together, and they might cause food poisoning when consumed together, a warning can be shown.	PA3
I think maybe the consumers would not bother to read these labels, because usually I do	PA2

not read them.

I understand. Sometimes I have difficulty in understanding those labels and I skip them.	Researcher
Sometimes I do not even bother to read those large words on the packaging, sometimes I do not even read the price tag. It is tiring.	PA2
For important purchase maybe people are more interested to read.	Researcher
Right, for important purchase, maybe I would read.	PA2
Energy label is easier to read, because it shows a traffic light system which is obvious for different colours are shown.	PA3
What about the incentive of people? Maybe there are incentives that motivate people to read the labels, such as cost or penalty?	Researcher
Perhaps if the designs are better, people are more motivated to read these labels.	PA1
I have got quite a lot of useful comments from you. Thank you very much.	Researcher

2. Transcript of second focus group in DS3

Content	**Speaker**
[focus group background introduction]	Researcher
I think it is like creating a tailored experience isn't it?	PB2
It is, exactly.	Researcher
And what tablet thing is there? Is that just like an iPad thing, or is that like a smartphone or?	PB2
So that is some sort of technology which they can just use and look at all the information?	PB2
It could be anything.	Researcher
Yes, even for Google Glass they have got a tiny computer inside, so it works just like a tablet but the thing is projected into your eyes.	Researcher
Why would you wonder whether this is a tablet?	Researcher
I think it is a question to be answered by designer. I have not decided any detail in the scenario.	Researcher
So if someone comes into a shop with whatever they got, it automatically can read the information from here? Or do you have to just click and scan and read the information?	PB2
So they are going with their device and if they want to know some information they can look at it, basically.	PB2
And it is all tailored to the specific thing they are interested in.	Researcher
Yeah I think so.	Researcher
It kinds of like how cookies work isn't it, on my computers. They track what you like and present to you.	PB2
It is like Amazon purchase assistant. You purchase on Amazon then recommend you	PB7

something that you might buy.	
And it shows on my Facebook and every website I browse.	Researcher
Regarding to this framework, how do you think it can be used, or it can't?	Researcher
I think it needs time for the user to build up certain categories of criteria that users are interested in. For example I recently use a swipe keyboard on my smartphone.	PB7
It is basically a keyboard that learns my typing or writing habit, then it automatically suggests the next word when I type something. So it builds up a sort of profile of what I might say. It is sort of an AI type of thing. You can certainly type in what kind of thing you are interested in or you care about. For example I am interested in animal welfare. You can't really go into the details, it would be too tedious to do that. So there might be a way that this device or technology, I think, learns your purchasing habit and they are sort of trying to understand what you are interested in and you care about. So without users thinking about it, they can suggest you products.	PB7
It is an area in research of context-aware system. Those technical guys are doing different kind of information architecture and search engine to see which way can be tailored to suit the user.	Researcher
I actually found many frameworks for those context-aware information systems, but those are really techy and they are for engineers. So my question is 'do you think what does can be used by designers'. Because I believe those could be quite difficult to be used by designers.	Researcher
Well certainly there are elements which designers can use within this framework.	PB7
Maybe a designer can design a product overlooking all this framework, but at the same time, designers can maybe look at one aspect of this framework. As a framework itself, it makes sense in terms of how I interact with a product and how products interact with each other.	PB7
The only worry that I have is the economic viability of these systems. You are talking about eco system, which has a lot of agents are in play. You talk about RfID chips, you cannot put that in a milk bottle. It is too expensive.	PB7
Actually it is not so expensive. RfID chip can be very cheap.	Researcher
Considering how much milk bottle is produced.	PB7
It can still be possible if it is for the same batch of milk. Say there is a basket and for the same batch of milk then all of them will carry the same history.	Researcher
I think it is possible economically and their prices are dropping and dropping.	PB5
There are possibilities for designers.	PB7
The framework is good. Maybe designer need to remind the users or the customers about the eco information.	PB5
Do you have any suggestions for improving the framework? What do you think about the framework in general?	Researcher
Maybe when we find something online, we find a product. Then we open a new tab to check another website. But the product appears on screen. It will remind us all the time all the time.	PB5
So I think it is useful.	PB5
So you think personalisation of information is useful?	Researcher
Yeah.	PB5
So you think tailor information can be useful in persuading customers?	Researcher
It is useful. If like for example, when you buy a milk you got your tailored experience. You use it constantly. You are going to use it again, on the same sort of thing that you already	PB2

got the information.

And gradually you want to have that continuous embedment. I do not know how it'd actually work. Like if you want into a shop or something which you will find your stuff beeping or something to let you know like products are...	PB2
Actually my focus is on the framework...	Researcher
Yes I know. This is like an aspect of user experience of the framework kind of thing.	PB2
Right, you mean how a personalised system can be designed. How would you relate that to the framework?	Researcher
The framework itself it works as a framework. It would work, by just looking at the diagram.	PB2
But it is worth the difficulty of incorporating that into something using the different types of agents and the sort of approach you want to use.	PB2
I have a question here. You said the product can exchange information here. But how products exchange information?	PB3
An example here is the fridge got a RfID writer, then it can communicate between themselves.	Researcher
Oh so it is not two products communicate to each other.	PB3
If necessary it can still communicate.	Researcher
This morning another guy suggested when you buy food ingredients for some dishes, sometimes you can't eat two different foods at the same time because it will product toxin. And then he said this kind of system, although that may not directly relate to eco information system, can help to let the person to know if that kind of danger appears.	Researcher
Because if you put both products into the shopping basket, and your device senses that you are buying both of them, then it can warn you. So it may be able to communicate with each other through the device, because the device knows that you are getting both of them.	Researcher
Yeah I think I would want to compare those two shop brands. If I only get the information from only each brand, I would want the device to compare them and analyse the data. I would want the device to do the job. So I can choose wisely.	PB4
The next question is... because nowadays most of the context-aware information system are researched and created by engineers and computer scientists. Designer's involvement... because this field is actually very broad and has got a long history, but designer's involvement is not that much. However actually when designing this kind of system a range of human factors are needed to be considered. So I want to ask how do you think User Centred Design methods can help to inform and develop and evaluate such kind of system. This question implies 'what do you think the role of designer is'. This is two pages of one paper that shows key activities in human centred design. Here is a good table summarising human centred design methods.	Researcher
How do you think human centred design methods can help to inform designing this kind of system. For example this table says for planning maybe usability planning and scoping... this kind of method would be useful. For learning requirements, maybe 'stakeholder analysis' or 'persona'. For the design, maybe 'card sorting' or 'paper prototyping'. So this is just a reminder of what UCD methods can be.	Researcher
What is the fundamental aim of research and how does the device work?	PB4
Do you mean this focus group or...?	Researcher
No, [I am talking about] the device.	PB4
Do you want to include people to buy more eco friendly products or...?	PB4

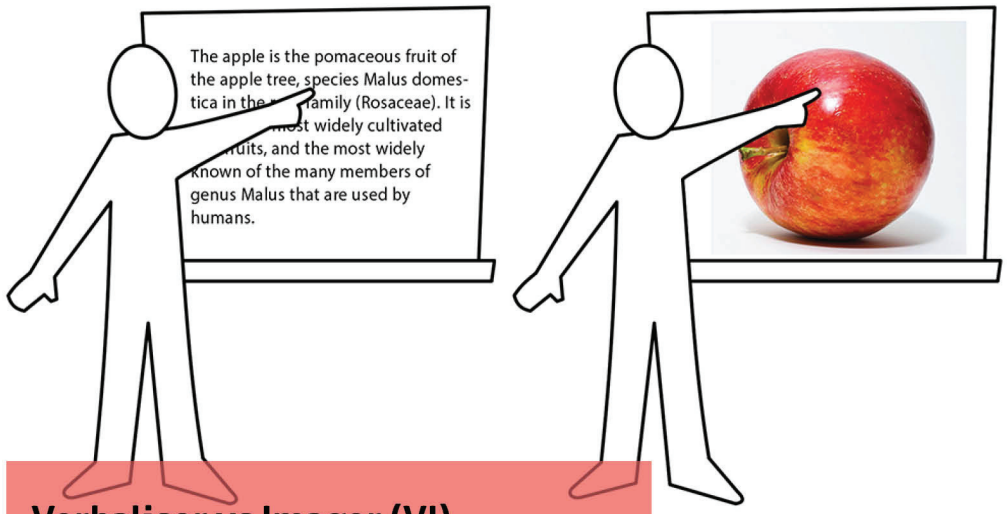
My research hypothesis is 'people's sustainable behaviour would be encouraged or persuaded when appropriate information is given in appropriate situation'. Before my interest was on augmented reality. But later I think augmented reality is just a way to display. The essence of augmented reality is how the contextual technology and the context can follow you around, and how can the emerging technologies can help to tailor information to suit your personal goal.	Researcher
It is not that I want to push people or educate people to be more sustainable. For example, it is not in an eco labelling context, if the person wants to quit smoking, maybe it is very difficult. But if you have such a system to illustrate the progress of losing weight, and in different scenarios, maybe it keeps track of the food consumption or the exercise amount. Maybe it helps to achieve personal goal. Going back to this framework, I just see what is the designer's _____ towards a thing like this.	Researcher
And for contextual technology, a new term, I think it embraces a lot of things that we've kind of heard of but not that familiar with. Like big data, lifelogging, internet-of-things and as such... Here I tried to break down the contectual technology into four stages. I think it is composed of how you capture data, how you store the data. These are not design methods. Do you think we can map it and enrich the framework by considering this. What do you think? What is the role of designer in designing this kind of individualised information system?	Researcher
The stakeholder analysis is used [in marketing and business discipline] to identify groups of end user, and see the type of person who is going to use it, and what sorts of scenarios, like stakeholders analysis. But stakeholder analysis is only going to give you one specific type rather than a broad spectrum. It gives you one type of user, but then you can branch it into different categories of users. But I think it will be useful to understand the needs of an individual user. Who is going to use it in what sort of environment, and who is really interested in using something like this? Because I do not think everyone will be wanting to use something like this. This understanding will better benefit the design of the individualised information system.	PB2
Do you think designer's strength is in understanding user needs, especially in this kind of system which targets more at individual, compared to the tradition system which may target at general people.	Researcher
Yes I think it is important to look at the individual, specific groups of people because I know there will be some people who already want to use this type of thing, and there are people who aren't that interested in using something like that.	PB2
So looking at the general sort of target which has been done. And look at specific needs of people whether they would like something like that.	PB2
Yes I agree.	PB6
Yes I think so. Human centred design is more about human needs.	Researcher
I agree with you.	PB7
I would like to add... in terms of how designers might use the system in their everyday design of things.	PB7
The strength of designer is about emphasising with customers.	PB7
Specifically to target audience that he or she is designing to.	PB7
Then if this system keeps feeding in information of specific.... and sort of understand how much or how many users are willing to buy this type of product if this has these certain eco elements. This is like an automatic feedback system that designers can interpret. If it is done properly then it could be a quite powerful tool for designers, or even engineers for that matter, who actually do new product development. Whether it	PB7

will also be in a marketing department, they can have a better understanding of the consumers. But having said that, if that's the case, if this system can understand what people's purchasing habit is, automatically without designer's using these UCD methods, then do we need designers to go out and do the field research, and consumer research in terms of what they want?	
I think there is a both side of the argument.	PB7
Yeah because I think UCD methods such as field study and user observation are important for deciding the function of the system, timing to intervene and the information to be displayed. For example if I walk into the shop and all the information pops up in the Google Glass then I would want to turn it off. Whereas when you look at, maybe when somebody picks up two of the same products, then the comparison details come up and one of the sustainable stamps could come up and influence the buyer's decision and that could be important. If I am walking through the shop then maybe I do not want to see any of the labels, if I do not even know what I am going to get first.	PB1
Yeah I think that partly answer your question as well. Because those observations and judgements cannot be replaced simply by the vast amount of data that you collect.	Researcher
Yeah I mean interpretation of the data is quite important.	PB7
Yes the interpretation is very important as you said. And I think your point about designer's strength is to sympathising with people, that's a very good point.	Researcher
My opinion is more or less the same as PB2's. I think consumers want to get the right information at the right timing. I think it is a good idea to provide good information at the point of purchase.	PB4
From the point of view of information architecture, data is already there. But designers are needed to organise and give meanings to them.	PB4
Would this system encourage people to be sustainable in terms of their purchasing? Would this system help them to choose better product for them? I certainly think so.	PB7
If it is easy for me to see the difference between two products, like when they pick up they can see the difference of those two products in terms of how eco friendly they are. Yes it is complex in the sense that it may have a good point in terms of eco friendliness in animal welfare, and this product might have good things about reducing carbon footprint. If I pick this up, if I am more interested in animal welfare, then I might choose this instead of this, even though these two products have some sort of good thing about being eco friendly. I am certain that personalised information feeding back to me will definitely make it easier for the consumers to have better behaviour.	PB7
It depends on how stubborn the customer is. The character of the customer is... your eco tool/ device/ app is important for designers to consider the characters of the customer.	PB5
It is a bit off track but if I am allowed to explain the intention of me designing the tool... which is not specify as the framework.... that is not that much about encouraging people to behave more sustainably. Because there will be ethical issues about a person's free will, etc. I think the beauty of this kind of system is you can help those who are already motivated to achieve their goal. If someone really does not care, they are not pushed to do anything about it.	Researcher
Your model is just to help those people who are already motivated?	PB3
Maybe if I am going to design my PhD project's device out of it, I think the eco labelling device will only target at those who are already motivated to make a change. And to see whether this kind of individualised information system can enable them to change more easily.	Researcher

And for those stubborn people or those who do not care...	Researcher
So you have already found your target user, right?	PB5
Yes and I think that is the essence of it. That's why the personal data is that important. It empowers the person to do what they want to do.	Researcher
Just now you have all agreed that user centred design method will be useful in understanding users, that is extremely important when designing this kind of system. How about evaluation? Do you think designer has a role in evaluating this kind of system design using this framework?	Researcher
Who evaluate it?	PB6
I mean when designing this kind of system, now I assume that most people involved are technical people and designers are less involved. Do you think designer has a role, for example, in helping evaluation of the system?	Researcher
In my point of view, I think the consumers should be the evaluators. Because just as everyone said, if you are looking for a product that always pop up on your browser, sometimes it is quite annoying. I mean yeah you need this kind of product, you searched for it, but you don't really want it show up in every webpage you see as an advertisement. Sometimes information is overloading.	PB3
Yes of course.	PB6
I think the consumer will be better to be the evaluator who finds the balance, so the information would not be too much and too annoying, but it is very suitable there. But not too much to push people to feel uncomfortable.	PB3
So you are talking about how much information should be displayed, and consumer should be the one who control and evaluate?	Researcher
Yes.	PB3
How about for the system, you know consumers are the users for the system, but the system needs to be designed. For example these [scenario 1 & 2] are already very different systems. How do you think designers can help in evaluating the system?	Researcher
You mean designers not only to design something like this.	PB3
Designers may be the ones who decide whether they are using Google Glass or tablet or whether there should be sensors, should there be a QR code here or should motion sensor be put on the t-shirt.	Researcher
It is the engineers who are responsible for the technological part and they would not concentrate so much on the user. Designers can put the user needs together and decide what kind of technology to be used.	PB1
Are you talking about evaluating a system which is already in use, or are you talking about evaluating the concept of the system... when you say about design process, you develop something, you conceptualise a product and then you test it, with the user for example, and see whether they like it or not, if they do, what sort of things do they like. That's before you launch the product, that's the evaluation that I think designers are quite useful. When you are talking about after production, and after sales, evaluation of how successful this system or this product is, designers tend to have less voice in that. It is to do with how much they sell and what sort of financial benefits that this product or service provides to the company. So, are you talking about the system before the launch or after the launch?	PB7
I don't have any opinion on that. You think designers are already good at evaluating before the system is launched?	Researcher
Well yeah I think so.	PB7

It is exactly what he said in terms of understanding users and empathising with the user. You know engineers might be more into technical ability of these systems but designer's strength is to understand the users and how they use it. They might focus more on the intuition of the user.	PB7
Do you think this framework would be useful for designers, when designing this kind of system, to specify different elements. When designers are involved in designing this kind of system, how can they be involved especially from a human centred design perspective. You have already mention some points. Just want to see if you have anything to add.	Researcher
I agree with Yu Han's idea. If you want to influence people's behaviour, you need to know what are their specific interests, especially motivation. You need to know your target group's behaviour features and then to find out their motivation and the behaviour you want them to do. For example, to be nice to animal, to stay away from smoking.	PB6
You need to find out their motivation. That is the designer's work, not the psychologist's. Well... probably the psychologist's, but they do not design actually. They know the behaviour and conceptions, but they do not design.	PB6
That's true. Designer is the one who constructs actually.	Researcher
Well this is a team work. Engineers do the technical works. Psychologists do the analysis of behaviours and psychological models. Marketing people will find out target groups, so we can design the products that people are willing to use.	PB6
What do designers do then?	Researcher
Combine them together.	PB7
Designer can be the mediator between teams.	PB6
I think designers will more focus on visualising data. So designers can design information and not to frustrate them, not to cause too much information overload. They should also think about how well information is communicated, or delivered to consumers. Also to help consumers to get information more intuitively.	PB4
The last question that I want to ask is, how about other applications of the system framework? Although I plan to try it on designing eco labelling, as an example, it could be applied in different areas because it is quite general. Do you have any ideas of how this framework can be adapted in designing other systems? For example, health care, to encourage people to lose weight.	Researcher
It can work in the same situation, if you just tailor it specifically towards various types of people. In the context of losing weight, there is lots of things you can do, like what to do in the gym, what to do when shopping food, what specific protein do you need. You can adapt it to different situations, it is just how useable it would be. You have got to think about people who would lose weight when they carry the phone with them and when they have the device when they are exercising whatever.	PB2
I am interested in how companies can benefit from this system. We live in a capitalist world. They have to have some benefits from this system. That's why I was talking about marketing.	PB7
I think the biggest challenge and also biggest asset of this system is to individualise information feedback and the data exchange. You know that data is so valuable that Google uses that to basically be a multi-billion pound company. If you can use that well, that may be you would be able to sell more to customers.	PB7
At the same time, whether that's ethical or not, that's another issue.	PB7

But in terms of product communication, I think, within the same company system. Samsung is using phone and watch together to sort of do stuff. If that can be expanded into different products and into different companies' or lines' of products, for example Samsung phone can work with Phillips light, those kinds of things can produce a synergy. Whether that is possible or not? That's another issue. Whether they are willing to share.	PB7
Yes, we have left most of the ethical concerns, privacy etc, untouched. We are well aware of that.	Researcher
Anything to add?	Researcher
Let me just clarify this, are you trying to design this framework and trying to apply this framework to different applications. Is the designer's role in your mind a person who design the system or framework, and then apply it whatever he wants to apply... are you talking about system designer or are you talking about product designer?	PB7
Because product designers are probably somewhere here [participant pointed and drew on the diagram], but I do not know he or she can design the whole system.	PB7
So you are asking when I say designer, what kind of designer am I talking about? I again haven't specified, but I think actually it is quite inseparable. Nowadays sensors and all kinds of technology have become so common that more or less you gotta make use of it. Even if you're just a student working on a student project, you might have designed the whole system, although you are just designing an app, or you are just adding a motion sensor on it, or adding an infrared sensor on it. I have not specified whether it is system designer for complex system or it is just a product designer, but I think there are some grey areas and I wonder they will find this kind of framework useful in clarifying their communication.	Researcher
Product designers seem to think about _____ and environment. It is a similar thing, I think. System designer and product designer share similarity. Maybe system designer focuses more on procedures in displaying information. Product designer thinks about product and environment and the relationship between them, and also the customers. So three main parts: customers, environment and the product itself. All designers need to think about these.	PB5
For other application, for example smoking. Maybe also tracking criminal behaviour.	PB6
Actually it is happening already. Police are checking phone records with phone company, then people cannot fake evidence.	Researcher
I just realise that this system is very powerful in reinforcement. When you have to control people you need this system.	PB6
Nowadays we have wearable cameras, in China policemen are already wearing it, and they can take photos or video record when they confront anyone.	Researcher
Just like CCTV in the UK	PB7
Police have body's camera on their suits in the UK.	PB2
I have asked all my questions and I have got enough feedback.	Researcher



Verbaliser vs Imager (VI)

1. Verbaliser vs Imager

Cognitive styles

Research on information display formats shows that not all people learn in the same manner[1]. There is not 'one optimal' format[2]. To delineate the ways in which different people characteristically approach different cognitive tasks, Riding[3] suggests the Cognitive Style Analysis (CSA) test to measure cognitive style on a verbal-imagery (VI) dimension and a wholist-analytic (WA) dimension. These two fundamental dimensions exist independently and are not contingent upon one another, i.e. an imager has an equal chance to be a wholist or an analytic[4].

The verbal-imagery (VI) dimension of Riding's[3] cognitive styles describes ways in which a person tend to process information and knowledge, in words (verbal) or mental pictures (images). Based on the position on the VI dimension, people can be classified as verbalisers, imagers or bimodals[5].

Examples of (L) text based eco label and (Right) image based eco label

Wholist vs Analytic (WA)

Person Card Eco Info Individualisation Toolkit

Preference & Interest

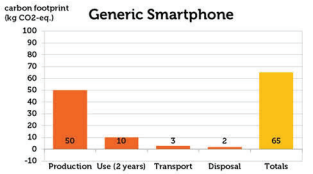
2. Wholist vs Analytic

Cognitive styles

The wholist-analytic (WA) dimension of Riding's[3] cognitive styles describes the habitual way in which people view, process and structure information in wholes or parts[5].

Environmental information involves a large number of factors and can be very complex. For example, a product's environmental impact can be assessed by calculating various footprints incurred from various product's life cycle, or be judged by seeing if it is ethically produced.

Designers can tailor the information format for the user, who may be a wholist, an analytic or an intermediate, to enhance receptiveness.



Above are examples of graphical representation of carbon footprint (CO2-eq). (L)Carbon footprint of a generic smartphone, represented in an analyical way, broken down into five life cycle stages. (R) Carbon footprint value presented in a wholistic symbol .

3. Preference & Interest

What product attributes are valued?

People are primarily motivated by self-interest. A label is more effective if it can emphasise more clearly in what ways the product can satisfy the consumer's preferences and interests, for example increased product quality or health benefits[6,7].

There is a number of ways to elicit user's preference and interests. A direct method is to ask the user to rate their preferences using a questionnaire. Various techniques of 'choice modelling' are being developed by researchers in the hope to reveal or predict consumer preferences for various product attributes based on the discrete choices made by individuals.

In reality, people may make choices intuitively after subconsciously balancing a number of factors, e.g. price, quality, style, eco-ness, without knowing explicitly their preference. With the computing power of portable devices, it will be possible for the device to estimate the user's preference based on their shopping record and help decision making by analysing complex problems involving multiple factors for the user.

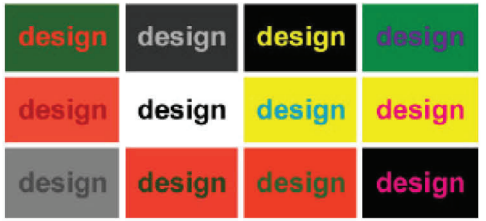
4. Physiological

Physical ability varies among individuals

Physiological context is a subgroup of personal context that can be stored in user's profile. It can contain information like age, gender, eyesight, weight, physical ability, glucose level, etc.

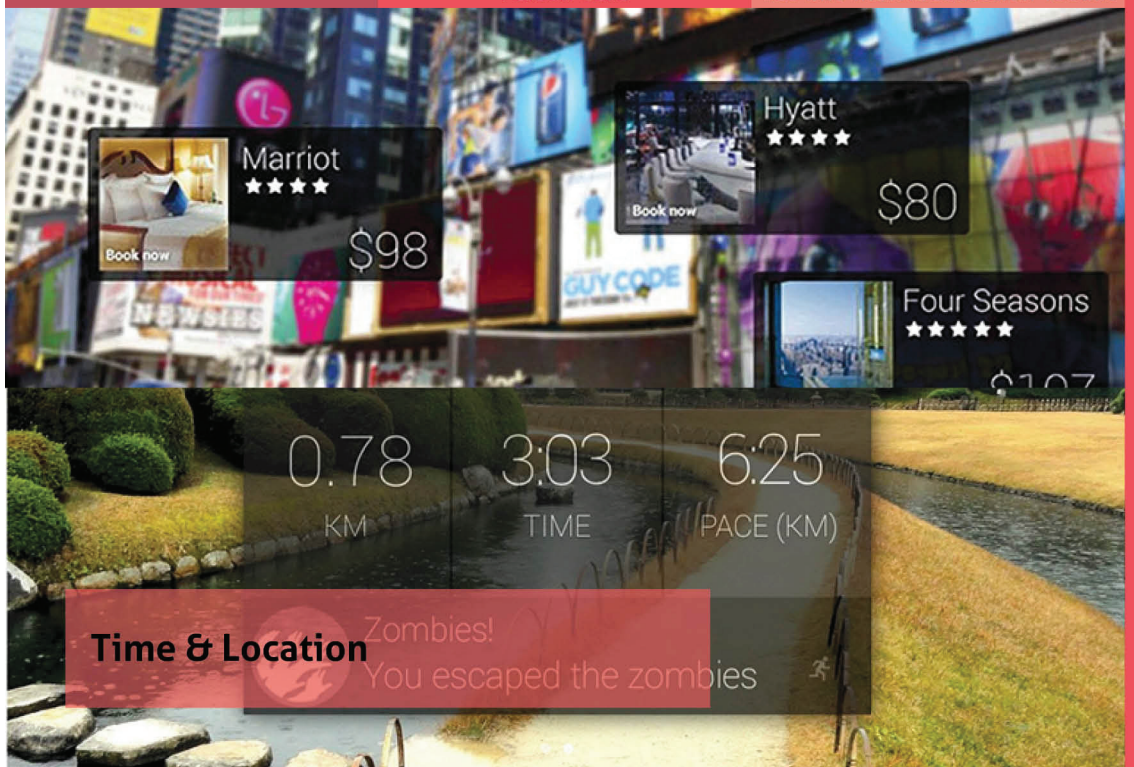
A significant portion of the population has limited vision, common conditions include short and long-sightedness, limited colour vision, reduced contrast sensitivity. For instance, larger fonts are advisable for people with poor eyesight.

Physiological information can also be included for applications in combination with eco information display. For instance, glucose level could be a determinant when a diabetic person is shopping for food. Some products, even with desirable eco attributes, have to be filtered out if they have conflicts with the user's health concern.



To find out which colour combinations are effective, multiple versions of design can be viewed at various distances and with or without squinting[9].

Person Card Eco Info Individualisation Toolkit



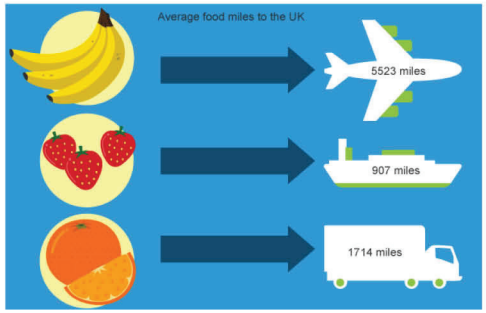
5. Time & Location

Essential for an adaptive system

With today's mobile technology, it is fairly easy to detect the time and location of the user. This contextual information can be used to record and understand many user behaviours, and enable a wide range of tailored functions.

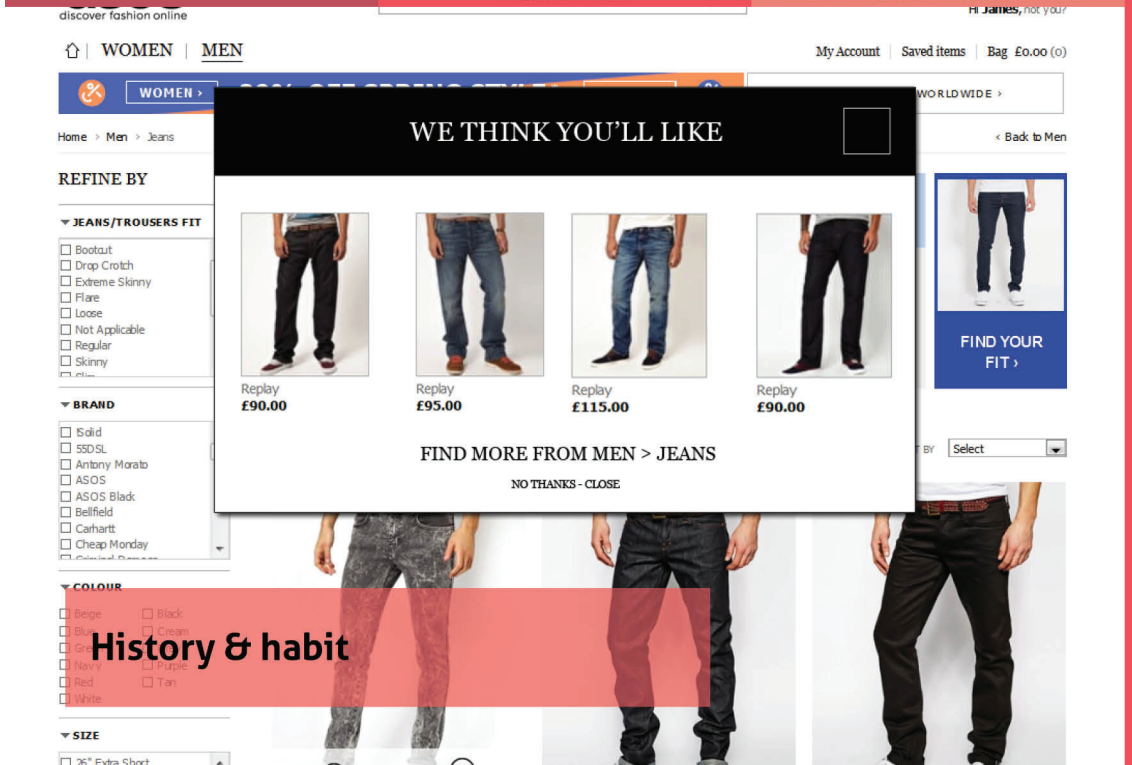
Time and location data can increase the accuracy of environmental impact. For example, knowing the user's location can help calculating transportation distances of products, or retrieving more accurate readings about the energy mix (say renewable or not?).

Information given to user based on their location and time can have a bigger impact on their interest[9]. The user can be reminded of, for example, where the nearest recycling spot is; whether the food product is locally grown; or the opening times of certain shops.



Nowadays the products we consume everyday may come from any part of the world. Transportation distance makes a significant difference to their embedded energy. 'Food miles' is the term that describes how far food has travelled from production to consumer.

Person Card Eco Info Individualisation Toolkit



6. Task Related

Task-specific information motivates behaviour change

Research[11] has shown that environmental friendly behaviour often depends on specific, actionable, task-related information. Drawing a close link between specific actions and their effects helps activate various motives that appeal to different consumers[11,12].

When competing options are available, consumers need specific reliable information to make the most environmentally friendly choice. The requirement of such varies across contexts such as product categories and shopping situations. For instance, the type of information desired when shopping groceries in store would be different from that when choosing an electrical appliance from an online shop.

A study on feedback about energy consumption shows that relevant features that determine the effectiveness of information display include content, information format, medium, frequency, duration, break-down and comparisons. Such feedback is more likely to be successful if it:
- is based on actual consumer usage;
- is given frequently;
- involves interaction;
- involves appliance-specific breakdown;
- is given over a longer period;
- involves historical or normative comparisons;
- is designed in an understandable and appealing way[11].

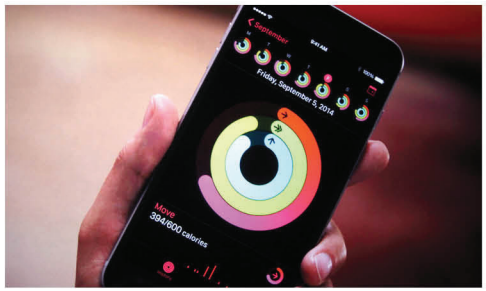
7. History & habit

Self-tracking for behaviour change

Behavioural data, such as shopping records, can provide two types of useful insights for eco information individualisation.

Firstly, shopping record gives an account of actual environmental impact consumed. Research shows that people tend to spend more money than they estimate[13]. Similarly it is believed they have difficulty in estimating the environmental consequences caused by their consumption. Self-tracking their shopping behaviours ubiquitously provides an objective measurement for evaluation.

Secondly, knowing oneself's pattern of behaviours, i.e. habit, helps self-understanding. Say a person can compare his/ her weekly personal footprint to the national average, or can then set a realistic personal goal based on their motivation.



Insights can be gained from Health & Fitness apps that encourage workouts or healthy eating. These apps aim to promote behaviour change and habit formation by tracking, self-monitoring and social support[14].

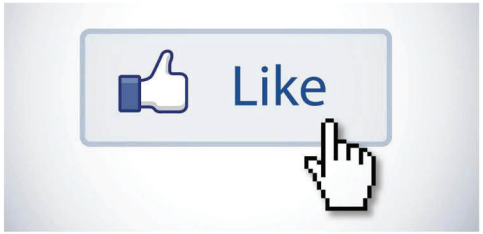
8. Social factors

What do others like?

Social context can contain information about friends, relatives, neighbours, co-workers and online community for instance. User might have to consider social context for two reasons:

Firstly, an individual may be shopping for people around him or her, therefore has to consider their needs which could range from their taste to medical condition, such as food allergy.

Secondly, the purchasing behaviour of peers can have great influence on people's purchasing choice[15]. The 'bandwagon effect' refers to conformance when people desire to be associated with a certain social group or to be fashionable or stylish[16].



71% of consumers are more likely to buy something based on social media referrals[17]. Increasing the visibility of eco label adoption enables consumers to indicate the virtue of their purchases to peers[6], thus potentially encourage sustainable purchasing.

9. Product Category

What is the user looking at?

Product category is an important determinant of shopping context, and it affects the choice of eco information content displayed and format used.

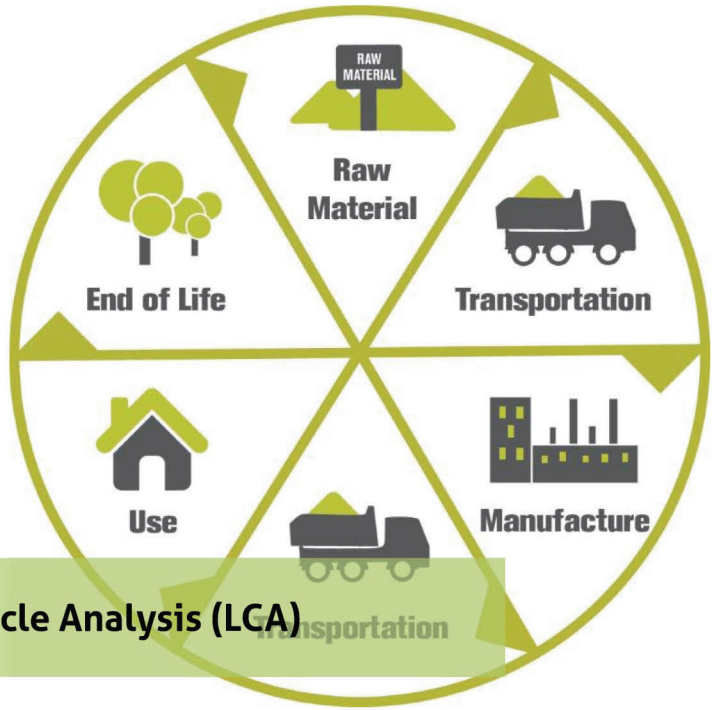
Some eco information is particularly relevant to certain product categories. For example energy efficiency may be an important consideration for energy consuming appliances (e.g. washing machine); organic may be more applicable to food, health, beauty and textile products.

And some information formats can better convey the meaning of certain eco attributes for certain products. For example, colourful rating chart helps comparisons of different energy efficiency ratings.

Existing eco labels are mostly developed independently for a narrow range of products. Traditionally, the most promising initial products should be identified before starting a labelling scheme[7]. While an individualised eco information system has the potential of embracing a wider range of products, meaningful insights about product choices can be borrowed from existing schemes.

Issuing organisation

Eco Information Type | Product Card | Eco Info Individualisation Toolkit



Life Cycle Analysis (LCA)

10. Issuing organisation

Where does the information come from?

Eco labelling organisations can broadly be divided into three types: governments, third-party certification organisations and private companies. They are the bodies that set protocols and standards, verify, certify and monitor the labels.

Consumer's trust and confidence in the green claims are affected by their knowledge about the issuing organisation. Research shows that consumers' uncertainty about who issues the labels reduces their trust. Some people may be sceptical about 'greenwash' by private companies. Depending on the person's beliefs, eco information guided by national/ international standards and monitored by third-party organisation, on the other hand, might increase their confidence[11].

When designing individualised labels, we can ask questions like 'Does this person want to know the source of this eco information?' 'Will the user's preference be affected by knowing who the issuing organisation is?'

Examples of eco labels issued by different parties. (L) National Carbon Offset Standard (NCOS) is introduced by the Australian Government. (Middle) Forest Stewardship Council (FSC) label is verified by an independent organisation (third party). (R) The UPS Carbon Neutral shipping label is issued by the company UPS.

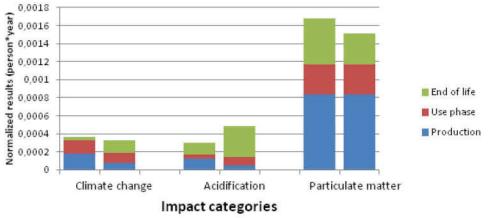
11. Life Cycle Analysis (LCA)

Holistic and accurate framework for assessing impact

Life Cycle Analysis (LCA) is a holistic, systematic framework for assessing products and services. Using a quantitative approach, LCAs deliver the most comprehensive and accurate evaluation of the environmental aspects and potential impacts associated with a product[18].

Typically LCA results in an inventory of materials and energy used throughout various product life cycle stages such as 'material', 'manufacturing', 'processing', 'transportation', 'usage' and 'end of life'.

Interpreting the results and comparing that of various product/ service designs inform decision making of both the consumers and producers.



Most of the existing eco labels were developed under pre-set categories of criteria based on life-cycle analysis. These eco labels may be inaccurate as data may be based on averages, for instance the label issuing organizations make assumptions about how a product would be used or disposed. Also LCA results are extensive and complicated, therefore difficult to be explained thoroughly in a simple label.
Technology can solve these problems by tailoring labels based on actual behaviour of user, and displaying labels according to the user's preference.

12. Eco attribute

Sustainable qualities of product

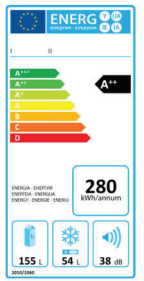
There can a wide variety of eco attributes. The classification of eco attributes is complex and no single scheme can be expected to be complete.

Some eco attributes are numerical and are based on LCA consideration, e.g. energy efficiency, carbon footprint, water footprint. Some are 'seals-of-approval' and are certified when certain criteria are met, e.g. forest protection, marine stewardship, organic. Some focus on ethical production, e.g. fair trade, animal friendly.

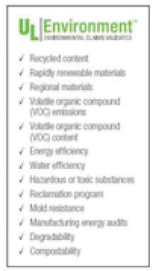
Eco labels can be either single-attribute or multi-attribute standards[19].

Carbon footprint

Fair trade



Energy efficiency



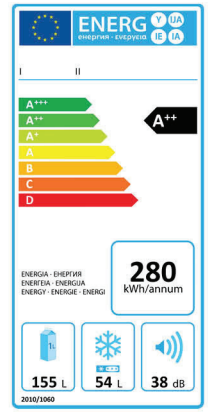
Multi-attribute

13. Colour

More than aesthetics

The use of colours can attract attention, classify elements, convey meaning, and enhance aesthetics.

Saturated colours (pure hues) are seen as more exciting and generally attract more attention. Desaturated colours are perceived as professional. However, there is no universal symbolism for different colours - meanings to colours differ across cultures and individuals. So the effects of colour combinations on a particular target audience are worth consideration prior to use.



Traffic colour rating can be used to indicate meaning. For example, the EU Energy Label uses different colours to represent grading of a product eco performance.

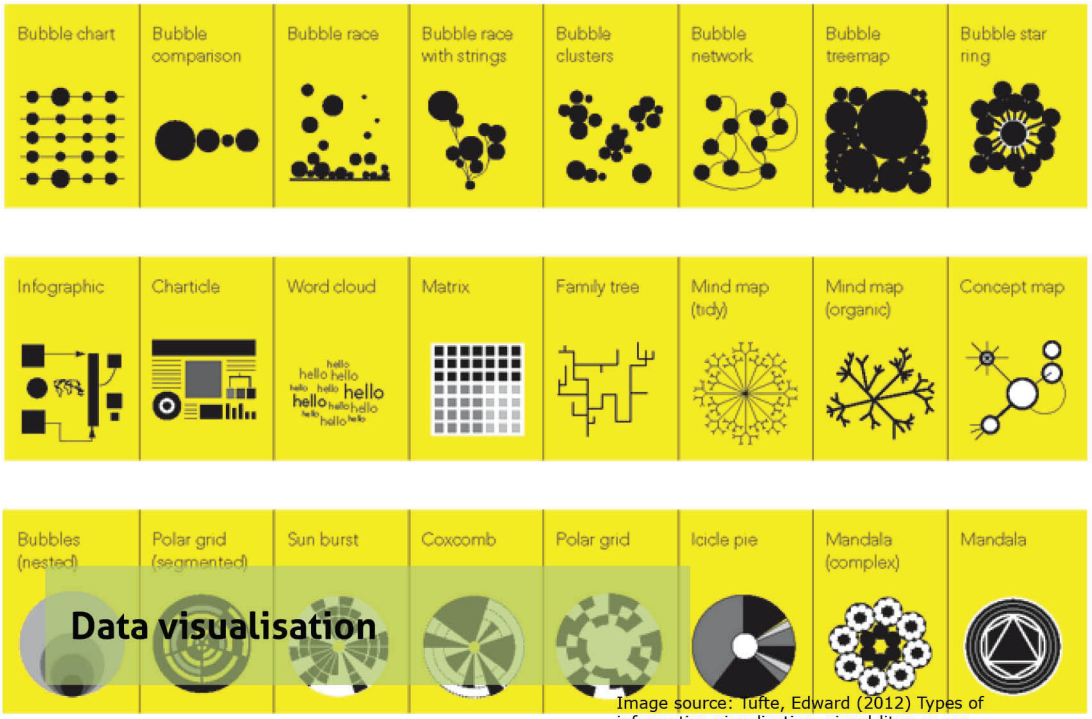
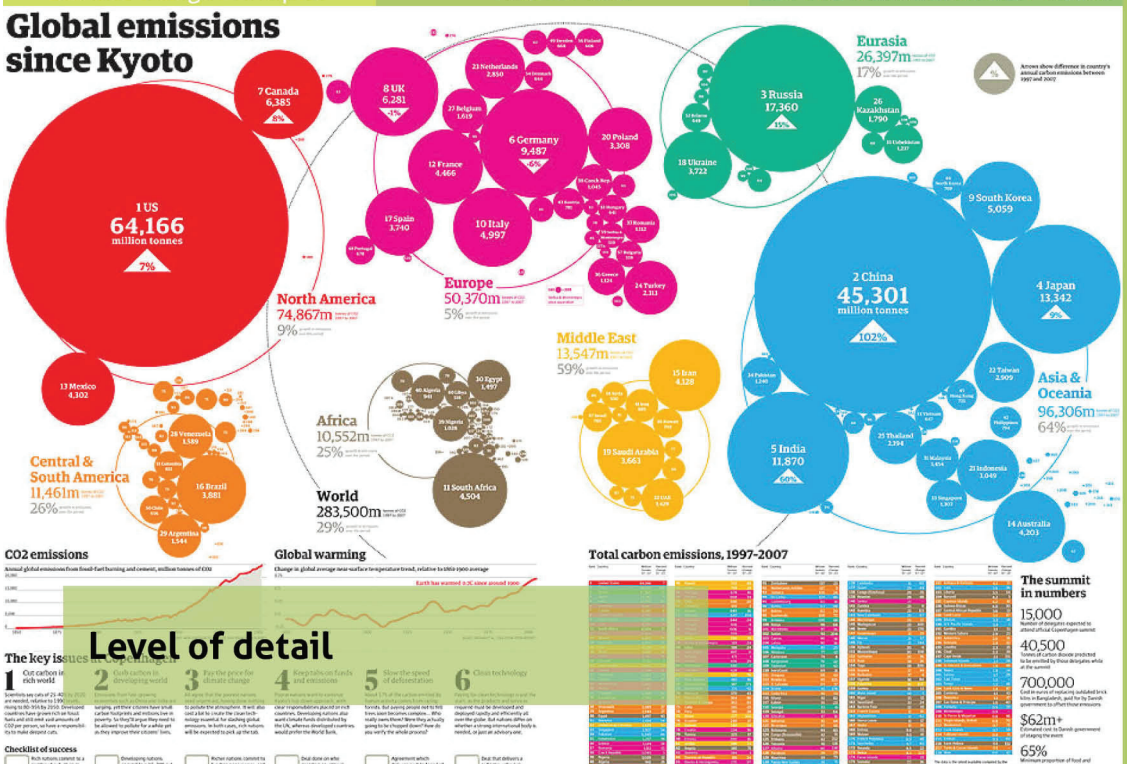


Image source: Tufte, Edward (2012) Types of information visualization, visual-literacy.org

Eco Info Design Principles | Product Card | Eco Info Individualisation Toolkit



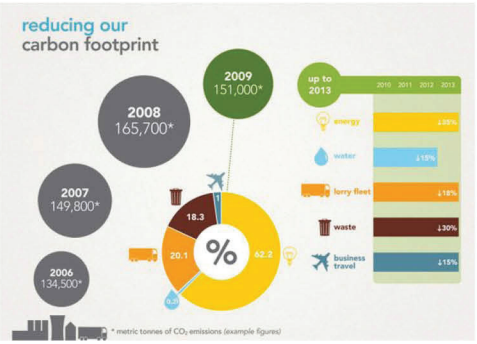
14. Data visualisation

Analytical infographic helps decision making

Cognitive fit theory suggests that decision making is aided when the task representation and information representation format match each other, because this helps the decision makers to develop a more accurate mental model of the problem[2].

With the use of digital technology, eco information display can become more analytical than a small size, static graphical label. Depending on the user's level of environmental literacy, information design principles such as comparison, contrast and differences can be used to convey more engaging messages.

Some ideas for comparison include historical comparison (i.e. compare present and past consumption), normative comparison (i.e. compare to an ideal standard)[20], comparing between product choices and analysing impact of different product life cycle stages.



This is an example of infographic showing the carbon footprint of a company. It compares the total footprints in 4 consecutive years and shows a breakdown analysis for its environmental goal.

15. Level of detail

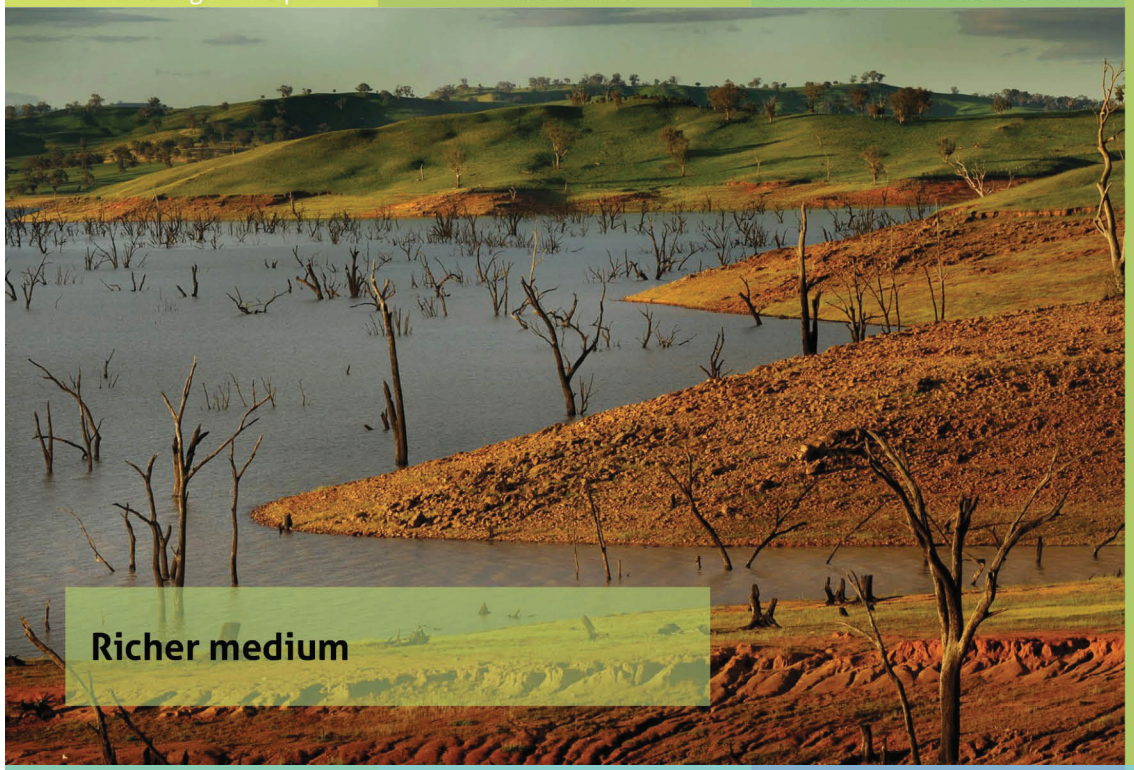
How much is enough?

There is no 'one' optimal format for all people. It depends on the consumer's preference and the type of the product or the task performed.

Research studies have shown that there exists diverse requests for the amount of information displayed on eco labels[21]. Some consumers prefer simplified label. Some consumers seek supplementary information that inform product comparisons. On the other hand, some consumers are more satisfied when detailed information is displayed, and in this case a detailed label helps educating consumers about the environmental consequences of a product.

EU organic products label

Burn Wise EPA label



16. Richer medium

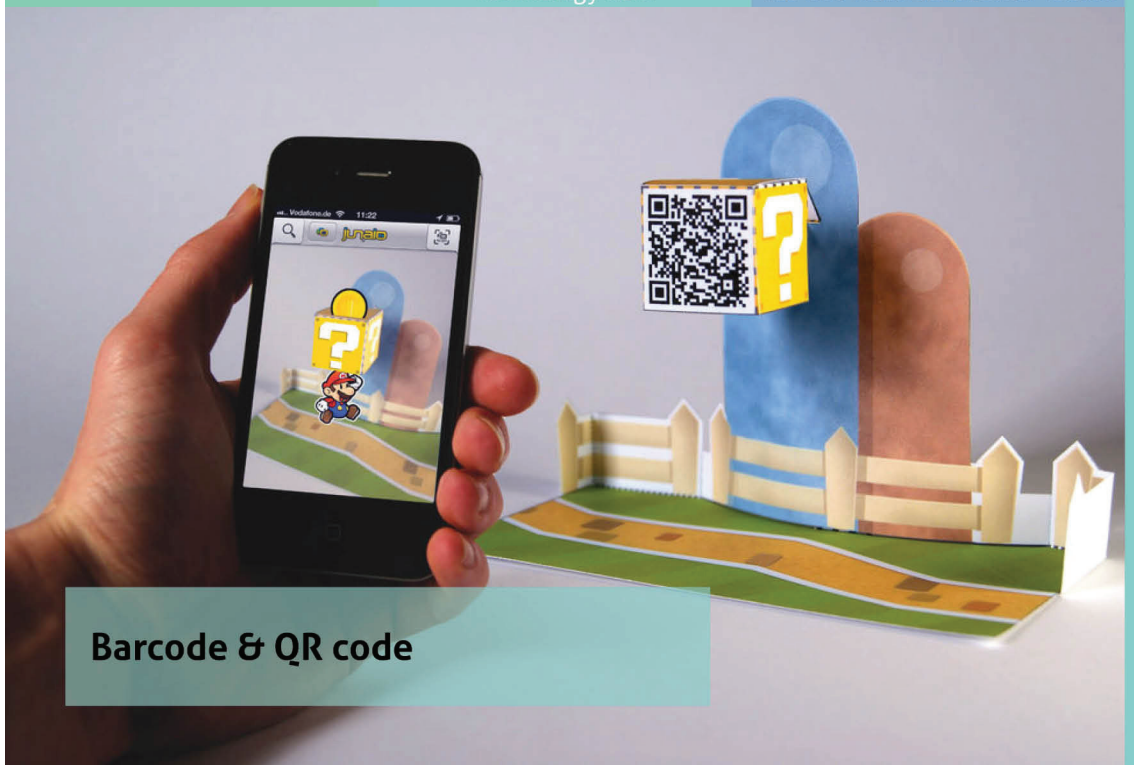
Photograph provides realness that provokes engagement

Existing eco labels are mostly graphical symbols for clarity (the label size is generally small) and ease of printing.

Emerging technology is enabling the use of richer media, such as photos, videos, or even interactive programmes which provide more detail and perhaps persuasiveness.

Environmental consequences can be distant and difficult to picture for consumers. Using this, the consumer can better imagine what is happening (e.g. what animals are used in production), what changes can be brought (e.g. ideal landscape) and how this relates to the consumer (e.g. showing personalised images of scenery that he has been to.)

These cigarette packages are examples that use the power of persuasion provided by photographs to warn smokers about the risks of smoking. Imagine, in the case of information individualisation, would it be even more persuasive if the portrait of the passive smoker is replaced by that of the user's own kid?



17. Barcode & QR code

Popular optical label for information

Barcode is a machine-readable optical label that contains information about the item to which it is attached. QR or Quick Response Code is a type of matrix barcode. These barcodes can be read by an imaging device, e.g. scanner, smartphone with camera. They can link directly to text, websites, email and URLs for augmented reality contents.

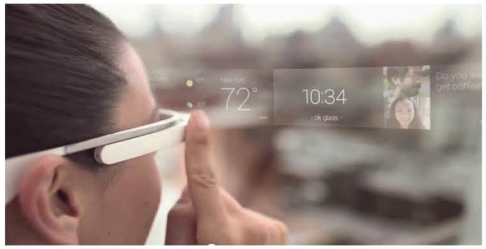
Due to its fast readability and considerable information capacity compared to standard barcodes, QR code system became popular in a broad context, such as product tracking, item identification, marketing and customer service[22].

Aestheticodes has evolved from a research project that makes aesthetic decorative patterns interactive. Visual codes that can be recognised by computers are embedded in beautiful images, resulting in the same interactivity as that of the QR code[23].

18. Augmented Reality

Display in real time and in context

Augmented Reality (AR) is a human-computer-interaction technology that overlays computer-generated information on the real world environment. The advantage of AR over other offline data sources is that the virtual information can be displayed at the same location as the object it relates to. This provides context for the information, often making it more engaging and easier to understand[24,25].



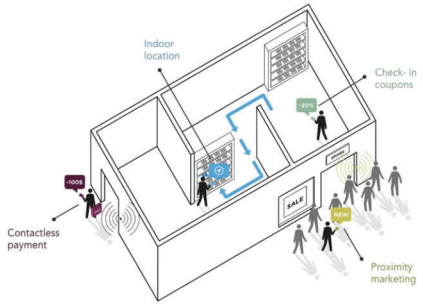
Google Glass is an optical head-mounted display in the shape of a pair of eyeglasses. It displays information in a hands-free format by projecting text or video into the vision of the wearer, who can communicate with the device via language voice commands. In 2013, Google started selling a prototype of Google Glass. The headset has received massive criticism and legislative action due to privacy and safety concerns. In 2016, the Glass is still underdevelopment.

Technology Card Eco Info Individualisation Toolkit

19. iBeacon

One-way transmitter to nearby devices

iBeacon is a technology developed by Apple to extend Location Services. It is a low-cost, wireless one-way transmitter that broadcast their signals to nearby portable electronic devices, such as smartphone, using Bluetooth low energy (LE) proximity sensing. A specific app has to be installed on the receiving device to interact with the beacons (the broadcasting devices) to ensure only the installed app can track users as they walk passively around the transmitters. The beacons can be detected within 70m range with no obstructions. They are usually stuck to walls or hidden in other objects[26,27].



Two useful applications of iBeacon are indoor positioning and message distribution. Smartphones can determine their approximate location with the help of an iBeacon. iBeacon can also distribute contextual content (e.g. special offers, helpful reminders) at a specific Point of Interest (e.g. shops).

20. RfID & NFC

Wireless tagging and tracking

Radio-frequency identification (RfID) is a form of wireless communication that uses electromagnetic fields to automatically identify and track objects. Near field communication (NFC) is a specialised subset within the family of RfID technology. Both RfID and NFC tags contain electronically stored information that, unlike a barcode, can be scanned without a direct line of sight of the reader.

RfID is a one-way process, and NFC is capable of complex two-way communication between devices. However both RfID and NFC are commonly used for one-way communication between a reader and a passive tag.

The maximum read distance of RfID tags depends on the type of tags (passive or active, frequency range), the reader, antenna power and material, etc. A low frequency passive RfID tags typically has a read distance of 10-30cm. An active RfID tags (with on-board battery) can be read within a range of approx. 100m. The scan range of an NFC tag is typically between 2cm to 6cm.

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21. Mobile & Wearables

Technologies to wear

Today many mobile devices (e.g. smartphone, tablet and Google Glass) come with a growing set of powerful embedded sensors, such as accelerometer, digital compass, gyroscope, GPS, microphone, camera and NFC/ RfID sensors, which enable a wide range of mobile sensing applications[28,29]. Powerful self-monitoring and personalised information tools can be developed using these sensor-equipped mobile devices.

Lifelogging, the process of tracking personal data generated by the user's behavioural activities for large portions of their lives, is an example enabled by the advancements in wearable technology.

[Above] 'Autographer', one of the wearable cameras on the market for lifelogging
[Below] 'Fitbit', an activity tracker bracelet that tracks fitness and sleep activity data

22. Social Media

Pervasive interaction with peer

Social media refers to a variety of online channels connecting users interested in specific subjects. Examples include Facebook, twitter, Wikipedia, Linkedin and Pinterest. It has become a platform where people read and share highly personalised information every day. This content gives clues about the context of who people are, what they are doing and what they are likely to do next.

Social media can leverage peer pressure and social norm to promote greener choices by making visible the behaviours within communities[30].

Image source: http://www.brandanew.co/how-does-social-media-impact-consumer-purchases/

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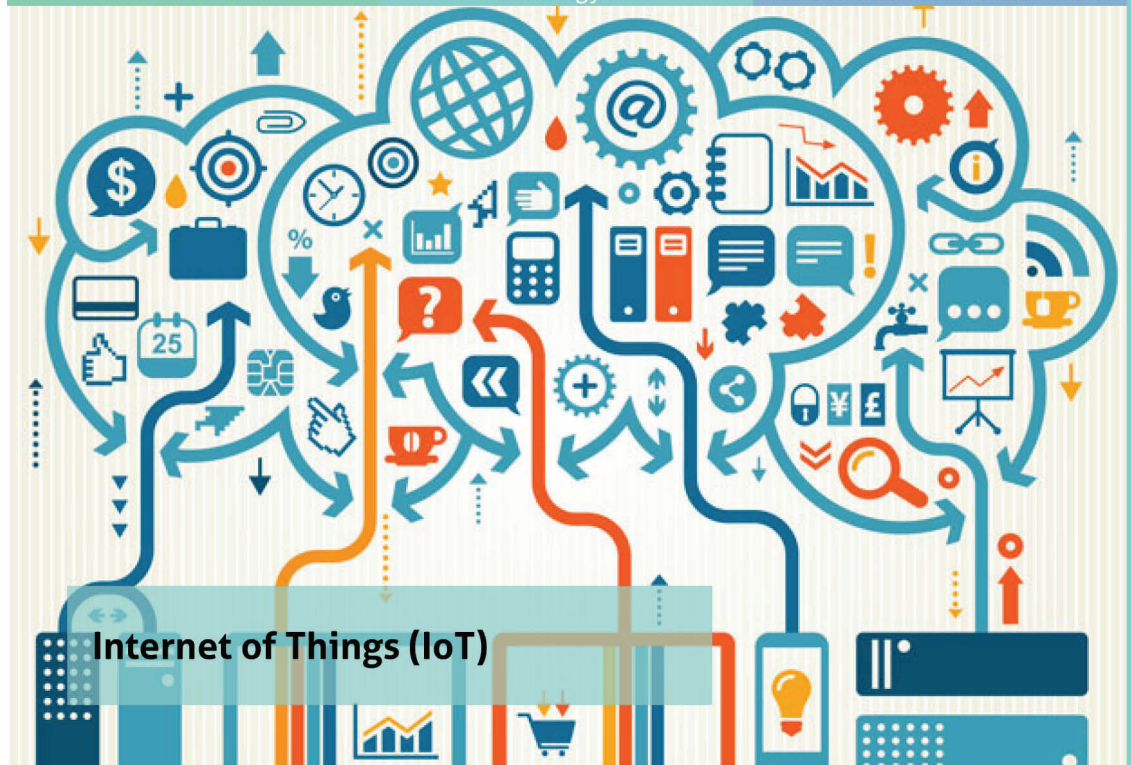


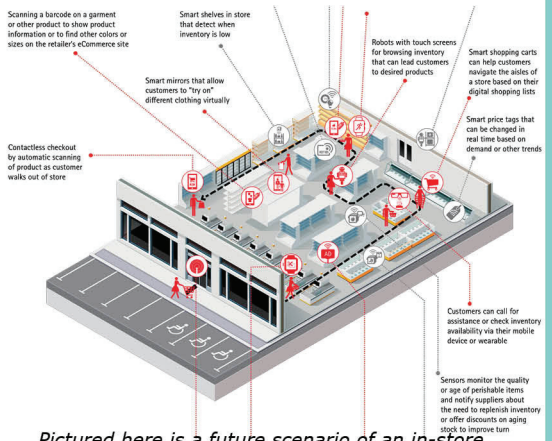
23. Internet of Things (IoT)

Connecting devices over the internet

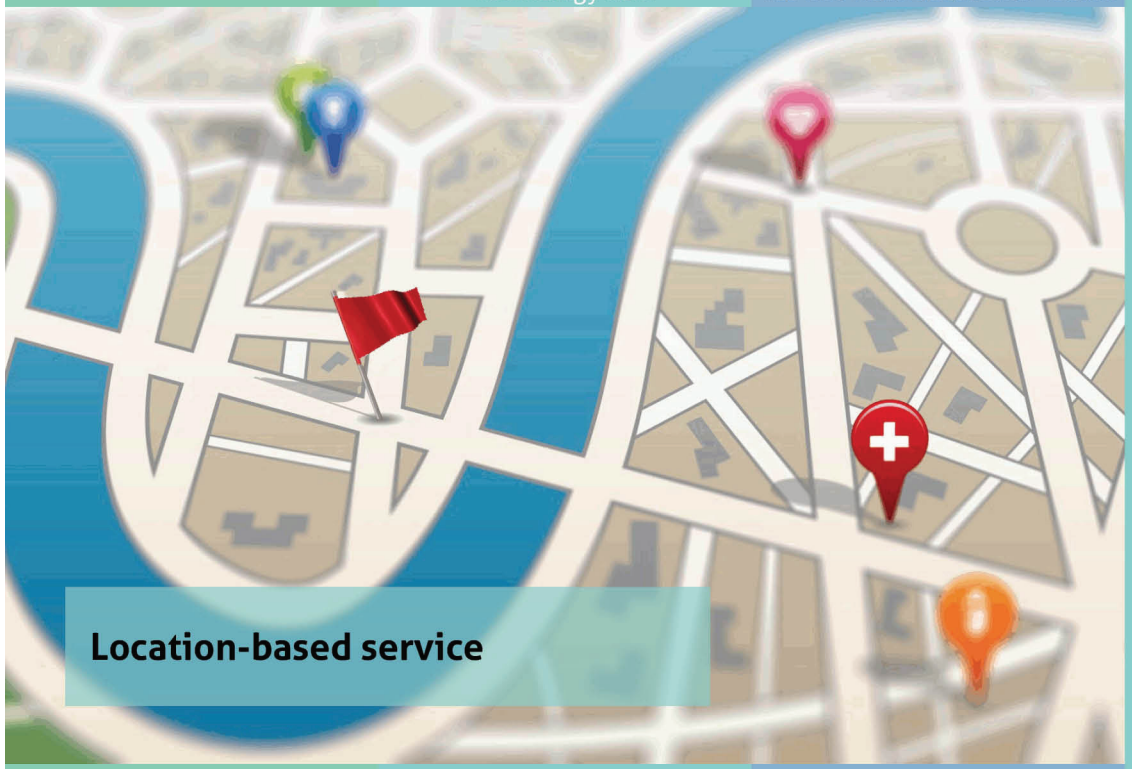
The basic idea of the Internet of Things (IoT) is the pervasive presence around us of a variety of things or objects – such as RfID tags, sensors, mobile phones, vehicles, etc. – which collect data and interact with each other. With this novel advancement in sensor technology, we can have access to a multitude of information about our surroundings and control objects remotely.

The US National Intelligence Council envisages that 'by 2025 internet nodes may reside in everyday things – food packages, furniture, paper documents, and more'.

IoT offers great potential for improving the efficiency for many things, such as more efficient energy solutions, smart retail, smart supply chain, etc.[20,31]



Pictured here is a future scenario of an in-store experience with IoT, in which customers can use their smartphone or wearable devices to quickly scan products and call up information, smart price tags can be changed in real time based on demand or trend, smart mirrors can allow customers to 'try on' clothing virtually[32].

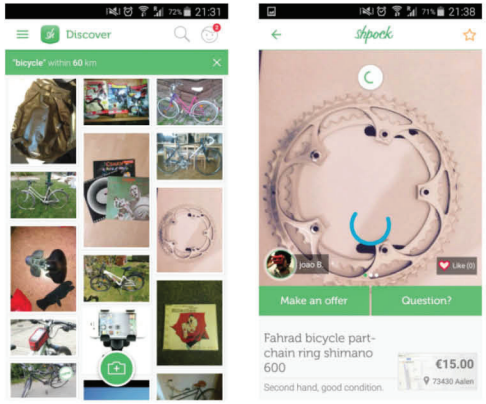


24. Location-based service

Positioning yourself, friends and things

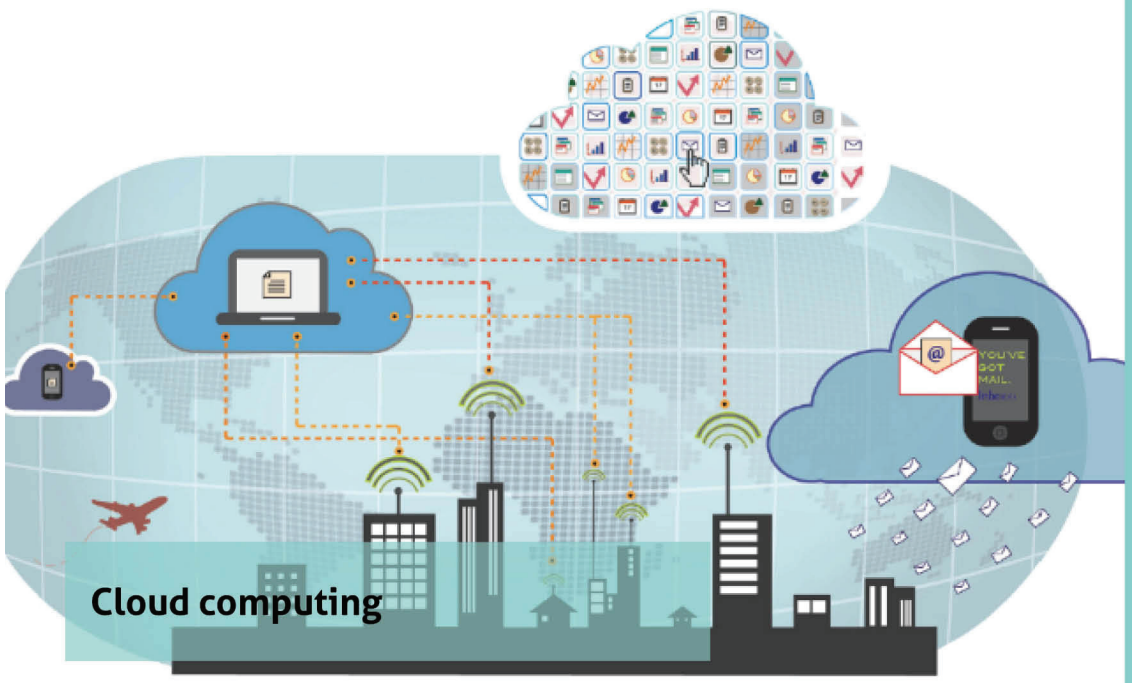
Location-based service tracks the location of a person of object using real-time geo data from a mobile device if the person has given permission to the service to do it. Some applications allow people to 'check-in' at places like restaurants, stores, attractions or events. This provides opportunities to interact with users at the point of purchase. For example, it helps pushing suggestions for purchases, discovering the nearest ATM or the location of a friend, or personalising weather reports.

The simple and standard solution for location-based service is to use GPS technology. However GPS does not work very well indoors, in that case alternative techniques such as iBeacon indoor positioning or self-reported positioning can be used[33,34].



Shpock is a classified and boot sale app. Items are listed based on the seller's location and are advertised to people from the same neighbourhood.

Technology Card Eco Info Individualisation Toolkit



25. Cloud computing

Sharing computing resources from remote servers

Cloud computing is a type of Internet based computing. It refers to both the computing services (applications) delivered over the Internet (the 'cloud') and the hardware and systems software in the data centres that process these applications. Some common applications are webmail, online file storage, social networking and games, etc.

Cloud computing provides a shared pool of computing power, memory and storage resources in remote data centres, which could be used to overcome the resource limitation of mobile devices[35,36].

You can interact with many cloud applications using a web browser without installing specific software on your devices. Examples of cloud apps include Facebook, Google Docs, Gmail, Youtube, Evernote, Dropbox.

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A guide for designing

Eco Information Individualisation

Sze Yin Kwok David Harrison Alessio Malizia

Appendix 15
PS2 – Guidebook as part of the design tool

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A guide for designing

Eco Information Individualisation

Sze Yin Kwok
David Harrison
Alessio Malizia

Brunel University London

Contents

Introduction

This guidebook gives a brief introduction of the concept of eco information individualisation, and guides the designing of individualised eco information through a conceptual framework and a design tool.

An individualized information system is believed to benefit consumers by convenient access to relevant product eco information, have a potential for impact on consumer behaviour, and can be made an effective tool to encourage sustainable consumption.

Background

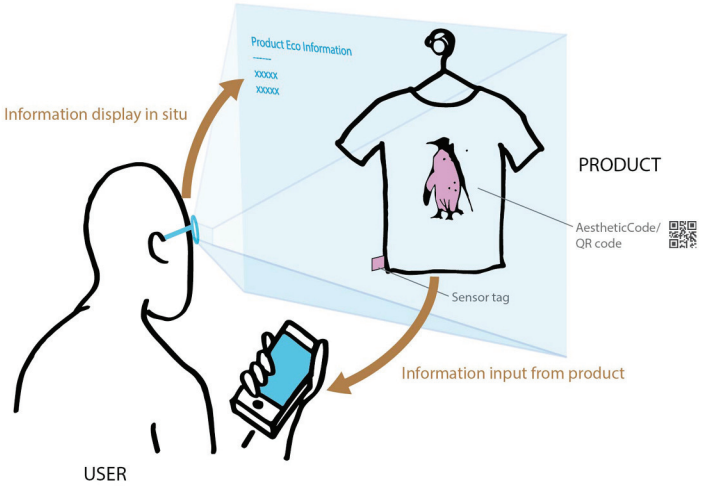
Eco information can be used as a design intervention strategy to influence consumer behaviour for a shift towards more sustainable consumption patterns.

Eco labelling is defined as a practice of providing information to consumers about a product with improved environmental performance and efficiency (Global Ecolabelling Network, 2013). Amongst the major existing eco information tools that promote sustainable behaviour, eco labelling addresses individual consumer behaviour most directly (Kwok, Harrison, & Qin, 2013). Despite the growth in consumer awareness and acceptance of eco labelled products, it is found that consumers have difficulties in perceiving and understanding eco labels (Kwok, Harrison, & Qin, 2014).

Left: Over 400 different eco labels or certification schemes exist around the world. (Cohen & Vandenbergh, 2012; Ottman, 2011).

Contextual technology

Contextual technology is a collective term for various technologies enabling the 'Age of Context'(Scoble & Israel, 2014), such as mobile, social media, big data, sensors and location-based technologies. These technologies are believed to be useful in enabling information exchange between people and products, and the ubiquitous provision of tailored eco information.

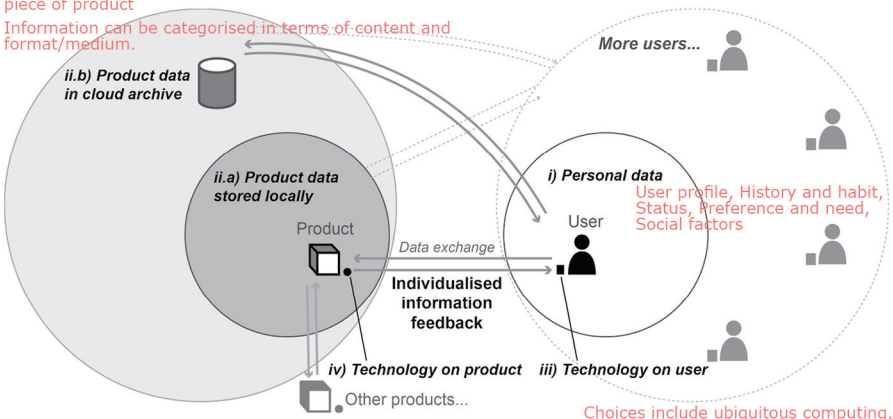


Both product and user can act as data carriers. Ubiquitous information exchange between user and product is possible.

Framework

As shown on the right is the conceptual framework of eco information individualistion. Four components are required for eco information individualisation to encourage sustainable consumer behaviour, namely 'personal data', 'product data', 'technology on user' and 'technology on product'(Kwok et al., 2014).

Archive: database storing all information about products
Product type: storing information for each product type
Product life: storing record of each individual batch/ piece of product
Information can be categorised in terms of content and format/medium.

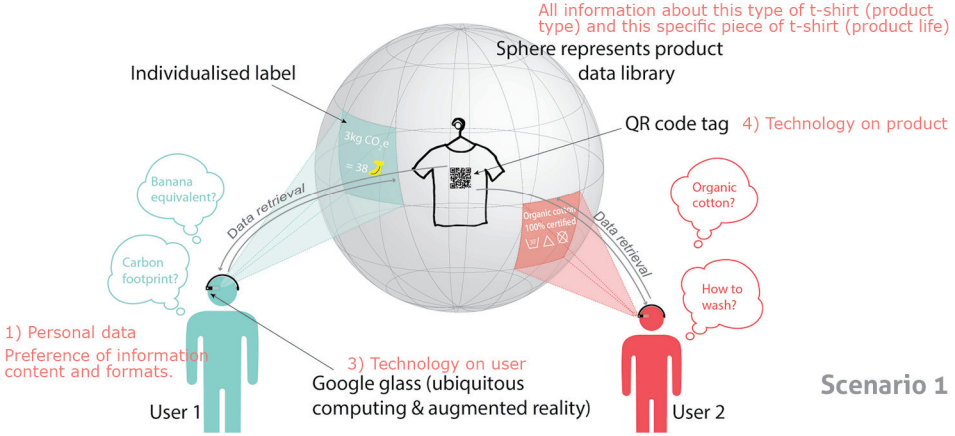


Choices include GPS, tags (e.g. QR code, RfID, NFC), digital memory, wireless signal transmission (e.g. Bluetooth, Wifi, infrared), tag sensor and tag writer (e.g. RfID writer).

Choices include ubiquitous computing, GPS, sensors (e.g. camera, accelerometer, proximity, touch, light...etc.), display (e.g. screen, head mounted display, projector), wireless signal transmission (e.g. Bluetooth, Wifi, infrared).

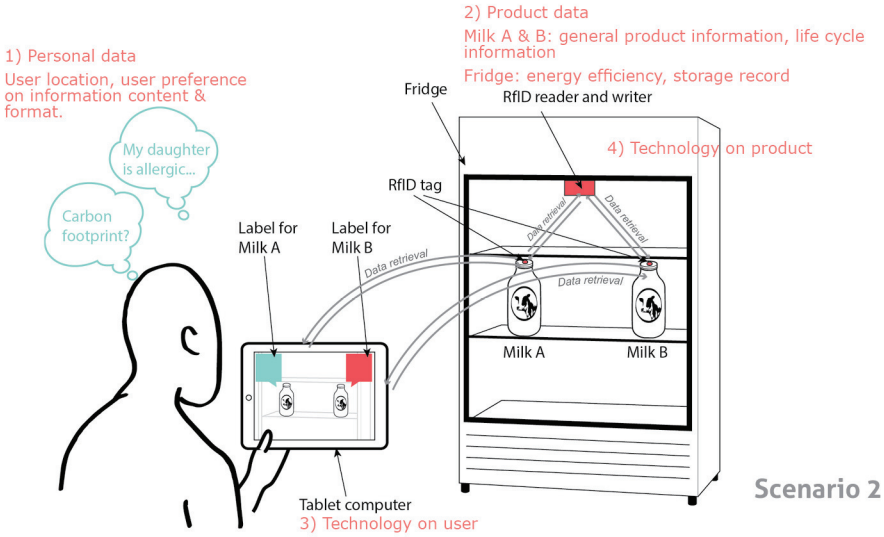
Applications

Here are two application scenarios to illustrate how an individualised eco labelling system works in relation to the proposed conceptual framework. Scenario 1 shows an example where two users see different individualised labels when looking at the same shirt.



Scenario 1

Scenario 2 shows an Internet-of-Things example.

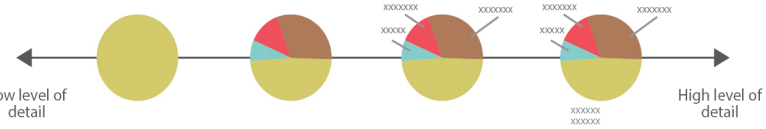


Scenario 2

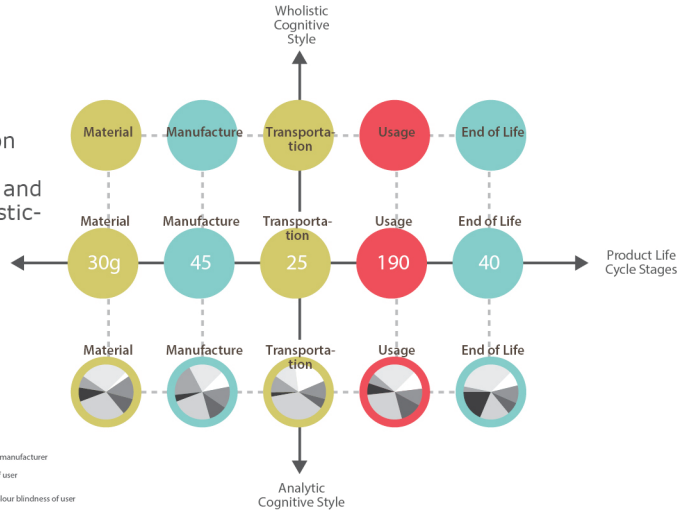
Dimensions/ Axes of continuum

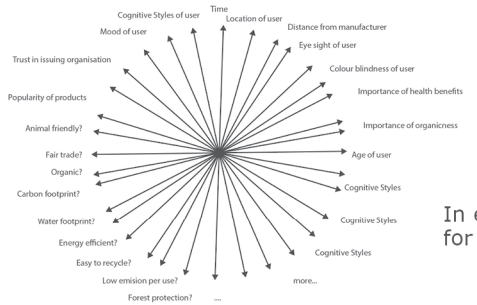
The idea of information individualisation is rooted in the fact that context around user and product can be very complex and the amount of contextual data captured can be enormous. When visualising this data in the form of an eco label, there may exist many possible polarities/ dimensions for tailoring - cognitive styles, time, location, social parameters, parameters of environmental impact, and size of fonts to name a few. Each dimension consists of a continuum of label designs, so that individuals with different needs would see different labels accordingly.

Below is an example of 1-dimension tailoring upon the dimension of 'level of detail' with 4 variations. Designers should create a continuum of labels with different levels of detail in order to satisfy different individuals.



This is an example of 2-dimension tailoring with 5 variations on the axis of 'product life cycle stages' and 3 variations on the axis of 'wholistic-analytic' cognitive styles.

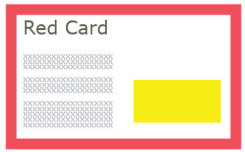




In essence the number of polarities/ dimensions for information tailoring can be unlimited...

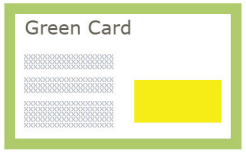
Structure of the tool

The tool consists of 3 sets of cards (25 cards in total) and 2 worksheets that guide through the user centred design process of designing individualised eco labels.



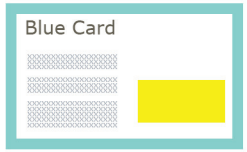
Person Card

illustrates ideas around the user's context and how to use personal data when individualising eco label.



Product Card

describes product eco information that are especially relevant to eco information individualisation, in terms of both content and presentation formats.

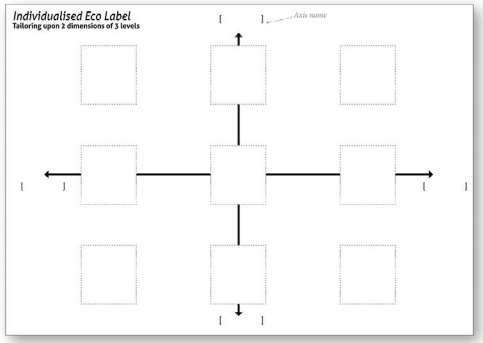


Technology Card

gives information about useful technologies that enable eco information individualisation.

User scenario worksheet

can be used for sketching the imagined usage and technological requirements.



3X3 Matrix worksheet

is a design template created to help position 9 design variations in the form of a 3X3 matrix. This template provides a basic structure for 2-dimensional eco information individualisation, with 3-levels of variation on each dimension.

Complete list of the cards

Person cards

1. Verbaliser vs Imager (VI)
2. Wholist vs Analytic (WA)
3. Preference & Interest
4. Physiological
5. Time & Location
6. Task Related
7. History & habit
8. Social factor

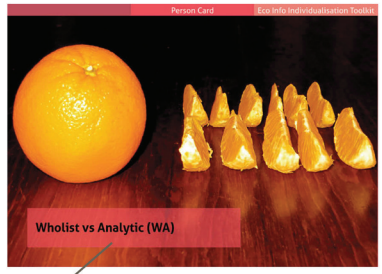
Product cards

9. Product Category
10. Issuing organisation
11. Life Cycle Analysis (LCA)
12. Eco attribute
13. Colour
14. Data visualisation
15. Level of detail
16. Richer medium

Technology cards

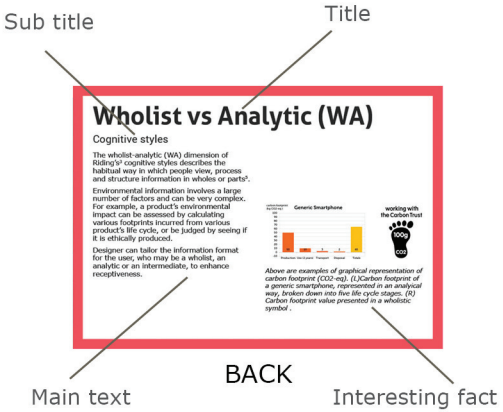
17. Barcode & QR code
18. Augmented Reality (AR)
19. iBeacon
20. RfID & NFC
21. Mobile & Wearables
22. Social Media
23. Internet of Things (IoT)
24. Location-based service
25. Cloud computing

On the front of each card is a big image to illustrate the overall concept. On the back are 4 items - title, sub title, main text and an interesting fact supplemented with an explanatory image. Each card gives an idea about one type of contextual factors which could be developed into dimensions for information tailoring.



FRONT

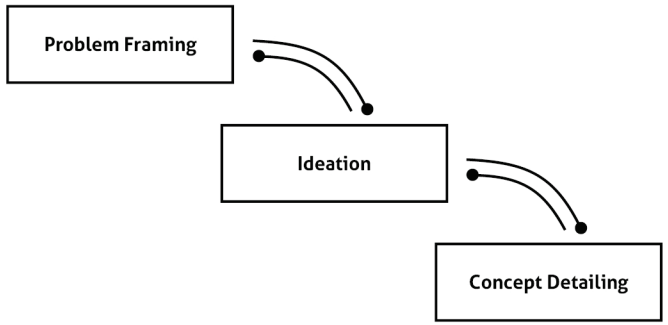
Title



BACK

How to use the tool

This design tool supports three iterative stages of the design process of the designing of eco information individualisation, namely problem framing, ideation and concept detailing. The anticipated outcomes are detailed design concepts that can be used for further prototyping and testing.



Iterative design process supported by this tool

Problem Framing

- Explore the contexts around the users, the product(s) and applicable technologies. Designers can use the 3 sets of cards to find inspirations related to contexts around the users and the product(s), and learn about related technologies. They can write down the contextual factors on the worksheets or blank papers.
- Identify the design challenge. Designers can define the design scope by reviewing the factors written previously, and define the problem by selecting the factors to focus on.

Ideation

- Brainstorm the possible dimensions for tailoring. The 3X3 matrix design template can be used.
- Brainstorm the usage scenario of the eco labels and its technological requirements. Designers can seek insights from the card sets, and sketch their ideas on the user scenario worksheet.

Concept Detailing

- Further develop the ideas sketched in the previous stages and create detailed drawings.

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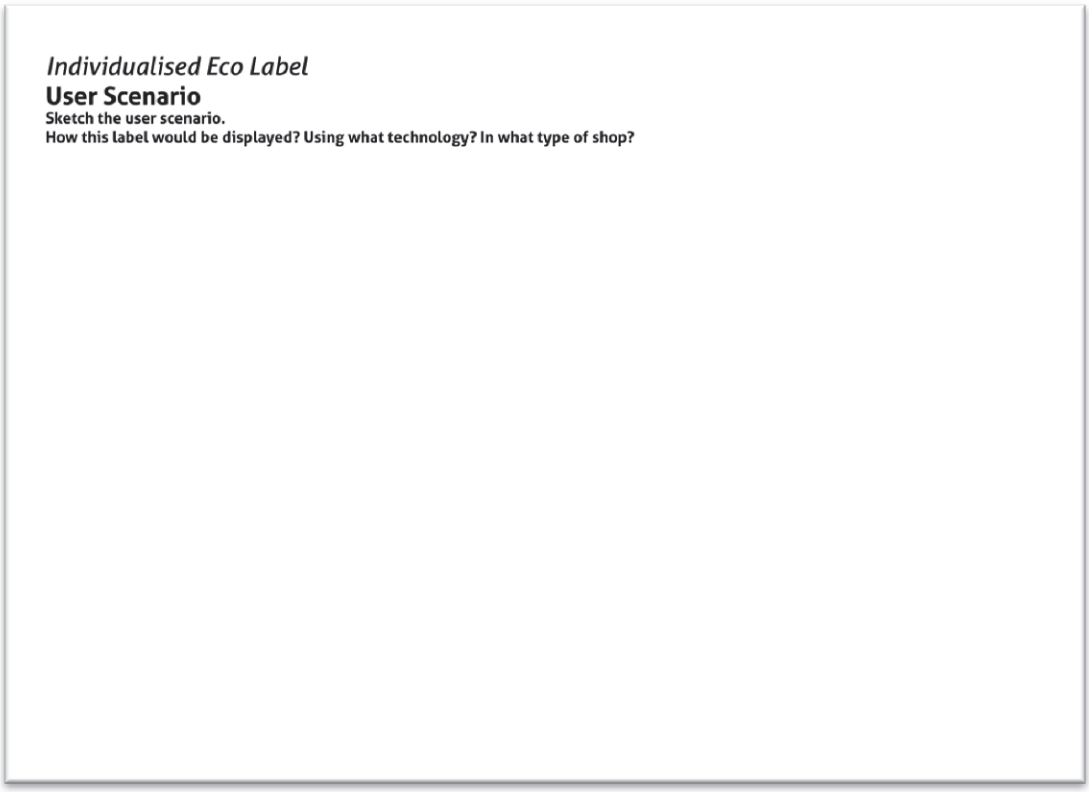
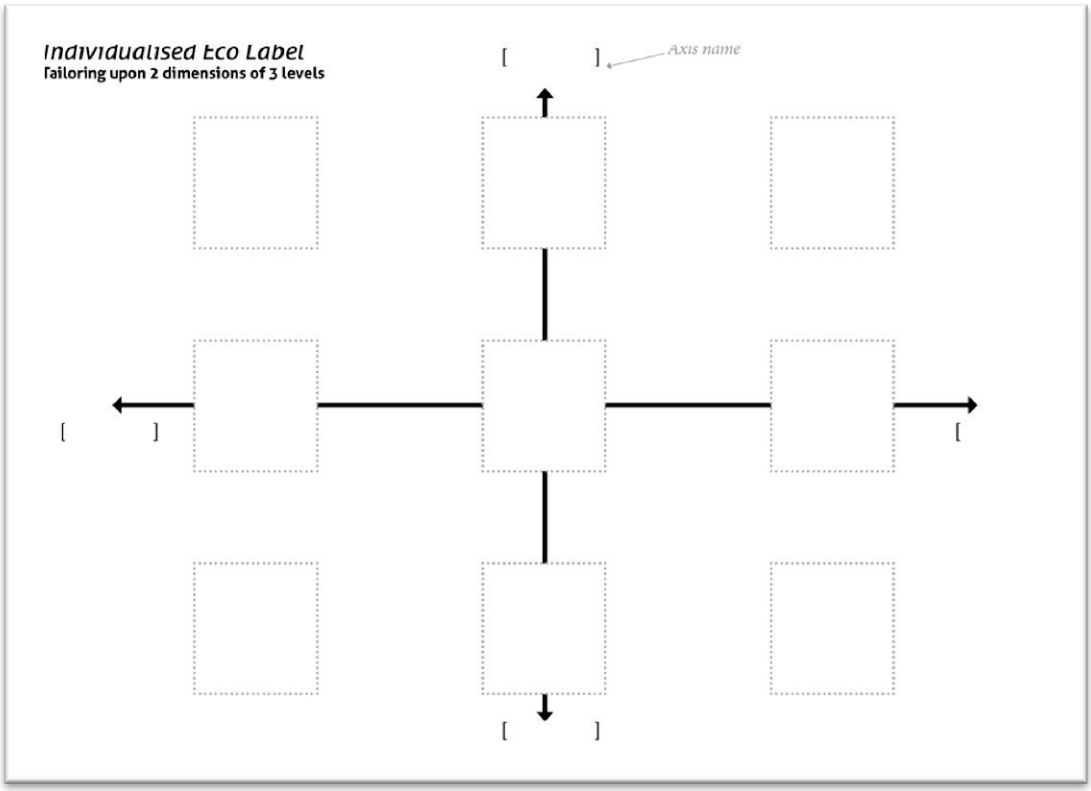
Appendix 16 PS2 – The worksheets of the design tool



(Above) User Scenario worksheet (Below) 3X3 Matrix label design template



Appendix 17 DS4 – The four personas used during the workshop

Appendix 18 DS4 – Workshop post-task questionnaire design

Question no.	Question	Meaning of 1	Meaning of 5
Q1	The text content on the cards is informative.	Strongly disagree	Strongly agree
Q2	The images on the cards are informative.	Strongly disagree	Strongly agree
Q3	The cards provide the information you need.	Strongly disagree	Strongly agree
Q4	To what extent does the tool (worksheet + presentation + cards) make your understand about designing Eco Information Individualisation?	I do not understand at all	I thoroughly understand how to design individualised eco label
Q5	To what extent does the tool (worksheet + cards) support the problem framing process?	It did not support my problem framing process.	It effectively supports my problem framing process.
Q6	To what extent do the worksheets trigger ideas out of your thinking?	It did not any trigger ideas	It triggers a lot of ideas.
Q7	To what extent do the cards trigger ideas out of your thinking?	It did not any trigger ideas	It triggers a lot of ideas.
Q8	Is this tool (i.e. worksheets + cards) useful in guiding the design process of designing individualised eco labels?	Not useful	Extremely useful
Q9	The information on the card is well structured.	Strongly disagree	Strongly agree
Q10	The text content on the cards is clear.	Strongly disagree	Strongly agree
Q11	Layout of the cards	Very bad	Excellent
Q12	Layout of the worksheets	Very bad	Excellent
Q13	Colours used of the cards	Very bad	Excellent
Q14	Readability of the cards	Very bad	Excellent
Q15	Size of the cards	Very bad	Excellent
Q16	Your experience using the design tool (worksheets + card)s	Very bad	Excellent
Q17	Your experience attending the workshop	Very bad	Excellent
Q18	Do you have other comments about the tool design?		
Q19	Do you have other comments about the workshop?		

Appendix 19 DS4 - Responses to post-task questionnaire

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19
P1	4	4	5	5	4	4	4	3	4	4	4	4	5	4	5	4	4	Well done. Seems like the complexity of the topic is massive and you made a good clarification and categorisation of all elements.	The final task wasn't clear at the beginning. You maybe could explain better how to use ALL cards to trigger ideas.

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19
P2	3	5	3	5	4	2	4	3	3	3	4	3	5	4	4	3	4	*It has helped to give more insight into how the design process goes. *Gives me new possibilities of using this in my design	* Good to understand how to design better. * I wished I understood the content much better.
P3	4	5	5	4	4	3	4	4	3	4	4	4	4	4	4	5	5	*simplify the text *more graphical	*good workshop but need to more organised *should have video recording since that is a part of proof and can be useful for your thesis
P4	3	5	5	2	2	4	4	4	4	4	2	5	5	3	3	4	4	I would redesign the card to be more readable. Too many information in such a little space. Titles on each card should be clearer and stand out from the background. The toolkit should provide inspiration rather than frame and constrict designer's creativity. The simplification of the content of the card will improve their effectiveness!	I really enjoyed the workshop - I'd expected more team work rather than individual activities and a final showing of our concepts.
P5	4	4	3	5	4	5	4	3	4	4	4	4	5	3	5	4	4	Some aspects of the cards overlap to each other. If there are more numbers of bigger categories in the 'person card' group, it would cover more factors.	
P6	5	4	5	3	4	4	3	4	4	3	5	4	5	5	5	3	4	However I like the diagram --> [diagram of 9 boxes is drawn] Goals were no very clear. Too many tasks at the same time. Persona, type, many cards, etc.. More focused goal and expected result. Boundaries should be stricter.	
P7	4	4		3	5		5		3	2	4	3		3	4	3	4		Make the workshop more clear, explain better, and have less informations. Too many informations are displayed, and is not really clear the objective of the workshop. You end up with too many things on the table.
P8	3	4	2	3	2.5	2	2	2	3	3	3	2	3	4	5	3	4	*Less cards *Broader, focus a eco labelling, rather than individualisation *more understanding of project aims and direction --> conflicting information	*I enjoyed the workshop and found it thought provoking
P9	3	4	3	4	3	2	3	2	2	3	4	3	4	3	4	3	4	*Toolkit has potential *There are so many options/ variables that need to be considered. but the context of design needs to be clearer and more restrained	*Clearer task instruction *Breakdown of tasks *Remark for Q9> Introduced too late within process
P10	3	4	5	4	4	4	4	3	3	4	3	3	3	2	3	4	4	At what point will this be implemented? B2B?	Interested to see outcome --> physical/ VR --> feasibility??
P11	5	4	5	5	4	4	4	3	3	5	4	4	5	5	5	4	4	It could be made even more visual and easy and quickly to understand if icons are added for: - core values -personal goals -frustration - shopping habits	I think more time it needs to be provided for the first exercise because there is a lot of information to take in and to start ideating.