Loughborough University

Designing and evaluating a behaviour change intervention that introduces modification of time perceptions as a solution to promote sustainable behaviours.

Doctoral Thesis

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Loughborough University

Certificate of originality

This is to certify that I am responsible for the work submitted in this thesis, that the original work is my own except as specified in acknowledgments or in footnotes, and that neither the thesis nor the original work contained therein has been submitted to this or any other institution for a degree.

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Abstract

This research presents the design and evaluation of an intervention that introduces modification of time perceptions as one of the solutions to promote sustainable behaviours. It is demonstrated in this thesis that unnecessary energy use is often caused by temporal tensions, defined as the relation between actions to be performed and available time. This research proposes that it is possible to deliberately reduce temporal tensions, and this can motivate people to behave more sustainably. Persuasive technology and human-computer interaction provided the tools needed to manipulate time perceptions and therefore bring about changes in the specific behaviours that result in unnecessary energy usage.

Previous studies indicate that behaviours play an important role in energy consumption. From the different domains of energy use that could be examined, cooking was chosen to be the platform where the studies on behaviour change and energy use would take place. How behaviours influence energy use motivated the design of empirical studies to understand behaviours related to domestic energy use and identify what are the determinants of these behaviours. Each determinant was related to a strategy to be included on a behaviour change intervention. A wider survey was developed to understand students' acceptance of a set of proposed energy saving techniques, and resulted in a vast volume of information about user preferences and intentions to perform the suggested energy saving behaviours for cooking. It emerged that participants rushed into the cooking tasks without much deliberation, consequently not following preparation procedures and thus using more energy. Information gathered during the first studies also showed that participants' behaviours were partially motivated by the need to speed up the cooking process in order to reduce boredom when they were waiting for the food to cook, consequently resulting in extra energy usage.

The knowledge gathered from the preceding steps and a literature review informed the design of strategies to modify the non-sustainable behaviours and promote energy saving. A user-centred design process involving an idea generation session and scenario analysis was used to provide a set of strategies to be embedded in an intervention, containing the specific methods to tackle the correspondent determinants of behaviours. The specific needs of the cooking activity indicated that an electronic intervention was an adequate platform to be implemented and tested. Two high resolution working prototypes of the electronic interventions were developed as mobile phone applications. The final study comprised the evaluation of the proposed interventions in improving aspects of the cooking activity, the acceptance of the interventions and effectiveness in promoting energy saving.

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Publications

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1 Introduction

This introductory chapter gives an overview of the contents of this PhD thesis. It starts with a description of the background to this research with definitions of the aims and objectives of the study. It then states the hypothesis, presents the research questions, the approach to address these research questions and describes the scope of this research. The introduction also includes a quick overview of the contents of each of the following chapters.

1.1 Energy use

Human activities have been increasing the amount of carbon released into the atmosphere, consequently contributing to making the planet warmer due to the greenhouse effect (Mann, Bradley et al. 1999, Crowley 2000). It is clear that it is necessary to reduce the CO_2 emissions to minimize the threats to life for future generations. About 75% of UK electricity is produced by thermoelectric plants (DECC 2010), which are responsible for a big share of the carbon emissions. The housing sector accounts for more than one third of the energy consumption (DECC 2010). The government has been trying to implement projects to reduce energy consumption with different strategies such as the UK Low Carbon Transition Plan and the Smart Meter Implementation Plan (DECC 2011, DECC 2009). However, reports show that greater understanding of how to reduce domestic energy consumption is needed in order to meet carbon emission reduction targets (Tyndall Centre for Climate Change Research 2009, DEFRA 2009).

Two important ways of reducing domestic energy consumption are through efficiency and curtailment. It is possible to build products that use less energy via better product engineering, and it is also possible to reduce the energy consumption by the way people use these products and perform their daily activities (Attari, DeKay et al. 2010). The energy efficiency of appliances has been increasing in recent years (Geller, Harrington et al. 2006). However, owning efficient appliances or living in energy efficient homes is not a guarantee that the energy use will reduce (Crosbie, Baker 2010, Gill, Tierney et al. 2010). Furthermore, consumers are buying more appliances and having more standby devices (Firth, Lomas et al. 2008).

This research brings together Sustainable Design and human-computer interaction (HCI), with the intention to evaluate the role that HCI plays in promoting sustainable behaviours. The design of products and services can influence how we behave and ultimately contribute to minimizing the negative environmental impact of energy consumption (Lilley, Lofthouse et al. 2005, Lockton, Harrison et al. 2010). HCI was introduced into the research design for evaluating the relationship between users and appliances mediated by information-communication technology (ICT) applications designed specifically to influence energy consumption (DiSalvo, Sengers et al. 2010, Goodman 2009). The possibility to leverage HCI to motivate sustainable behaviour is positioned in the context of domestic energy use, to evaluate the opportunity of influencing people to use less energy whilst dealing with the existing appliances. The main proposition made as a starting point for this research is that it is possible to design effective and acceptable behaviour change interventions in order to motivate people to use less energy.

1.2 People's behaviours

Occupant behaviours play an important role on energy usage. Several studies demonstrate that user behaviour enormously influences the energy use for different household appliances and activities. These examples range from heating system management (Verhallen, Raaij 1981), dish washing (Berkholz, Stamminger et al. 2010, Fuss, Bornkessel et al. 2011, Elizondo, Lofthouse et al. 2011), laundry (Stamminger 2011), computer use (Chetty, Brush et al. 2009) and cold appliances use (Tang, Bhamra 2009).

The cost of energy can be a motivator for sustainable behaviour (Chetty, Tran et al. 2008). However, certain groups of people do not have this financial incentive. These comprise university students whose bills are included in the fees (Brewer, Lee et al. 2011), people living in areas where bills are only estimated (Darby 2006), residents of apartments in buildings that have one single master meter (Slavin, Wodarski et al. 1981) and people whose bills are paid by the government (McMakin, Malone et al. 2002), landlord (Levinson, Niemann 2004) or employers (Foster, Lawson et al. 2012). The lack of financial constraints poses significant challenges to the reduction of energy use but also creates opportunities to measure the effectiveness of interventions without the influence of financial incentive.

There is substantial work already done on strategies that can be implemented to change people's behaviours towards energy conservation. These strategies range from simple graphic reminders such as printed posters asking people to switch off lights (Sussman, Gifford 2011) to computational systems of higher complexity. Research often investigate the use of ICTs designed specifically to change people's attitudes and behaviours, and report different levels of success in promoting energy conservation. Feedback on energy use has been extensively covered in the literature. Since electricity itself is invisible most of the time consumers are not aware of how much they (and their homes) are consuming (Darby 2008, Yun 2009, Ueno, Sano et al. 2006, Darby 2001, Darby 2006).

Practical examples in the literature report the application of HCI-based interventions targeting energy saving (Blevis 2007, DiSalvo, Sengers et al. 2010). Recent studies have been able to promote conservation in different forms of domestic energy use. Examples include shower water usage displays to motivate use awareness and savings (Kappel, Grechenig 2009), shower time comparison (Laschke, Hassenzahl et al. 2011) or tap water usage (Arroyo, Bonanni et al. 2005). These studies make use of inherent features and possibilities of ICTs to convey the strategies that might motivate change.

Persuasive technology is a recent field focusing on the study of computers as tools, media and agents designed to change what people think and do (Fogg 2003). There are a number of examples demonstrating how persuasive technology can be used to promote sustainable practices using a range of strategies. These methods include for example websites (Aleahmad, Balakrishnan et al. 2008), online social networks (Foster, Blythe et al. 2010, Olsen, Kraft 2009, Mankoff, Matthews et al. 2007, Mankoff, Fussell et al. 2010), electronic games (Bång, Torstensson et al. 2006) and mobile phones (Gustafsson, Bång 2008, Bång, Svahn et al. 2009).

1.3 Intervention design

The evidence that user behaviours play an important role in energy consumption aligned with previous research on intervention methods designed to change people's behaviours indicates fruitful ways to promote sustainability. There are comprehensive behaviour theories that can be applied to understand energy consumption, notably the Theory of Reasoned Action (Fishbein, Ajzen 1975) and the Theory of Planned Behaviour, which are widely used and tested (Ajzen 1991, Fishbein, Ajzen 2010). In order to increase the chances of success, an intervention needs to be created with a broad understanding of the behaviour to be changed, and also the determinants of these behaviours (Uitdenbogerd, Egmond et al. 2007, Abrahamse, Steg et al. 2005, Jelsma, Knot 2002).

User Centred Design methods can contribute to further understanding how and why people use energy (Kuniavsky 2003, Sharp, Rogers et al. 2007), and this knowledge can inform the design of interventions to promote energy conservation. Fogg (2009, 2003) presents objective guidance on the design of interventions, which combined with the Persuasive Systems Design process (Oinas-Kukkonen, Harjumaa 2009) can contribute to the development of persuasive applications to change people's behaviours and promote sustainability. This information, together with general behaviour change techniques (De Young 1993), Design with Intent tools (Lockton, Harrison et al. 2010) and Design for Sustainable Behaviour strategies (Tang, Bhamra 2008) were used as inspiration for the development of the interventions presented during this research.

Previous research demonstrate the potential impact of mobile devices in promoting energy conservation (Gustafsson, Bång 2008, Bång, Svahn et al. 2009), but also indicate the need for more research in this field, especially regarding user acceptance and tolerance to the persuasive methods implemented (Lilley 2009). Literature reviews mention the need for more research on sustainable HCI, persuasive technology interventions (DiSalvo, Sengers et al. 2010, Goodman 2009, Blevis 2007) and success evaluation (Huang 2011, Steg, Vlek 2009, Silberman, Tomlinson 2010).

1.4 Scope of research

Among the diverse domestic appliances and situations of use that could be subject to research, cooking was the one chosen to be studied. The efficiency of the cooking activity is seldom subject to research, even though the amount of energy used for food preparation is highly influenced by people's behaviours. Cooking demands several interactions between users and appliances, the user is in close proximity during operation, and there are numerous energy saving behaviours that can be performed during the cooking activity (Wood, Newborough 2007). There are also diverse techniques that the user can apply in order to reduce the energy use, depending on the food prepared (Oberascher, Stamminger et al. 2011, Das, Subramanian et al. 2006, Wade, Hinnells et al. 1995).

It emerged during the initial phases of this research that participants rushed into the cooking tasks without much deliberation, consequently not following recommended preparation procedures and thus using more energy. Information gathered during the first studies also showed that participants' behaviours were partially motivated by the need to speed up the cooking process in order to reduce boredom and discomfort when they were waiting for the food to cook, consequently resulting in extra energy usage. This knowledge motivated the addition of the Flow Theory (Csikszentmihalyi 2000) into the design process. In a state of *flow* people are performing at their optimum, when challenges from the environment match personal capabilities, therefore boredom and anxiety are avoided. The designed intervention added strategies to employ time perception manipulation (Flaherty 2000) during cooking. It is believed that these strategies can minimize temporal tensions (Oulasvirta, Tamminen 2004) during activities that use energy. The notion of temporal tension is presented here as the relation between action and time, when task deadlines are faced with the current pace of work. The lack of time available to carry out the needed activities can make people rush and bring about anxiety. Conversely, when simply waiting, people might not have much to do during a timeframe, and it can cause boredom.

The diverse influences of energy use in the kitchen and the vast possibilities of savings prove to be interesting avenues for research. One of the purposes of this project is to increase the knowledge about behaviours and respective determinants related to cooking processes. Another motivation is the need for more research and evaluation of methods and strategies based on persuasive technology designed to change people's behaviours and promote energy saving. Finally, there is also demand for research applying and evaluating methods that manipulate time perceptions to reduce temporal tensions and furthermore reduce energy use.

During this research a persuasive application was designed to work as test bed for a set of techniques in the attempt to promote sustainable behaviour. Specific strategies to reduce temporal tensions during the performance of activities that use energy were also implemented. These strategies attempt to reduce anxiety and boredom during the cooking process by making people stretch their time during the preparation phase and also making time seems shorter during waiting. It was believed that manipulating perceptions of time it could bring about desirable behaviours. From the diverse instruments that could be implemented, a smartphone application was chosen as the form of presentation of the intervention to be tested.

1.5 Aim

The aim of this research is to design and evaluate an intervention that brings modification of time perceptions as one of the solutions to promote sustainable behaviours.

1.5.1 Objectives

Within this overall aim, specific objectives were developed, providing a breakdown of the main research aim. The specific objectives of this research are as follows:

- Examine the literature relating to using technology to promote behaviour change. This includes research within the following fields:
    - Household energy consumption, trends and indicators
    - Behaviour change theories and habit studies
    - The role of people's behaviours in domestic energy use

  - Existing frameworks and methodologies that guide the design of behaviour change interventions
  - Existing intervention strategies to change people's behaviours and reduce energy use
  - How design has previously been used to promote sustainable household appliance use
  - How HCI and Persuasive Technology are being used to promote sustainability
  - Ethical considerations when designing behaviour change interventions
- Selection of one specific domestic appliance (cooker) that presents good opportunities to investigate the relationship between the user and energy consumption
- Definition of a set of techniques related to cooking that can provide energy conservation
- Understanding of energy related behaviours among a target population and identification of the determinants of these behaviours in the context of cooking using electric cookers
- Identification of possible behaviour change interventions for energy saving taking in consideration:
  - Existing successful strategies and theory
  - Observed behaviours and correspondent determinants
  - Acceptance of a set of energy saving techniques
- Evaluation of which aspects of the proposed behaviour change interventions can be effective or not in the effort to change people's behaviours and reduce energy usage whilst cooking
- Understanding of the ideal features in a behaviour change intervention from the users' point of view
- Assessment of user acceptance and tolerance to the proposed behaviour change interventions
- Explanation of the reasons why the aspects of the proposed interventions were effective and accepted or not
- Definition of guidelines to contribute to the knowledge base of behaviour change intervention design, to facilitate future designs targeting energy conservation

1.6 Research questions

The following research questions are to be answered during the course of this PhD:

1. What is the current background of research related to energy use, and how does it indicate possible strategies to guide the design of behaviour change interventions?
2. What are the key energy related behaviours and what are the determinants of these behaviours associated with cooking?
3. What is the acceptance of a set of energy saving techniques for cooking among the target population?
4. How can the knowledge of user behaviours inform the design of new interventions to reduce electricity consumption while cooking?
5. What is the role of persuasive technology and time perception manipulation in changing people's behaviours and reducing energy usage in the cooking context?
6. How can this knowledge contribute to the development of future HCI-based behaviour change interventions?

1.7 Approach to address the research questions

To answer these research questions, a range of methods were developed. An extensive literature review took place to answer the first research question. One study consisting of user observation, semi-structured interviews and energy monitoring was designed to address the second research question. One large scale survey was developed to address research question 3. Question 4 was answered analysing the results of the previous studies together with user-centred design methods involving scenario analysis and iterative design. The 5th question was resolved by testing a fully functional prototype via a specific study based on user observation, rating scales and interviews. The last research question is addressed in the conclusion chapter. The diagram below illustrates the main studies, inputs and outcomes.

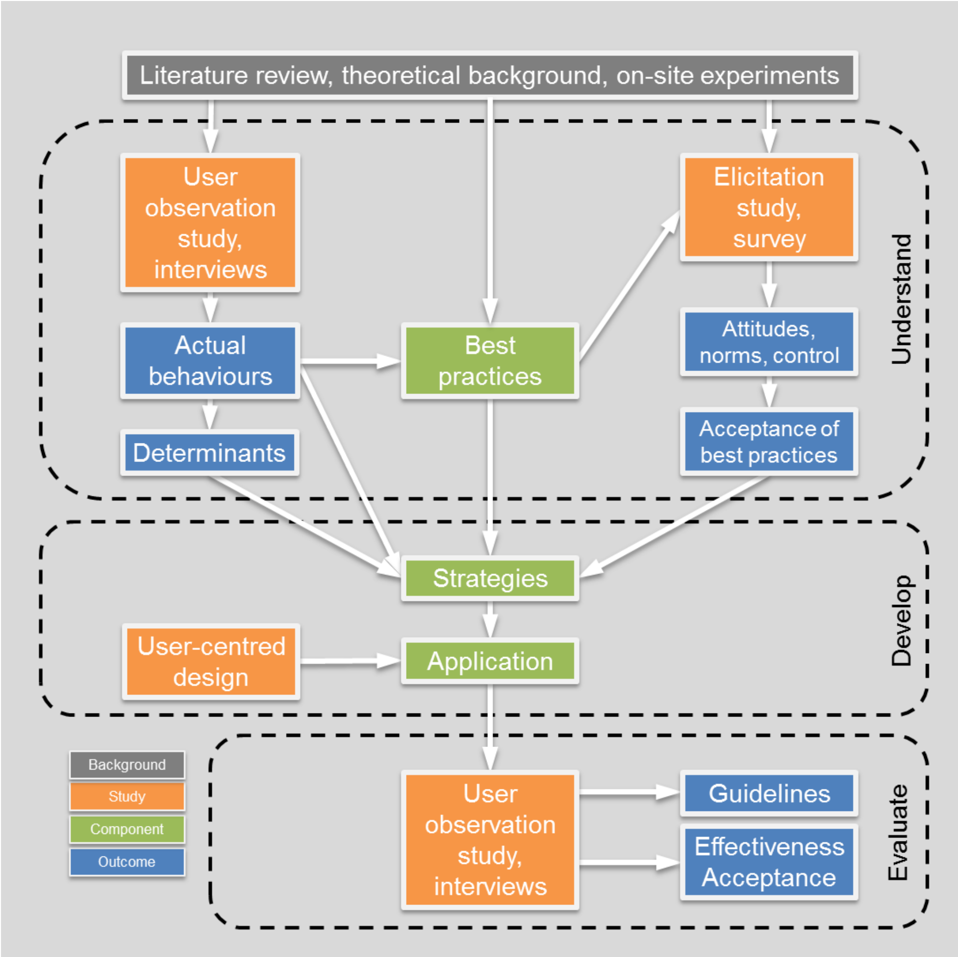


Figure 1 – Research diagram

Figure 1 indicates how the different elements of this research relate to each other. It shows the main studies performed during the course of this PhD, namely a user observation study followed by interviews, an elicitation study followed by a large scale survey, a user centred design study followed by the evaluation of the final application via another user observation study and interviews. Outcomes of the first phase of the research (Understanding) included the knowledge about students' actual behaviours for cooking linked to the respective determinants of these behaviours, and it motivated the definition of the best practices for cooking using less energy. Another outcome was the understanding of attitudes, perceived social norms and perceived behavioural control towards these best practices for cooking, and the possible acceptance of these propositions. During the intermediate phase (Develop) a set of strategies were developed into an application through a user-centred design process. The final phase of this research (Evaluate) had as outcomes general guidelines for the design of persuasive applications, and the evaluation of the effectiveness and acceptance of the proposed application in reducing temporal tensions and promoting energy saving.

2 Literature review

This chapter answers the first research question:

> ***RQ1: What is the current background of research related to energy use, and how does it indicate possible strategies to guide the design of behaviour change interventions?***

2.1 Introduction

This chapter presents the study performed to understand the state of research regarding the disciplines within this thesis. Figure 2 illustrates the literature review in a schematic way, demonstrating the main areas of knowledge that fed the work presented here. An interdisciplinary approach was necessary to cover the diverse literature that was needed to orient the studies performed during this PhD program.

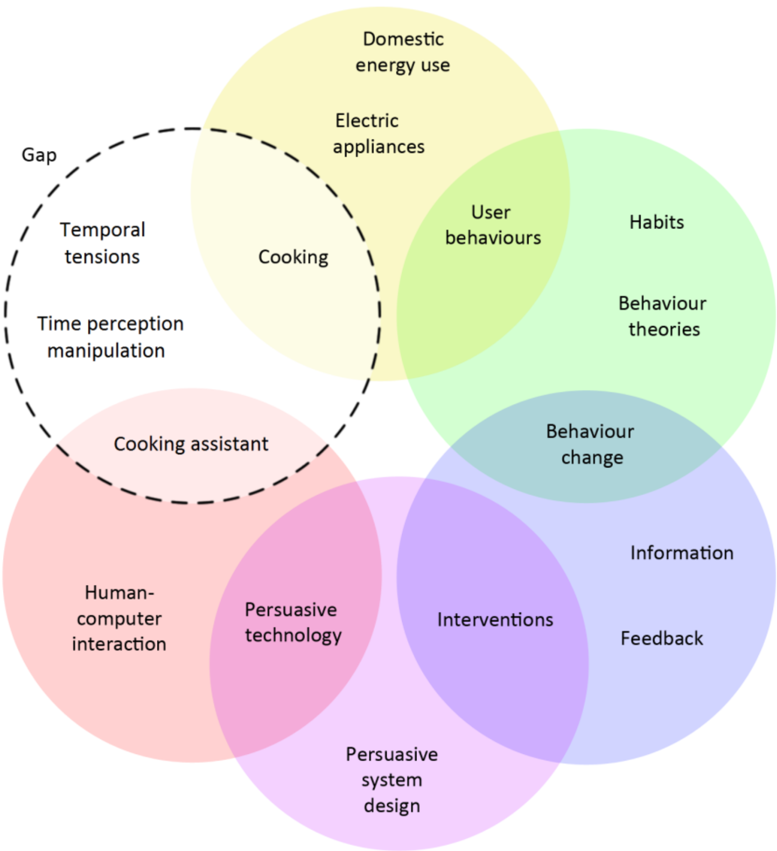


Figure 2 - Literature review diagram

Beginning from the top of the image, this chapter states the energy problem and positions the share of the domestic energy use in terms of carbon emissions. It then indicates the role of the built environment and people's behaviours in energy use. This section also presents the challenges to sustainability, and introduces some of the explanations of why this is a rather complex issue.

Clockwise on the diagram, the literature review continues listing behaviour theories and habit studies. The examples of research listed here include theories that predict and explain user behaviours. This topic overlaps with the domestic energy use behaviour, and continues with a description of studies that try to promote behaviour change.

The next section describes previous research on interventions that try to promote behaviour change towards sustainability in the domestic sector. It contains descriptions of studies on information in the form of feedback, energy monitoring and other technological approaches trying to motivate energy savings through behaviour change. This section has an emphasis on cooking devices since this was the appliance chosen as the scenario for research on behaviours and energy use.

From the analysis of intervention methods, the literature review leads to persuasive technologies, and how computers can change what people think and do. A practical approach is described by the review of persuasive system design methods. Examples of studies involving advanced intervention designs based on computational systems are listed and described.

A following section, focusing on human-computer interaction, discusses previous research that attempted to engage users into sustainable behaviours using electronic platforms such as standalone devices, computers or mobile phones. It also cites different previous research evaluating how technology can help improve different aspects of cooking activities.

This PhD research sits in the last circle in the diagram, where the dashed line indicates gaps in the literature. More research can be done to close the cycle, combining the 6 overlapping areas to contribute to the knowledge available. This literature review indicated that a cooking assistant could be designed and evaluated as one type of persuasive technology intervention to change behaviours and motivate people to use less energy whilst interacting with cooking appliances.

2.2 Energy problem

One of the main sources of CO_2 is energy production, and the carbon released into the atmosphere is contributing to make the planet warmer due to the greenhouse effect (Mann, Bradley et al. 1999, Crowley 2000). Human activities impose tough challenges to sustainability, and governments try to reach agreements on carbon emissions in the attempt to combat climate change (United Nations 1998, United Nations 2009). Countries often have programs targeting energy conservation in diverse fields such as greener generation and efficiency, often with limited success (Geller, Harrington et al. 2006).

The UK government has made commitments to reduce greenhouse gases, for example cutting 34% of UK emissions by 2020 (DECC 2009, DECC 2011), and considerable effort will be required to achieve them. Reports suggest that this figure should be at least 42% to have any real impact on climate change (Tyndall Centre for Climate Change Research 2009). By 2050 every building, domestic or business, should be carbon neutral (Boardman 2012). Meanwhile, the use of fossil fuels for electricity generation in the UK is increasing (DEFRA 2009), and coal, gas, oil and other fuels are responsible for about 80% of the total energy generation in the UK (DECC 2009), even though the UK government claims a more positive scenario on its Carbon Plan (HM Government 2011). One recent effort from the UK government in the attempt to reduce carbon emissions is the Green Deal project (DECC 2011). This scheme tries to reduce financial barriers by eliminating the initial costs of energy saving retrofits. Refurbishment of properties will be supported by the scheme via a loan, and the debt will be added to (hopefully reduced) gas and electricity bills. Studies show that predicted savings can be overestimated, and hard-to-treat dwellings and residences in fuel poverty are unlikely to be included (Booth, Choudhary 2013). The housing sector accounts for more than one third of the total energy use (DECC 2009). For that reason, any effort that reduces consumption within the domestic sector will have an important effect on the overall consumption, helping the whole country to decrease energy use and consequently reducing CO_2 emissions.

2.3 Sustainability

Sustainability can be defined as having a world "in which humans can survive without jeopardizing the continued survival of future generations of humans in a healthy environment" (Brown, Hanson et al. 1987). The original principle of sustainability grew from economic considerations, when humans faced serious environmental challenges. During the Middle Age the population increase led to overuse and depletion of the limited supply of timber in Central

Europe, causing an economic and ecologic crisis, and consequently the collapse of the population in the 14th century. The problem at that time was geographically contained, "and the measures to overtake the problem relatively simple". Sustainability today "extends its focus from a regionally and temporally limited challenge to a worldwide and long-term one" (Zink 2008). The challenges to promote sustainability are remarkable considering that the negative environmental consequences of human behaviours are difficult to visualize due to the geographical and temporal displacement of the effects (which may occur sometime in the future and in remote places on the planet). More recently, sustainability gained momentum thanks to Non-Governmental Organizations and increased awareness of consequences of resources usage. It encompasses issues such as trade justice, anti-globalization, activism, need for more legislation and corporate social responsibility (Bhamra, Lofthouse 2007).

One extreme outcome of resources usage in a reckless manner is the concept of "the tragedy of the commons". In a widely referred article published more than 40 years ago, Hardin (1968) explains that individuals seek to maximize their gains, and it ultimately results in the depletion of the resources available from common environments. He exemplifies the commons as a plot of land where herdsman can introduce their animals. This scenario represents the limited availability of resources, and there is no limit to the number of animals that one can put. The tragedy strikes when the oversized herd deplete the pasture, making the land uninhabitable. In a world of increasing population and limited natural resources, the tragedy of the commons is a constant threat. "Ruin is the destination toward which all men rush, each pursuing his own best interest in a society that believes in the freedom of the commons. Freedom in a commons brings ruin to all" (Hardin 1968). This rather pessimistic approach is criticized by subsequent research, which states that Hardin's work is determined by the "assumptions of open access, lack of constraints on individual behaviour, conditions in which demand exceeds supply and resource users who are incapable of altering the rules" (Feeny, Berkes et al. 1990). It is possible to limit the "tragedy" pictured in the herdsmen fable. Upon noticing declining yields, the herdsmen can meet and come up with regulations to impose limits to each other's behaviours. They can control access to the pasture, and define set of rules of conduct that effectively limits exploitation. Groups of users and local communities can organize and manage local resources effectively. Societies have the capacity to constrain the behaviour of individuals, mainly through norms, agreements and rules. In a global scale, the accumulation of carbon dioxide in the atmosphere is a global tragedy of the commons in the making. However, governments generally agree on co-management strategies of natural resources usage and pollutants production (United Nations 1998, United Nations 2009).

Dawes (1980) contributes to this debate when he introduces the Social Dilemma framework, which gravitates around "the three crucial problems of the modern world: resource depletion, pollution, and overpopulation" (Dawes 1980). He defines the two principles that characterize social dilemmas are (a) that each individual receives better payoffs for defecting behaviours than for cooperative behaviours, regardless of what the rest of the society members do, and (b) that all individuals in the society receive lower payoffs if all of them behave defectively than if all cooperate. Campaigns often advertise the best practice of turning the thermostat down in order to reduce the usage of gas and consequently reducing carbon emissions. Individuals who follow this suggestion will have colder houses, and the individual who choose to ignore this advice will enjoy the comfort of a warm house. In this scenario, the warm household receives the payoff in the shape of a comfortable house. But if all houses abuse the energy supply, the pollution levels, fuel shortage and greenhouse effect will bring serious problems in the future. The same applies to other measures such as replacing light bulbs for energy efficient ones. They are more efficient and last longer, but people's opinions are relatively negative towards these lights (Chetty, Tran et al. 2008). Whoever installs these bulbs suffers these drawbacks, whereas others can enjoy warm lights. In short, if everyone contributes, all benefit. If everyone exploits, all suffer. If just one abuses the resource provision whilst others conserve, this *free rider* individual will enjoy the benefits possibly without suffering the negative environmental consequences of his or her behaviour, and also escape social consequences as long as the behaviour remains in anonymity (Dawes 1980). If there's no evidence that other members of the group are also cooperating, individuals feel demotivated to act in ways that benefit the whole group, especially if it demands self-sacrifice (Göckeritz, Schultz et al. 2010).

This brief overview of the problems facing sustainability presented the challenges that motivated the development of this PhD. Humankind needs to find ways to achieve a sustainable future. However, given the scale of the problem it seems a daunting task. Difficulties are found in individual, societal and global scales in the attempt to tackle a problem that humans themselves caused. These challenges indicate the need for the development of innovative strategies, even if small scale, domain-specific, to somehow reduce the impact that humans cause in the environment.

2.4 User behaviours

2.4.1 Behaviour theories

Human behaviours are generally complex and are determined by diverse factors such as demographic variables, personality characteristics, situational and domain-specific factors related to the behaviour under investigation. However, Fishbein and Ajzen (2010) argue that "people approach different kinds of behaviour in much the same way and that the same limited set of constructs can be applied to predict and understand any behaviour of interest". Icek Ajzen and Martin Fishbein, in the 1970s, started to measure how attitudes and social norms can influence intentions and consequently determine behaviours (Fishbein, Ajzen 2010). They formulated the Theory of Reasoned Action (TRA), an influential approach that measures attitudes, normative influence and intentions in order to predict behaviours (Fishbein, Ajzen 1975), and it forms the base of several other behaviour theories used today, applicable to numerous behavioural contexts.

From the 1980's onwards Ajzen added another element to the TRA: other than an individual's attitudes and social norms, external factors might also contribute to the capacity or autonomy to perform behaviours. He proposed the Theory of Planned Behaviour (TPB) and it states that when people are confronted with a situation when they have to decide a course of action, they consider the consequences of available alternatives, weigh the normative expectations of reference individuals or groups and they also consider required resources and impediments or obstacles. According to his model, intentions precede behaviours, and these intentions "can be predicted with high accuracy from attitudes toward the behaviour, subjective norms, and perceived behavioural control" (Ajzen 1991). These three aspects combined can be strong predictors of behaviours (Kaiser, Hübner et al. 2005). This understanding can allow the "disentangling of psychological and nonpsychological influences on individual behaviour" (Kaiser, Wölfing et al. 1999) and scrutinize the predictive power of diverse influences on behaviours. Schwartz (in   Bamberg, Schmidt 2003) describes the Norm Activation Model (NAM), where moral obligations are the determinants of people's behaviours. People have to be aware of the consequences of the behaviours and also feel some responsibility for these consequences in order to behave in a more sustainable way. Another theory to explain and predict environmentally significant behaviour is the Value-Beliefs Norm (VBN) (Stern 2000). This theory relates to the previous TPB and NAM comprising attitudinal factors, contextual forces (including interpersonal influence, community expectations, regulations, costs, equipment and technology), personal capabilities and include the element of habit and routine to explain environmentally significant behaviour. Habits are important determinants of behaviours (Ouellette, Wood 1998), and projects that intend to change people's behaviours and promote sustainable consumption must consider ways to break or create new consumer habits (Verplanken, Wood 2006).

Fishbein and Ajzen present in their recent joint book the developments of the TRA and the TPB into a more definite version, named Reasoned Action Approach (RAA) (Fishbein, Ajzen 2010). This framework follows the same structure as the TPB but adds the background factors as antecedents of the theory's three constructs: behavioural beliefs, normative beliefs and control beliefs. These background factors are social, individual and informational aspects. Another addition is the consideration of skills, abilities and environmental factors influencing the actual control level that the individual has.

More recently, Klöckner and Blöbaum (2010) developed the Comprehensive Action Determination Model (CADM) to explain ecological behaviour. In the attempt to create an integrated framework, they proposed a development from the TPB and NAM and added a more complex measurement of perceived control, including objective and perceived (or *ipsastive*) situational constraints and opportunities. CADM proved to have a higher explanatory power than TPB or NAM to predict travel mode choices, but more research is needed to apply this model into other fields of energy use, and there is also the need to validate it with bigger datasets (Klöckner, Blöbaum 2010). One comprehensive research project on the relation between environmental attitudes and behaviour demonstrated that knowledge and values are significant preconditions of intention. About 40% of the variance of ecological behaviour intention was explained by environmental knowledge and environmental values (Kaiser, Wölfing et al. 1999). Rational or economic views of human activities are often prone to criticism. Decision making processes and human reasoning can be complex, and people do not always have all the information they need at hand (Simon 2000). The Transtheoretical Model of behaviour change adds to the complexity by arguing that new patterns of behaviour come as a process through different stages, and different people are in different stages of readiness to change (He, Greenberg et al. 2010).

The fitness of different behaviour theories in predicting behaviour is the subject of a number comparative studies (Bamberg, Schmidt 2003, Kaiser, Hübner et al. 2005, Armitage, Conner 2001), and TPB often presents a stronger explanatory power than other behaviour theories. However, since there is no consensus about the universality of these theories, the selection of the model of choice should take in consideration the suitability of the theory of choice. TPB has been applied to a number of studies on user behaviour and sustainiability, for example to evaluate determinants of domestic energy use (Gill, Tierney et al. 2010), understand recycling habits (Nigbur, Lyons et al. 2010), assess how beliefs influence kerbside recycling (Tonglet, Phillips et al. 2004), investigate sustainable transportation choices among students (Bamberg, Schmidt 2003) and analyse barriers to energy conservation at universities (Stokes, Mildenberger et al. 2012).

2.4.2 Habits

Human consumption of products and resources is linked to social conventions and habits. These activities are generally resource intensive, meaning that preservation of natural resources will have to count on a significant change in consumption behaviours (Shove 2005). Often, behaviours are performed in an automated way, causing them to be carried out without much deliberation. At this point, it is possible to say that this behaviour was transformed into a habit (Ouellette, Wood 1998). More than just the repetition (or past behaviour frequency), it is necessary that the individual respond automatically to certain cues from the environment (Verplanken, Orbell 2003). A cue-response mechanism is created, and the respective action is trigged quickly. These cues are present in the environment, and one way to avoid the automated responses is to provoke or make use of changes in the environment: "the dependence of habits on environmental cues represents an important point of vulnerability" (Verplanken, Wood 2006). Behaviour change interventions can be more successful if they are targeted to break old habits and form new ones. It can be applied during natural occurring periods of change in lives, for example when moving to a new location or changing jobs. Also, the intervention can be designed to change context cues that trigger existing habits, promote incentives and intentions that encourage new actions, and incentive the repetition of new actions in order to form new desired habits (Verplanken, Wood 2006).

2.5 Domestic energy use and behaviours

In the attempt to reduce energy use in the domestic sector, there are two main actions that can be performed, namely increasing energy efficiency or promoting curtailment (Attari, DeKay et al. 2010). However, efficiency improvements often involve large expenditures (Brandon, Lewis 1999, Parnell, Larsen 2005) or are obstructed by dwelling type (Wood, Newborough 2003) or occupation characteristics (Levinson, Niemann 2004). A recent study claims that "user practices are at least as important as the efficiency of technology when explaining households' energy consumption", and both efficiency and practices have to be included in energy demand reduction policies (Gram-Hanssen 2011). One study on awareness campaign evaluation reported the impact of physical efficiency measures (such as home insulation) and behaviour change measures (for example keeping lids on pans, turning the thermostat down, only using the washing machine when having a full load). Results show that people changed their behaviours much more frequently than performed physical interventions, meaning that behaviour change caused estimated reductions in CO_2 emissions more than 10 times bigger than physical efficiency measures (Murray 2010).

Technological advancements have allowed appliances to become highly efficient. For example, refrigerator and freezer improvements meant that the European Union Energy Label system have had to create three additional classes (A+, A++, and A+++) to the original classification to follow the technological progress (EU 2010). However, this pattern of improvement is not shared by all lines of appliances, and owning efficient appliances does not necessarily mean that people will use less energy. Even when living in low energy houses, inhabitants can behave in a non-efficient way (Crosbie, Baker 2010). Considering the constraints involved with retrofit and the challenges related to replacing appliances with newer and efficient versions, focus on people's behaviours represents a less expensive and more feasible a way to reduce energy demand.

Understanding energy demand in the domestic sector can provide insights into how to promote reductions in expenditure (Mansouri, Newborough et al. 1996, Newborough, Augood 1999). Sometimes people who indicate that they behave pro-environmentally do not necessarily use less energy (Gatersleben, Steg et al. 2002), and diverse demographic, external and internal factors shape how people behave (Kollmuss, Agyeman 2002). "The decision to behave in a certain way towards energy use is informed by a range of internal and external factors" (Faiers, Cook et al. 2007). People's behaviours should be considered not as isolated actions but as activities inserted into social contexts, in view of interactions with others and with the environment.

2.5.1 Information

UK households are currently exposed to several campaigns trying to motivate people to use less energy. These measures take many different forms from leaflets to metering systems. The Energy Performance Certificate (EPC), similar to the labels used on fridge doors and on new cars, displays building energy efficiency and includes a recommendation report, providing information about ways to improve the energy performance of the property. Research has shown that this information often fails to persuade householders to adopt energy saving measures (McGilligan, de Wilde et al. 2008) and needs to be improved before it stimulates significant behaviour change (Parnell, Larsen 2005). A new proposal from the government suggests a few modifications on this information sheet in order to make it more meaningful to the user, since consumers found the EPC relatively difficult to interpret (Cabinet Office 2011).

One possible media to deliver information to consumers is through energy bills. However, these documents would require improvements in its form and content in order to deliver the information that people need (Henryson, Håkansson et al. 2000). Some domestic electricity consumers receive their bills quarterly, making it difficult to keep track of the expenditure or relate their past behaviour to actual figures on the bill. "Infrequent energy bills and energy reports mean that, in the majority of UK homes, domestic consumers have little way of knowing which of their everyday behaviours contributes most to their energy bills" (Cabinet Office 2011). Often the supplier does not actually read the meter but simply sends the bill containing an estimated value based on past readings or a standard rate. People therefore may not know what to do to save energy, and feel powerless to act on the information given. They rarely link energy use to specific appliances, services or more importantly, behaviours and practices.

Electricity bills can be more informative, but it requires a more efficient metering system. In the attempt to solve these problems, the government proposed the installation of smart meters in every dwelling in the UK (DECC 2011). These electricity meters can read the consumption automatically and send it to the supplier in regular intervals. This can facilitate data gathering by the suppliers and will reduce the problems that estimated bills cause. The project defends that "consumers will be able to engage with an in-home display which will provide real-time feedback on the effect of their behaviour on energy consumption and will support other forms of feedback and advice" (Cabinet Office 2011). However, completion of the smart meter roll-out is not due until 2019 (DECC 2011).

2.5.2 Appliances and user behaviour

The role of behaviour in domestic energy use is often the subject of research focusing on different appliances. Verhallen and Raaij (1981) presented a study of the energy used for home heating, showing that occupant behaviours explain 26% of the variance of energy use. They demonstrated that levels of awareness, commitment to energy saving measures and personal preferences vary enormously from one person to another (Verhallen, Raaij 1981). One study on washing up methods showed that people behave in diverse ways, and on average use more detergent, water, energy and time than a regular dishwasher, and the plates are usually less clean when people do the dishes by hand (Berkholz, Stamminger et al. 2010). But when a set of 'best practice tips' were given to consumers as instructions, they "used around 60% less water, 70% less energy and 30% less detergent compared with the average everyday behaviour the other subjects used. Additionally, they achieved a slightly better cleaning result" (Fuss, Bornkessel et al. 2011). Cultural differences showed to be an important factor on user behaviours for dish washing, influencing water and detergent usage (Elizondo, Lofthouse et al. 2011, Elizondo, Lofthouse 2010). Laundry and dish washing energy use was reported to be highly influenced by lifestyles, and "results show a variation of a factor of five between a more sustainable and a more careless behaviour" (Stamminger 2011). Cold appliances use also provided an interesting platform for the study of human behaviours. Video evidence shows that families have particular ways of storing and retrieving food from the fridge, and the frequency and length of interactions with the appliance can affect the energy consumption (Tang, Bhamra 2009, Tang, Bhamra 2012). One user observation study demonstrated that people perform their daily activities with a high level of interaction with kitchen appliances, sometimes causing unnecessary energy usage (Elias, Dekoninck et al. 2008).

One thorough case study performed by Gill and colleagues (2010) involved evaluations of the energy performance of low-energy houses together with behavioural survey, interviews and measurements of satisfaction and comfort of occupants. Their results showed significant variation of electricity use, with the highest consumer using 2.8 times the amount used by the most efficient residence. The conclusion is that behaviour accounts for around 37% of electricity consumption, even between neighbours living in similar houses with similar appliances. Remarkable variations in energy use were also observed during a study of flats with the same number of residents, comparable built infrastructure and fixed appliances, occupied by students of roughly the same age, similar study and work schedule: some units used almost three times the electricity of other similar apartments. They conclude that "the way occupants inhabit their apartments is a significant source of variation" (Morley, Hazas 2011). To sum up, numerous studies can be found demonstrating the role of behaviours in electricity, gas and water consumption, even people using the same appliances, performing the same tasks or using the same infrastructure (Gill, Tierney et al. 2010).

2.5.2.1 Cookers

A recent survey of 251 households in England reports that cooking activity accounts for 13.8% of the overall domestic electrical power demand (DEFRA 2012). One French investigation found similar figures: combined cooking related energy consumption accounted for 14% of the total electricity usage from the 100 households surveyed (Sidler, Waide et al. 2000).

The energy consumption of all hobs in the UK is estimated at 4.8TWh/year from gas and 3.2 TWh/year from electric devices, and it is believed that the energy consumption will gradually rise due to increases in number of households (DEFRA 2009). Approximately 55% of households have a gas hob, and 45% use electric (DEFRA 2009), and the stock of electric cookers is estimated in 12 million units (EC 2011).

Energy use monitoring demonstrates that cooking activity can contribute to the concentration of electrical load during specific periods of the day (Newborough, Augood 1999). Generally, the aggregate electricity demand associated across the use of hobs, grills, ovens and kettle last for about 5 minutes on average. However, "[e]lectric cooking creates the greatest peak demands of any single domestic activity" (Newborough, Augood 1999). These peaks happen during the time of the day when there is already coincident demand of electricity (DEFRA 2012). Figure 3 below illustrate how concentrated cooking activities at 5:00 pm lead the way through the evening peak electricity demand, which put tension on the generation and distribution grid.

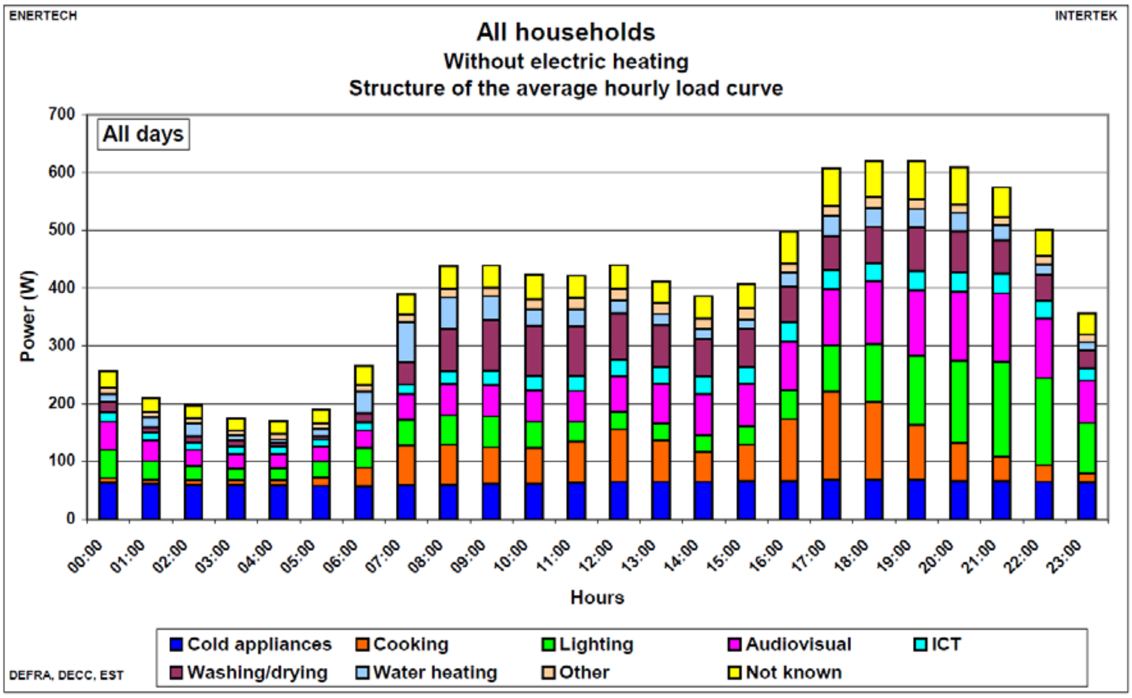


Figure 3 - Electricity consumption - Hourly load curve (DEFRA 2012)

The energy effectiveness of cooking appliances attracts little attention, and developments in cooker design have been concerned mainly with making the appliances easier to use and clean, improving their appearances and reducing cooking time, which generally increases the electricity load (Probert, Newborough 1985). Since modern cookers can use even more electricity than old models of same technology, their replacement is not included in recommendations by government campaigns due to the lack of potential savings (DEFRA 2012). In addition, historical data of cooking appliances shows that "limited improvements in efficiency have been offset by an increasing number of households" (Wade, Hinnells et al. 1995).

Different studies report that conventional electric resistance cookers use more energy than induction and ceramic hobs (Sidler, Waide et al. 2000, Newborough, Probert et al. 1990). These hobs take more time to heat and also present more thermal hazards than halogen or induction hobs (Newborough, Probert et al. 1990). For example, a coil hob (or radiant ring) is "capable of more precise temperature control and, being of smaller mass, heats up more rapidly than the comparable size hot-plate" (Probert, Newborough 1985). However, considering only the financial aspect, updating to modern technology such as induction hobs is not a worthwhile option compared to resistance hobs. One study shows that taking in consideration the prices of induction cookers, the average usage and the stand-by energy consumption, the payback time might be as long as 282 years (Sidler, Waide et al. 2000). This indicates that households have low motivation to own more efficient cookers, since better technology comes with higher costs. Buyers rarely take into account energy consumed during products lifecycle, and installations are often chosen on the basis of the lowest quote (EC 2011). Furthermore, the replacement of cooking appliances occurs rather slowly, given that the average life for a free-standing cooker is about 15 years (Probert, Newborough 1985) or even 20 years according to various sources (EC 2011). Those might be the explanations for the modest market penetration of induction hobs: a report from the European Commission estimates that they represent less than 1% of the stock of domestic hobs in the UK (EC 2011).

2.5.2.2 The cooking activity

The cooking activity demands several interactions between users and appliances. As described by Wood and Newborough (2007), the user is next to the appliance during energy consumption, and the consumption is highly influenced by this interaction (as opposed to boilers or fridges which use energy in the background). Furthermore, there are numerous energy saving behaviours that can be performed during the cooking activity. Consequently, people's behaviours play an important role in energy consumption.

Caraher et al. (1999) performed extensive studies on the relationship between cooking and skills among the English population. They established that there are considerable variations in knowledge about how to cook. Their results point towards "a population unsure of specific cooking techniques and lacking in confidence to apply techniques and cook certain foods". DeMerchant (1997) observed how people cook one specific menu and concluded that participants' behaviours partially explained energy usage. She noticed subjects pre-heating the cookware, using high heat, leaving the heat source on after cooking was completed and not controlling the temperature adequately.

Previous research on cooking methods presents a few examples on how to prepare food more efficiently. When it involves boiling, there are several techniques that can be performed and reduce significantly the energy use, time to prepare and even water needed (Das, Subramanian et al. 2006). These involve, for example, pre-soaking grains, fine-controlling the temperature and using a pressure cooker. Heat is needed in order to cook food, make it soft, taste better and be safe for consumption. However, the water can be below 100º C (consequently requiring less energy) and still cook most foods such as vegetables, grains and beans (Potter, Ruhlman 2010, McGee 2004). Experiments performed by Oberascher et al. (2011) indicate that it is possible to improve the efficiency of cooking if people switch between stove, kettle, microwave and other appliances according to the quantity of food that is being prepared. The possible savings from these techniques indicate that "[p]roviding information to users on ways to cook efficiently is thought to be worthwhile and to have a greater impact on energy consumption than improvements in design" (EC 2011).

This section presented diverse issues related to energy use for cooking activity. These comprise the lack of efficiency improvements of traditional cookers in recent years, slow replacement of old appliances, prohibitive prices of more efficient technologies, problems related to peak electricity consumption, role of people's behaviours in consumption, people's lack of cooking skills, and the amount of energy that can be saved by performing a number of techniques targeting energy saving. These issues indicate that there is room for improvement and also suggest an avenue for further investigation on ways to reduce energy consumption in the kitchen. By selecting cooking behaviours as the object, this research is targeting an area with high potential for environmental improvement.

2.5.3 Interventions

The concept of intervention is widely used in psychology, counselling and health services (Bartholomew, Parcel et al. 2001). For the purpose of this thesis, intervention is defined as an effort to promote good behaviour in general, as to steer specific behaviours for people to perform. Interventions are also frequently used to promote sustainable behaviour, using different methods and having different levels of success (Uitdenbogerd, Egmond et al. 2007, Abrahamse, Steg et al. 2005).

It is recommended that a thorough and interdisciplinary understanding should take place prior to any strategy aimed at change (Owens, Driffill 2008). However, it is not always the case that researchers and program developers take care of understanding behaviours and determinants. "Policies designed to promote sustainable consumption are generally founded upon an extraordinarily narrow understanding of human behaviour" (Shove 2005). Interventions can be more effective if there is systematic planning, implementation and evaluation. Key issues to be addressed include identification of the behaviour to be changed and examination of the main factors underlying this behaviour (Steg, Vlek 2009). Two extensive literature reviews on energy-related intervention studies indicate that it is possible to increase the effectiveness of an intervention by targeting the determinants of energy use (Uitdenbogerd, Egmond et al. 2007, Abrahamse, Steg et al. 2005). It is necessary to identify behaviours that significantly contribute to environmental problems, and also examine factors that make these sustainable behaviour patterns unattractive, such as motivations, opportunities, and perceived abilities. In order to overcome the barriers to sustainable behaviour, it is first necessary to identify and evaluate how strong these barriers are, to evaluate the role they play on the unsustainable behaviour, and then develop specific strategies to tackle these barriers. It is recommended "a stronger focus on the behaviour of target groups and their determinants and that interventions be based on a more systematic problem-oriented approach" (Uitdenbogerd, Egmond et al. 2007).

The literature provides numerous design frameworks and protocols to help the development of intervention methods. It is common for these guides to have a few distinctive phases to explore behaviours, create design interventions and then evaluate the outcomes (Selvefors, Pedersen et al. 2011) . One widely used is the Intervention Mapping Protocol (IMP), with which researchers can guide the procedures of planning activities and methods for change (Kok, Lo et al. 2011, Bartholomew, Parcel et al. 2001, Uitdenbogerd, Egmond et al. 2007). The IMP consists of the following steps:

1. Problem analysis, with an analysis of energy relevant behaviour, the determinants and context factors;
2. Choose specific behaviours, determinants and target groups, resulting in program objectives;
3. Select theory- and evidence-based methods and practical techniques;
4. Develop the programme;
5. Make an implementation plan;
6. Make an evaluation-plan.

Every time people are subject to a behaviour change intervention there is possibility of a negative reactance: people can feel that their behavioural freedom is being lost or threatened, and consequently do the opposite of what was asked (Brehm 1966). Also, the rebound effect should be considered, when parts of the reductions in energy use are lost due to new wasteful behaviours (Greening, Greene et al. 2000). An intervention should point people to new behaviours that represent advantages to them, and not make them feel that they need to compensate somehow.

2.6 Persuasive technology and HCI

Persuasion can be defined as the process aiming at changing a person's or a group's attitudes or behaviours by using communication to convey information, feelings, or reasoning, or a combination of them[1]. The concept of rhetoric, from Aristotle's classic work, is central for persuasion since it is with the delivering of the communication that persuasion takes place: "persuasion is produced by the speech itself" (Aristotle 2012).

It is common to associate persuasion and rhetoric with psychologists, lawyers and marketers. Designers of HCI systems can also include persuasion in the technology they are developing. Persuasive technology describes a field where computational systems induce transformation of either attitudes or behaviours (Oinas-Kukkonen, Harjumaa 2009). Persuasive technologies can be used to increase energy use awareness, change people's behaviour and motivate them to commit to more environmentally friendly actions (Fogg 2003).

Well-designed technical environments or systems have a great potential for supporting environmentally sustainable behaviour (Midden, Kaiser et al. 2007). A number of studies evaluate this role of technology as promoter of sustainability using different methods. This new field of research, positioned between sustainable design, persuasive technology and HCI is referred with diverse labels such as Sustainable Interaction Design (Blevis 2007), Environmental HCI (Goodman 2009) or Sustainable HCI (DiSalvo, Sengers et al. 2010, Silberman, Tomlinson 2010, Huang 2011). Independently of the nomenclature, there is need for more research on the use of technology for behaviour change (DiSalvo, Sengers et al. 2010, Goodman 2009, Blevis 2007) and success evaluation (Huang 2011, Steg, Vlek 2009, Silberman, Tomlinson 2010).

Fogg published in 2003 his ground breaking book on Persuasive Technology, introducing a vast collection of ways to use computers in order to change what we think and do. He presents how computers can work as tools, media and social actors delivering behaviour and attitude change, and lists several examples in each of these categories (Table 1). The Persuasive Systems Design (Oinas-Kukkonen, Harjumaa 2009) is one of the guides available for developing behaviour change interventions using technology. It describes the steps for creating interventions and also presents a list of 28 design principles (Table 2) which can be implemented with technology, with examples of application. Some of these principles are widely used, for example *reduction* (when the system simplifies a complex task, making it

[1] http://www.businessdictionary.com/definition/persuasion.html

easier for the user to perform the desired behaviour) or *tunnelling* (when the system guide the user through a process in sequence).

Table 1 - Persuasive Technology triad (Fogg 2003)

Tools	Media	Social Actors
Increases capability	**Provides experience**	**Creates relationship**
A tool can be persuasive by making target behaviour easier to do, leading people through a process or performing calculations or measurements that motivate	A medium can be persuasive by allowing people to explore cause-and-effect relationships, providing people with vicarious experiences to motivate and helping people rehearse a behaviour	A social actor can be persuasive by rewarding people with positive feedback, modelling a target behaviour or attitude and providing social support
• Reduction • Tunnelling • Tailoring • Suggestion • Self-monitoring • Surveillance • Conditioning	• Simulated cause-and-effect scenarios • Simulated environments • Simulated objects	• Physical cues • Psychological cues • Language • Social dynamics • Social rules

Table 2 - Persuasive System Design (Oinas-Kukkonen & Harjumaa, 2009)

Primary task support	Dialogue support	System credibility support	Social support
Supports the carrying out of the user's primary task	Provides some degree of system feedback to its users	Describes how to design a more credible system	Shows behaviour performances to raise awareness
• Reduction • Tunnelling • Tailoring • Personalization • Self-monitoring • Simulation • Rehearsal	• Praise • Rewards • Reminders • Suggestion • Similarity • Liking • Social role	• Trustworthiness • Expertise • Surface credibility • Real-world feel • Authority • Third-party endorsements • Verifiability	• Social learning • Social comparison • Normative influence • Social facilitation • Cooperation • Competition • Recognition

Another comprehensive list of persuasive design principles can be found on The Design with Intent Model (Lockton, Harrison et al. 2010). They developed 101 cards (Lockton 2011) with patterns for influencing user behaviour through design in different categories, for example the *architecture lens* (influences user behaviour through the design of the environment), *errorproofing* (eliminating or reducing the chances of user making errors) and the *cognitive lens* (for situation where users make poor decisions, the design of the system can help indicating better choices).

Figure 4 - Architecture lens example #13: Simplicity (Lockton, 2011)

2.6.1 Feedback

The government promised to introduce smart meters for every dwelling in the UK and to "effectively complete the rollout in 2019" (DECC 2011). However, having smart meters does not make the consumer aware of the overall energy consumption, let alone the usage associated with particular appliance or practices. It is necessary to present the energy consumption in a meaningful way to the user. Several studies show that feedback can play an important role helping people save energy (Darby 2006, Darby 2001, Anderson, White 2009, Yun 2009). Since most of the time consumers are not aware of how much electricity they are spending, energy monitors are being introduced to show the consumption in real time. These devices, also known as ‘smart displays’, can allow people to view the energy expenditure on a screen. They often consist of a sensor attached to the mains and a wireless display that can be put in a convenient place. One of the problems with those devices is that most of these displays were not designed using a user-centred approach, so they lack usability and do not deliver the information in a meaningful way (Anderson, White 2009). Households may be resistant to installing these devices as there is an initial cost and some provide online features which require monthly payments. Most monitors show the consumption for the entire house making it difficult to know the consumption of one specific appliance or understand how specific behaviours influence consumption. Another issue is that the consumer needs to interact with the smart monitor repeatedly in order to learn how much electricity each appliance uses and consequently discover how consumption can be reduced over time. Consumers want these displays showing information with more detail and data that is “more closely linked to consumption actions” (Fischer 2008). It is recommended that the energy use information is displayed clearly, especially in households with low literacy levels. The display of energy saving devices should be more inclusive, with texts, graphics and interactive features “easily read, readily accessible and easily manipulated by a wide range of prospective users” (Lilley, Bhramra et al. 2009).

One application of persuasive technology is the visualization of energy use in an indirect way. Ambient displays can give consumption feedback without interfering with the primary task. Examples include iconic representation of a coral reef that goes from grey to colourful and healthy, according to computer idle time (Kim, Hong et al. 2010), a LCD-display picturing a tree, where “modest electricity consumption results in a thriving fast growing plant and heavy consumption makes the plant wither” (Broms, Bång et al. 2009), a shower fitted with LEDs that makes progressively visible the quantity of water consumed (Kappel, Grechenig 2009) or a sink tap add-on that allows visualization of water consumption and comparison with other users (Arroyo, Bonanni et al. 2005).

2.6.2 Websites

Websites have been used as platforms to convey and understand the influence of persuasive strategies. One study designed two comparative websites displaying direct persuasion or indirect messages to assess attitudes and actual behaviours (Aleahmad, Balakrishnan et al. 2008). They evaluated the frequency of sustainable choices by measuring how often users selected responsible sourced seafood ingredients for a recipe when using each of the sites. Social networking sites can provide a platform for testing the role of technology in motivating energy saving. The Internet is a popular and potentially powerful medium for motivating change, especially if projects leverage "websites that people already visit frequently for other purposes" (Mankoff, Matthews et al. 2007). *Whatsupp* integrated energy monitoring with Facebook, making the information on personal consumption public to participants' friends (Foster, Blythe et al. 2010). Sharing individual's energy consumption proved to encourage conservation behaviour among the *experiment condition* population. *Stepgreen.org* evaluates the effectiveness of using public commitment, competition, group participation, feedback and goal setting. A social network website was built to encourage participants to share their goals and comment on each other's commitments. Results "suggested that motivating factors like public commitment and competition are effective, and better leveraging these factors will likely lead to even greater appeal and effectiveness" (Mankoff, Fussell et al. 2010).

Other sources of information that claim to promote sustainable behaviour are the online carbon calculators. Websites provide ecological footprint indices that estimate the impact of an individual on the planet's resources. Users enter their lifestyles into different fields relating to transportation ("how often do you take a long haul flight?"), domestic behaviours ("how often do you take a bath?") and so on. However, one study demonstrates that most online carbon calculators suggest ecological damage irrespective of consumer behaviour and ecofriendliness, and that it "could potentially have the opposite of the intended effect and discourage consumers from improving their behaviour further" (Franz, Papyrakis 2011).

2.6.3 Mobile phones

Mobile phones can also work as a platform for persuasive interventions. One group of researchers demonstrated that a phone application can encourage people to engage in more healthily physical activities (Consolvo, McDonald et al. 2009). They developed the *UbiFit Garden* software that required self-reporting and uses the screen background of a mobile phone to display a garden that blooms as the user performs physical activities throughout the week. Upon meeting weekly goals, butterflies and flowers appear (Figure 5). Most of the participants managed to improve their activity levels while using the application. Gustafsson and Bång (2008) developed the *Power Agent,* a pervasive mobile game aiming at encouraging behaviour change amongst Swedish teenagers. They were challenged to reduce the electricity consumption of their houses, measured by a smart monitor. The results show that energy consumption during 'mission time' was lower but returned to normal after the trials.

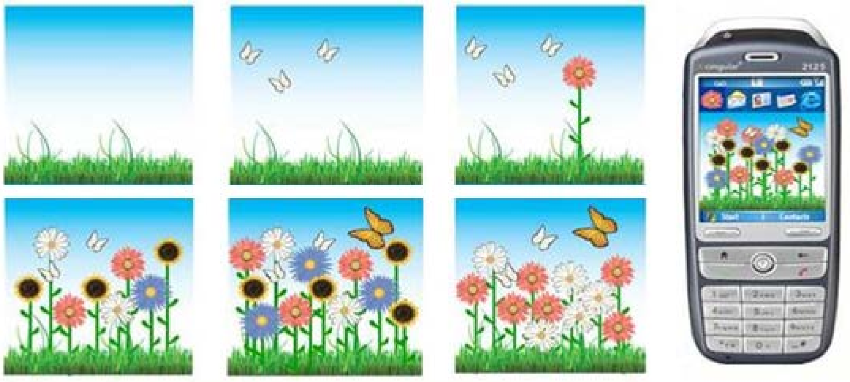


Figure 5 - UbiFit Garden (Consolvo et al, 2009)

Bång, Svarn and Gustafsson (2009) presented another pervasive mobile phone intervention where competitors have to interact with real appliances in their homes to improve their performances in the virtual game. In one of the scenarios, players have to reduce their real domestic electricity consumption to succeed in the game. Other available mode requests players to manipulate the energy usage (like switching on specific appliances) in order to control the speed of the avatar in the game. Another level can be controlled by the players by switching on and off specific energy demanding appliances to gain advantages and resources in the game (Bång, Svahn et al. 2009). This study tried to prove that by an iterative learning process, the pervasive mobile phone application can result in improved awareness of energy use and ultimately lead to behaviour change.

One recent project demonstrates how mobile phones can be used to motivate sustainable behaviour through a remote thermostat control combining the geo positioning system present in mobile phones (Koehler, Dey et al. 2010). This study provided feedback on indoor temperature with comparison with previous days, giving positive reinforcements for good performance and also presenting recommendations for domestic energy saving. The attempt was to promote self-efficacy among users, and finally evaluating if participants became more confident to change their environmental behaviours.

Another study shows how a computing system was used in the attempt to make people adopt sustainable choices. Using mobile phones, family members could report eco-friendly activities which influence the scenario in a game. When behaving in a non-sustainable way, the sea level rises compromising the life of their virtual family placed on an *EcoIsland* (Shiraishi, Washio et al. 2009). Similarly, another game presents a threatened polar bear that sees the size of an ice floe reduce or increase according to the player's behaviours regarding 15 different environmentally responsible activities, from domestic appliance usage to transportation habits (Dillahunt, Becker et al. 2008).

2.7 Designing Persuasive Technology

The design of persuasive systems can be facilitated by tools for identifying available persuasive strategies to match desired goals. Examples include the Behaviour Wizard (Fogg, Hreha 2010) that provides a simple grid where people select how the behaviours should be changed and the duration of the change. Fogg (2009) adds to the field of intervention design by providing eight practical steps to create persuasive technologies. Another model is the Behaviour Change Support System (Oinas-Kukkonen 2010) which includes a matrix with types of change (compliance, behaviour or attitude change) and outcomes (form, alter or reinforce change). These examples indicate how researchers can design persuasive systems by informing how to correctly match available persuasive strategies and desired outcomes of intervention methods.

Even though not specifically created for developing computer-based interventions, other design methods provide inspiration on ways to select and implement strategies. These comprise for example the Design for Sustainable Behaviour (Bhamra, Lilley et al. 2011), which indicate the balance between power and control in the user-product relationship. On the first level the user is provided with *eco-information* in order to reflect upon resources consumption and behave in a sustainable way. With this principle the user has complete freedom to perform otherwise. On the other side of the spectrum there is *clever design*, when the product or service acts automatically to save resources, without requiring change in behaviours.

As can be seen from the literature, there are numerous design principles and patterns available to be implemented during behaviour change intervention projects. It suggests that a rigorous process of identifying the adequate ones to the behaviours in question should take place. The selection process should account for psychological factors (attitudes and intentions), normative processes (personal and social norms), situational factors (the context where the behaviour takes place), and habitual processes (list adapted from Zachrisson, Boks 2010).

Another issue to take into consideration is the adequacy between the task that the intervention wants to improve and the proposed technology used as intervention. The task-technology fit must be adequate in order to result in utilization. "[S]oftware authors need to be aware that actual utilization depends not only on perceived usefulness and ease of use, but also on how well the tool functionality matches the needs of the task at hand" (Dishaw, Strong 1999).

2.8 University campus energy use

Cost is commonly an incentive to reduce energy consumption, since less energy usually means lower bills. However, certain groups of people do not have this financial incentive. These groups include: students living in halls of residence where usually all bills are included in the fees (Brewer, Lee et al. 2011); people living in areas where bills are only estimated (Darby 2006); people living in military bases (McMakin, Malone et al. 2002); lodges living in houses where the landlord pay for the bills (Levinson, Niemann 2004); and also office workers (Foster, Lawson et al. 2012). This creates challenges in how to motivate behaviour change towards energy use reduction. These contexts also indicate that these populations cannot choose the appliances they use. That is the case with tenants living in furnished houses or students living in halls of residence who seldom select the installed equipment. The building owner should have the responsibility for reducing building-related energy use, and occupants should have responsibility for the energy used in appliances and equipment available for them (Boardman 2012). However, the relationship between landlords and tenants can be harmful for the environment. Renters often have to use appliances that are not very energy efficient (Davis 2010) and landlords are usually less proactive to fix appliances and infrastructure when they are not responsible for paying energy bills (Dillahunt, Mankoff et al. 2010).

There are numerous studies in the literature targeting students living in university accommodations. Some of them achieved a relative success on energy saving by offering feedback, information and financial incentives (Hayes, Cone 1977, Bekker, Cumming et al. 2010, Petersen, Shunturov et al. 2007). However, these studies do not always report trying to understand student's behaviours or motivations.

Students at the University of Hawaii took part in a dorm competition as part of a study investigating the effectiveness of information technologies in promoting energy saving (Brewer, Lee et al. 2011). Energy consumption and improvements in energy literacy of participants were measured to assess the success of the project. The strategies implemented included goals, commitments and near real-time energy feedback via a website. They suggest that feedback systems should be more engaging to users otherwise "the long term impact of energy feedback may be diminished due to habituation" (Brewer, Xu et al. 2013), and propose using feedback on energy as part of an attractive experience incorporating game play.

Another study involving students was performed using simultaneously web-based feedback, educational materials posted in dormitories and a competition among halls to evaluate which ones would reduce resource consumption to win a prize (Petersen, Shunturov et al. 2007). Results show that it is possible "to encourage building occupants to teach themselves how to conserve resources by engaging them in resource conservation decision making". Their analysis indicates that smart buildings remove the decision making from users who lose the interest becoming "only passively engaged and uninformed about the importance of resource conservation. For this reason, it could be argued that 'smarter' buildings may lead to environmentally dumber people". They conclude that, in contrast to the smart building philosophy, the objective of programs on feedback, information and behaviour change "is to construct environmentally smarter people in what are often environmentally and technologically dumb buildings" (Petersen, Shunturov et al. 2007).

Slavin et al. (1981) performed a study in student accommodations that have one single master electricity meter per building. With this system the consumption is not individually measured and occupants pay a fixed percentage of the master consumption. They tested the effectiveness of financial incentives (corresponding to the actual savings in energy compared to a baseline) combined with a sequence of activities (appeal for conservation, energy saving tips and extensive question-and-answer periods) in student flats. They concluded that this sort of group contingency can indeed modify energy conserving behaviours. However, their effects are likely to be moderate, especially given that master-metered apartments "use about 35% more electricity than similar individually metered buildings" (Slavin, Wodarski et al. 1981).

Students at Lancaster University (UK) also participated in a research project investigating energy use, especially for cooking (Clear, Hazas et al. 2013). The aim was to understand the impacts of energy use and embodied greenhouse gases (GHG) due to food preparation. They combined observations in real kitchens with life-cycle analyses, estimations of GHG emissions and qualitative data of motivations behind the practices observed. The outcome was "a range of design interventions that might be applied to reduce the impact of these food practices". These interventions comprise modifications to the appliances (to improve efficiency), support of communal organizations (since cooking as a group can promote savings) and changes to food habitually eaten (their calculations indicate that about 80% of the embodied emissions related to cooking are caused by the ingredients).

One parallel study described students' energy use in four flats and mapped the opportunities for change (Bates, Clear et al. 2012). Through appliance-level, fine-grained energy monitoring, they presented a detailed account of usage over a 20-day period. The richness of the data emerged when they combined this information with face-to-face interviews with occupants. Participants also provided responses to text messages giving 'mini-accounts' of events during the study. By combining the energy data with student's explanations, their research provided a broader picture of energy consumption as a service structured in the context of everyday life.

2.9 Cooking and HCI

A number of studies report the use of ICTs as assistants for cooking. These studies evaluate the role of technology in different aspects of the cooking activity, for example the attempt to increase users' confidence and fun when preparing unknown and complex recipes via a multi-display interactive system and a 'personal chef' (Mennicken, Karrer et al. 2010). A cooking navigation system helps novice users to cook two dishes in parallel by optimizing time and processes, helped by text, video and audio from a touchscreen device (Hamada, Okabe et al. 2005). Other research examines the use of HCI to overcome cognitive deficits via pervasive behaviour tracking and information (Giroux, Bauchet et al. 2008) The *panavi* system integrates wireless sensors to measure temperature and pan movements, and this data feeds the system that displays the situated instructions, helping users to "master professional culinary arts" (Uriu, Namai et al. 2012) Another study evaluates the *Cook's Collage*, a system that tries to prevent users losing track of the cooking progress by implementing a visual summary of on-going cooking activity, working as a memory aid during the process (Tran, Calcaterra et al. 2005). The *SuChef* system allows friends and family to share recipes and cook suggested dishes, working between geographically dispersed households (Palay, Newman 2009). An automated cabinet system assists the user in retrieving or storing items in the kitchen according to the recipe selected (Ficocelli, Nejat 2012). Another study evaluates the acceptance of different multimodal features of a cooking assistant depending on the context of use (Vildjiounaite, Kantorovitch et al. 2011). Studies at University of York (UK) investigated different options of electronic recipe presentations to understand cooks' preferences (Buykx, Petrie 2011, Buykx 2011, Buykx, Petrie 2012). Hupfeld and Rodden (2012) investigated food consumption in seven British households and reported how they organise "domestic eating, paying particular attention to the artefacts, spaces, people, and their mutual relations". Their objectives were to indicate the challenges involving the introduction of digital technologies to the table and to inspire digital innovations. They conclude that it is important to have a richer picture of food and eating in HCI in order to "make more informed choices about their digital augmentation".

This comprehensive list indicates that there are a number of studies on cooking assistants, their particular features' effectiveness or acceptance. However, the issue of energy consumption is seldom covered. Also, people's behaviours were not always investigates before designing these applications. The systems presented here were designed and tested in its attempt to foster confidence, skills or knowledge, overcome cognitive deficits, mobility limitations or geographic barriers and improve interface features or recipe presentation. It is possible that by addressing these diverse issues the cooking assistants will have better usability and present an improved user experience, and users will became more proficient and make less mistakes. Nevertheless, no studies were found on cooking assistants addressing energy consumption during the cooking activity. This aspect represents an important gap in the literature since food preparation is usually energy intense (Newborough, Augood 1999) and user behaviours play an important role in energy consumption (Wood, Newborough 2007).

2.10 Temporal tensions, Flow and Motivators

The cooking activity presents special challenges for time management, and it reflects on the temporal perceptions experienced by cooks. One extensive study with chefs working for restaurants describes how they can feel either bored or anxious depending on the demands of the shift and the time available (Fine 1990). The sense of duration can vary according to the activities at hand and the amount of time they have to perform those activities. A shift passes quickly if a routine (even if busy) can be performed without unexpected events, without problematic rush that brings emotional concern. An evening without many bookings might be seen as a luxury to busy restaurant kitchens, but it in fact makes the job boring: “The inability to fill one's time with a productive activity generates frustration” (Fine 1990). Cooks prefer when there’s a busy schedule and things go smoothly. “It's too boring when it's slow”, says one of his participants.

Bergson (2002) was one of the pioneers to describe duration of time, and to position it as one of the basic constituents of consciousness. He points out the relation of perception of duration with the notion of change, as a succession of qualitative movements perceived by our senses, identifying a measurable unit. Memory plays an important role in the perception of duration, since it allows the identification of separated instants and the duration between them, defining the perception of time. Time can be perceived and lived, or conceived as an imagined construct (Bergson 2002). It is through associating perceptions and memory that people can identify *before* and *after*, a succession (Bergson 2002). Through memory people “reconstitute the succession of experienced changes and anticipate changes to come” (Fraisse 1963).

Flaherty (2000) introduces the metaphor of ‘density of experience’ to illustrate the different perceptions of time: similarly to gondola cars of freight trains that can be filled with different amounts of ore, time units can be filled with unspecified quantities of experience. This density can be *protracted*, synchronized or compressed. In periods of waiting and boredom time lasts longer than expected or usual: there is not much to fill the units of time, then it can create emotional concerns. The emptiness of time can trigger cognitive involvement with the empty situation itself, which raises worries and preoccupations.

It is common to say that ‘a watched pot doesn’t boil’, in reference to the “situation in which there is the perception that time is passing slowly” (Flaherty 2000). The notion of time is dependent on how people experience succession and duration. The conception of time can be more painfully vivid during expectation. “When we have to endure delay we become conscious of the interval that separates us (in the present) from the awaited moment” (Fraisse 1963). On the other hand, temporal compression can occur with low complexity of routines or habits involving low conscious deliberation.

A group of researchers from the University of Helsinki (Oulasvirta, Tamminen et al. 2005, Oulasvirta, Tamminen 2004, Tamminen, Oulasvirta et al. 2004) observed the concept of temporal tensions and defined it as the psychological construct made by assessing the availability of temporal, mental, physical and social resources. Sometimes it is necessary to fit more actions into a time frame. Other times the relationship between time and action is stretched, when people are just anticipating outcomes that are about to happen. Previous studies demonstrated that it is possible to manipulate the perception of time providing absorption with attractive images (Gable, Poole 2012) or filler interfaces presented during periods of wait (Lee, Chen et al. 2012). These studies present evidence of the possibility of manipulating individual’s perception of time in specific settings.

In boredom or apathy, “the low level of challenge relative to skills allows attention to drift” (Nakamura, Csikszentmihalyi 2002). In the opposite state, when the user experiences anxiety, the focus on his shortcomings creates “a self-consciousness that impedes engagement of the challenges”. The optimal relation between the challenges of the environment and one’s skills determines an ideal state that is referred as *Flow* (Csikszentmihalyi 2000). Characteristics of flow include a distortion of temporal experience as people tend to lose track of time, and intense concentration when “attention is wholly invested in the present challenge” (Nakamura, Csikszentmihalyi 2002). Figure 6 illustrates the concept of flow, where in the centre there is the optimal state, when an individual’s skills match the challenges of the environment. However, if one’s level of skill is high and there is not much challenge, this individual feels bored. Conversely, if the challenges are higher and there are not enough skills to cope with these challenges, anxiety builds up. In a state of flow people’s attention is entirely focused on the task at hand, they tend to lose track of time and start doing things spontaneously and automatically without having to think (Csikszentmihalyi 2002). Performing activities such as playing instruments, doing sports, dancing, playing chess or even working with something that requires a high level of concentration (such as surgery) can promote a state of flow, which brings enjoyment and satisfaction (Csikszentmihalyi 2000).

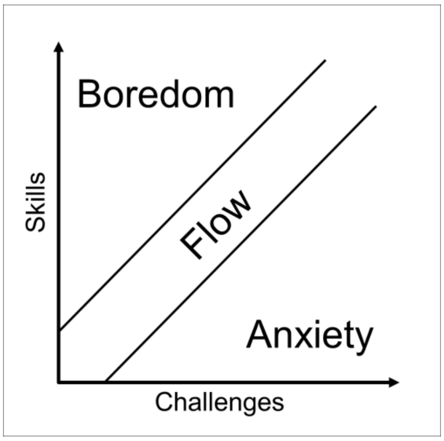


Figure 6 - Flow diagram (Csikszentmihalyi 2000)

The example of a restaurant kitchen illustrates the application of the theory of flow. Chefs are usually skilled and manage pressure quite well. If running smoothly, busy schedules can be enjoyable. In this situation, individual's skills match the challenges of the environment. On the other hand, when challenges are higher than skills, or time shorter than needed to accomplish tasks, it increases the chances of mistakes and creates tension and anger. Fine (1990) reports that the tension in the kitchen could be seen when cooks were short of time to prepare complex dishes. The challenges of the situation in terms of demands and time available made them struggle, with chefs being "sarcastic to servers, and servers bothering cooks for their dishes. No one had the time to do things right, including being polite". In the opposite scenario, chefs became easily bored if the challenges of the restaurant are not high enough for their skills.

Human behaviours are frequently influenced by the presence of intrinsic and extrinsic motivations (Ryan, Deci 2000). Researchers often test the effectiveness of external rewards such as the effect of recompense for conservation behaviours (Petersen, Shunturov et al. 2007, Bekker, Cumming et al. 2010, McClelland, Cook 1980). Csikszentmihalyi (2000) argues that external rewards are not always effective, since different people are driven by different motivators, and research exploring its effectiveness might not present an accurate picture of people's real motivations outside the experimental condition.

Table 3 - Intrinsic and Extrinsic motivators (based on Ryan & Deci 2000)

Intrinsic	Extrinsic
Internally motivated, interesting, enjoyable, fun, positive experiences, challenge • Exercising and extending one's capacities • Creatively applying skills • Increase feelings of competence • Enhance self-efficacy	External prods, pressures, rewards, approval, separable outcome • Satisfy an external demand • Obtain external reward • Attain ego-enhancements or pride. • Avoid guilt or anxiety

Table 3 list some characteristics of intrinsic and extrinsic motivators. Intrinsic motivators are interesting drivers of behaviours since they are related to activities that have rewards within themselves, as opposite to extrinsic motivators that need external rewards or punishment (Ryan, Deci 2000). Flow seems to work as an intrinsic motivator when it promotes the use of one's capabilities on an optimum level, when demonstrating competence and self-efficacy, usually with creative engagement. Extrinsic motivators might not always be effective, usually require the supply of a tangible reward (which are commonly based on expensive or scarce resources that place challenges on sustainability), and generally more reward is needed to keep the motivation up (Csikszentmihalyi 2000). De Young (1993, 2002) indicates that intrinsic motivators should be preferred in the attempt to promote environmental responsible behaviours, and have a higher likelihood to 'make it stick'.

2.10.1 Temporal tensions and energy saving

One of the reasons for people wasting energy is the fact that they do not want to wait nor put effort into energy saving. Chetty and colleagues (2009) verify this with the classic example of how people use computers. Their results indicate that "computers in the home, particularly desktop computers, are left on much more than they are actively used". The main explanation for this behaviour is that people do not want to experience the frustration of long boot up times. Previous study with people who act pro-environmentally also illustrates the correlation of time and energy use. Their results indicated that "efforts to be environmentally responsible typically required significant dedication of time, attention, and other resources" (Woodruff, Hasbrouck et al. 2008). In the context of cooking, energy saving can sometimes increase cooking time. Some of the cooking methods designed to prepare food more efficiently involves using less heat (Das, Subramanian et al. 2006), which can sometimes increase the length of the process. Recommendations for efficient cooking involve extra care such as taking consideration to measurements of quantities and time. Not dedicating attention to the correct procedure often lead to energy wastages (Probert, Newborough 1985). One extensive research observed that "when consumers were stressed, they tended to hurry and were not as careful with the cooking system under investigation" (DeMerchant 1997). Results show that when behaving patiently, cooks used the least energy to complete a research menu. Conversely, users in a hurry generally presented the highest energy consumption due to pre-heating saucepans, using high heat and not matching the diameter of heat source and cookware.

Having the right information on how to act efficiently may not be enough to motivate sustainable behaviours. Temporal tensions seem to make it more difficult for people to perform certain behaviours, especially those believed to increase time to complete tasks. Reducing temporal tensions appears to be one way to motivate sustainable behaviours. Designing systems that promote a better involvement with the tasks has the potential to alter the sense of duration, make time appears to pass quickly and consequently reduce temporal tensions during specific activities. Apart from increasing user satisfaction, reducing temporal tensions might be also beneficial to promote energy saving. The relation between tasks, temporal tensions and energy saving is one of the avenues of research presented by this literature review.

2.11 Conclusion

The aim of this literature review was to present the background of research that guided this PhD project. It indicated possible strategies to inform the design of behaviour change interventions targeting energy conservation. Previous studies from diverse perspectives provided the basis and starting point for this work. The background was built to understand the domestic energy usage in the UK, what the role of users in this process is, how other studies motivated people to use less electricity at home, and what possible strategies can be developed and tested during this research.

Some gaps in the current literature shows that more research can be done combining specific areas of knowledge to contribute to the knowledge already available. Previous studies indicate that there is still need for research in the following aspects:

- The energy problem in the UK indicates that more research is needed on practical methods and strategies for energy curtailment
- There is research on several aspects of domestic energy use, including heating systems, shower usage, tap water usage, dish washing, computer standby management and fridge use. However, only a few tap into cooking devices,

concentrating on developing energy saving techniques or observing how people use energy

- Cooking practices present an interesting area for research, given the high potential for improvements to reduce energy consumption in the kitchen
- Studies on domestic energy consumption either provide a picture of energy use, or design an intervention. Studies demonstrating all steps from understanding, designing and testing energy saving interventions are not common
- Most interventions doesn't start from a deep understanding of people's behaviours and determinants
- Interacting with technology provides a key opportunity for reducing energy consumption
- Most research on HCI and domestic energy use evaluates the introduction of a new device such as a feedback system or an ambient display. There is demand for innovative uses of persuasive technology
- There is not strong evidence that an electronic cooking assistant would be efficient and acceptable for changing people's behaviours, hence the need for testing
- Studies on interventions focusing on university hall energy conservation gravitate around feedback, competition and incentives for savings but usually don't specify the behaviours to be changed and don't give clear instructions on how to save energy
- Intrinsic motivators might be more efficient to promote behaviour change than extrinsic motivators
- Most studies on behaviour change interventions focus on extrinsic motivators, indicating the need for research on intrinsic motivators
- There is the need for validation of persuasive methods using electronic interventions for sustainability
- The cooking activity presents moments of temporal tension, and this tension can trigger boredom or anxiety
- Avoiding boredom and anxiety could improve user experience and could also reduce energy consumption during the performance of specific activities
- Although there is research on temporal tensions in different contexts, no research was found relating these tensions to energy use
- No studies were found attempting to reduce temporal tensions to promote energy saving
- Technology could be used to manipulate time perceptions and consequently reduce people's temporal tensions during activities that use energy

This literature review demonstrated examples of previous research related to domestic energy use including challenges presented in the attempt to promote sustainability. It was verified the need for more research in specific areas, and is in this ‘gap’ where this PhD project is positioned. This chapter also indicated particular strategies that can be combined and implemented on the design of behaviour change interventions. The studies presented in this literature review demonstrate the existence of an avenue of research for HCI, where persuasive technology could be used in order to reduce temporal tensions during activities such as cooking to foster flow by reducing boredom and anxiety. One of the outcomes of a design project such as this would be the possibility to evaluate the acceptance of specific persuasive interventions and the effectiveness of the strategies in the attempt to promote sustainability at the same time.

3 Methodology

3.1 Introduction

This chapter presents the methodology that oriented this research. It lists established research philosophies and strategies and indicates those chosen for each study performed during this research. Here the reader will also find explanations and justifications for each method selection. Parallel to examples and frameworks from the literature, the methods chosen to be used will be demonstrated and explained.

The process of selecting the research methods presented here followed the purposes of the study and was focused on answering the research questions set out in section 1.6. It is important to add that individual values held by the researcher influence the research topics and also the choice of data collection techniques (Saunders, Lewis et al. 2009). The researcher generally considers practical aspects of the work, and also their personal views of the phenomena and the particular perspectives with which they decide to face the data, prior to decide which research philosophy to take (Saunders, Lewis et al. 2009). The research methodologies presented here were selected taking in consideration the suitability to answer the research questions and also the particularities of the researcher and objects to be studied.

3.2 Overview

The Intervention Mapping Protocol (IMP) is a framework that guided the development of this project (Kok, Lo et al. 2011, Bartholomew, Parcel et al. 2001, Uitdenbogerd, Egmond et al. 2007). It consists of distinct phases for understanding behaviours, understanding determinants, finding the theoretical background to orient the project, designing interventions to tackle these determinants, and evaluating the effectiveness of the interventions. A focus on understanding the situation from the perspective of current and potential users of a certain service is commonly seen in different design processes. Concepts of service design also helped during the research design (Stickdorn, Schneider 2010).

Robson (2011) developed a framework for research design suggesting some directionality on the process of planning a research work (Figure 7). It starts from the general purpose of the research: what is the study trying to achieve. The second aspect is the consideration of the conceptual framework: the theoretical background ranging from previous research, pilot studies, expert opinions and so on. This knowledge should be organized in order to provide understanding on how different aspects are involved and related to each other. After establishing these two first aspects of the framework for research design it is possible to generate the research questions. Basically, they state what the questions are for which this research is trying to provide answers, or what needs to be known in order to achieve the purpose of the study. After developing the research questions, then it is possible to "make decisions about the methods and the procedures to be used when sampling" (Robson 2011). The application of this framework for the specific needs of this research is shown in Figure 8.

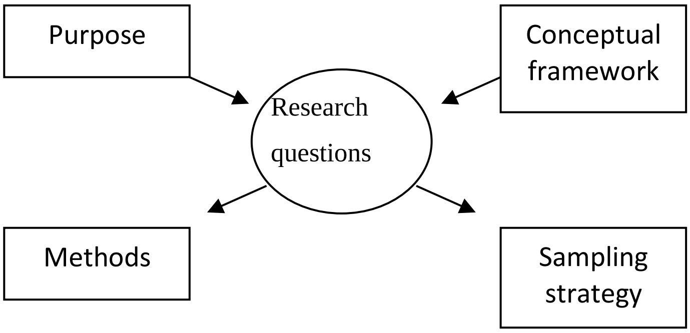


Figure 7 – Robson's Research framework

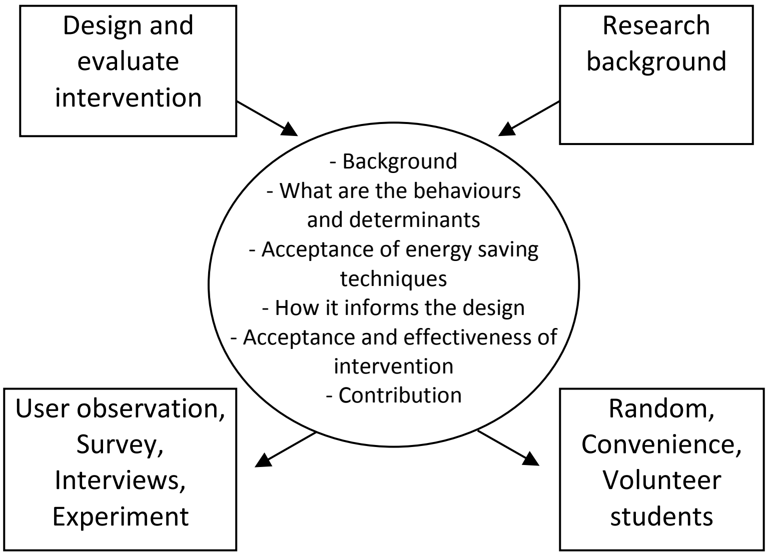


Figure 8 - Modified framework for research design specific for this PhD

Figure 8 illustrates the framework for research that is being used during this research. As could be seen in the introductory chapter, the purpose of this research is to evaluate an intervention that brings modification of time perceptions as one of the solutions to promote sustainable behaviours. It fills the first box on the top left corner of the diagram. The second box to the right on the diagram indicates the position of the conceptual background within this research. It benefited from the literature review presented in the previous chapter, and provided a deep understanding of the research methods and practices. Combining the purpose of research with the background of research, it was possible to develop the research questions used during this PhD project (central circle), as described in the introductory chapter. The methods (bottom left box) were developed strictly to answer the specific research questions, and the sampling strategy (bottom right box) indicates the suitable procedures to recruit participants to help answer the research questions.

3.3 Research process

One of the references used during the development of the methodology for this research is the research process 'Onion' as described by Saunders et al. (2009). Starting from the external layers of the onion diagram (below) the researcher can visualize the main aspects involving the most common research methodologies. It illustrates six levels of methods and guides the researcher from the broader perspective of research philosophy to the narrow and specific details of data collection and analysis methods.

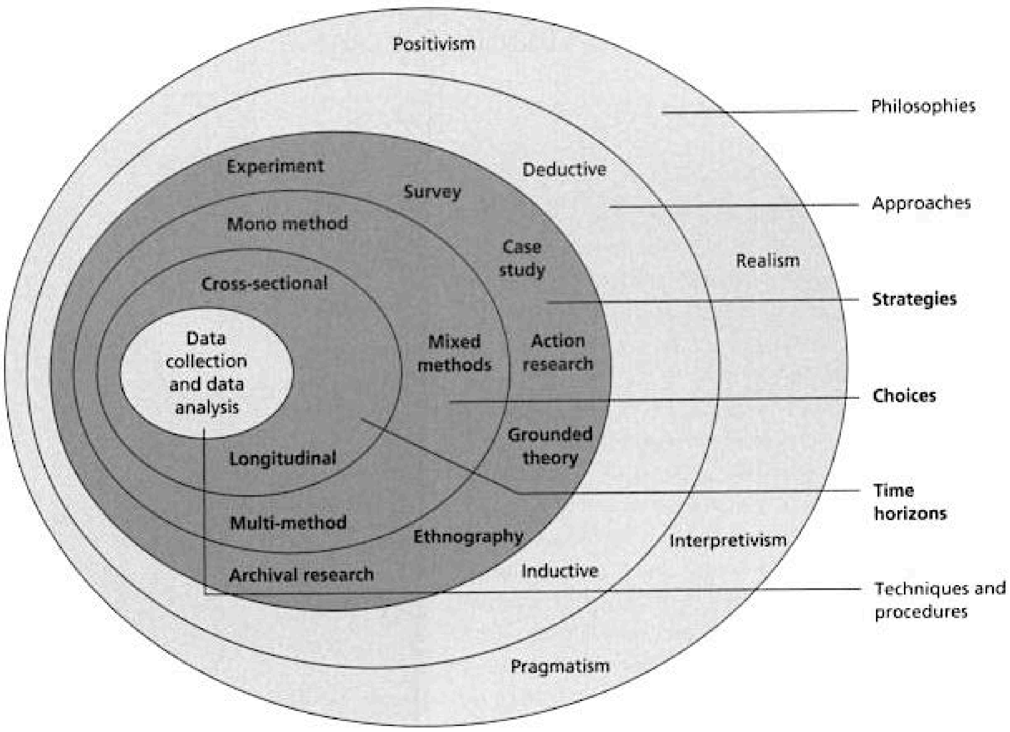


Figure 9 - Research process 'Onion' (Saunders, Lewis et al. 2009)

3.3.1 Philosophies

The research philosophy can have different lines, from Positivism, Realism, Interpretivism (also referred to as Constructivism) or Pragmatism. The philosophy of Positivism, familiar to natural scientists, involves the observation of the real world through strict rules and procedures and through the test of hypothesis, undertaken in a value-free way (Saunders, Lewis et al. 2009). The outcomes from this type of research comprise universal causal laws that can be generalized (Robson 2011). One criticism of the original Positivism perspective includes the fact that it might be impracticable to achieve the objectivity expected "when working in real life settings, where the researcher has, or develops, an emotional involvement" (Robson 2011). Realism, similarly to Positivism, advocates that it is possible to understand the world through observation, since human senses show us what, in reality, is the truth (Saunders, Lewis et al. 2009). Realist research often takes place in the field, trying to provide explanations on 'how' and 'why' certain phenomena occur (Robson 2011). The third research philosophy approach listed by Saunders et al (2009) is Interpretivism, which raises the concern that social phenomenon "is far too complex to lend itself to theorising by definite 'laws' in the same way as physical sciences". It is necessary to understand particularities in humans as social actors, and that there are differences between conducting research among people and objects. The interpretivist researcher has to "enter the social world of the research subjects and understand their world from their point of view" (Saunders, Lewis et al. 2009). The last philosophy, Pragmatism, consider practical experience rather than theory, generally focusing on a problem and trying to solve it. "The central idea is that the meaning of a concept consists of its practical implications" (Robson 2011).

Since this research is pursuing an understanding of the diversity of people's behaviours and their determinants regarding energy use, and also creating and evaluating intervention methods trying to change how people use energy, an interpretivist (or constructivist) approach was used. This research philosophy guided the main aspects of the project and indicated that it was necessary to interact with participants and interpret the subjects to construct meaning and knowledge. The last phase of this research saw a shift towards a positivist approach, with objective measurements taking place in order to test the propositions developed during the first studies.

3.3.2 Approaches

The next internal level of the 'onion' is the research approach that can be Deductive or Inductive. In a deductive approach, reliability and validity are important, meaning that the study has consistency and accuracy. Objectivity is also sought, and a distance between the researcher and participants are maintained. The ideas or concepts are tested using a deductive logic. The research involves measurement and quantification, focusing on assessing behaviours regarding what people do or say using a quantitative approach (Robson 2011). On the other hand, an inductive approach bases on reasoning to generate hypothesis. The content is generally presented verbally or in other non-numerical form, preferably in the context where they naturally occur. Typically, inductive research involves qualitative data from small-scale studies, and might not be possible to generalize the findings to a wider population (Robson 2011).

This research involves qualitative and quantitative approaches, since results are in the form of both verbal and numeric information. The data used were gathered from interviews performed with a relatively small group of participants, video footage of experiments, surveys with rating scales filled by a large group of users and observation data. Some of the phases combined both approaches during one single study. For example, the first user observation experiment collected quantitative data such as energy usage, time usage, quantification of behaviours and performances, and also audio, video and textual responses which determine that this research is multi-approach in essence.

3.3.3 Strategies and choices

The next internal layer of the 'onion' is the Research Strategy. At this point the researcher develops the design of the project according to the kind of research that is needed: exploratory (to get a understanding or clarify a phenomena when the nature of the problem is not very clear), descriptive (to portray a specific phenomenon in detail) or explanatory (to explain relationships between variables) (Robson 2011, Saunders, Lewis et al. 2009). Experiments, surveys, case studies, action research, grounded theory, ethnography and archival research are some of the variations. Multi-strategy research designs, or mixed methods research, are commonly adopted.

The research strategy implemented here combines a few elements to better produce the knowledge needed for the different phases of the work. This research started from exploratory grounded theory during the First Study, which helped develop explanations for observed behaviours. A grounded theory study is "[p]articularly useful in new, applied areas where there is a lack of theory and concepts to describe and explain what is going on" (Robson 2011). The grounded theory should provide clear hypotheses which can be verified, and should be "meaningfully relevant and be able to explain to the behaviours under study" (Glaser, Strauss 2009). The development of the theory benefited from observations and inductive process. Knowledge acquired during the First Study indicated the need for a survey on the Second Study (explanatory), followed by user centred design phase and finally an experiment containing another user observation study for the last study (descriptive). Consequently, a multi-method research choice was used.

3.3.4 Time horizons

Time horizons specify how the research will be carried on regarding duration or periodicity. A cross-sectional study means that all measures are taken at the same point in time or during a brief period: the measurement of relationships occurs when the researcher analyse data from different readings from different elements at approximately the same time (Robson 2011). A longitudinal study denotes that data are collected at different points in time. Commonly there is a pre-test and post-test phase in longitudinal studies, meaning that measurements happen before and after some sort of intervention, which is being evaluated. "The appeal of longitudinal research is its ability to establish causality and to make inferences" (Cohen, Manion et al. 2011).

The time horizons chosen during this project included both cross-sectional and longitudinal. A single observation of each participant at a specific point in time was implemented during the user observation study, characterizing a cross-sectional study. The same approach was taken during the Second Study, which consisted of a survey with ranking scales administered once, and also during the user-centred design phase. But for the Fourth Study a longitudinal study was required: data prior and posterior to an intervention needed to be collected in order to provide evaluation of effectiveness, acceptance and outcomes. Also, data from the intervention phase (Fourth Study) were compared with the user observation phase (First Study) meaning that a wide longitudinal aspect was implemented.

3.3.5 Techniques and procedures

The most central and final layer of the 'onion' is the selection of techniques and procedures for data collection and data analysis. These comprise the tools to effectively gather information and knowledge about the phenomena and measure the aspects of reality that are object of the study. For example, when dealing with people and trying to understand their behaviours, it is possible to watch what they do (observation), ask them about the phenomena in question (interviews, questionnaires, tests or attitude scales) and determine their abilities (via standardized tests) (Robson 2011). The following section will describe briefly the techniques used during this research. Details of methods used during each phase of the research will be presented in their specific chapters.

3.3.5.1 Literature review

An extensive literature review was performed prior to all the subsequent phases of this research. This stage helped answering the first research question: "*What is the current background of research related to energy use, and how does it indicate possible strategies to guide the design of behaviour change interventions?*" Books, articles, papers, reports and communications were clustered, compared and associated according to themes, and later critically reviewed to produce a wide picture of the background of research.

3.3.5.2 First Study – Understanding cooking behaviours

The First Study pursued a broad understanding of users, their behaviours and determinants. Due to the diverse nature of data to be collected, a multi-strategy design was implemented. An observation study was designed (Sharp, Rogers et al. 2007) including video recording, energy monitoring and note taking to understand and specify the context of energy use (Hutchinson, Mackay et al. 2003). Quantitative data was analysed in terms of correlations between energy use, behaviours performed and time to complete the task. This research also intended to understand participants' motivations behind the observed behaviours to better answer the second research question: "*What are the key energy related behaviours and what are the determinants of these behaviours associated with cooking?*" Post-experience, semi-structured interviews followed the observation study (Kuniavsky 2003). For each aspect noted during the performance observation, a question was placed to get the explanation from the user regarding the behaviour. This qualitative information was later coded using thematic analysis to produce a set of determinants, and each determinant was related to a strategy to be included in a behaviour change intervention. This list of strategies indicated the proposed methods to work as platforms for this intervention.

3.3.5.3 Second Study – Theory of Planned Behaviour survey

The knowledge of user behaviours and correspondent determinants guided a wider survey to understand participant's attitudes, perceived social norms and beliefs regarding their level of control to perform a set of proposed energy saving techniques. The Theory of Planned Behaviour guided the development of an elicitation study and a survey. This study used online questionnaires as the instrument of data collection, having as its outcome a vast volume of information about user preferences and intentions to perform the suggested energy saving behaviours for cooking. This phase answers the third research question: *"What is the acceptance of a set of recommended best practices for cooking among the target population?"* Statistical analysis included analysis of variance and mean tendencies towards acceptance or not of the proposed energy saving techniques.

3.3.5.4 Third study – Intervention design

The Third Study constituted a user-centred design process to develop an electronic intervention. The knowledge gathered from the preceding steps and a literature review informed the design of strategies to modify the non-sustainable behaviours and promote energy saving. The researcher was responsible for proposing some of the solutions, justifying each decision based on research evidence and previous studies. Furthermore, an idea generation session took place. Scenario analysis was used as the method to motivate participants to suggest strategies and contribute to the proposed design. Three cooking scenarios were introduced to generate discussion and contributions from participants. The Technology Acceptance Model guided the definition of themes used during the qualitative data analysis. The outcomes were a set of strategies to be embedded in an electronic application, containing the specific methods to tackle the correspondent determinants of behaviours. Two high resolution working prototypes of the electronic interventions were developed. This phase then answers the fourth research question: *"How can this knowledge of user behaviours inform the design of new interventions to reduce electricity consumption while cooking?"*

3.3.5.5 Fourth Study – Intervention evaluation

The Fourth Study comprised the evaluation of the proposed interventions in improving aspects of the cooking activity. It also evaluated the acceptance of the interventions and effectiveness in promoting energy saving. By doing so it answers the fifth research question: *"What is the role of persuasive technology and time perception manipulation in changing people's behaviours and reducing energy usage in the cooking context?"* To accomplish that, one experiment was designed, consisting of a two-phase user observation study to evaluate both prototypes. Quantitative data was collected from video footage, energy monitoring, note taking and rating scales. Qualitative data comprised semi-structured post-experience interviews. Thematic analysis was performed to consolidate results from the interviews, and this information was combined with the quantitative data to provide comparative evaluation of both versions of the application.

3.4 Data analysis

A combination of quantitative and qualitative data was gathered during this research and, for each case, specific methods for analysis were used (Miles, Huberman 1994). During the process of quantitative data analysis, software packages such as Microsoft Access, Excel and IBM SPSS assisted during the process of statistical analysis, processing matrixes of data and plotting graphs. To work with qualitative data, QSR NVivo was used in order to facilitate thematic analysis (Braun, Clarke 2006). Further description of how the quantitative and qualitative data from every study were analysed can be found in the next chapters.

3.5 Study population

The population for this research comprises undergraduate students living in university halls of residence, specifically in Loughborough, UK. A few advantages can be listed from this approach. Firstly, hall residents comprise a relatively homogeneous group regarding age and educational level. Secondly, since the halls in question are fitted with similar appliances, the variations in behaviours due to equipment characteristics are minimized. Thirdly, university students are a "renewable resource", there is regular turn-over in occupancy making it is possible to perform different experiments each year. Also, hall residents do not have the typical financial incentive for behavioural change, since all bills are included in the yearly hall fees. Another aspect is that research involving students can involve hundreds of participants, providing a relatively large subject pool for analysis (Brewer, Lee et al. 2011). Finally, using students as subjects for energy conservation studies has the advantage of timing. For most of the students, this will be the first time they are away from home and, consequently, they are in the process of learning how to prepare their own meals. Previous research indicates that lack of skills is a common issue and it affects how students perform, what they cook and how they cope with this 'new' life (Blichfeldt, Gram 2013). Students are often anchored in parental practices, but living away from home brings challenges to them since they have to generate their own food practices and habits. Marquis (2005) reports that students living in halls prefer to eat something that is easy and simple to prepare and is readily available. Her results indicated that "convenience appears to be the most important food motivation retained by students living in residence". This might be an important time to introduce and present best practices, as habits are not yet well formed (Verplanken, Wood 2006). Learning how to cook in an energy saving way whilst living in university accommodations means they could carry on performing these techniques when living elsewhere.

3.6 Sampling

For the First Study [Understanding cooking behaviours], the strategy to select the participants for the trials consisted of quota sampling. This strategy was used to obtain the desired number of representatives of the population (Robson 2011). The variable considered was gender: 10 male and 10 female subjects were selected to match the UK demographic distribution and also to be close to the relative proportion in which they occur in the specific population: according to the hall residents list, from the 309 students registered in 2010, 167 (46%) were male and 142 (54%) were female. A snowball technique (Robson 2002) was also used, with some of the participants recommending their friends to take part, until the adequate quota was reached. The strategy to define the number of participants involved recruiting, study, analyse and stop recruiting new participants when saturation of the data occurred. The number of participants was set to 20 since no more remarkable variation was coming from the data so there was no advantage in increasing the sample size.

The sampling for the Second Study [Theory of Planned Behaviour survey] was a non-probability sample, since invitations were sent to all students living in specific self-catered halls of residence, and those who decided to reply took part on the survey. There is no indication that those who responded are a representative share of the student population. For this reason, it is not possible to specify the probability that any person will be included in the sample. It also is inadequate "to make a statistical generalization to any population beyond the sample surveyed" (Robson 2002).

The Third Study [Intervention design and development] used a convenience and purposive sampling since involved "choosing the nearest and most convenient persons to act as respondents" (Robson 2002). Students enrolled on the module of Qualitative Methods at Loughborough University were invited to participate. There was the need for deeper interaction with participants, to perform specific tasks, evaluate the concepts and give contributions. These participants seemed to be an adequate group according to the researcher's judgement and could satisfy specific needs in a project.

The Fourth and final study [Intervention evaluation] also used a convenience sampling approach: students living in the same hall of residence as the researcher were selected. The researcher also provided the kitchen to function as the experiment setting, and it made it easier for the energy monitor to be installed and tested. Emails were sent to residents with details of the research. It is understood that it might bias the sampling to a group of students that is more extrovert or eager to help in the first place (as is the case with all the studies). However, the advertising process did not mention energy saving or behaviour change intervention testing in order to avoid biasing the sample towards participants who felt more comfortable with the subject or were particularly concerned with sustainable issues.

3.7 Conclusion

This chapter presented the methodology used during this research. It started from the research framework, as suggested by Robson (2011), and described how the aims and objectives, together with the background of research, determined the research questions that needed to be answered. Then, these research questions indicated the appropriate research methods and sampling strategies necessary to address these questions.

Using the research process 'Onion' (Saunders, Lewis et al. 2009), this chapter demonstrated in detail the approaches undertaken during the different phases of this PhD project. These range from the broader aspects of the research philosophies down to the narrow details of techniques and procedures for data collection and analysis. Table 4 below presents a summary of the methodology described in this chapter, indicates the approach chosen and justify it with examples from the studies undertook during this PhD research.

Table 4 - Research process summary

Theme	Approach in this thesis	Explanation
Philosophies	Interpretivist (constructivist) and positivist	Interaction with participants and interpretation of the subjects were used to construct meaning and knowledge
Approaches	Deductive (quantitative) and inductive (qualitative)	Ideas or concepts were tested using a deductive logic, using data from measurements and quantification. Also, inductive approach based on reasoning was used to generate hypothesis.
Strategies and choices	Exploratory – grounded theory, Descriptive – survey, Explanatory – experiment	Grounded theory generated explanations for observed behaviours and experiments followed to validate theory.
Time horizons	Cross-sectional and longitudinal studies	Single observation and comparison 'before-after' are used
Techniques and procedures	Observation, interviews, questionnaires and rating scales	There was the need for understanding the users and evaluating proposed designs in separate phases of the research, hence combining diverse methods

4 First Study – Understanding cooking behaviours

This chapter answers the second research question:

RQ2: What are the key energy related behaviours and what are the determinants of these behaviours associated with cooking?

4.1 Introduction

The First Study of this research was designed with the objective of understanding users and getting a clearer picture of behaviours related to cooking activities and the determinants of these behaviours. This information helped answer the second research question and provided material which informed the design of interventions aiming at motivating people to use less energy. The approach taken to this study was based on Grounded Theory (Glaser, Strauss 2009) in a sense that it searches for evidences to formulate theory (Robson 2002).

The literature indicated that usually food habits and practices that students bring with them from home differ profoundly (Blichfeldt, Gram 2013) and that people's behaviours can vary when cooking the same food, resulting in diverse energy use (DeMerchant 1997). However, no conclusive information was available in the literature about particular behaviours and respective determinants in relation to cooking and its influence on domestic energy usage. This study attempts to generate this knowledge grounded in observations, and use it systematically to feed the subsequent phases of this research.

Using a combination of methods, this study provides a substantial amount of data regarding the energy use involved with the energy-related process. Observational methods including video recording were applied to understand and specify the context of energy use (Hutchinson, Mackay et al. 2003). This information was combined with interviews and questionnaires to offer more data on user behaviours and determinants. This joint approach was chosen instead of only relying on techniques such as surveys in order to avoid discrepancies between reported and real behaviours (Robson 2011). Furthermore, focusing only on observation studies underutilizes the potential of interviewing actual users to understand their reasons and motivations. Combining the user observation study with in-depth attitudinal questions can create a richer set of data to analyse (Kuniavsky 2003).

Data from this study provided information about the energy use, participants' behaviours and also helped to explain why people behaved as they did. Results provided comprehensive data on user behaviours influencing energy use, indicated which behaviours should be modified to save energy and also listed the determinants of these behaviours. This study generated some interesting findings as can be seen in the Results section below.

4.2 Demographics

The population for this study comprised undergraduate students living in university halls of residence in Loughborough, UK. Hall residents are a relatively homogeneous group regarding age and educational level. The sample for this study comprised 20 subjects, 10 male and 10 female, between 18-22 years old, all undergraduate students. All flats in the hall of residence in question are fitted with similar appliances, which guaranteed that variations in results due to equipment characteristics were minimized. All students had been living in the selected hall for at least 2 months so participants had opportunity to be familiar with the appliances available for them.

As it is a common practice for students' housing, halls of residency on Loughborough University campus provide electricity, heating and water bills included in the accommodation fees. This presents interesting opportunities since residents do not have the typical financial incentive to save energy. It presents singular opportunities for studies targeting behavioural change since there is no monetary gains in saving energy in this context, therefore the effect of interventions can be measured without the interference of financial motivators.

All participants were British, in the attempt to guarantee a homogeneous demographics and limit cultural differences, which otherwise could interfere in the results. International students might have different procedures to perform the same tasks or different attitudes towards energy saving. Also, participants of the same age might have different levels of cooking skills according to their cultural backgrounds. Participants were invited to take part via their university email, a Facebook group and a poster fixed in their hall of residence. A £5 supermarket gift card was offered for all participants upon completing the study.

4.3 The task

In order to investigate further the relationship between users and energy consumption, one specific domestic activity had to be selected. Preference was given to an area with high potential for environmental improvement (Boks 2011). As demonstrated in the literature review, there is room for improvement in a number of issues surrounding the appliances and the cooking activity. However, this study decided to focus on behaviours instead of structural improvements.

With the purpose of understanding the energy related behaviours and determinants related to cooking, one simple task was given to all participants. They were asked to cook one packet of instant noodles. This meal was chosen as the research task due to a number of reasons:

- Time to prepare: it is a meal that can be prepared fairly quickly
- Simplicity: it is a meal of rather simple preparation and does not demand much previous cooking knowledge
- Familiarity: most of the students are used to cooking instant noodles
- Price: One packet of instant noodles, at the time of the experiment, was 9 pence.

Even though it is one of the simplest hot meals available, the preparation procedure presents a few aspects that can influence energy use. The cooking instructions involve boiling water and simmering, which can be done in different ways, as observed during a pilot study.

4.4 Observation

One structured observation study was designed containing a coding scheme (or checklist) to follow the user's behaviours and report activities as done or undone, and items as present or absent (Kuniavsky 2003, Sharp, Rogers et al. 2007). This coding scheme was defined after an exploratory observation of cooking behaviours performed during a pilot study, and was one of the items designed to help answer the second research question. The development of the coding scheme used during this study followed some of the considerations described by Robson (2011): the items should be focused (in the sense that they report what is going on and provide useful data), objective (without the need of inference from the observer) and easy to record (for example, by just ticking a box). These codes are the following:

- If the participant read the package instruction
- If the participant followed the package instructions
- If the participant used the kettle. If yes, what was the approximated volume of water used
- If the participant measured the amount of water before filling the pan
- Which pan size the participant chose
- If the participant used the lid to cover the pan

- Which hob the participant chose
- Which settings the participant used (energy marks sequence)
- If the participant checked the time to cook

Due to the nature of the experiment, it was difficult to design a pure unobtrusive observation study. A certain degree of participation from the researcher was required, especially when giving instructions, setting up the equipment and collecting data. However, this participation was carried out as naturally as possible, trying to make the subject relaxed during the experiment.

4.4.1 Preparation

Standard user observation methods as described by Sharp, Rogers and Preece (2007) guided the design of this experiment. It is important during any user observation study that the participants are informed that they are not being judged. They should know that what is being analysed is the interaction process, the system, the interface or the device itself (Kuniavsky 2003). Participants should be made comfortable and be informed that there is not an ideal performance otherwise they could be too concerned about doing it right that it would affect the results. For example, during website usability studies, observers make clear to the participant that it is the system (e.g. a website) that is being analysed in order to find its flaws, consequently any error observed during the test means that the system is problematic. Likewise, during this study, participants were informed that this research involved the analysis of the cooking process, and that diverse cooking behaviours are being observed, from different students. A script was developed "to guide how the participants will be greeted, be told about the goals of the study and how long it will last, and have their rights explained" (Sharp, Rogers et al. 2007). These points were clarified via the Participant Information Sheet (Appendix 1.2). They were also re-informed of these details during the introductory chat prior to the trial, highlighting that there is no right or wrong way of doing it. Participants were asked to act as they normally would, as if they were cooking in their own flats, doing exactly what they would do if they were not participating in a study. They were also reminded that the test is to understand cooking practices, so there is no right or wrong performance.

4.4.2 Kitchen

A regular kitchen in Butler Court, one self-catered hall of residence at Loughborough University was used for this experiment. This research used one specific kitchen instead of the participant's one because it was necessary to offer the same appliances, utensils and environment to all participants. It is understood that using participants' real kitchens would provide examination in context, meaning that the results would be more realistic (Lazar, Feng et al. 2010). However, having the trials as a case study at the students' flats would add difficulties to the project: several energy monitors would have to be installed in different flats; since students share kitchens, the trials could either be disturbed by people cooking at the same time or be an inconvenience to flatmates; appliances in different flats can be dirty, older or faulty, consequently present different energy consumptions and affect results. Having one single kitchen set up as a lab can avoid differences caused by external factors other than the user behaviours.

4.4.3 Video recording

This user observation study included video recording. The video recordings produced during the trials helped the researcher to double check the codes observed during the experiment, and also to code the sequences of behaviours that were unnoticed 'live' during the observation study. These codes include:

- The amount of time that the appliances were 'on', actually using energy
- The amount of time used for each temperature mark
- Which resources the participant used to have feedback on the temperature
- Which resources the participant used to control the temperature

The physical layout of the kitchen was arranged in a way to look as little like a lab as possible (Kuniavsky 2003). The only modifications were the presence of the video camera and the researcher on the background taking notes on the kitchen table used for the interview. The researcher was doing a 'relaxed observation' during the performance of the cooking task, just as "a bystander in the kitchen who is 'looking on' whilst someone is getting on with their work" (Martens 2012). The video camera was positioned directed to the cooker, in an angle that could also capture the participants' hands and body movements. The same camera was used as audio recorder during the subsequent interview.

4.4.4 Materials

Three different sized pans and lids were made available so participants could choose the one they preferred. These pans are from the same set, with their diameters measuring 16, 18 and 20 centimetres with matching lids, from the manufacturer Prestige. A plastic measurement jug was provided for those who wanted to measure the amount of water to use. All the material was placed on the same counter and the students could see all of them, but no indication was given about which utensils to use. They were made aware that if they needed any other utensil, they could ask for it. Participants could use any hob from the cooker available (Beko D-531) and also a kettle (Micromark). Even though there is a microwave oven available for students living in halls of residence, that appliance was excluded from this experiment.

4.4.5 Monitoring

The cooker was fitted with a domestic energy monitor (The Owl). This device collects and displays the energy consumption in real time and also the cumulative usage, and with this data it was possible to know how much electricity each participant used during the task. The difference between the data recorded at the end and the data logged at the beginning of the trial represents the amount of energy used, in Watts hour (Wh). This monitor has a clip sensor that goes around the mains cable, one wireless transmitter and a display. Originally, energy monitors like that are used to measure the energy from an entire house, since their sensors are commonly clipped around the live incoming mains cable, between the meter and the fuse box. However, the university flat used for this experiment does not have an energy meter: there is just one single meter for the whole hall of residence. In addition, it was necessary to isolate the consumption of the cooker from the other appliances in use in the flat during the trials. To accomplish that the clip sensor was installed around the live cable that feeds the cooker, inside the switch box.

The energy monitor screen was kept out of sight during the trials, so as not to influence participants' behaviour, and energy measurement was not mentioned during the briefing. Diverse studies in the literature use feedback information of energy use to motivate savings, either through energy monitors (Ueno, Sano et al. 2006, Darby 2006, Riche, Dodge et al. 2010) or ambient displays and indirect cues (Kim, Hong et al. 2010, Broms, Ehrnberger et al. 2009, Kappel, Grechenig 2009). These studies indicate that individuals can change their behaviours when provided with feedback on energy use.

A socket monitor was used to record the energy usage from the kettle. To avoid making participants aware of energy monitoring and influence their performance, a different method of measuring the energy usage from the kettle was developed. Since this appliance has only an on-off status and a constant consumption, this figure was recorded beforehand (2.150 kW). Its electricity usage during the trials was assessed according to the duration of use.

4.5 Interview

After the completion of the cooking task, participants were asked to explain each of the activities they performed and also give their opinions about a number of aspects of the cooking activity and the energy use. This post-experience, semi-structured interview phase was conducted following a coding scheme designed by the researcher. Open ended questions were used to obtain qualitative data from the participants. The semi-structured method was selected because it permits extra information being gathered during the process, according to users' answers. This is particularly important when trying to understand the determinants of participants' behaviours observed during the test, and to really explore the user experience (Kuniavsky 2003).

Table 5 - Main aspects that can influence energy consumption for cooking

Aspect	Variables	Question
Instructions	Read and consider package instructions	Why did(n't) you read and follow the package cooking instructions?
Kettle	Use the kettle first	Why did you use the kettle?
Water	Volume (ml)	Why did you use this amount of water? Why did you use this method to measure the amount of water to be used?
Pan	3 different sizes	Why did you choose this pan?
Lid	3 different lids	Why did(n't) you use a saucepan lid?
Hob	2 hob plate sizes and 2 different power inputs	Why did you choose this hob to use?
Marks	6 energy marks	Why did you use these energy marks to cook?
Time	Check time	Why did(n't) you keep track of time it took to cook?

During this experiment the subjects were observed regarding a set of different aspects of the cooking process and respective options for each aspect (Table 5). For example, for cooking noodles, participants can measure the 200 ml of water indicated on the packet instructions. Or they can simply ignore the precise volume and just open the tap to fill the pan. Participants could also use the kettle to have boiling water or simply cook from scratch pouring cold water directly in the pan. Three different sized pans and their correspondent glass lids were available, but participants could freely choose from the small one (which will heat up quicker and consequently use less energy) to the biggest one (which is heavier and demands more energy to heat up). The available cooker has 6 different settings from 1 to 6, which produces more heat and consequently consumes more energy. Participants could also check the time to follow the packet instructions that recommends 2-3 minutes of boiling. All these aspects of the cooking experience were noted during the trials and marked on the coding scheme, and subsequent questions followed the observations as demonstrated on the table above.

4.5.1 Questionnaire

The second phase of the interview comprised a questionnaire with 20 questions. Participants were asked about their previous knowledge about cooking and where they get information about how to cook. A rating scale ranging from 1 (not important) to 5 (totally important) was used to understand how participants rate the quality of the final meal, the time it takes to prepare, the complexity of the preparation, the amount of electricity used, how many pans and lids they are using, and the nutritional facts when cooking. These items were suggested during a pilot study and were included in the questionnaire in order to understand how people choose their meals, the cooking procedure and how their preferences can affect the energy consumption. A widely used questionnaire to measure ecological awareness was also used. An exploratory phase of the questionnaire asked their awareness of energy saving techniques, their likelihood to adopt recommended energy saving techniques, and what would be good ways to present them with these techniques. The final phase of the interview comprised revealing the electricity usage during the test, discussions about these figures and a discussion about preferences on how to cook noodles regarding consistency, amount of water and seasoning.

4.6 Energy saving techniques

To select the adequate conservation techniques presented here six topics were taken in consideration, according to those demonstrated by Booth (1996):

- **Potential for impact on the problem** – if performing each of these energy saving techniques, will the energy use be reduced? The energy monitoring proved that it is possible to reduce the electricity use drastically comparing to the amount used by the participants from this study. For graphs and analysis, see the item 4.8 (Results) below.
- **Existence of approximations to the ideal behaviour** – Are students' performance similar to ideal behaviours? It was observed that sometimes participants performed the proposed techniques, indicating that there are approximations between actual and ideal behaviours (4.8.3 - Qualitative data, below).

- **Positive consequences** – Will the participant have positive consequences, either observable or perceived, by performing the suggested techniques? Other than energy saving, one observable advantage of following the proposed techniques is a quicker cooking process, which was reported to have high importance among the participants (item 4.8.6.1 - Importance scale, below).

- **Compatibility with cultural norms or current practices** – Are these techniques compatible with current acceptable practices? Energy saving and sustainability are highly positive concepts, and most participants demonstrated having positive ecological worldview as verified by the New Ecological Paradigm scale, described below (item 4.8.6.2 - New Ecological Paradigm evaluation). However, the importance of energy use during cooking was rated as having a rather low score (item 4.8.6.1 - Importance scale, below).

- **Costs** – Will participants have to pay, in terms of time, energy, money or materials? No financial cost is involved in the proposed techniques, and is possible to save time during the process. Furthermore, it can save the students money when they have to pay for their own bills.

- **Complexity** – Do these techniques require more thinking or training? A higher level of concentration and effort is needed to cook following the energy saving techniques.

Prior to the user observation study, a series of experiments took place to simulate the cooking process and understand appliance behaviours with the ultimate goal of finding the most efficient way to cook the same food. The electricity monitor was used to understand the energy usage (and consequently heat produced) per hob and per temperature mark. Figure 10 illustrates the results of these individual measurements. It is possible to see that the small hob at the front uses more energy than the similar one located at the back only when on mark 6. It happens because it is equipped with a 'fast heat element' (Beko 2006, Beko 2011). This hob was quicker to heat up but can incur in extra energy use, unless the user controls the heat input as described below.

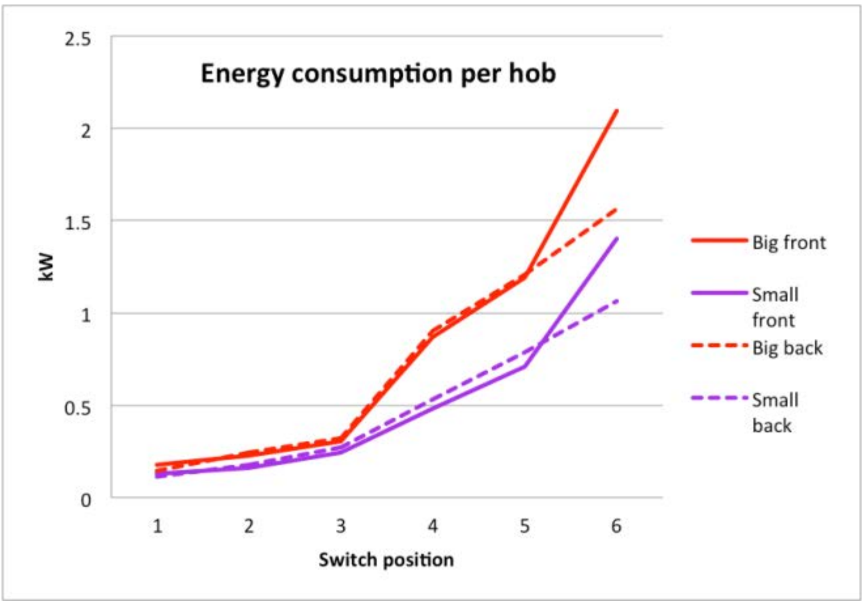


Figure 10 - Energy use per hob for each control mark

Figure 11 shows the time and the internal temperature of a pan with its lid containing 200 ml of water on the small hob at the front. This data was recorded every 30 seconds using an electronic thermometer with its tip in the water. It was possible to switch the heat source off even before the water had started to boil. 2 minutes and 40 seconds were enough to keep the water boiling for about 4 extra minutes, enough time to cook noodles thoroughly. It is possible to turn the hob off even before the water temperature reaches the boiling point and still have heat to cook for a few minutes. The hob was left on for less than 3 minutes and it produced heat enough to keep the water boiling for about 4 minutes. Since water stays at a maximum 100° C no matter how much energy is put in, the source of heat should be controlled to avoid waste. The water temperature could even be below 100º C and still cook pasta (McGee, 2004), resulting in further savings but it can increase cooking time slightly (Das et al., 2006).

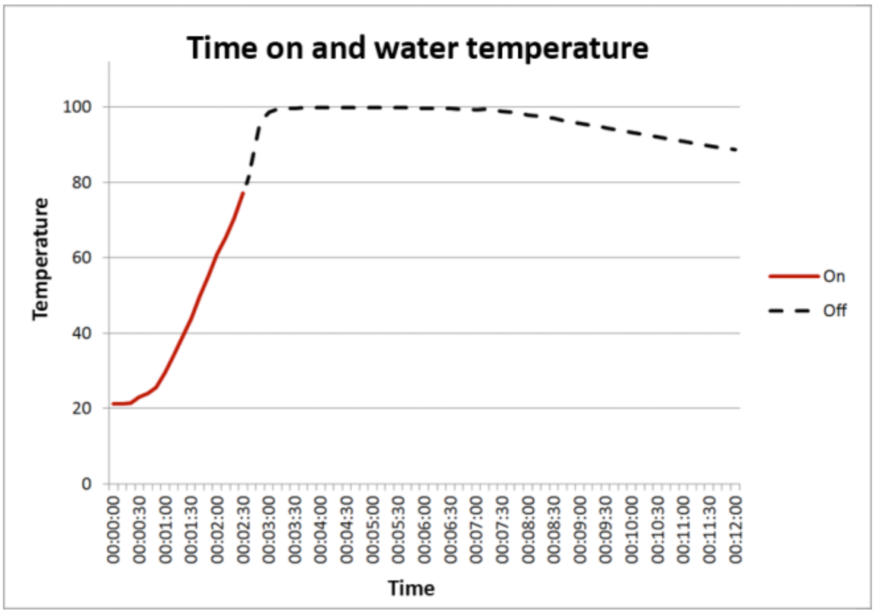


Figure 11 - Time on and water temperature

Previous research helped during the process of selecting the energy saving techniques for cooking used during this research. The comprehensive literature review performed by Probert and Newborough (1985) presents numerous recommendations on how to manage cooking equipment and utensils more efficiently, focusing on fundamental principles such as thermal performance for energy conservation. The user manual for the specific cooker used during this research was also consulted to understand its characteristics (Beko 2006). This information was added to techniques to reduce the energy use to prepare food that involves boiling (Das, Subramanian et al. 2006), define the efficient temperature needed to cook pasta (Potter, Ruhlman 2010, McGee 2004) and find the ideal volumes, utensils and appliance settings to improve the efficiency of cooking (Oberascher, Stamminger et al. 2011). Data from a pilot study with four participants were also used in order to understand behaviours and evaluate which ones would be investigated further.

The following set of energy saving techniques was constructed with information from the literature review, the on-site experiments performed by the researcher and the pilot study. They had the purpose of finding the most efficient cooking process and could be applied to single meals that involve boiling:

- **Read and follow the packet instructions:** Reading and following the packet instructions, where the amount of water and the length of the cooking are stated, could guarantee low energy usage. It is important to adopt measurements of quantities of the constituents for a meal instead of rough estimates "because the latter often lead to both energy and food wastages" (Probert, Newborough 1985).

- **Keep track of time**: Too long a cooking time can compromise the quality of food and also influence the energy consumption.
- **Measure the amount of water:** Not measuring the amount of water can result in participants having to heat more water and consequently increasing the energy use since more energy is needed to heat more water (Oberascher, Stamminger et al. 2011).
- **Do not boil water in the kettle:** Boiling water in the kettle and pouring this water in the pan is a common practice, as reported during the pilot study. Kettles can provide hot water fairly quickly, but in certain circumstances can increase the amount of energy necessary to cook noodles. This happens mainly because cooking instant noodles requires just 200 ml of water, and the kettle found in the students' kitchen has a minimum mark of 500 ml, resulting in boiling more water than needed. Kettles are still the most efficient way of heating water comparing to a pan or a microwave oven (Oberascher, Stamminger et al. 2011) when just hot water is needed, for example when making tea.
- **Use the smallest pan:** To increase the energy efficiency and reduce cooking time, a small pan should be used. As this experiment involved cooking one single packet of instant noodles, a small pan would be enough to fit the contents. Smaller pans need less energy to heat because they have small mass and consequently smaller thermal inertia. Furthermore, cooking single noodles in small pans guarantees that the water will cover the noodles better than bigger pans.
- **Choose a small hob:** A small hob is more indicated for cooking single noodles: it fits the pan and avoids wasting heat to the air (Beko 2006).
- **Use the lid:** By using a lid it is possible to maintain the heat inside and make the cooking process quicker. Previous research has shown that simply using lids on saucepans can make the energy consumption three to five times lower (cited in Wade, Hinnells et al. 1995, Brundrett, Poultney 1979).
- **Reduce the heat when the water is boiling:** The hobs used during this experiment consist of a heating element inside a solid metal plate. This hob heats up by its embedded electrical-resistance elements and then transfers heat to the base of the pan. Due to the cast-iron plates, it has a high thermal inertia. This type of hob usually needs to be energised in advance in order to attain its operational temperature (Newborough, Probert et al. 1990). For this reason, a few minutes are necessary for the hob to heat and then transfer the heat to the pan, and it also takes a longer time to cool down. The remaining heat on the hob indicates that the heat source could be turned down when the pan is hot enough (or even turned completely off, as explained below) in order to save energy.

- **Turn off the heat a few minutes before the end of the cooking time:** For short cooking processes, the accumulated heat might be enough to carry on cooking without the need for any extra heat input. It is possible to reduce energy use by more careful time planning, switching "the appliance off before the end of the actual period of use" (Wood, Newborough 2007), applying what can be called "time frugality".

Each of these techniques are analysed below, together with participants' explanations for whether they performed it or not (item 4.8.3 - Qualitative data). After developing a set of energy saving techniques, the researcher cooked the same food to determine the minimum amount of electricity necessary. This figure was used as the baseline against which the energy consumption of the participants performing the same task was compared. The energy efficient cooking techniques identified by the researcher were not communicated to the participants until they had finished cooking but were used during data analysis to evaluate each participant's cooking behaviours.

4.7 Data analysis

Different data types were gathered to help understanding user behaviours. These data included demographic information from the participants and extra information including course, department and year. When participants started the task, video images were collected and checklists containing the code scheme were completed by the researcher. Another important measurement consisted of the energy data at the start and end of the process, read from the energy monitor. Importance scales and attitude measurement surveys were filled in by the participants. Interviews also provided a wide range of information for this study, as described below.

The results from this observation study and semi-structured interview comprised different data sets which required different methods of analysis. First, the demographic details, data from the energy monitor and the closed ended questions that comprised quantitative data were input to a computational system through a customized Microsoft Access entry form. Gathering this information in a database allowed deep analysis and cross-comparison of data to better understand and visualize the results. Microsoft Excel was used to perform calculations and draw graphs as can be seen on the Results below.

The second phase of the data analysis involved dealing with video and audio recordings from the user observation study and interviews. These files were imported into the QSR International NVivo software. This application allows qualitative data examination, and was fundamental to provide a wider comprehension of the results and facilitate working with the themes raised during the study, connecting ideas, managing data and organizing it in a meaningful way (Bazeley 2007). Transcriptions of the interviews were undertaken entirely through NVivo, helped by its internal modules for media playback, synchronization and transcription.

One important phase of the qualitative data analysis is the definition of the coding system in order to better organize the information (Bazeley 2007). The conceptual framework, the list of research questions, the hypotheses, problem areas and the key variables related to this study guided the development of the coding structures for this research (Miles, Huberman 1994). Every thematic area was coded into nodes and sub nodes, which could later be referenced and clustered into separated groups of information, organized "to find repeated patterns of meaning" (Braun, Clarke 2006). This organization helped the qualitative data analysis and facilitated the extraction of specific quotes for relevant themes as seen in the item 4.8.3 - Qualitative data below.

4.8 Results and discussion

Data analyses from the trials showed surprisingly diverse information regarding energy use and also time to complete the task. The performance of participants was compared with the recommended procedure representing a set of energy saving techniques designed by the researcher. Figure 12 below shows the energy used combining cooker and kettle (when used). Participant 0 (leftmost bar) is the researcher applying the energy saving techniques. These results show that cooking using the energy efficient techniques required 3 times less energy than the average consumed by the participants. When using the energy saving tips during the controlled experiment, only 63 Watt hours (Wh) were used to cook the noodles. The mean value from all the participants was 191.4 Wh. The energy use differed by a factor of 2.8 between participants, with the lowest value 102 Wh and the highest 282 Wh (Figure 12).

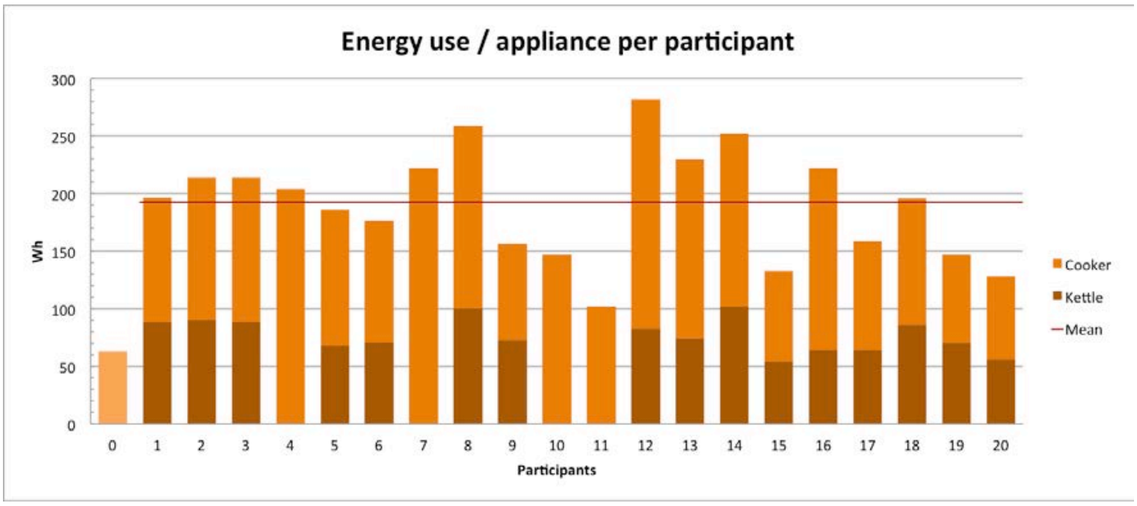


Figure 12 - Energy used for cooking

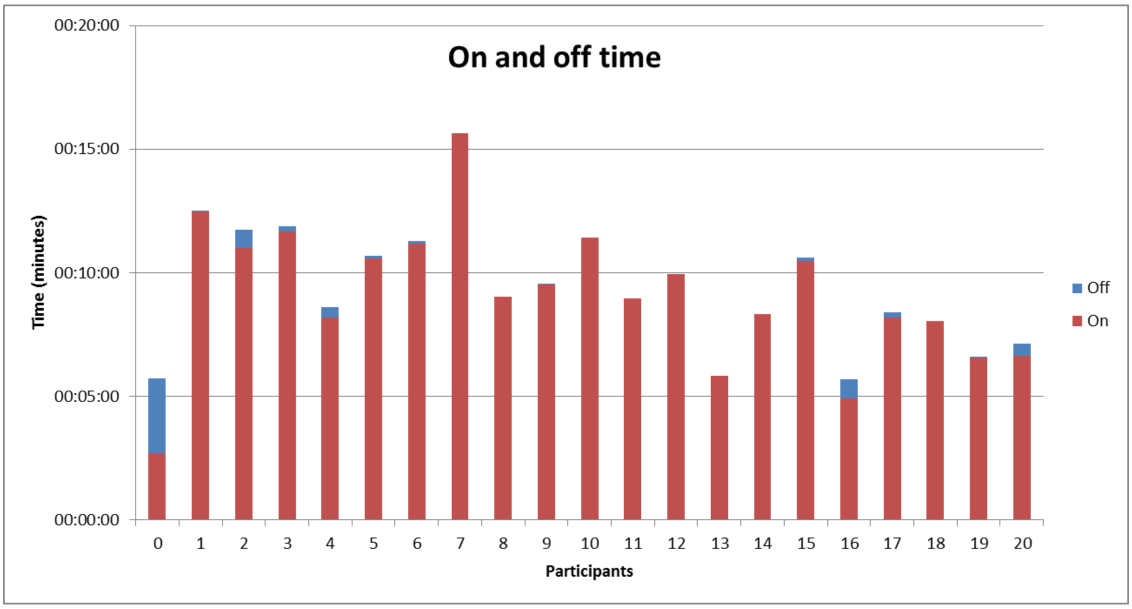


Figure 13 - Cooking time effectively using energy (on) and off

Another surprising result is regarding the time to cook the noodles (Figure 13). Even if the package recommends cooking it for 2 to 3 minutes, participants spent much more than that, affecting directly the energy consumption. The mean value from the moment they turned an appliance on until they turned it off was 9 minutes and 26 seconds. Some participants turned the hob off before the end of the cooking time. However, only four of them used the remaining heat for longer than 20 seconds (up to 45 seconds, participant 2 and 16). Participant 0 is the researcher applying the energy saving techniques. It can be seen that it was possible to cook the noodles with the hob off for further 3 minutes. In total, the researcher used substantially less time than the average.

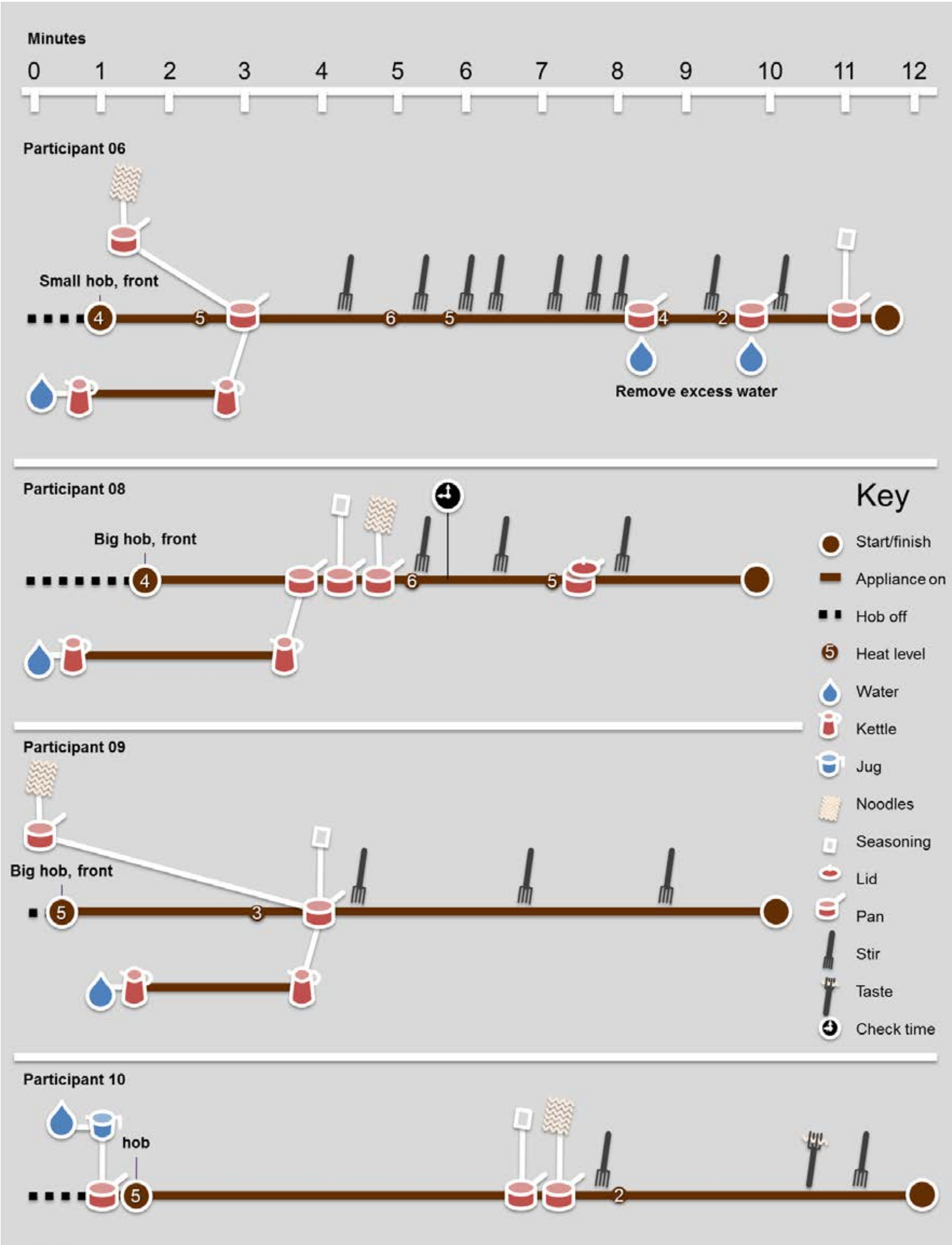


Figure 14 – Participants' cooking timeline

The diversity of behaviours is illustrated on Figure 14 above, where the cooking processes of four participants are represented as timelines, in a schematic manner for visualization purposes. It is possible to see differences in the sequence of steps taken, use of kettle, measurement of water, hob used, heat level, size of pan, use of lid, how often they stir, when participants added the ingredients and duration of the process. For example, participant 06 starts filling the kettle and then pre-heats the hob whilst placing the noodles in the pan. This student pours the boiling water in the pan, stirs the noodles a few times and changes the heat level a couple of times, until realizing that there was too much water. The participant then removes the excess of water and adds the content of the seasoning sachet at the end. Participant 08 had a similar procedure, although adding the noodles and seasoning in the middle of the process. It was noted that this student produced a mobile phone and glanced at the screen half way through the cooking, but did not check it again, just estimating the remaining time needed to cook. Participant 09 starts unpacking the noodles, placing it in the pan, pre-heating the hob and then filling the kettle. When the water boils, s/he pours over the noodles and adds the seasoning, keeping on a steady heat, stirring it from time to time. Participant 10 starts measuring the amount of water, then places it in the pan, heats it on mark 5, adds seasoning then the noodles, stirs, reduces the heat level to 2, tastes the noodles, stirs a bit more then considers that it is ready. These differences in behaviours help explain the variation in energy and time usage observed during this study.

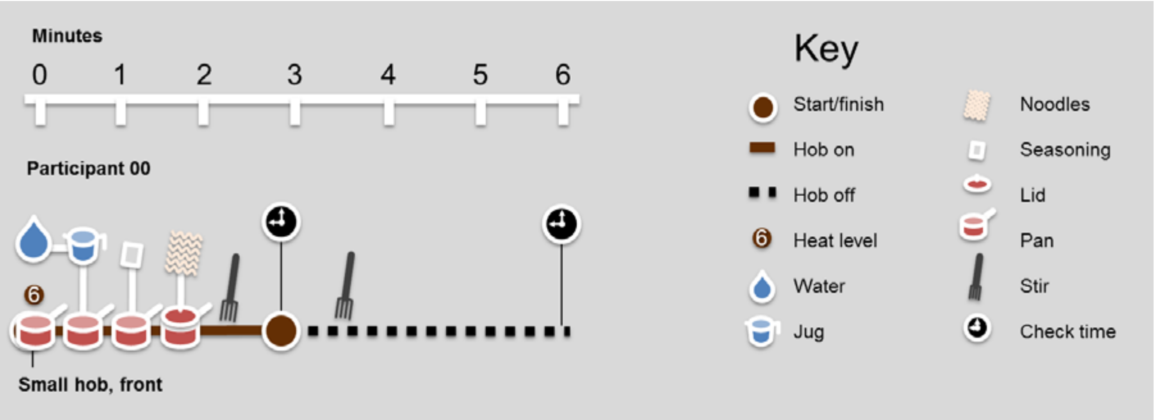


Figure 15 - Efficient cooking

The cooking procedure performed by the researcher, here described as 'participant 00', can be seen on Figure 15. The time spent actually using energy was less than 3 minutes, and it was only possible by following the recommended energy saving techniques. The pan was placed on the small hob at the front using mark 6 to heat up 200 ml of water. The ingredients were added then the pan was covered. The stirring was kept to a minimum to avoid opening the pan and losing heat, and the boiling time was measured. The hob was switched off right before boiling and the pan was kept covered to continue boiling by using the remaining heat stored in the metal plate hob. The controlled nature of this cooking process explain the low energy use, although the target was to explicitly conserve energy whilst making sure the noodles were properly cooked, maintaining the quality of food and not increasing cooking time.

4.8.1 Food choices

The selected set of energy saving techniques was designed having in mind a cooking process that involves boiling. This approach was taken because by boiling water it is possible to cook a variety of foods, and it is a simple process that is be performed rather frequently. Indeed, this was the most common method of cooking reported by the participants of this study. As can be seen on Table 6 below, pasta and rice were the most frequent responses for the question "what do you cook, normally?"

Table 6 – Food habits

Food	Number of participants who mentioned
Pasta	15
Rice	8
Chicken	6
Vegetables	5
Meat	4
Noodles	4
Stir fry	3
Pizza	3
Curry	3
Frozen food	3
Eggs	2
Casserole	2
Beans	2
Bacon	1
Omelettes	1
Chilli	1
Potatoes	1
Fast food	1
Toast	1

Canned soup	1
Lasagne	1

4.8.2 Cooking process

From the user observation study a wider understanding was developed of why participants used more energy and time than needed. Out of the 20 participants, five of them did not read the packet instructions at all. Ignoring the instructions meant that they did not pay attention to the amount of water and the time it takes to cook. Even those who read the instructions did not follow all the recommendations. All participants cooked the noodles for longer than recommended on the packet, therefore resulting in extra energy being used. Just five participants measured the volume of water to bring to boil, while the others used more water than needed. Overlooking the amount of water substantially increased the overall energy expenditure because more energy is necessary to heat more water. The volume of water also had an indirect influence in the energy consumption as three participants kept the noodles boiling for longer, did not use the lid and used high temperature marks in order to make the extra water evaporate. To speed up the process, 16 of the participants used the kettle first then poured boiling water into the pan. Four participants used the medium sized pan provided instead of the small one. Twelve participants used a big hob and a small pan resulting in wasted energy to the air. Just four of the students covered their pans. Only four of the participants turned the hob off more than 20 seconds before the end of the cooking process.

4.8.2.1 Appliances and interaction

It was observed that each of the four hobs produces different heat. Two of them have a diameter of about 6 inches and the other two 7 inches. But even with hobs of the same size, the energy consumption (and consequently the heat produced) is different. It happens because the two at the front contain a ‘rapid heating element’, but the interface or even the user manual does not give any more information about it (Beko 2006, Beko 2011). Only after analysing the energy consumption per hob and for each mark was it possible to comprehend that the rapid heating feature only occurs when the control is on mark 6. This creates enormous differences in heat production that could potentially confuse users, with mark 6 using almost double the energy of mark 5 for the two specific hobs at the front. Four participants had their hob overheating and, since it stays hot for a long time, had to keep just half of the pan on the hob to limit the heat transfer (Figure 16). This observation is in accordance with findings from previous research: Even experienced catering chefs perform this common ‘control’ practice, since the total power dissipation from solid hobs often remains high and the cook "arranges the pans so that they cover only partially the available heat source" (Newborough, Probert et al. 1990). One participant realized that the hob was hotter than needed and decided to start heating another hob to finish the cooking process with less heat.

Figure 16 - Participants trying to minimize the heat transfer due to overheated hobs

The electricity monitoring showed that mark 1, 2 and 3 use about the same energy across all hobs, as Figure 10 illustrates. Regarding variation of heating control, two participants used only one single heat level during the whole process, nine participants used two different marks to cook, seven moved the control between three marks, and the remaining two participants used four different marks to cook. This suggest that maybe six options are more than needed, especially considering that three marks produce about the same heat.

According to a comprehensive study by Mansouri et al (1996) the two rings at the front are used more often and for longer than those at the back. Their results are similar to what was noted during this cooking observation study. Seventeen of the participants used the hobs at the front, and just three of them used the ones at the back, as can be seen on Figure 17. Combining this information with the electricity consumption per hob observed during this study (Figure 10) provides interesting inferences. Since the hobs that are used more frequently have higher energy consumption, it indirectly causes unnecessary extra energy use. The user is not aware of this expenditure since there is no clear information about the different energy used by each hob.

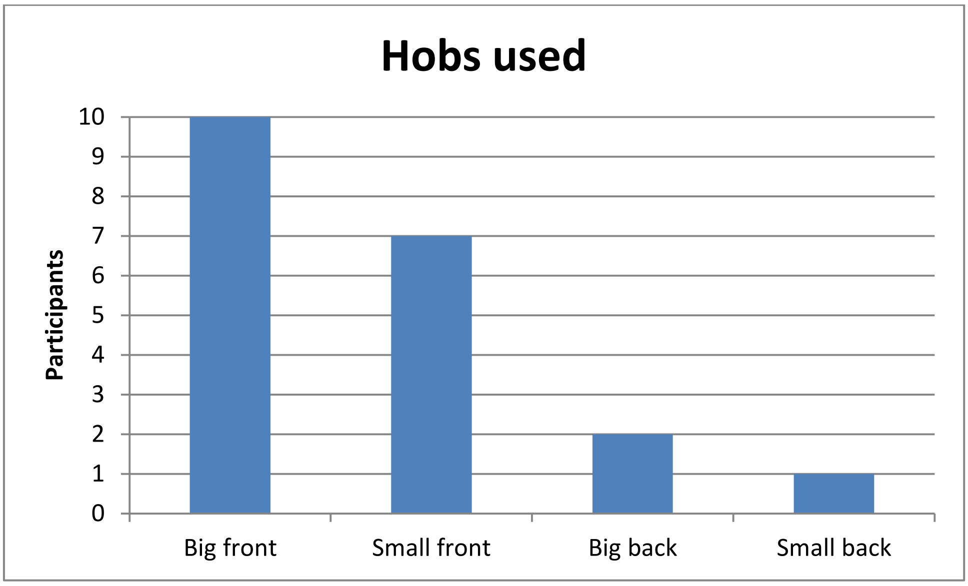


Figure 17 - Hobs used per number of participants

The cooker used in this study has four burners arranged in a square but the controls are arranged in a line. Norman (2002) comments on this issue: "Most stoves have controls arranged in a line, even though the burners are arranged rectangularly. Controls are not mapped naturally to burners. As a result, you have to learn which control goes with which burner." Studies show that "control configurations should match those of the displays in a one-to-one geometrically corresponding linkage, that is, they should be isomorphic" (Chapanis, Yoblick 2001). Previous research (Ray, Ray 1979) proved that when having controls on the same disposition as the burners, "no subject incurred any errors", whereas if the controls were disposed in a line and the hobs in quadrature, a minimum of 8.6% of errors occurred, up to 19.2% depending on the arrangement. In accordance to these studies, participants from this experiment also showed difficulty in relating the control with the burner that they were using, heating a different hob than intended or having to bend down in order to see closer or from a better angle, to refer to the little diagram and choose the right control (Figure 18).

Figure 18 - Participants bending down to deal with the controls

In addition, the cooker model used has just one pilot light for all hobs, making it difficult to know which one is being used. This is particularly important with this sort of appliance as there is no visual feedback on the hob comparing to gas cookers where the flame is visible or ceramic and coil hobs that glow red-hot. For that reason, eight of the participants had to put the hand over the burner to check if it was heating (Figure 19), and one of them ended up using the biggest hob because he selected its control unintentionally in the first place.

The design of cooking appliances appeared to determine how comfortable people feel when interacting with them, cause errors during the cooking process and increase the final energy use. These results came from a study with young undergraduate students, and these issues can be even more acute if other demographic groups are considered. Previous research demonstrates that limitations regarding vision, hearing, mobility, reaching and stretching, and dexterity imposed difficulties for older adults in their attempts to perform daily activities in the kitchen (Maguire, Nicolle et al. 2011, Sims, Maguire et al. 2012), therefore indicating that other demographic groups might be even more vulnerable to cooker design limitations.

Figure 19 - Participants checked the heat from the hob using their hands

4.8.3 Qualitative data

Combined with the observation study, an in-depth semi-structured interview was performed to understand participants' determinants of behaviours. The students were asked to explain the reasoning behind each observed behaviour noted during the cooking process. The main energy-related issues detected during the observation study are listed below, containing the number of participants who performed the listed behaviours and their main explanations for these behaviours. The energy-related issues were as follows:

4.8.3.1 Packet instructions

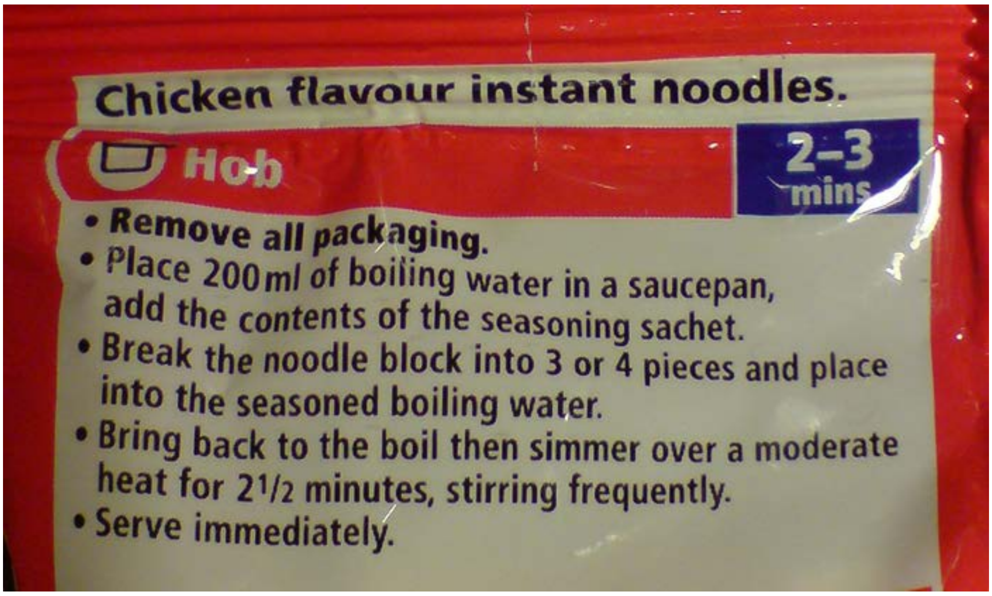


Figure 20 - Instant noodles cooking instructions

Out of the 20 participants, five of them did not read the packet instructions. Ignoring the instructions regarding the amount of water and cooking time influenced substantially the overall energy expenditure. During the semi-structured interview, they explained this behaviour as being due to the characteristics of the meal or experience. For example, participant 2 mentioned that *"it's just because you can't really go too wrong with noodles"*, or *"it seems quite straight forward"* (participant 4) or *"it's because I've done it before"* (participant 13). Interestingly, these participants spent more electricity than the average.

4.8.3.2 Kettle

Although it is a common practice, this experiment showed that boiling the kettle increases the amount of energy used to cook noodles. Cooking noodles requires just 200 ml of water, and the kettle found in the students' kitchen has a minimum mark of 500 ml, resulting in boiling more water than needed. In addition, heating the hob and the pan also takes energy and time. Sixteen participants used the kettle to obtain boiling water and then poured it in a pan. When asked why they used the kettle, participants explained that they wanted to do it quicker, due to habit and influence of family members. As participant 18 illustrates: *"It's just habit. My parents have always done that, that's why I do, I guess"*.

4.8.3.3 Amount of water

Just five of the participants measured the amount of water used. It affected directly the energy consumption because more energy is necessary to heat more water. It also had an indirect influence as some of the participants kept the noodles boiling for longer, did not use the lid and used high temperature marks in order to make the water evaporate. Participant 4 illustrates: *"I just poured an amount that I thought it'd require, I didn't quite measure the amount. I just thought, well, half of the container would do"*. Their reasons were habit, convenience and the lack of utensils like a measurement jug. Participant 2, when asked why they did not measure the water, said that *"just because, for convenience, we just pour it whatever"*. Other issues involving the student's life also prevented them from measuring the water, as participant 8 explains: *"we don't have one* [measurement jug] *in our flat, but your own is different, but in our flat, even if we did, it's all filled with alcohol, it's just left dirty from cooking.* […] *It's too much effort to go and get something to measure it, because you need a jug to measure the water. And then it's too much effort"*. When asked why also not measuring the amount of water for cooking, participant 14 said that *"it's too much time wasting, too much faffing. It's much more simple just to put in, roughly"*.

4.8.3.4 Pan size

Even though bigger pans take more time to heat, four participants used the medium sized pan for cooking one single serving due to wrong size judgement or habit. Some participants used the small pan because they understand it would make the cooking process quicker. Participant 4 says that *"it would take the shortest time to heat up"*. Two participants mentioned that they frequently cook bigger meals so they are used to cooking with bigger pans.

The need for convenience also motivated students to choose smaller pans for cooking. When asked the reason for using the small pan, participant 20 declared: "*Because I guess it saves you from washing a big pan. I use the smallest pan possible for what I'm doing then I don't have much to wash up, and then you can use the smaller hob as well instead of heating up the bigger hob*".

4.8.3.5 Hob size

Only eight students used the small hob as recommended for a small pan. Participants who used a bigger hob explained it as habit, convenience, or because they wanted to cook quickly, and they understand that bigger hobs provide more heat. Participant 4 illustrates this concern: "*If I'm in a rush, then obviously I want to cook as quick as possible, […] I can't see myself going for the small plate, because it just seems a waste of time*". The same student adds when asked about using the big hob: *"I think that it's quicker to heat up. It was all about speed, to be honest"*. Participant 10 also reports that *"it will be quicker, probably. That's what I would think normally, anyway. I don't know why though. You know, it's about heat time than everything else"*.

The convenience was also a reason for choosing the hobs at the front, which use more electricity when used on the highest heat mark. When asked why, participant 2 said that *"it is within a more reachable distance, I could use this one but, bad reach distance on the back hob"*, participant 9 added saying that *"[it's] just because I was standing next to it, I used that one"*. Other students justified this option by saying that they have chosen a bigger pan in the first place.

4.8.3.6 Lid

Just four of the participants used the lid on the pan, demonstrating that they understand that it helps keep the heat in and makes the process quicker. The others explained that it is a habit, and using the lid to cook noodles depends on various factors: they wanted to stir it, it is a quick preparation, they believe that there is no need for lids when the water is already boiling, they wanted to let the water evaporate, the instructions do not mention it, their friends do not use it or they do not have lids for their pans. Three students mentioned that they had problems with the water boiling over, as participant 18 explains: *"normally when I use a lid I just end up with the water boiling over, so I tend to just not use it anymore. Even though I know it keeps the heat in more, but I just normally don't use it, so, you don't get the water like boiling over the top and spilling out"*.

Participant 4 used the saucepan lid and explained why: *"Well, if you, like, with the noodles, some people cook it by just putting the noodles in the water and boiling it that. Like, straight. But I reckon that if you boil water first, with the lid on, obviously, it boils faster, does it not? And keeping the heat in"*. Participant 20 also explains that using the lid can speed up the cooking process: *"when I want things cook quicker, then I put the lid on, because then like, the steam, it keeps the steam inside"*.

For most of the students, that is the first time they are living away from home, and they have to learn to cook for themselves. Since they are not very experienced and do not have strong habits, the way other people act have a strong influence in their behaviours, as one of the participants mentioned: "*I don't usually tend to [use the lid]. I know, I sort of watch what my mum does at home but, if my mum would have done that, but, since I've been in Uni I picked up on what other people are doing and not, and in my flat no one normally use the lid for saucepan, so I, I just never really put it on*" (participant 15).

4.8.3.7 Pre-heat the hob

Metal plate hobs can be slow to heat up. It might induce users to pre-heat it, a behaviour shown by most of the students: *"I've done that because in our flat our hob takes a long time to warm up, so I always, like, turn it on first. And then, it's just quicker to cook"* (participant 13). Participant 8 also comment on this issue: "*With gas cookers you can just put straight on to the flame, but with these you need the ring to heat up first"*. Commonly, students pre-heat the hob whilst boiling the kettle: *"[I pre-heat the hob] because the kettle takes long to boil. And whilst it's boiling, I pre-heat the hob because it takes ages to heat up. So it would just heat up faster, [...] otherwise the hot water would start cooling down because the hob isn't as hot yet"* (participant 20).

4.8.3.8 Heat level

Most of the participants reduced the heat level at some point during the cooking process. They understand that it can help avoid overcooking and also boiling over. But some participants explained why they keep the heat up towards the end of the process: *"I normally just put it on high heat, just to heat the food fast. I know if you do it slowly it cooks better, but sometimes you just want a quick meal, so you just put in a high one"* (participant 8).

4.8.3.9 Remaining heat

One of the reasons why participants used more energy than needed is because almost all of them left the hob on until the end of the cooking process. One of the techniques to save energy is to switch off the heating before the end of the preparation time. It is possible with electric cookers because, due to its high thermal inertia, the solid metal plate hob keeps hot for a few minutes after it is switched off. However, just four participants performed this technique noticeably during the experiment. The others left the hob on until the very end, when they removed the pan from the hob. Participant 16 demonstrates knowledge of this concept and also energy conservation concerns: *"Well, once I knew that it was nearly cooked I just decided to turn off the heat and let the residual heat from the ring just cook the rest, usually just to try to save a little bit of energy at the same time"*.

Some of the participants are aware of, and use this technique for some meals, as participant 20 explains: "*I try to put off the hob a few minutes before, I don't always do it but, like, I try and do it sometimes when I know 'ok my food is almost ready' and I just turn off and it's still hot anyway. If I need the oven, I do that when I use the oven because it keeps the heat on for longer so I put the oven off like a few minutes before"*.

Participant 15 illustrates how the lack of timing and not following the instructions can make it difficult to perform this energy saving technique. *"The only thing is that sometimes when I'm guessing, well, when I'm not reading the instructions and following the instructions completely, when I'm sort of guessing when it's done and, I wouldn't do that because I don't know when it is gonna be finished. But if I was to read the instructions and follow them religiously then I could definitely do that"*.

4.8.3.10 Timing

Seven of the participants checked the cooking time on the device screen, but none of them set a proper countdown timer or stopwatch to time the 2-3 minutes as recommended by the packet instructions. The others just checked the food visually or tasted the noodles to see if they were ready. This lack of control resulted in diverse time usage, as can be seen in Figure 13. Their explanations for not timing the process were personal preferences, like participant 11 points out: *"I tend to go by my taste. And if I think it's ready, because it's me who's got to eat it, so, if I think it's ready I'm happy to eat it, then I will"*. Other participants mentioned that they are experienced: *"Well, because I cook noodles quite often, I know what they look like when I like them ready. So I didn't keep the time because I thought I know by sight now, when I think it's done"* (Participant 5).

Other students also mentioned that they rely on their senses as a reason for not timing the process, indicating a lack of rigour, as participant 16 reports: *"I tend to just know roughly in my head what time there is, I know I'm not always right but if it looks like it's done, and if it looks like it's cooked then I usually take it off, basically I can tell if it's likely to become overcooked so I know then when to stop"*. Participant 18 also illustrates how loose the time control among the participants was: *"Well I looked to my phone when the time started and then I kind of looked again after about 3 or 4 minutes so, because things started to stay in really, I just thought, yes it's probably about ready, but I didn't test or anything so, it's just guessing"*.

Another reason for not timing is that the cooking length might vary according to the cooker being used: *"I do realize sometimes the instructions are wrong, depending on the cooker and stuff like that, that sort of thing. So you may end up cooking it a bit longer, so I've had that before, that at home I cooked, like, just exactly what it is said on the packet, so it hadn't been cooked properly"* (participant 15).

Evidence from this study showed student's motivations behind the poor time control demonstrating that they just did not put too much effort in the preparation process, supporting the desire for convenience. When asked about checking the time, participant 10 mentions that *"I* *thought about it, and then I was, I couldn't be bothered. Like, pure laziness. But I tend to do all my cooking by eating and seeing what it tastes like and tell if it's ready".*

The lack of precision of a timing process done by using the regular clock on a mobile phone screen was evident with participant 20. *"I just calculated so I guess, like, because the noodles say 2 and a half, and obviously, I can't tell the half, so I just ran then to like, 3 minutes"*. However, the video recording showed this participant boiling the noodles for 5 minutes.

Participant 10 mention how useful a timer can be, since it had been used for certain foods and worked as a convenient reminder: *"Our cooker's got a timer just in the middle, so we put a timer on, so like casseroles or things like that because it takes ages, it seems like ages. You put it on, because obviously you can notice when it goes. So and then you hear it go off and you 'oh I need to be doing something'"*.

Some of the students wanted to have softer noodles, hence cooking for longer. When asked why they did not time the process, participant 9 said that *"I guessed, until it was done and soft. Because I like them soft"*. Participant 17 also illustrates the role of preferences on the cooking process: *"I prefer food a bit of overcooked than undercooked"*. Participant 5 contributes to the need to consider personal preferences when declaring that *"I made the noodles how I like them, regardless of how long it took really. […] I wouldn't have it differently just so I saved more energy"*.

4.8.3.11 External factors

Some important factors that cannot fit into the previous categories were also found during this user observation study and interviews. One of them relates to the financial structure of the university accommodations. All the halls on campus are 'all inclusive', with all bills included in the hall annual fees. It makes the charging process simpler for the university and also makes the payments more convenient for the students. However, it imposes tough challenges for sustainable behaviour, since it eliminates the financial incentives to save resources. Students are aware of it and participant 5 illustrates this issue: *"We don't have to pay bills, we're not much aware of how much things cost, and how much energy is being used. Then if I was paying bills I think I would be more conscious about it"*.

Another factor that arose from this study was the lack of adequate utensils. When asked about their choices regarding pan size or lid usage, some of them reported that they behaved in accordance to what they are used to do in their own flats, and that these behaviours were influenced by past behaviours and their possession of utensils. Participant 17, humorously, said that *"I haven't got saucepan lids, so I never use it"*. Regarding the ownership of saucepan lids, participant 19 reports that *“maybe I left them at home”* and participant 15 adds to the concern that some students do not have lids, and even if they have, it does not mean that they are using them: *“I of all my flatmates I'm the only one who bought saucepans with an actual lid, so mine would be the only ones with lids, but I'm still not using them*”. Inadequate pan sizes showed to be an issue too, as participant 18 describes: *“I've got a smallish one, and a big one, I haven't really got like a medium sized one, so I tend just to use the bigger one”.*

As this study suggests, the ownership of kitchenware among students is limited, and the specific configuration of kitchens and appliances in university halls restricts their behaviours. Consequently, it constrains students’ ability to perform some of the suggested energy saving techniques in the real context.

4.8.4 Convenience

Participants often mentioned that convenience was one of the reasons for performing non-energy saving behaviours. Under the term *convenience* it is comprised the desire for an easy cooking process, behaviours that demonstrate that participants did not want to put much effort into the activity, or, by their own terms, ‘laziness’.

The balance between energy use and personal preferences was demonstrated by one participant who acknowledged the wasteful behaviours performed in order to have the desired convenience. Participant 10 could follow energy saving techniques only if *“it's not an inconvenience in me, by following them, but I wouldn't go out of my way, you know, loads of effort, which is bad but…* [laughs]*”.*

4.8.5 Preferences

Some subjects gave interesting insights on the relation between the quality of food and acceptance of energy saving techniques. When asked what would motivate students to follow the proposed techniques, participant 1 declared that *“I think they would be more interested in the quality of the food, so if you say, ‘improves the quality AND save the energy’, then they could do for the quality, really, I think”.*

4.8.6 Attitudes

In an attempt to better understand the participants’ motivations behind the observed behaviours, two extra questionnaires were administered during the First Study. One of them, based on preferences reported during a pilot study, involved an importance scale (from 1-not important to 5-totally important) of 6 aspects involving the cooking activity. The second questionnaire consisted of a widely used protocol to measure ecological concerns, the New Ecological Paradigm (NEP) (Dunlap, Van Liere et al. 2000). Results from both studies are shown below.

4.8.6.1 Importance scale

A simple importance scale was used to gather data from participants perceptions of the relative importance of different aspects of the cooking experience. The selected topics shown below were mentioned during the pilot study, and were asked during this main study in order to gather a better understanding of participant's attitudes regarding their cooking process. Students were asked to rate the importance of the following aspects when cooking:

- The quality of the final meal
- The time it takes to cook
- The easiness to prepare
- How much energy is spending
- How many pans and lids is being used
- The nutritional facts of the food prepared

These topics were added in order to shed a light on attitudes which can influence their behaviours and consequently affect the energy usage. By understanding how important these items are it is possible to infer the acceptance to change. In other words, this scale indicates if there is room for modifications on these aspects related to cooking, and provides hints on acceptance levels for interventions that attempt to change these aspects.

After observing the responses from the attitude questions, it was noticed that the quality of the meal was rated of highest importance by the participants (Figure 21), with most of them indicating that they really care about the quality of the dish. This result provides an interesting scenario to be considered during the intervention design. It indicates that any modification on the cooking process that threats the quality of the food will probably be rejected. Any suggested modification on the cooking process must advertise (and really promote[2]) improved food quality.

[2] It is understood that interventions should provide accurate information, especially if the intention is to promote long term change. Persuading people with one false argument might work once, but when they

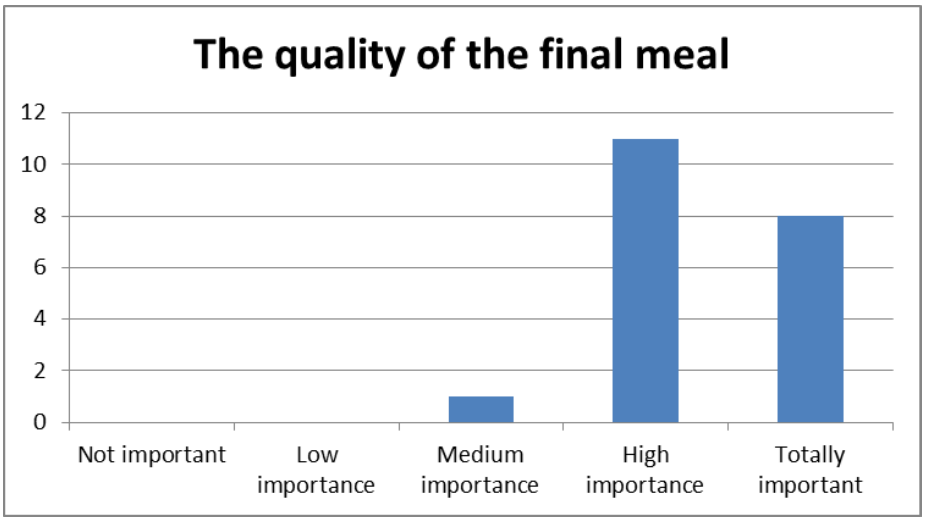


Figure 21 - Importance of the quality of food

The time it takes to cook was rated as slightly important, with most of the participants reporting it to be medium or highly important (Figure 22). This data shows that most participants will not be very inclined to follow recommendations that increase the cooking time. This information is in accordance to observed behaviours during the experiment and their correspondent explanations given by the students. Some of the behaviours were performed to make the cooking process quicker, regardless of the energy usage. This data indicates that interventions aiming at energy conservation should not extend the cooking time otherwise it will probably not be accepted.

realise that the outcome is not as expected, it causes negative reactance. As described by Ajzen (2006), people's beliefs are the information they have about a behaviour, for example the likely consequences of an action. It is possible to design interventions which "provide information that change some of these beliefs, or that lead to the formation of new beliefs. […] Only when the new beliefs accurately reflect reality can we expect that the effect of the intervention will persist over time" (Ajzen 2006).

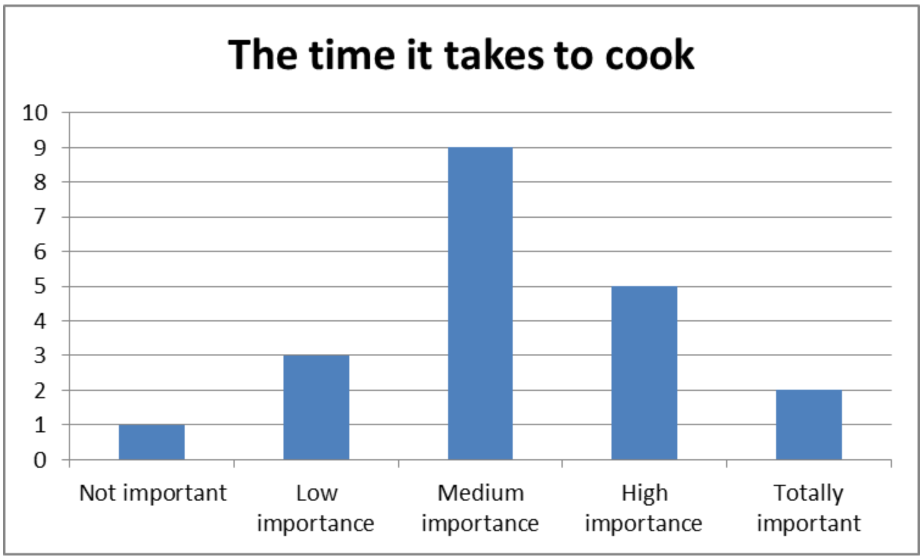


Figure 22 - Importance of the cooking time

Most of the participants consider the simplicity of the cooking process as being of medium or high importance (Figure 23). This information correlates to the observed data in the sense that participants tend to act in the most convenient way, as can be seen for example on the motivations for not measuring the amount of water or choosing the nearest hob. It indicates that perhaps they will not easily follow recommendations that make the cooking process more complicated.

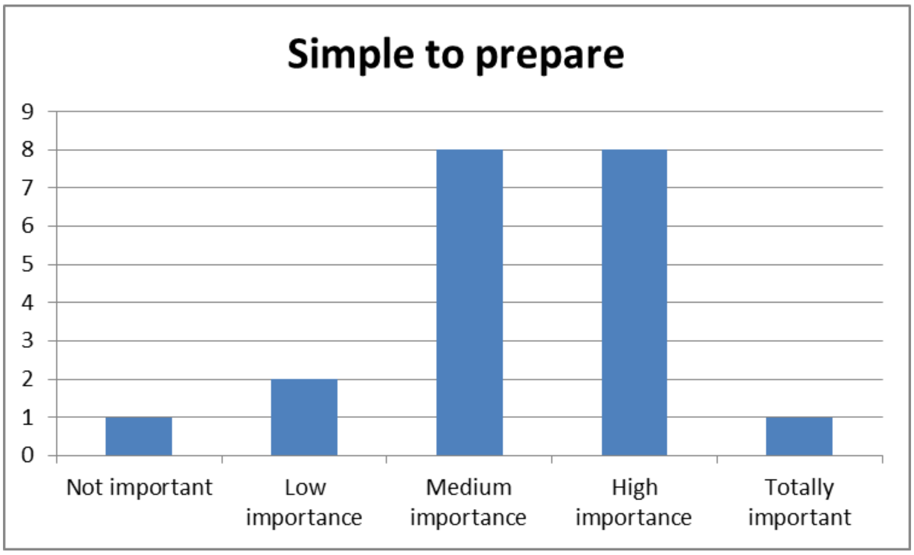


Figure 23 - Importance of the easiness to prepare

One very interesting fact is the rating of the importance of energy use during cooking. The majority of the students (17) say that the amount of energy being spent has low importance or is not important at all, as can be seen on Figure 24. This result imposes huge challenges to any intervention aiming at energy conservation. If they do not care about the electricity usage, other strong arguments must be developed to motivate a sustainable behaviour other than just energy saving for the sake of it. The use of adequate motivators is discussed in the Third study – Intervention design.

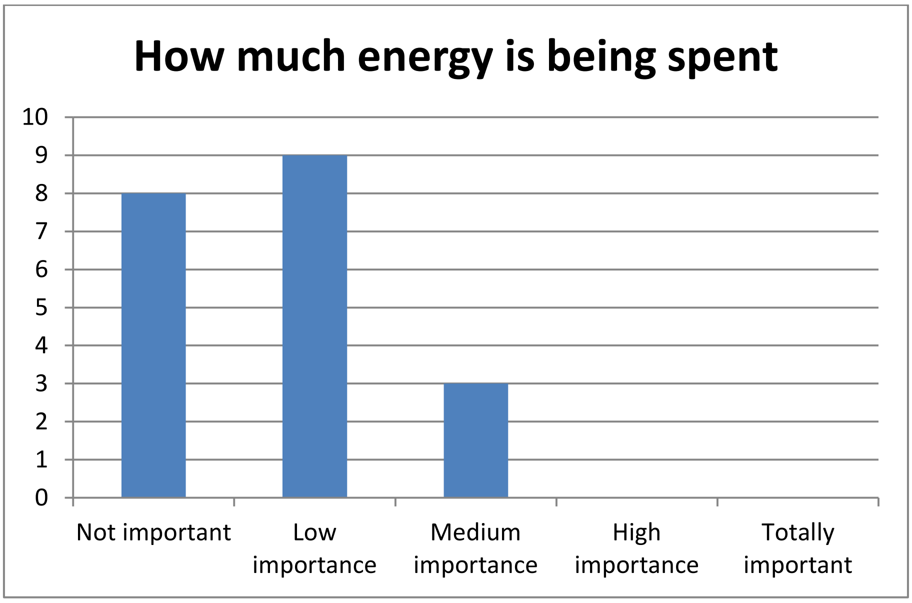


Figure 24 - Importance of energy use

The amount of pans, lids and dishes used was rated as medium to low importance (Figure 25). This information is important as one of the energy saving techniques include the use of a saucepan lid, which can increase the amount of washing up. On the other hand, small pans are easier to wash. Although this data shows a tendency to low importance, six of the participants consider that the amount of pans, lids and dishes used has medium importance, and four consider it as highly important. For that reason, the suggested intervention must avoid increasing the workload, especially if we consider that the participants mention convenience as a motivator for their behaviours. Furthermore, one intervention aiming at energy conservation should consider the target group preferences and also the efficiency of the whole process, since using more utensils means more washing up after cooking, which requires energy and water.

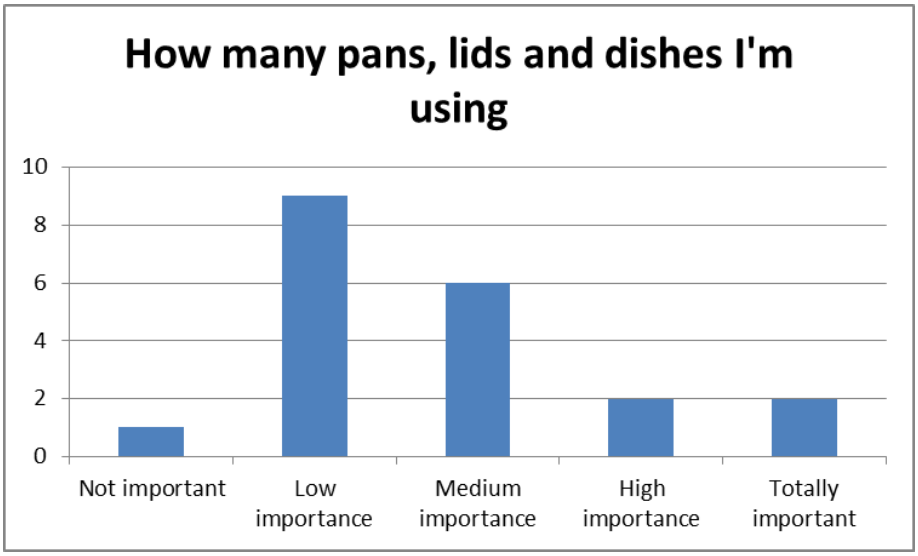


Figure 25 - Importance of amount of utensils used

One last item of the ranking questionnaire consisted of the rating of the nutritional facts of the meal that students prepare (Figure 26). Since Loughborough University can be considered a sports related university, this question was added to understand students' preferences about how healthily their meals are. In addition, this data can indicate if an intervention is likely to be accepted by students if its method involves the introduction of a specific dish for them to cook. Most of the students consider this aspect highly important. This data indicates that an intervention proposing a meal with good nutritional facts may have higher chances of being accepted.

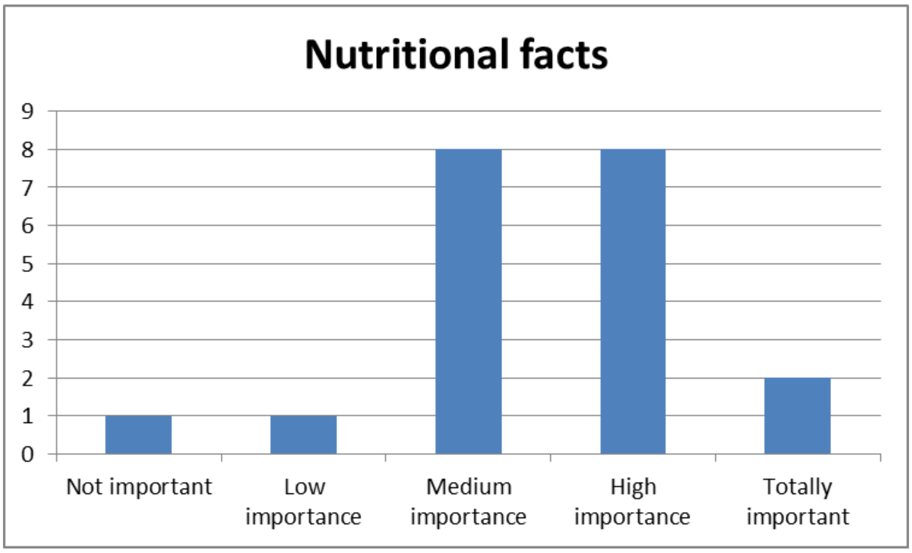


Figure 26 - Importance of the nutritional facts

4.8.6.2 New Ecological Paradigm evaluation

The New Ecologic Paradigm (NEP) scale was chosen to give an overview of participants' attitudes towards the environment (Dunlap, Van Liere et al. 2000). The set of 15 items is listed in a table with importance scales from 1 to 5 (strongly disagree to strongly agree), and the form applied during this study can be seen in the Annexes. The 15 statements are designed to tap into each of the five hypothesized facets of an ecological worldview: the reality of limits to growth, antianthropocentrism, the fragility of nature's balance, rejection of exemptionalism, and the possibility of an ecocrisis (Dunlap, Van Liere et al. 2000). One of the advantages of using the NEP scale is that it evaluates moral values as the core concepts of environmental attitudes. The statements are more generic and not domain-specific nor behaviour specific. Consequently, the scale can be used across different disciplines, for different target groups, independently of the behaviours to be analysed (Kaiser, Wölfing et al. 1999).

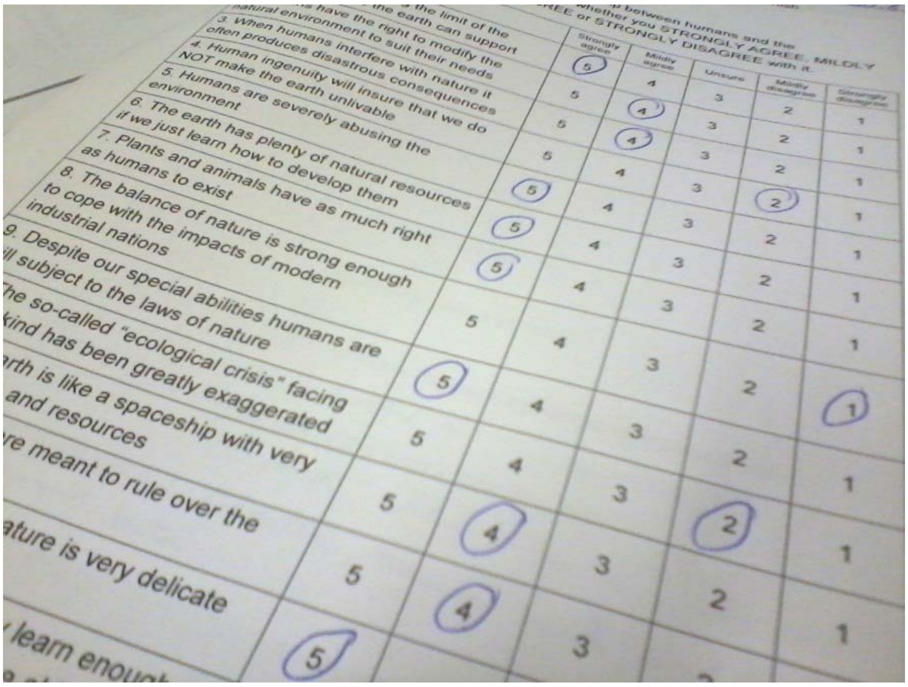


Figure 27 - New Ecologic Paradigm questionnaire

The possible scores on the NEP scale range from 15 to 75, and the median value is 45. Results show that on average, participants have a slightly positive attitude in relation to the environment. Participants from this study showed an average score of 50.85, a minimum value of 40 and maximum of 61. Only 3 of the participants scored below the median.

4.8.7 Correlations

During this observation study and semi-structured interviews, 19 different variables were gathered regarding participants' behaviours, attitudes and demographics. This data was logged from instruments used during the study, direct observation, information found on the video recording, demographic data informed by the participant and also attitudes measured by importance scales contained in the questionnaires. Measurements of attitudes were gathered by the NEP scale and also through importance scales regarding the quality of the final meal, the time it takes to cook, the simplicity of the cooking process, the amount of electricity used, the amount of washing up after cooking, and the nutritional facts of the food to be cooked. These attitudes measures are marked in red on the table below. The dataset also contains information from direct observation. It was logged if the participant measured the amount of water or not, which pan was used, if the participant put the lid on, the hob was used, if the participant read the packet instructions, and if he or she checked the time during the process. Demographic information was logged such as gender and age, and also information regarding the experience in cooking noodles and the year that the student was in.

All this information was compiled to be analysed to provide correlations and influences. The software IBM SPSS Statistics was used in order to tabulate this data. Two-tailed Pearson r correlations were selected to provide correlation coefficient and significance strength for each variable when correlated to each of the other 18 variables. However since some of the variables were in the form of text, in order to perform this analysis, the textual values had to be transformed into numeric values (Pallant 2007). For example, during the observation study, some students measured the amount of water while others did not. In this case, 'no' values were converted to 0, and yes were converted to 1. Other conversions were regarding the pan size (small=1, medium=2, big=3) and hob used according to the size and energy consumption per hob (small at the back=1, small at the front=2, big at the back=3 and big at the front=4 – this order follows the energy consumption per hob, as can be seen on Figure 10, and attributes the same sequence as the rate of consumption). The level of experience was converted as following: never cooked this kind of noodles before=0, cooked from 1 to 5 times=1, 6 to 15 times=2, weekly=3 and every day=4. The table containing the correlation results can be seen below.

Table 7 - Pearson r Correlations

	Time to complete the task	Energy actually used	New Ecologic Paradigm	Quality of the final meal	Time it takes to cook	Simplicity of the cooking process	Importance of electricity used	Amount of washing up	Nutritional facts	Measured the amount of water?	Size of pan used?	Used the saucepan lid?	Which hob used?	Read the packet instructions?	Checked the time?	Gender	Experience	Year	Age
Time to complete the task	1	.065	.023	-.079	.289	.175	-.113	.027	.148	.090	-.368	-.111	-.034	.050	-.217	-.118	-.272	-.008	.004
		.785	.923	.739	.217	.461	.634	.911	.532	.707	.111	.642	.886	.835	.358	.619	.247	.973	.985
Energy actually used	.065	1	-.021	-.051	.340	.381	-.167	.100	-.018	-.202	.260	.106	.325	.074	-.108	.013	.069	-.238	-.174
	.785		.930	.832	.143	.097	.482	.674	.939	.393	.268	.655	.163	.756	.650	.957	.771	.313	.463
New Ecologic Paradigm	.023	-.021	1	-.125	-.011	-.072	.175	-.121	.403	-.356	.312	-.008	-.163	.133	.286	-.056	-.315	-.153	-.129
	.923	.930		.599	.962	.763	.461	.612	.078	.124	.180	.973	.492	.575	.221	.815	.176	.520	.587
Quality of the final meal	-.079	-.051	-.125	1	-.125	.087	-.156	-.440	-.204	**.454***	-.306	.131	.055	-.101	.101	.437	.204	.041	.346
	.739	.832	.599		.600	.714	.510	.052	.388	**.044**	.190	.582	.816	.673	.673	.054	.389	.865	.135
Time it takes to cook	.289	.340	-.011	-.125	1	**.499***	**-.585****	.049	-.044	-.118	-.357	.026	.140	.257	.064	-.102	-.102	.095	.211
	.217	.143	.962	.600		**.025**	**.007**	.838	.853	.621	.122	.915	.557	.274	.788	.669	.669	.690	.373
Simplicity of the cooking process	.175	.381	-.072	.087	**.499***	1	-.199	.080	-.042	-.064	-.306	.111	-.016	.128	.338	.111	-.120	-.155	.103
	.461	.097	.763	.714	**.025**		.400	.738	.860	.788	.190	.641	.946	.590	.145	.641	.613	.513	.667
Importance of electricity used	-.113	-.167	.175	-.156	**-.585****	-.199	1	.258	.253	-.124	.358	.000	-.122	-.263	-.038	.358	-.060	-.100	-.058
	.634	.482	.461	.510	**.007**	.400		.273	.282	.602	.121	1.000	.607	.263	.875	.121	.803	.674	.807
Amount of washing up	.027	.100	-.121	-.440	.049	.080	.258	1	.169	-.415	.120	-.120	.386	-.276	-.126	-.048	.040	.201	.065
	.911	.674	.612	.052	.838	.738	.273		.476	.069	.615	.615	.092	.238	.598	.841	.867	.395	.785
Nutritional facts	.148	-.018	.403	-.204	-.044	-.042	.253	.169	1	-.031	.163	-.380	-.183	-.097	-.131	.054	-.154	-.025	.032
	.532	.939	.078	.388	.853	.860	.282	.476		.896	.492	.098	.440	.685	.582	.820	.517	.916	.892
Measured the amount of water?	.090	-.202	-.356	**.454***	-.118	-.064	-.124	-.415	-.031	1	-.289	-.289	-.028	.424	-.182	.346	-.385	-.054	-.031
	.707	.393	.124	**.044**	.621	.788	.602	.069	.896		.217	.217	.906	.063	.444	.135	.094	.822	.896
Size of pan used?	-.368	.260	.312	-.306	-.357	-.306	.358	.120	.163	-.289	1	.063	.220	.105	-.105	-.250	-.042	-.233	**-.570****
	.111	.268	.180	.190	.122	.190	.121	.615	.492	.217		.794	.352	.660	.660	.288	.862	.323	**.009**
Used the saucepan lid?	-.111	.106	-.008	.131	.026	.111	.000	-.120	-.380	-.289	.063	1	-.024	-.157	.419	.000	.271	**.466***	.244
	.642	.655	.973	.582	.915	.641	1.000	.615	.098	.217	.794		.919	.508	.066	1.000	.248	**.038**	.299
Which hob used?	-.034	.325	-.163	.055	.140	-.016	-.122	.386	-.183	-.028	.220	-.024	1	-.271	**-.446***	-.147	.138	-.205	-.268
	.886	.163	.492	.816	.557	.946	.607	.092	.440	.906	.352	.919		.247	**.049**	.538	.561	.386	.253
Read the packet instructions?	.050	.074	.133	-.101	.257	.128	-.263	-.276	-.097	.424	.105	-.157	-.271	1	.319	-.105	**-.681****	-.049	-.188
	.835	.756	.575	.673	.274	.590	.263	.238	.685	.063	.660	.508	.247		.171	.660	**.001**	.838	.428
Checked the time?	-.217	-.108	.286	.101	.064	.338	-.038	-.126	-.131	-.182	-.105	.419	**-.446***	.319	1	-.105	-.192	.244	.416
	.358	.650	.221	.673	.788	.145	.875	.598	.582	.444	.660	.066	**.049**	.171		.660	.417	.299	.068
Gender	-.118	.013	-.056	.437	-.102	.111	.358	-.048	.054	.346	-.250	.000	-.147	-.105	-.105	1	-.167	.280	.380
	.619	.957	.815	.054	.669	.641	.121	.841	.820	.135	.288	1.000	.538	.660	.660		.482	.232	.098
Experience	-.272	.069	-.315	.204	-.102	-.120	-.060	.040	-.154	-.385	-.042	.271	.138	**-.681****	-.192	-.167	1	-.078	.109
	.247	.771	.176	.389	.669	.613	.803	.867	.517	.094	.862	.248	.561	**.001**	.417	.482		.745	.648
Year	-.008	-.238	-.153	.041	.095	-.155	-.100	.201	-.025	-.054	-.233	**.466***	-.205	-.049	.244	.280	-.078	1	**.684****
	.973	.313	.520	.865	.690	.513	.674	.395	.916	.822	.323	**.038**	.386	.838	.299	.232	.745		**.001**
Age	.004	-.174	-.129	.346	.211	.103	-.058	.065	.032	-.031	**-.570****	.244	-.268	-.188	.416	.380	.109	**.684****	1
	.985	.463	.587	.135	.373	.667	.807	.785	.892	.896	**.009**	.299	.253	.428	.068	.098	.648	**.001**	

* / bold - Correlation is significant at the 0.05 level (2-tailed).

** / bold - Correlation is significant at the 0.01 level (2-tailed).

Items in **red** refer to participants' reported attitudes.

4.8.7.1 Correlation analysis

Correlation analyses provide a summary of the linear relationship between two variables. It can range from -1 to +1, and the sign in front indicates if it is a negative correlation (when one variable increases, the other decreases) or positive (when one variable increases, so does the other). A value of 0 indicates that there is no relationship between the two variables, meaning that “[k]nowing the value of one of the variable provide no assistance in predicting the value of the second variable” (Pallant 2007). As can be seen on the table above, a few significant correlations can be seen, which are marked in bold and stars. One star indicates a significance level of 95%, and two stars means 99% of significance. The main findings are described below.

One common assumption is that people who care about the environment will use less energy. However, no correlation was found between the NEP score and the energy actually used during this experiment. The resulting correlation coefficient was -.021, and the significance .930, N = 20. These data indicates that participants’ attitudes towards nature do not directly affect the real impact of their behaviours on energy use for cooking. Furthermore, no correlation was found between the NEP scale and any of the other variables gathered during the study.

The lack of correlation between attitudes and impact of students’ energy related behaviours corroborates what was demonstrated by previous research. For example, Gatersleben, Steg and Vlek (2002) demonstrated that those who indicate that they behave more pro-environmentally do not necessarily use less energy. It is essential to investigate more about the variables that influence the actual environmental impact of behaviour. Kollmuss and Agyeman (2002) demonstrate the gap between attitudes and pro-environmental behaviour and list demographic, external and internal factors that have some influence how people behave, and that “[m]any conflicting and competing factors shape our daily decisions and actions” (Kollmuss, Agyeman 2002).

Time it takes to cook x Importance of electricity used (r = -.585, p < .01): Students who mentioned that they want quick preparation also marked the amount of energy being used as having low importance (hence the negative correlation on the table above). It can be interpreted as those who want to cook it quickly don’t care about the energy used. This is valuable information since cooking quickly can in fact reduce energy use, if the participant follows the energy saving techniques. It is important to explore this relation, highlighting the short cooking time without concentrating on the energy savings, since this aspect is not of high importance among these students.

Time it takes to cook x Simplicity of the cooking process (r = .499, p < .05): Participants who consider the cooking time as highly important (i.e. those who want a short preparation time) also want a simple cooking process.

Quality of the final meal x Amount of water (r = .454, p < .05): Most participants who consider the quality of food as having high importance also measured the amount of water prior to cooking noodles. It indicates interesting possibilities for convincing students to measure the amount of water. It is possible to suggest that the amount of water influences the quality of food, in order to convince those who do not measure it.

Which hob used x Checked the time (r = -.446, p < .05) Students who used bigger hobs were more likely to keep track of time. It suggests that, since the bigger hob produces more heat, participants using these hobs were probably more cautious to check the time in order to avoid overcooking or burning their food.

Experience x Read packet instructions (r = -.681, p < .01): The more experienced students in cooking noodles were those who didn't read the packet instructions. This correlation was seen as having the highest value among all analysed data. This information corroborates the qualitative data gathered during the interviews. Participants who did not read the instructions mentioned that they were experienced, as can be seen on the section Packet instructions.

Age x Size of pan used (r = -.570, p < .01): Interestingly, one strong correlation noted was the age of the participants and the pan they've chosen. Younger students generally cooked using bigger pans than older students. This fact remains unexplained by this research, but a few hypotheses emerged. Older students might be more experienced and know that bigger pans take longer to heat up. Another explanation is that since it's more likely that they have been at university for longer, they probably collected more utensils like pans of different sizes. Or that they are more knowledgeable with measurements and understand that a smaller pan will be enough for a single meal.

Used the saucepan lid x Year (r = .466, p < .05): First year students are less likely to use a saucepan lid. This data suggest that perhaps first years are not in the habit of doing so because they are less likely to have lids for their pans. Maybe second and third year students tend to use a saucepan lid more often because they have collected more utensils after living in halls for longer. Consequently, they could have behaved during the experiment according to the habits already formed.

4.8.8 Limitations of study

The combination of video recording of the trials, semi-structured interviews, importance scales, a coding scheme used during the experiment and the energy usage data from the electricity monitor contributed to improve the reliability of this study. Some of the data stored were redundant, which helped checking the validity and consistency of the results and minimizing possible read errors or researcher biases. For example, the researcher was taking notes of the hobs and heat levels being used, and this information could be checked later on the video footage. The duration of use per heat setting combined with the known electricity consumption of those settings gives the total energy usage per cooking task, and this data can be checked with the values provided by the energy monitor. The same observer carried out all the experiments, however, the redundancy of the selected methods described here suggests that intra-observer reliability was pursued (Robson 2011).

Although valuable, the importance scales used here cannot be considered a proper Likert scale (Robson 2011). These data show preferences reported by a restricted group of participants. In addition, since the scales, statements and values were not broadly tested, they are not statistically validated, and do not permit generalizations.

While the correlation values presented on item 4.8.7 above showed interesting results, they cannot be generalized or extrapolated outside the scope of this study. Correlations often need bigger data sets, and also the distribution of the values needs to be normal in order to provide robust statistical analysis. These data is being used only as an addition to the qualitative and quantitative data gathered during this study. Although correlations do not indicate causality, it was possible to make suggestions regarding the links between the different forms of data.

This study is sometimes referred to as an experiment during this thesis. However, it does not contain some of the pre-requisites of a true experiment. For example, it does not fulfil the requirement for genuine random sampling. Participants were recruited via invitations, convenience sampling or snow ball technique, which could bias the responses. Furthermore, the kitchen used as a ‘lab’ could not control for all aspects that might affect energy use. The ambient temperature was determined by a domestic heating system originally installed in the flat. It could have made the room temperature fluctuate between trials causing the pans and hobs to have different initial temperatures. Also, the temperature of the water used for cooking could vary depending on the weather or time of the day, or how long the tap was run for. Those limitations are important to note since it might have contributed, even if minimally, to the diversity of energy usage observed here.

The results presented here fit the proposed aims of this study, and fed the subsequent phases of this PhD research, including the intervention design described on chapter 6. However, this study was conducted within a limited demographic group, using specific appliances and in a reasonably controlled environment. For that reason, further work will be needed if the intention is to gather a broader understanding of user behaviours in different contexts or provide generalizations. Nevertheless, these results can provide useful insights for behaviour change intervention development or even for appliance manufacturers who want to design products that can deliver an improved user experience and at the same time promote energy saving cooking.

4.9 Conclusion

This chapter presented the methods and results from a study designed to understand how people interact with electric cookers, what are the energy related behaviours and what are the determinant of these behaviours. Prior to this study, it was not evident how the target population would behave, their patterns of energy usage, the resulting levels of energy consumption and most importantly the determinants of behaviours. During this user observation study it was noted that participants behaved in diverse ways, even if cooking the same simple meal using the same appliances and utensils. As a result, the electricity usage and the time to complete the task varied considerably. It was also noted that participants have their own motivations, preferences and reasons for behaving as they did, often due to a lack of knowledge of how the cooker works, because they wanted to cook quickly, and due to convenience, habit or external factors like the lack of adequate utensils.

A few energy saving techniques specific for cooking single noodles on a solid plate electric cooker were developed. These techniques worked as a baseline to be compared with people's actual behaviours. The user observation study showed that participants seldom chose to use energy efficient techniques. Consequently, they used three times more electricity, on average, than someone following the energy saving tips. The students also demonstrated lack of knowledge about the idiosyncrasies of the cooking appliances available to them. Human factors issues were found to influence how people use these appliances and consequently resulted in unnecessary energy use. These issues gravitate around usability problems including poor feedback, the lack of a natural mapping of controls, and differences between how the appliances actually worked and the mental model held by the participant.

As these participants live in an all-inclusive hall, they are not motivated to save energy since they do not pay bills directly. Consequently, there is no financial incentive to use electricity reasonably. Environmental concerns were seldom mentioned, meaning that any discourse trying to motivate them has to go beyond the environmental impact of energy use. In order to be successful, an intervention aiming at changing their behaviours must consider the determinants of their behaviours (Abrahamse, Steg et al. 2005). Furthermore, the overall outcomes of the intervention must benefit them in some other way as they have their own interests (Crosbie, Baker 2010). The designed intervention must offer guidance on the energy saving methods, but must also provide other advantages to the participants, for example it must help them cook quickly and improve the quality of the food. To increase the chances of success, this intervention cannot compromise the cooking results, increase the time to prepare, make the cooking process more complex or be an inconvenience for them in the attempt to save energy. The low importance of energy usage during cooking indicates that interventions should not rely on messages involving sustainability. The intentions to promote energy saving might have to be disguised, emphasizing the advantages the user can obtain when interacting with such intervention.

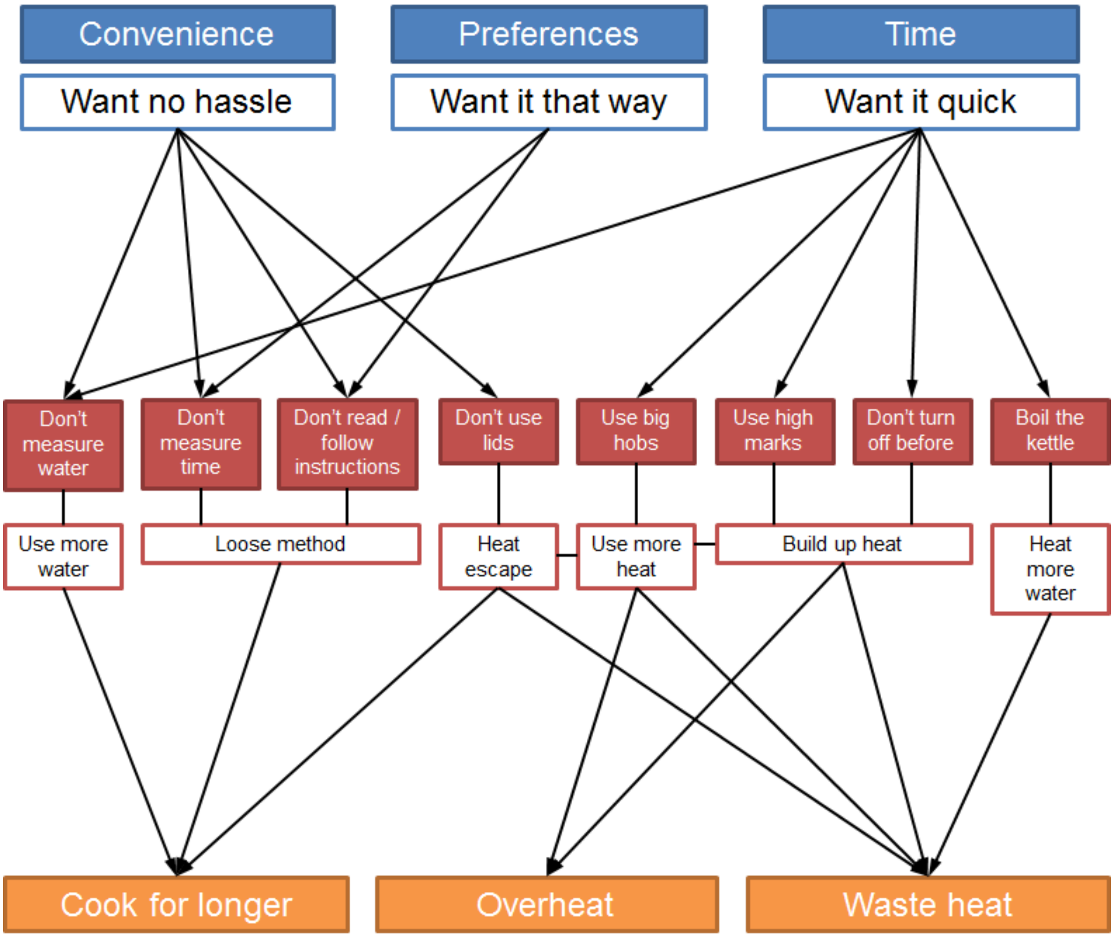


Figure 28 - Summary of behaviours and determinants

The user observation study and interviews provided a detailed view of the energy related behaviours for cooking and domain-specific factors that were identified as determinants of these behaviours. The evidence from observation of actual behaviours and qualitative data from a semi-structured interview and a questionnaire indicated several different determinants of behaviours that affected the energy usage. These determinants involve mainly user preferences, need for convenience and desire to cook quickly. Figure 28 presents a summary of these behaviours that affect all observed non-energy saving behaviours. The observed behaviours resulted in additional energy usage due to longer cooking time than needed, overheated hobs and wasted heat. Results also show that determinants include habit, how flatmates behave, how their family taught them to cook, knowledge, skills, the available appliances, utensils, the absence of financial incentive among others observed and reported factors. This myriad of motivators influenced participants' behaviours in different ways and with different strengths among the study population. With a better understanding of the students' motivators, it is possible to identify what could be changed to cause a change in behaviour.

5 Second Study – Theory of Planned Behaviour survey

This chapter answers the third research question:

RQ3: What is the acceptance of a set of recommended best practices for cooking among the target population?

5.1 Introduction

The user observation study and interviews presented on the previous chapter provided a detailed picture of the participants' cooking behaviours and their respective determinants, which constituted a myriad of factors. This knowledge indicated that further research is needed in order to measure how strongly these factors influence behaviours among the study population. With a better understanding of the students' opinions, it is possible to identify which beliefs have to be changed to cause a change in intention and behaviour, and whether other factors need to be incorporated into an intervention.

Aggregating participants' determinants in fewer categories indicates that three main groups of factors influenced participants' behaviours. The first group can be termed as attitudes, involving student's preferences regarding food quality, desire of a short cooking time, need for convenience and environmental attitudes. The second group of factors involves the perceived social norms, including how family and friends influence participants' behaviours. The last group of factors is the perceived level of control to perform the behaviours, comprising the available information and level of knowledge to perform the cooking tasks, the ownership of adequate utensils, the available appliances and the billing structure present in halls of residence. The main factors observed during the First Study fit the constructs present in the Theory of Planned Behaviour, arguably the most commonly used behaviour theory (Bamberg, Schmidt 2003). This model was selected to guide the design of this Second Study, and further explanation is given below.

5.1.1 Behaviour theories

For many years, human behaviour has been subject of study in the field of environmental psychology. The literature review provided different models to help understanding behaviours and determinants. From the analysed models, the Theory of Planned Behaviour (Ajzen 1991) here referred as TPB, offers adequate constructs that suit the specific observed behaviours and determinants. Previous research supports the idea that TPB can be a unifying framework to guide research on environmental attitudes (Kaiser, Wölfing et al. 1999), providing often a high explanatory power of people's behaviours (Bamberg, Schmidt 2003, Kaiser, Hübner et al. 2005).

Human behaviours are generally complex and are determined by diverse factors such as demographic variables, personality characteristics, situational and domain-specific factors related to the behaviour under investigation. However, Fishbein and Ajzen (2010) argue that a limited set of constructs can be used to predict and understand any behaviour. These constructs are defined as attitudes, perceived norms and perceived behavioural control, which together affect the formation of intentions, and that intentions are the immediate antecedent of behaviours.

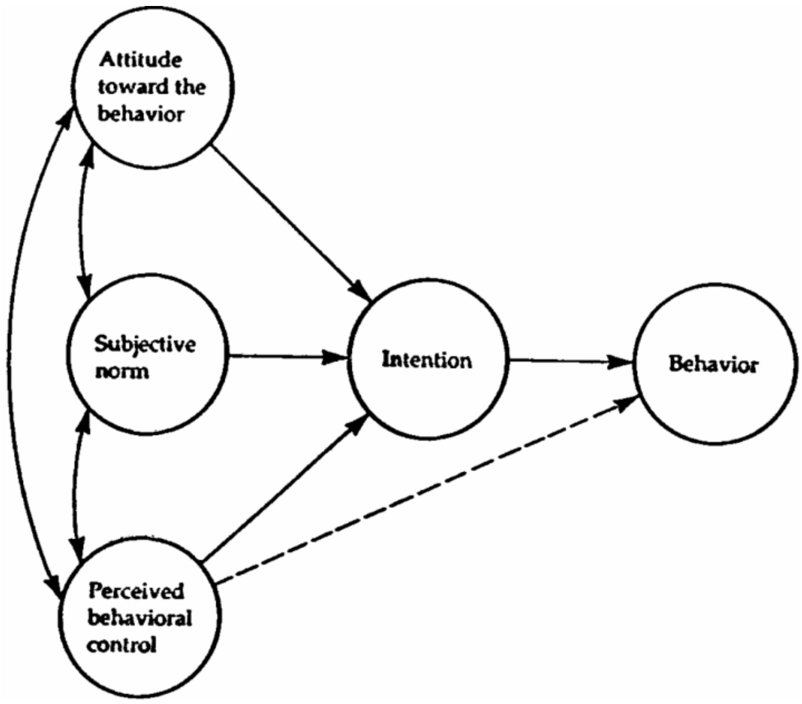


Figure 29 – The Theory of Planned Behaviour (Ajzen, 1991)

The Reasoned Action Approach (Fishbein, Ajzen 2010) referred as RAA, is a more recent development of the TPB and the Theory of Reasoned Action (TRA) (Fishbein, Ajzen 1975), from the same authors. The RAA and TPB have the same basic structures, with just a few differences seen only outside the core of the models. For this reason, both TPB and RAA are referred to here often simultaneously, and were chosen to guide the development of further analysis of behaviours and determinants among the research population.

According to the TPB and RAA, people behave according to their intentions, and these intentions are formed by their attitudinal beliefs, perceived norms and perceived behavioural control. But "the relative contribution of attitudes, perceived norms, and perceived behavioural control to the prediction of intentions is expected to vary from one person to another, from one group of individuals to another, and from one behaviour to another" (Fishbein, Ajzen 2010). For that reason, a detailed measurement of each of these three constructs is necessary in order to evaluate the real impact of each of them on people's behaviours within a specific context.

By understanding the salient beliefs among university students it is possible to obtain insights into the considerations that guide their decisions and actions. With a detailed understanding of the attitudinal, normative and control beliefs that work as the basic motivators of behaviours among this study population, it is possible to identify how strongly these beliefs affect behaviour. This knowledge of enablers and constraints of behaviours can suggest the adequate interventions to be implemented that could result in change in intention or behaviour (Ajzen 1991, Fishbein, Ajzen 2010).

5.1.2 Using the Theory of Planned Behaviour

Prior to designing behaviour change interventions that leads to energy conservation, it is assumed that the target population is performing the specific behaviour in a way that needs to be changed, and that it is necessary to make them perform it in a more sustainable way (Fishbein, Ajzen 2010). But it is necessary first to verify this assumption, and for this reason a user observation study was performed. As can be seen on the results from the First Study, there is a remarkable variation on students' behaviours regarding cooking, with most of them not performing the recommended techniques for energy saving.

With a TPB / RAA questionnaire it is possible to measure the correlation strength between each of the constructs of the theory, namely the attitudinal beliefs, normative beliefs and perceived behavioural control, and the intention to perform a given behaviour. By measuring the most discriminating beliefs it is possible to select those with greater influence on intentions, and these will present a greater likelihood in changing intentions and consequently in changing behaviours (Ajzen 1991, Fishbein, Ajzen 2010). For this reason, this specific study was designed to assess and measure the determinants of the energy-related behaviours among university students.

The Theory of Planned Behaviour (Ajzen 1991, Ajzen 2006, Ajzen 2006, Ajzen 2002) and the Reasoned Action Approach (Fishbein, Ajzen 2010) have been used in hundreds of projects and have some interesting applications and useful manuals for questionnaire design (Francis, Eccles et al. 2004). For example, one recent study used the TPB questionnaire to understand domestic energy use among residents of high-performance buildings and explain differences between occupants of similar houses (Gill, Tierney et al. 2010). Other research used the TPB questionnaire to evaluate recycling habits of residents and compare their beliefs and intentions with actual observed behaviours (Nigbur, Lyons et al. 2010), and another study evaluated how beliefs influence kerbside recycling and provides suggestions for waste management schemes (Tonglet, Phillips et al. 2004). Another example investigated sustainable transportation choices among students (Bamberg, Schmidt 2003). One recent study applied TPB to analyse barriers to energy conservation at the University of Toronto (Stokes, Mildenberger et al. 2012). They used this theory to improve the understanding of the factors impeding behaviour change and to evaluate the barriers of energy conservation and other environmental programs. Results highlighted the importance that students place on attitudinal barriers to energy conservation, such as discomfort, laziness and forgetfulness. Results indicated that using barrier analysis "can help point to important and often overlooked challenges to the design of effective proenvironmental programs" (Stokes, Mildenberger et al. 2012).

The results from a TPB / RAA questionnaire can point out the 'primary' behaviour beliefs, that is, those with higher influence on the actual behaviour and with higher correlation with intentions to perform the behaviour (Fishbein, Ajzen 2010). This knowledge can inform the most suitable intervention to be implemented to change people's behaviours. This chapter presents the methods used during the design of a TPB / RAA questionnaire and the results from the online survey using this instrument. This study was designed to understand constraints and enablers involving the performance of the energy saving behaviours for cooking, according to participants' beliefs. Another outcome is the measurement of intention to perform the proposed energy saving tips for cooking and consequently having a prediction of the likelihood of adoption of the behaviour.

5.2 Methods

The design of a TPB / RAA questionnaire involves two main phases, one for preparation and another for application of the main questionnaire itself. The distinct steps taken during the preparation phase are listed here and explained in detail below, based on the methods found on the literature (Ajzen 2006, Ajzen 2002, Francis, Eccles et al. 2004, Fishbein, Ajzen 2010).

1. **Define the population of study** – This research has undergraduate students living in university halls of residence as the target population, as explained in the methodology chapter.

2. **Carefully define the behaviour of study** using TACT - Target, Action, Context, Time – It was defined that the behaviour of interest consists of cooking following the energy saving techniques in their hall kitchens whilst living in halls. *Cooking* is the target, and *following the proposed techniques* is the action, in the context of *students' accommodation*, *whilst living in halls* as the time frame.

3. **Perform an elicitation study**

    a. Define the most frequent advantages and disadvantages of performing the behaviour (**measuring attitudes**).

    b. Define the most important people or group of people who would approve or disapprove the behaviour (**measuring social norms**)

    c. Determine the perceived barriers or facilitating factors which could make it easier or more difficult to adopt the behaviour (**measuring perceived behavioural control**)

4. Decide how best to **measure intentions** – this research is using rating scales from 1 to 7, evaluating how participants rate their intentions to perform behaviours exemplified in statements.

5. **Design the first draft of the questionnaire** to measure attitudes, norms and control.

These phases are detailed below, providing a better explanation of each step and its design process.

5.2.1 Define the population of study

Similarly to the First study, the population for the Second Study consisted of undergraduate students living in self-catered halls of residence at Loughborough University. These students were reached via their personal academic emails, which guaranteed that only the target population was invited to fill in the questionnaire.

5.2.2 Careful selection of behaviours to study

The behaviours investigated during this research were the cooking activities that can result in energy saving, as developed during the First Study. By performing these behaviours it was possible to use one third of the electricity comparing to the average used by the 20 participants. They consist of:

- Measure the amount of water
- Time the process
- Choose small pans for single meals
- Choose small hobs that match small pans
- Use the saucepan lid
- Reduce the heat when the water is boiling
- Turn off the hob a few minutes before the end of the cooking time

One of the behaviours suggested during the First Study, “do not boil water in the kettle”, was excluded from this part of the research due to the controversy caused. When boiling water in the kettle to pour in a pan, the users can have hot water quicker than heating in a pan from scratch, if they pre-heat the hob whilst waiting for the kettle to boil. However, adding the electricity usage from the kettle with the one used by the hob, the total consumption for boiling can be higher, depending on the volume of water needed (e.g., for cooking noodles, using only the pan would be more efficient since it needs only 200 ml and most of the kettles have a minimum mark of 500 ml). Kettles can be the most efficient way of heating water compared to a pan or a microwave oven (Oberascher, Stamminger et al. 2011) when just hot water is needed, for example when making tea, or when using bigger volumes of water. Due to these different variables and the difficulty to communicate it during an online survey, questions about using the kettle were removed from the final questionnaire.

5.2.3 Elicitation study

An elicitation study is where the researcher gets a broader understanding of the reported enablers and constraints regarding a given behaviour, according to participants’ opinions. This investigation is performed with a sample of the target population, generally between 20 to 30 respondents. A 9 item questionnaire is commonly used, which can be set up online, given to participants, applied during face-to-face interviews or during focus groups (Francis, Eccles et al. 2004).

From a list of residents from Butler Court, one of the self-catered halls of residence, random participants were invited to take part in an online survey containing the questions for the elicitation study. However, due to the exams period, the response rate was relatively small, and in order to complete the desired 25 participants, the remaining seven paper questionnaires were given to random students in their flats and collected on the following day. Moreover, some of the participants from the First Study were also invited to contribute to this elicitation process. It is important to note that, since more than one year had passed since the First Study, six of these participants were living in shared houses in town. For that reason, their responses, although included below, were taken with caution, especially regarding the financial advantages of the energy saving techniques. Nevertheless, comparison between the results with or without these participants did not show biases: students living in halls or in town presented the same variation in responses, even regarding savings related to conservation measures. Even students living in university halls on campus mentioned that the proposed techniques can reduce bills.

The questions for the elicitation study are open-ended and encourage respondents to express their own beliefs. This instrument has the objective of gathering people's perceived advantages and disadvantages of performing a behaviour in question (attitudinal factors), people or groups that approve or disapprove the performance of a behaviour (important individuals which opinions and expectations constitute the social norm) and enablers and constraints to perform a behaviour (perceived behavioural control). These questions were extracted from the literature and compared with the questions used in this research, as shown on Table 8 below.

Table 8 - Examples from the literature and proposition of own questions for the TPB elicitation study

	(Francis, Eccles et al. 2004)	(Ajzen 2002)	Questions used for this study
Attitude toward behaviour	What do you believe are the ***advantages*** of [measuring the patient's blood pressure during a consultation]?	What do you believe are the ***advantages*** of your walking on a treadmill for at least 30 minutes each day in the forthcoming month?	What do you believe are the ***advantages*** of following the energy saving techniques for cooking?
	What do you believe are the ***disadvantages*** of [measuring the patient's blood pressure during a consultation]?	What do you believe are the ***disadvantages*** of your walking on a treadmill for at least 30 minutes each day in the forthcoming month?	What do you believe are the ***disadvantages*** of following the energy saving techniques for cooking?
	Is there anything else you associate with your own views about [measuring the patient's blood pressure during a consultation]?	Is there anything else you associate with your walking on a treadmill for at least 30 minutes each day in the forthcoming month?	Is there anything else you associate with your own views about following the energy saving techniques for cooking?
Subjective norm	Are there any individual or groups who would ***approve*** of your [measuring the patient's BP during a consultation]?	Are there any individuals or groups who would ***approve*** of your walking on a treadmill for at least 30 minutes each day in the forthcoming month?	Are there any individual or groups who would ***approve*** of your following the energy saving techniques for cooking?
	Are there any individual or groups who would ***disapprove*** of your [measuring the patient's BP during a consultation]?	Are there any individuals or groups who would ***disapprove*** of your walking on a treadmill for at least 30 minutes each day in the forthcoming month?	Are there any individual or groups who would ***disapprove*** of your following the energy saving techniques for cooking?
	Is there anything else you associate with other people's views about [measuring the patient's blood pressure during a consultation]?	Are there any other individuals or groups who come to mind when you think about walking on a treadmill for at least 30 minutes each day in the forthcoming month?	Is there anything else you associate with other people's views about following the energy saving techniques for cooking?
Perceived behavioural control	What factors or circumstances would ***enable*** you to [measure the blood pressure of a patient with diabetes during a consultation]?	What factors or circumstances would ***enable*** you to walk on a treadmill for at least 30 minutes each day in the forthcoming month?	What factors or circumstances would ***enable*** you to follow the energy saving techniques for cooking?
	What factors or circumstances would ***make it difficult or impossible*** for you to [measure the blood pressure of a patient with diabetes during a consultation]?	What factors or circumstances would ***make it difficult or impossible*** for you to walk on a treadmill for at least 30 minutes each day in the forthcoming month?	What factors or circumstances would ***make it difficult or impossible*** for you to follow the energy saving techniques for cooking?
	Are there any other issues that come to mind when you think about [measuring the blood pressure of a patient with diabetes during a consultation]?	Are there any other issues that come to mind when you think about the difficulty of walking on a treadmill for at least 30 minutes each day in the forthcoming month?	Are there any other issues that come to mind when you think about following the energy saving techniques for cooking?

To answer all the 9 questions from the elicitation study participants were asked to consider these energy saving techniques:

- Measure the amount of water
- Time the process
- Choose small pans for single meals
- Choose small hobs that match small pans
- Use the saucepan lid
- Reduce the heat when the water is boiling
- Turn off the hob a few minutes before the end of the cooking time

5.2.3.1 Responses

From the 25 survey responses, the similar answers were clustered into ordered lists sorted by number of occurrences. It facilitated the data analysis and provided insights regarding the modal salient outcomes, referents and control factors as reported by the participants. The aggregated list of responses is shown in the tables below, following each question. It is important to note that participants could provide as many answers as they wanted for each question, and it explains why the responses count in several of the following tables is greater than 25.

Table 9 – Question 1 – Advantages of following the energy saving techniques

Advantages	Responses
Save bills	13
Save energy / electricity / heat	12
Environment / natural resources	11
Quicker	9
Saves water	3
Safety / less hazardous steam	3
More efficient	2
Ensures it cooks properly	2
Reduce problems	1
Easy	1
Improve skills	1

Even though most of the respondents (19 out of 25) were living in halls where their electricity bills are included in the accommodation fees as a fixed price, they understand that energy saving techniques can save money. This response was then removed from the subsequent questionnaire because it does not apply to students living in halls. As can be seen on the table above, 12 participants mentioned that applying the proposed energy saving techniques can help save electricity, and 11 stated that it can reduce environmental damage and avoid natural resources depletion. Some participants also mentioned that these techniques can make the cooking process quicker and more efficient, in agreement with results from the First Study.

Table 10 – Question 2 – Disadvantages of following the energy saving techniques

Disadvantages	Responses
Can take time	13
Takes effort / needs monitoring / more difficult	7
Takes concentration / thinking / ability	6
Hassle	4
People won't use	1
Reduces efficiency	1
Can't fit food into a small pan	1
Habit	1
Take the fun out of cooking	1
Cold food effect	1
Don't have pan lids or small pans	1
Awkward	1

Most participants believe that following the proposed techniques will make the cooking process longer. Also, they think that it will be a hassle by taking effort and concentration.

Table 11 – Question 3 – Personal opinions

Personal opinion	Responses
Useful / worth doing / good	10
I use most of them	5

Can't do some of them / some are not good	4
Easy / simple / Involve small changes	4
Helpful / for the environment / avoid waste	4
Students won't do it / Overlooked by students	3
I don't follow them / It doesn't bother me / I don't care	3
I would use just the ones that don't add time	2
Effective	2
The preparation adds time / can be time consuming	2
Won't save much	2
Pans must match hobs	1
I prefer gas cookers	1
Must highlight the economic and environmental impact	1
Need a leaflet	1
Save energy	1
Save time	1
I would use just the easiest ones	1
I'm more interested in the food	1
There is no financial incentive	1

Generally, participants had a positive attitude towards the proposed techniques. But some limitations were seen, mainly regarding the ability to perform some of them, or expressive lack of care towards them.

Table 12 – Question 4 – People who approve of the energy saving techniques

Individuals or group of people who approve	Responses
Eco-friendly people / environmentally friendly / green people / environmentalists / conservationists	9
Flatmates / housemates / students hoping to save money	5
Greenpeace	3
Family / parents / dad	3
House owners / landlord (in all inclusive) / who pay bills	3
Everybody / Anyone rational and sensible	2
Green party	1

Hall (hall points)	1
Friends	1
Scientists	1
Government	1
University	1

'Green' people or organizations were seen as the most important ones that would approve the use of the proposed techniques. Their immediate peers like housemates and flatmates were also reported to be important referents. The mention of Flatmates here could have been motivated by a competition among halls to see which ones reduce their energy use, where the winners can get points and money towards RAGs – Raise and Give – the University's charity scheme. For obvious reasons, house owners, landlords and whoever pays bills were also mentioned as people who would approve the energy saving techniques. Surprisingly, the university as a whole was mentioned just once.

Table 13 – Question 5 – People who disapprove of the energy saving techniques

People who disapprove	Responses
People in a hurry / who you are cooking for, if it takes longer	3
Chefs / People enthusiastic about their food	2
Lazy people	1
Gas and electricity companies	1

Not many participants had expressed opinions on this topic. However, one perceived negative aspect of the proposed techniques is that they would make the cooking process longer, and consequently it would bother people who they are cooking for. Participants also had the impression that it can compromise the quality of food, which would impact on those people enthusiastic about food.

Table 14 – Question 6 – Other referents

Other people	Responses
Conservationists / environmentalists / eco-friendly people / naturalists	4

My parents / mum / family	4
Flatmates / housemates	2
Bill payers	2
Green party	1
Lesions at school or at home	1
Other wasteful students	1
Scientists of global warming	1

Question 6 was presented to participants to check if they had other comments that could shed a light on the social influence on their behaviours. The responses were similar to the ones from question 4, focusing on environmentally conscious people, family, flatmates, housemates and bill payers.

Table 15 – Question 7 – Enablers of the energy saving techniques

Enablers	Responses
Having more time	7
Array of kitchen items / right equipment / pans / lids / jugs / timers / better kettle	7
Information / reminders in the kitchen	6
Knowing the facts / costs and savings	5
Space in the kitchen for preparation / facilities / bigger cupboards	4
Automation	1
Enforcements	1
Peer pressure	1
Technology	1
Thinking I'm contributing to save energy	1
If I cared more	1
Simplicity of the dish	1
Living with less people	1

Question 7 asked participants to describe what factors or circumstances would enable them to follow the energy saving techniques for cooking. Participants reported that having more time would be a facilitator. From their point of view, the proposed techniques would consume time to be performed, even though some of them consider that it can make the cooking process quicker, as seen in question 1. Another strong enabler would be the presence of adequate utensils, demonstrating that not all students are well equipped to perform the proposed energy saving techniques. The lack of information and knowledge was pointed quite frequently. Having more space to prepare food or store utensils was also reported as an enabler to the performance of energy saving techniques.

Table 16 – Question 8 – Constraints of the energy saving techniques

Constraints	Responses
Being short of time / in a hurry / in a rush	11
More people cooking at the same time / Small hobs not available	5
Laziness / being tired / lethargic	3
Improper equipment / lack of clean utensils	3
Not concentrating	2
Knowing that they don't save much	1
Habit	1
Being hungry	1
Not having money	1
Lack of awareness	1
I don't care	1
Being on a hangover	1
Incorrect facilities	1
Cooking complex dishes	1

Question 8 asked students what factors or circumstances would make it difficult or impossible for them to follow the proposed energy saving techniques for cooking. The most frequently reported constraint was the lack of time. Students indicated that they are often in a hurry and do not have enough time to dedicate to it.

Table 17 – Question 9 – Other issues

Other issues	Responses
You would estimate the amount of water	1

People must be made aware of energy saving	1
Generalize these techniques to other areas of energy use	1
Only useful for specific meals	1
Worth only because of the saved money on bills	1

A few general remarks were made on this last question, contributing to the overall elicitation of salient beliefs towards the proposed energy saving behaviours.

5.2.3.2 Outcomes of the elicitation study

The elicitation study provided interesting insights on the salient beliefs among this sample of the study population. Their responses demonstrated their readily accessible behavioural outcomes, normative beliefs and control factors. A content analysis of the responses to each of these constructs resulted in lists of modal salient outcomes, referents, and control factors. These lists were used to develop the items included in the final questionnaire, which is described below.

The most frequent responses were used to guide the design of the main questionnaire, which can be seen below. Previous research seems to be inconclusive regarding the number of modal beliefs to be used (Agnew 1998). The items used on the final questionnaire varied according to the questions, and a number between 2, 3 or 4 of the most frequent responses were used. The selection process involved a careful evaluation of the responses content and the quantity. This information was also combined with results from the previous study, where participants also gave their opinions regarding the energy saving techniques.

5.3 Questionnaire design

The development of the TPB / RAA questionnaire used during this research is presented here based on instructions from Fishbein and Ajzen's recent work (2010), the guide Constructing a Theory of Planned Behavior Questionnaire (Ajzen 2006), a comprehensive manual for TPB questionnaire design (Francis, Eccles et al. 2004) and examples from the literature (Gill, Tierney et al. 2010, Tonglet, Phillips et al. 2004, Nigbur, Lyons et al. 2010). The items are presented in thematic order, but were shown on the final questionnaire in random order as recommended by Ajzen (2002).

For usability purposes, all scales on this questionnaire are unipolar, ranging from 1 to 7, to provide consistency, facilitate filling and avoid confusion or extra mental load. There is some debate if scales should range from 1 to 7 or -3 to +3 (bipolar) (Sparks, Hedderley et al. 1991, Hewstone, Young 1988, Ajzen 1991). Since there is no universal indication of which method to be used, this research took in consideration the large number of questions to be filled in order to adopt a uniform approach and have only unipolar scales. Finally, comparisons with other questionnaires that are regularly administered to students suggested that unipolar scales would be more familiar to the study population.

The scales used range from 1 (the negative aspect e.g. false, bad) on the left hand side, to 7 (the positive aspect e.g. true, good) to the right throughout the questionnaire. This way the participants could select quickly the respective option without having to refer to the table headings every time. The questionnaire design is explained in detail below. It is separated into different sections for each measurement. These sections are intentions, the 3 main constructs of the TPB (attitudes, social norms and control) and also a range of extra questions (demographics and added measurements).

5.3.1 Intentions

According to Fishbein and Ajzen (2010), an appropriate measure of intentions to perform a given behaviour is a good predictor of its occurrence. They argue that people's estimate of the likelihood or perceived probability of performing a particular behaviour is indicative of the chances of this behaviour being in fact performed. An accurate measure of intention is necessary because it is the immediate precedent of behaviours (Ajzen 1991). Moreover, different levels of intentions require different intervention methods. For example, do the students have the *intention* to perform the recommended techniques for cooking? If not, then the focus must be on changing the constructs that lead to the lack of intention, being their attitudes, perceived social norms or perceived behavioural control. If they have the intention, what is preventing them from performing in a more sustainable manner? In this case, an intervention must focus on the *limitations* to perform the desired behaviour in order to be more effective.

The most commonly used method to measure the eagerness to perform the proposed behaviour is referred as Generalized Intention (Francis, Eccles et al. 2004), where statements are put randomly on the questionnaire. For example, the intention measure for this study have the following declaration and a scale ranging from *Strongly agree* to *Strongly disagree*:

- *For the next time I'm cooking in halls, I intend to measure the amount of water*

This question was repeated for each of the 7 proposed cooking techniques: Measuring the amount of water; Measuring the time; Using a small pan; Choosing a small hob; Using a saucepan lid; Reducing the heat when the water is boiling; Turning the heat off before the end of the cooking time.

5.3.2 Attitudes

Attitude can be defined as a latent disposition or tendency to respond with some degree of favourableness or unfavourableness to a psychological object. To measure attitudes, a unipolar evaluative dimension is used, which produce a score representing the respondent's attitude toward the object (Fishbein, Ajzen 2010). These scales have often 7 places or alternatives, ranging from opposite concepts such as *like – dislike, good – bad, positive – negative* or *favourable – unfavourable*.

5.3.2.1 Direct measurement of attitudes

The direct measurement of attitudes on this questionnaire used the question: *What is your personal opinion about these cooking techniques (when cooking single meals in halls)?* This question was followed by the 7 proposed cooking techniques. Participants had to select the appropriate value, from 1 (inconvenient) to 7 (convenient), as Figure 30 below demonstrates.

***6. What is your personal opinion about these cooking techniques (when cooking single meals in hall)?**

	1 - inconvenient	2	3	4	5	6	7 - convenient
Measuring the amount of water is	○	○	○	○	○	○	○
Measuring the time is	○	○	○	○	○	○	○
Using a small pan is	○	○	○	○	○	○	○
Choosing a small hob is	○	○	○	○	○	○	○
Using a saucepan lid is	○	○	○	○	○	○	○
Reducing the heat when the water is boiling is	○	○	○	○	○	○	○
Turning the heat off before the end of the cooking time is	○	○	○	○	○	○	○

Figure 30 - Attitude measurement question

When dealing with environmentally related behaviours, the focus of attention can be on the benefits for the individual or for the environment. By presenting the rating scale from *good* to *bad*, participants can be confused if the outcome evaluation is regarding the individual benefits or environmental benefits, which are often conflicting. For this reason, the options are often broken down to two or more statements to cover the 'affective' and 'evaluation' aspect of attitudes (Francis, Eccles et al. 2004, Ajzen 1991).

5.3.2.1.1 Experiential items

The experiential (or affective) measurement question used to understand attitudes towards the proposed techniques could use any of the following pair of terms to gather the 'experiential' beliefs: *pleasant – unpleasant, interesting – uninteresting, satisfying – unsatisfying, convenient – inconvenient, enjoyable – unenjoyable*. These terms measure the perception of how the statement influences the 'self', or how it feels to perform the behaviour (Ajzen 2002, Francis, Eccles et al. 2004, Fishbein, Ajzen 2010). For this research, the pair '*convenient – inconvenient*' was used due to this term being used often by the participants: it was reported during interviews on the First Study and also during the elicitation phase of this Second Study.

5.3.2.1.2 Instrumental items

In order to understand participants' attitudes concerning the general benefits of the proposed behaviours, the same question was used, but with different rating scale. With an instrumental (or evaluative) approach, the objective was to know whether the behaviour achieves something. For that purpose, the terms could be the following (with their respective negative pairs): *Good practice; Beneficial; The right thing to do; Appropriate; Worthwhile*. This research used the pair *the right thing to do – the wrong thing to do*, since these terms give a clear idea that the intended measurement is the general benefit of the behaviours, without considering personal preferences (which was covered on the previous question).

5.3.2.2 Indirect measurement of attitudes

Another way to measure attitudes is through an expectancy-value evaluation (Sparks, Hedderley et al. 1991, Kaiser, Hübner et al. 2005, Bamberg, Schmidt 2003). Statements for this measurement use the modal salient beliefs gathered during the elicitation study shown above and evaluate its relation with the behaviours. Questions are presented and scales of agreement or disagreement are provided. The four modal beliefs selected from the elicitation study combined with results from the First Study are:

- *The cooking process will take longer if I measure the amount of water*
- *It will compromise the quality of food if I measure the amount of water*
- *It will take more effort if I measure the amount of water*
- *I will save energy if I measure the amount of water*

Participants related these 4 modal beliefs with the 7 proposed cooking behaviours and selected the appropriate response from a scale ranging from 1 (false) to 7 (true).

The second part of an indirect measurement of attitudes includes the assessment of the 'value' of the statement. Participants provide responses related to the outcome evaluation of the belief. The statements used during this research were, from 1 (bad) to 7 (good):

- *Taking time for cooking is…*
- *Doing something that reduces the quality of food is…*
- *Putting effort into what you are cooking is…*
- *To cook in a way that saves energy in halls is…*

The belief strength multiplied by the outcome evaluation produces an overall expectancy-value index (Fishbein, Ajzen 2010, Francis, Eccles et al. 2004). Figure 31 shows the formula to calculate this index, where: **A** is the attitude towards the behaviour; $\mathbf{b}_i$ is belief i about the behaviour (i.e., the subjective probability that the behaviour is related to attribute *i*); **v*i*** is the evaluation of attribute *i*; and ***n*** is the number of beliefs (Sparks, Hedderley et al. 1991, Hewstone, Young 1988).

$$A = \sum_{i=1}^{n} b_i v_i$$

Figure 31 - Expectancy-Value formula

5.3.3 Perceived social norms

The way people behave can be strongly influenced by the social environment. This social influence is described as the *social norm*, representing what is an acceptable or permissible behaviour in a group or society. "The stronger the perceived social pressure, the more likely it is that an intention to perform the behaviour will be formed" (Fishbein, Ajzen 2010).

Perceptions of the social influence, which an individual experiences, can be either descriptive or injunctive. Descriptive normative beliefs refer to what an individual thinks others do in a particular situation, and injunctive normative beliefs describe what an individual thinks others approve or disapprove of (Göckeritz, Schultz et al. 2010). In this study the used statements were descriptive, combined with the identification with referent measurement. The selected referents were the most frequently cited during the elicitation study and also during the

First Study interviews, being university friends, flatmates and family members. The questionnaire read:

- *How often do your flatmates or university friends measure the amount of water for cooking?*
- *How often do your family members measure the amount of water for cooking?*

The same questions were repeated for each of the 7 proposed behaviours. In addition, a measure of the identification with referent was introduced to provide the two elements of the expectancy-value measurement (Sparks, Hedderley et al. 1991). The statements used were:

- *I like to cook the same way as my flatmates or university friends do.*
- *I like to cook the same way as my family members do.*

These two items multiplied provided an index of normative influence to be used during the data analysis. Generally, studies also use injunctive measurements of normative influence, combined with the evaluation of the motivation to comply with these influences (Francis, Eccles et al. 2004, Ajzen 2006, Fishbein, Ajzen 2010). It is done by asking participants what they believe that other people think they should do, and also if they want to do what people think they should do. But since this research involves the proposal of new behaviours which might not be part of students' practices, and seven different behaviours had to be evaluated, these measurements were excluded from the final questionnaire. Pilot studies demonstrated that it was difficult for the participants to infer their referents' opinion on these proposed behaviours. Furthermore, the length of the questionnaire was becoming prohibitive, and consequently some of the measurements had to be removed.

5.3.4 Perceived Behavioural control

One of the propositions of both the Theory of Planned Behaviour (Ajzen 1991) and the Reasoned Action Approach (Fishbein, Ajzen 2010) is that people are only able to perform their intentions if they have sufficient control over the behaviour. This control is often as it is perceived by the individual (as his underlying cognitive construct) or can be actual control (as imposed by the context). When individuals have strong control of their actions, their intentions produce good prediction of behaviours. Conversely, "when people lack control (i.e., when they are incapable of performing the behaviour), it is unlikely that the behaviour will be carried out" (Fishbein, Ajzen 2010). In the attempt to assess the perceptions of control of students regarding cooking, a range of questions were introduced to the survey to measure this control directly or indirectly. The direct measures of perceived behavioural control assess the autonomy and capacity to perform the behaviour, whereas the indirect measures evaluate the modal salient beliefs gathered during the elicitation study (Francis, Eccles et al. 2004).

5.3.4.1 Direct measurement of perceived behavioural control

The direct measurement of perceived behavioural control used in this study was built to assess capacity (or self-efficacy) to perform the proposed behaviours among the students. The question was designed to evaluate how easy or difficult the behaviours are, according to the participants' beliefs (Fishbein, Ajzen 2010). The rating scale used ranged from 1 (False) to 7 (True) and the phrasing of the question was:

- *If I want to, I can measure the amount of water for cooking*

This question was repeated for each of the 7 proposed behaviours. Other measurements of perceived behavioural control can include assessment of autonomy, through questions like *whether or not I (perform the behaviour) is completely up to me.* However, participants of the pilot study found it difficult to differentiate this question on autonomy from the previous question on capacity, which made them devalue the whole instrument. For this reason, this sort of question was excluded from the final questionnaire to avoid redundancy and to prevent the questionnaire to become too long.

5.3.4.2 Indirect measurements of perceived behavioural control

Generally, indirect measurements of perceived behavioural control use the expectancy-value model, combining the rating of the likelihood of these beliefs to happen and the evaluation of these beliefs. For example, it is possible to have the following statements:

- *I have the correct utensils that enable me to* (perform the behaviour)
- *Having the correct utensils would enable me to* (perform the behaviour).

However, due to the length of the questionnaire, only one of these measurements was used. The indirect measurement of perceived behavioural control used during this study includes three salient beliefs as reported by participants during the elicitation study and also from participants' responses during the First Study interviews. The selected aspects were the ownership of utensils, the information about how to perform the proposed techniques, and the fact that students do not have to pay for electricity. The questions had a rating scale ranging from 1 (False) to 7 (True), and the phrasing was:

- *I have the correct utensils that enable me to measure the amount of water.*
- *I have all the information that enables me to measure the amount of water.*
- *Having to pay for electricity would motivate me to measure the amount of water.*

These questions were repeated for each of the 7 proposed cooking behaviours.

5.3.5 Extra measurements

A few extra questions were included in the final questionnaire. These were an account of past behaviours to understand if participants use to perform these techniques, the demographic items (age, year at university and gender), which hall of residence the student live (to make sure it was a self-catered hall), how often the student cook (to exclude those with no cooking experience), the ownership of utensils (to have an assessment of the external limitations to behaviour) and a measurement of past behaviour frequency (to have a picture of the relation between past behaviour and students' attitudes, perceived social norms, perceived level of control and intentions).

5.4 Data collection

Emails containing a link to the questionnaire were sent to undergraduate students living in self-catered halls of residence. Hall wardens were asked to send the invitation email to students through their academic emails, making it easier to reach only the target population. All the data collection was made through the online service www.surveymonkey.com. This tool enables all entries to be downloaded as an Excel or SPSS file. Consequently, no manual data entry was required, which reduced the work involved for screening and cleaning the data (Pallant 2007). Since participants' responses to all questions were limited to checkboxes or drop down menu selections, all scores were within a range of possible values. Nevertheless, some errors were found and eliminated from the data set. The validation process was performed following recommendations from Pallant (2007).

Two main exclusion criteria were defined at the beginning of this study: (1) students that never cook whilst living in halls, and (2) students living outside the selected self-catered halls. These would not provide useful responses, since they might not be experienced with the cooking activity whilst living in halls, and might not be familiar with the kind of cooker in question. However, all participants reported being residents of the selected halls, helped by the communication method used to reach these students: the email invitations were sent only to students living in self-catered halls. Just one student selected "never" as the frequency of cooking on the introductory questions of the survey. This participant dropped out when reaching the second page, eliminating the need to exclude further entries from the database.

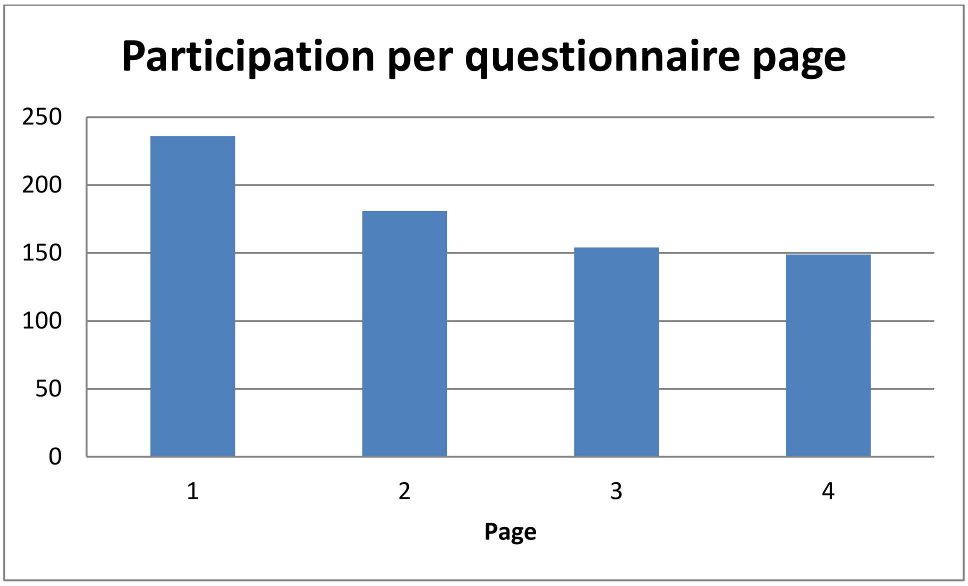


Figure 32- Participation per questionnaire page

This study had 240 participants in total, from 5 of the 10 undergraduate halls of residence on Loughborough University campus. All questions of the survey were marked as "required", meaning that participants had to select the desired option for each of the items. Students could just abandon the page or close the browser if they decided not to continue anymore. For that reason, the participation decayed from the first to the subsequent pages. Interestingly, the dropout rate was higher on the first pages but reduced on the following ones, as Figure 32 above demonstrates. In the end, 149 students filled all questions appropriately. Most of the analyses presented below take in consideration responses from these 149 participants. However, where correlations between different questions of the questionnaire were not necessary, the maximum available number of responses was used. The email invitations sent to students' academic email proved to be very efficient, with a participation ratio from 12 to 18% of the total resident population of the selected halls, which can be considered an excellent response rate. Previous research indicates that email recruitment rates can be as low as 0.24% (Koo, Skinner 2005).

5.5 Reliability

Table 18 - Reliability Statistics - TPB survey

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.913	.916	95

The reliability of a dataset can be evaluated by tests like Cronbach’s Alpha. This check provides a number between 0 and 1 that is used to rate the internal consistency (homogeneity) of the values in the dataset (Pallant 2007). Values above .7 or .8 indicate a good homogeneity, meaning that the chances of inadequate (random) responses among the results are reasonably low. This study presented a value of .913, indicating high homogeneity (Table 18).

5.6 Results

The survey performed as part of this study assessed participants’ intentions to perform a set of recommended behaviours and also their attitudes, their perceived social norms and perceived behavioural control related to the suggested behaviours. The responses to the survey collected from the 240 participants were analysed using different methods as recommended on the literature (Hankins, French et al. 2000, Pallant 2007, Armitage, Conner 2001).

Most of the questions on this survey provided results in intensely skewed distributions. This often happens with data arising from questionnaires, especially when participants have strong opinions regarding the research topics. Non-standard distributions require specific tests and need treatments before being subject to analysis. One common way to make this kind of data more suitable for processing is to collapse these variables into ‘bins’ (Pallant 2007). It is possible to divide the sample into groups of equal size according to their selections into, for example, ‘low’ and ‘high’ scores. For this purpose, the ‘visual binning’ procedure was applied to the independent variables.

For the statistical analysis, the three directly measured TPB constructs, as obtained by the survey, represent the independent variables, and the participants’ intentions to perform the selected behaviours were assigned as the dependent variable (Robson 2011). The measurements were performed in order to understand how the participants’ attitudes, perceived social norms and perceived behavioural control affect the intentions (dependent variable) to perform the proposed behaviours. Statistical analysis allowed the calculation of the relative influence of each one of the three constructs of the TPB / RAA into the intention to perform the selected cooking behaviours (Fishbein, Ajzen 2010, Ajzen 1991). To proceed with the testing, the independent and the dependent variables were submitted to analysis of variance (ANOVA) scales in order to produce the R^2 (R-square) statistics. This value represents the relative influence of one variable on the other, and ranges from 0 to 1, where 0 is no correlation and 1 is total correlation (Pallant 2007). Table 19 below shows this correlation data between the seven recommended cooking behaviours in comparison with participants' attitudes towards the performance of these behaviours, their perceived descriptive social norms regarding these behaviours, and also their perceived behavioural control which enables or constrains the performance of the proposed behaviours.

Table 19 – Analysis of variance of intentions according to the Theory of Planned Behaviour

Intentions to:	attitude	norm	control	*n*
Measure the amount of water	.139	.179	.055	88
Measure the time	.209	.158	.021	102
Use a small pan	.076	.026	.085	99
Use a small hob	.146	.060	.005	94
Use a saucepan lid	.099	.054	.029	93
Reduce the heat when it's boiling	.132	.161	.117	83
Turn the heat off before the end	.059	.359	.034	79

As can be seen on Table 19, attitudes explain from 6% to 21% of the intention to perform the proposed cooking behaviours. Social norms can influence from 3% to 36% of the intentions, and the perceived behavioural control accounts from 2% to 12% of these intentions to perform these behaviours. This table indicates that the influences are generally low, meaning that attitudes, social norms or perceived behaviour control are weak predictors of intentions for most of the techniques, and consequently weakly related to the actual behaviours. The number of respondents (*n*) is variable and smaller than the total number of participants because they could respond 'I don't know' to the descriptive social norm (if their families or friends perform these behaviours). Consequently these respondents had to be removed from the combined analysis.

One interesting result is that all figures on the table are positive, meaning that the correlations between variables are positive. Students that have positive attitudes, social norms and behavioural control towards the proposed techniques also have positive intentions to perform these techniques. For example, participants who think that measuring time is convenient, the right thing to do, preserves the quality of food, helps cooking quickly, makes the cooking process easier and saves energy generally intend to follow these cooking techniques.

The following sections present the data for each measurement separately to provide a simple visualization of each question, the tendencies of responses and likelihood of adoption of proposed behaviours. The series of figures below display the average score of evaluations on the y axis and all 7 proposed techniques on the x axis. Due to layout constraints the techniques are named in short following this sequence:

- **Water:** Measure the amount of water
- **Time:** Measure the time
- **Pan:** Use a small pan
- **Hob:** Use a small hob
- **Lid:** Use a saucepan lid
- **Reduce:** Reduce the heat when it's boiling
- **Turn off:** Turn the heat off before the end of the cooking time

5.6.1 Attitudes

Students' attitudes towards the proposed techniques were measured via a series of questions. Attitudes were gathered via direct (experiential and instrumental) and indirect (expectancy x value) measurements. Results are displayed on specific graphs and comments on data are provided below.

5.6.1.1 Experiential evaluations

When asking 'what is your personal opinion regarding these cooking techniques', this questionnaire assessed participants' experiential attitudes, and was rated on a scale ranging from inconvenient (1) to convenient (7). A total of 181 participants answered this question. The average values of attitudes based on experiential evaluations shows that the first behaviour (measuring the amount of water) is the only one evaluated negatively. Figure 33 shows that the perception regarding the first behaviour is slightly negative. On the other hand, the second and third behaviours (measuring the time and choosing a small pan) are evaluated positively. The last four items present responses with mixed evaluations and fall around the median scale value (4).

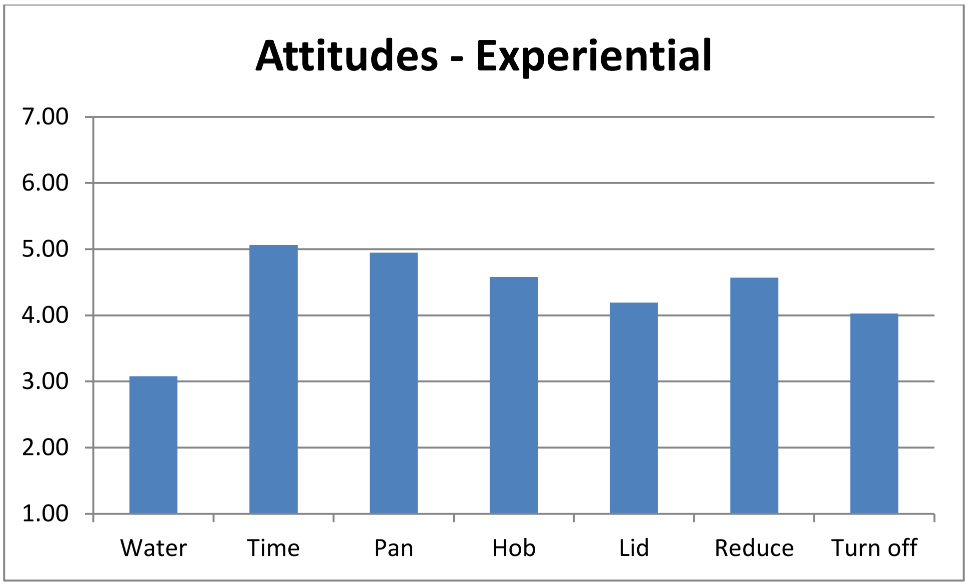


Figure 33 - Measurement of attitudes – experiential, averages: Performing these behaviours is inconvenient (1) – convenient (7)

5.6.1.2 Attitudes – instrumental evaluations

The instrumental evaluation of attitudes used the same question (*what is your personal opinion regarding these cooking techniques*) and a rating scale ranging from 1 (*the wrong thing to do*) to 7 (*the right thing to do*). Participants indicated generally a positive instrumental evaluation of the proposed behaviours. Most of the students consider that these techniques are the right thing to do. 'Measuring the time' was the item with better evaluation, and 'turn off the hob before the end of the cooking time' scored the poorer rating, although still above the median value (4).

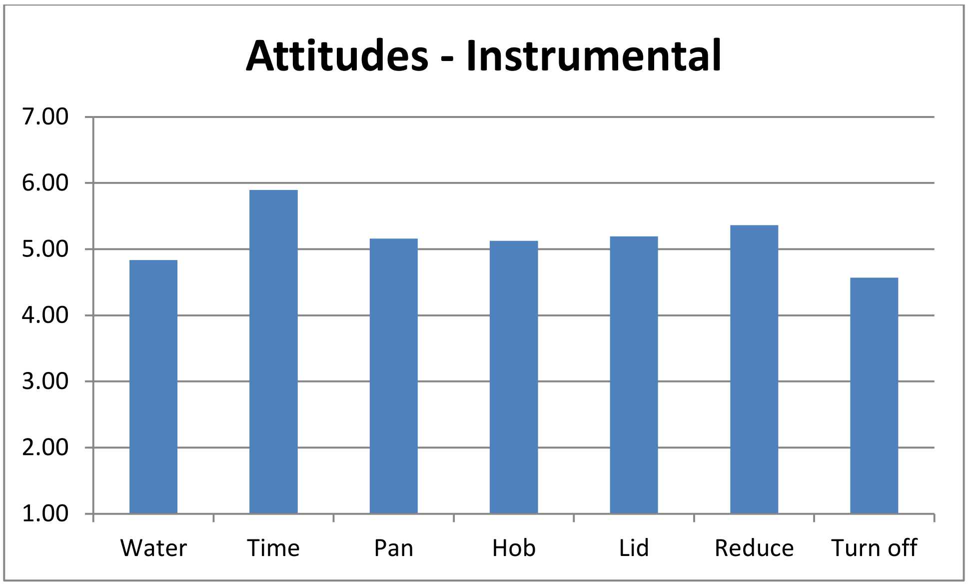


Figure 34 - Measurement of attitudes – instrumental, averages: Performing these behaviours is the wrong thing to do (1) – the right thing to do (7)

5.6.1.3 Attitudes – Indirect measurement – Increases time

The indirect measurement of attitudes involved questions to understand the likelihood of the consequences, constituting the expectancy of these consequences to happen. When asked if the cooking process would take longer when following the proposed techniques, participants indicated that they believe it is generally a false statement. ‘Measure the time’, ‘use a small pan’ and ‘use a saucepan lid’ scored the lowest values, meaning that most of the participants believe that it will not increase the time for cooking. However, ‘Measure the amount of water’ had a balanced number of extreme ‘false’ and ‘true’ evaluations, causing this item to have a median average response. One possible explanation is that it can take time to measure the water (with a jug or other utensils) but it can also make the cooking process quicker if you have the exact amount of water needed. Some students demonstrated concerns that using a small hob, reducing the heat level or turning it off towards the end of the cooking process might increase the time to cook.

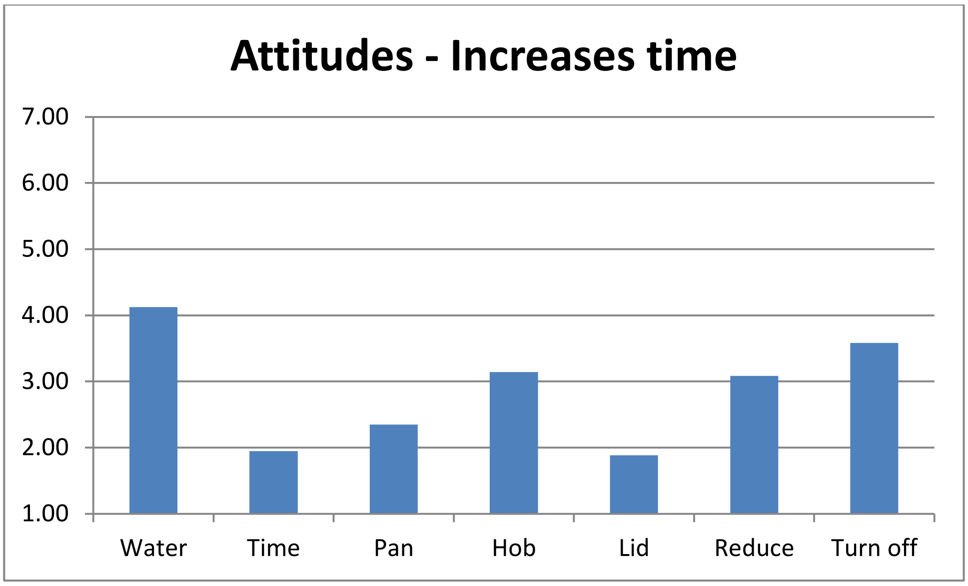


Figure 35 – Average measurement the expectancy of extra time: The cooking process will take longer if I perform these behaviours: false (1) – true (7)

5.6.1.4 Attitudes – Indirect measurement – Compromises quality

When asked if the proposed behaviours would compromise the quality of food, the clear tendency was to rate it as 'false'. The only item to score slightly higher was 'turn off the hob before the end of the cooking time', but still below the median value.

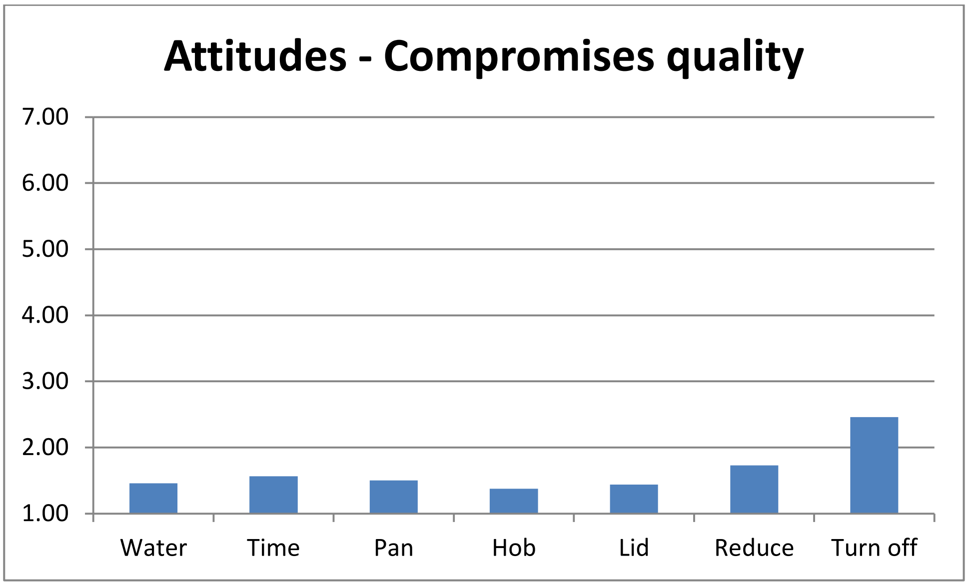


Figure 36 – Average measurement of expectancy of lower quality – It will compromise the quality of food if I perform these behaviours: false (1) – true (7)

5.6.1.5 Attitudes – Indirect measurement – Adds effort

Most participants indicated that measuring the amount of water will add effort to the cooking process. Measuring the time had mixed ratings, next to the median scale value. The other behaviours were reported as not adding much more effort to the process.

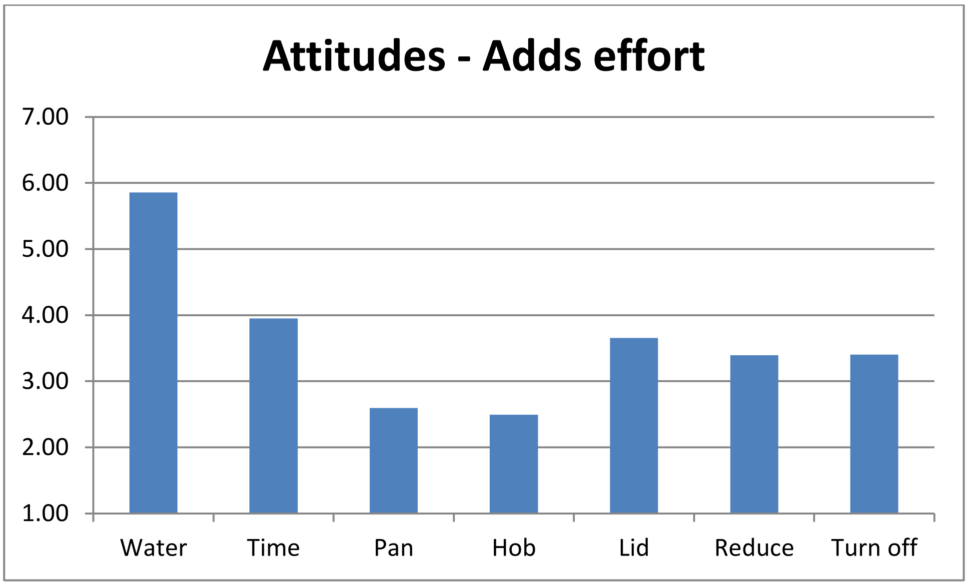


Figure 37 – Average measurement of expectancy of extra effort – It will take more effort if I perform these behaviours: false (1) – true (7)

5.6.1.6 Attitudes – Indirect measurement – Saves energy

When asked if the proposed techniques can save energy, the majority of the students indicated it as true. Figure 38 shows that all behaviours score rather positively, even though energy saving was not mentioned anywhere in the questionnaire. It indicates that students perceived these techniques as useful ways to save energy during cooking. This data also shows that knowledge of ways to save energy is not enough to guarantee that they will perform in a sustainable way.

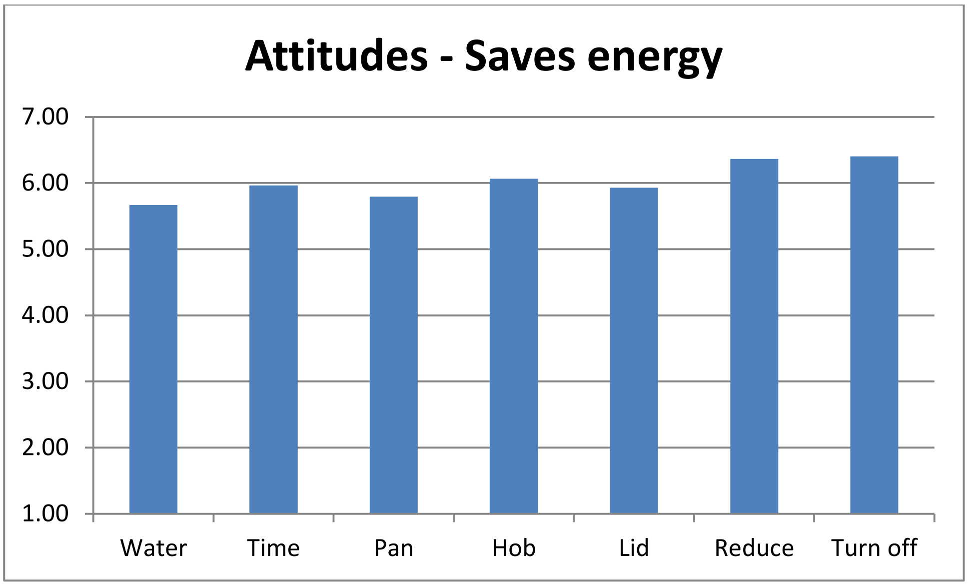


Figure 38 – Average measurement of expectancy of energy saving – I will save energy if I perform these behaviours: false (1) – true (7)

5.6.1.7 Attitudes – Value of beliefs

To understand the 'value' of each of the indirect measurements of attitudes (the time it takes to cook, effort, quality of final food and energy saving), extra measurements of attitudes were deployed, from 1 (bad) to 7 (good). 'Compromising the quality of food' was rated with a very low score, as can be seen on Figure 39. The other measurements had all positive scores: taking time for cooking, putting effort into what they cook, or saving energy have relatively positive perceptions amongst students.

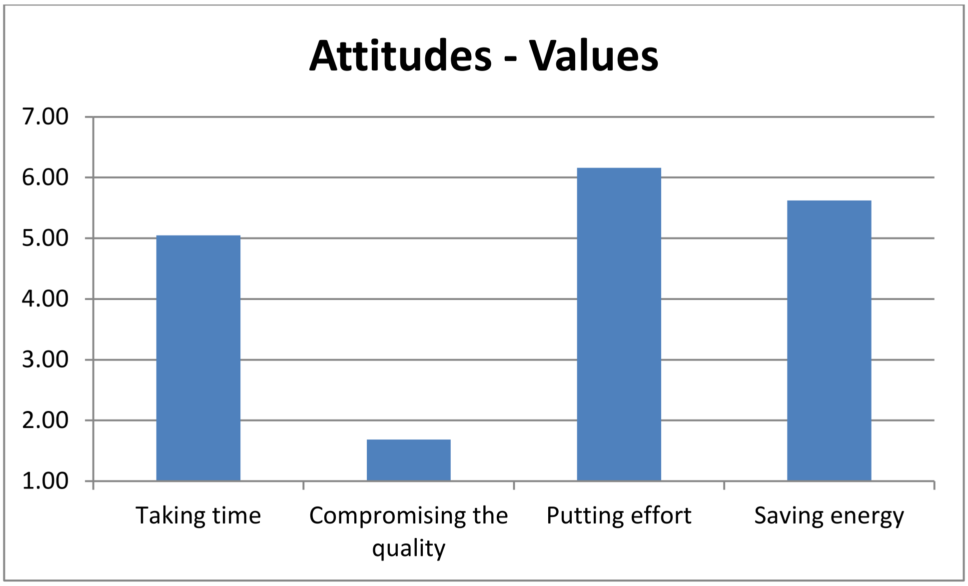


Figure 39 – Average measurement of values of these propositions: [Taking time for cooking] is bad (1) – good (7)

5.6.1.8 Attitudes – Total Expectancy-Value

Using the Expectancy-Value model (Sparks, Hedderley et al. 1991, Hewstone, Young 1988) demonstrated in the formula above (Figure 31) it was possible to aggregate all indirect measurements of attitudes into one single variable. The average results for the 149 participants who filled all these questions can be seen on Figure 40. The y axis represent the total evaluation of the four measurements of attitudes from the previous questions (time, quality of food, effort and energy use) multiplied by the evaluation of these attitudes (Figure 39). This information indicates that students have a somewhat negative attitude towards measuring the amount of water, but all the other behaviours score around the median scale value (100).

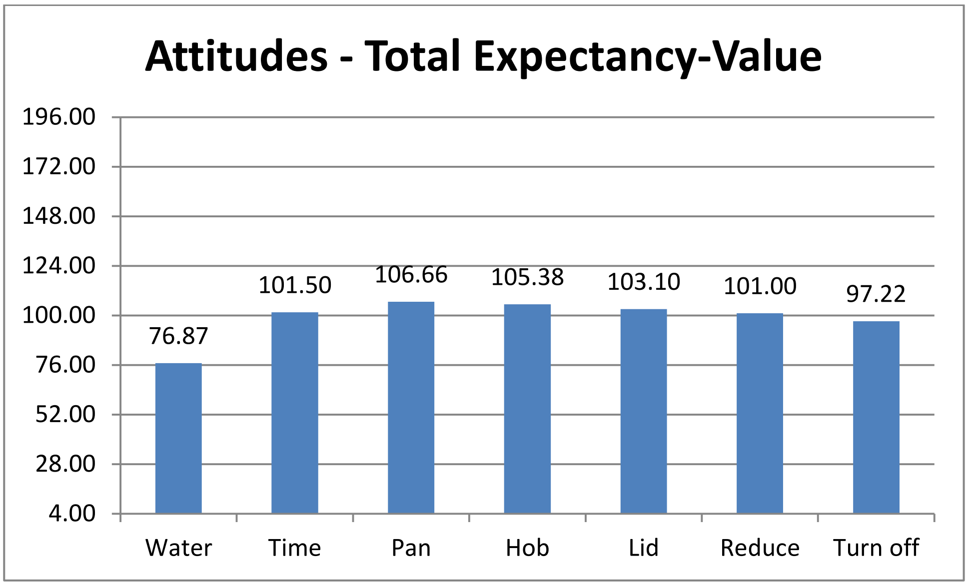


Figure 40 - Measurement of Attitudes – Total Expectancy-Value

5.6.2 Perceived Social Norms

To assess the normative influence on behaviours, four questions were implemented. Two of them are related to the perceived frequency in which friends and family perform the specific behaviours. The other two are related to the identification with the referent, in order to understand if they want to perform the same way as these two specific groups.

5.6.2.1 Descriptive norm – Friends

On average, participants reported that their flatmates and university friends do not measure the amount of water for cooking very often, do not use a saucepan lid, do not reduce the heat level when the content is boiling, nor turn the heat level before the end of the cooking time. According to their perceptions, the only behaviour commonly performed is the measurement of the cooking time. Using a small pan or using a small hob showed to be close to the median scale value, as can be seen on Figure 41.

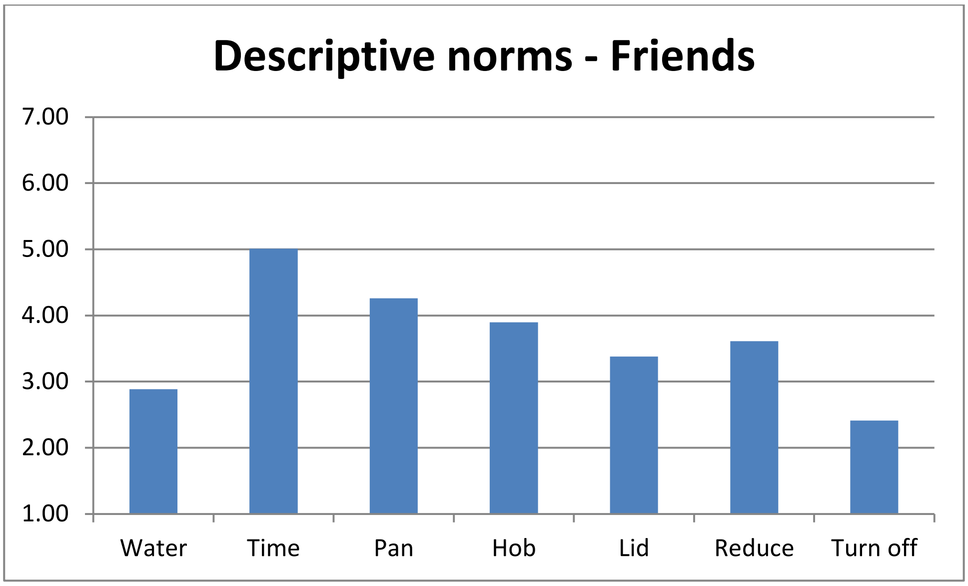


Figure 41 – Average descriptive norms – Friends: How often do your flatmates or university friends perform these behaviours? Never (1) – Always (7)

5.6.2.2 Descriptive norms – Family

Family members perform all suggested behaviour more often than students' friends and flatmates. The items with a lower average score are the measurement of the water and turning off the heat before the end of the cooking time, both around the scale median value.

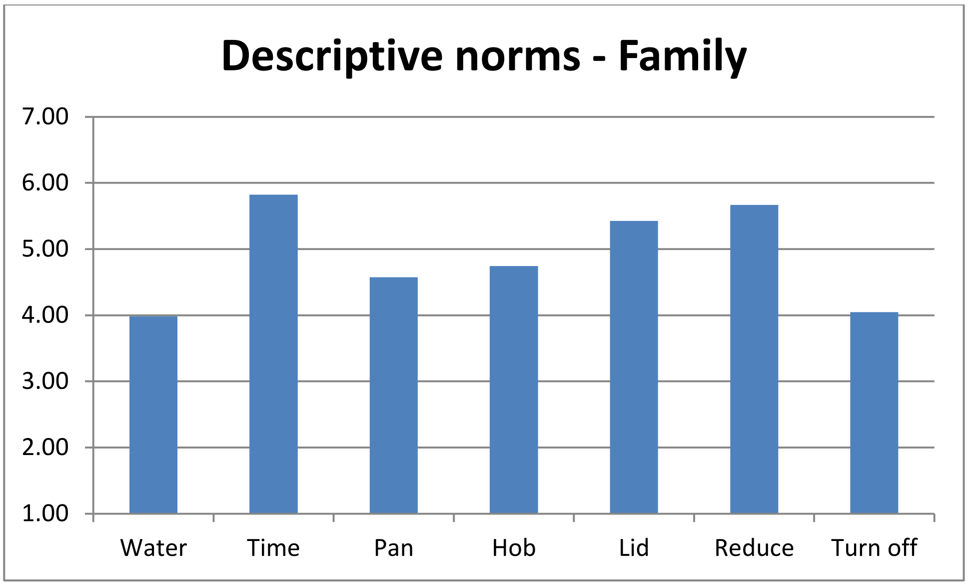


Figure 42 – Descriptive Norms – Family: How often do your family members perform these behaviours? Never (1) – Always (7)

5.6.2.3 Perceived Social Norms – Identification with referent

When asked if they wanted to cook in the same way as their university friends or flatmates, the score were significantly low. The same question related to their families produced remarkably higher scores. Figure 43 shows these results on a scale from 1 (false) to 7 (true).

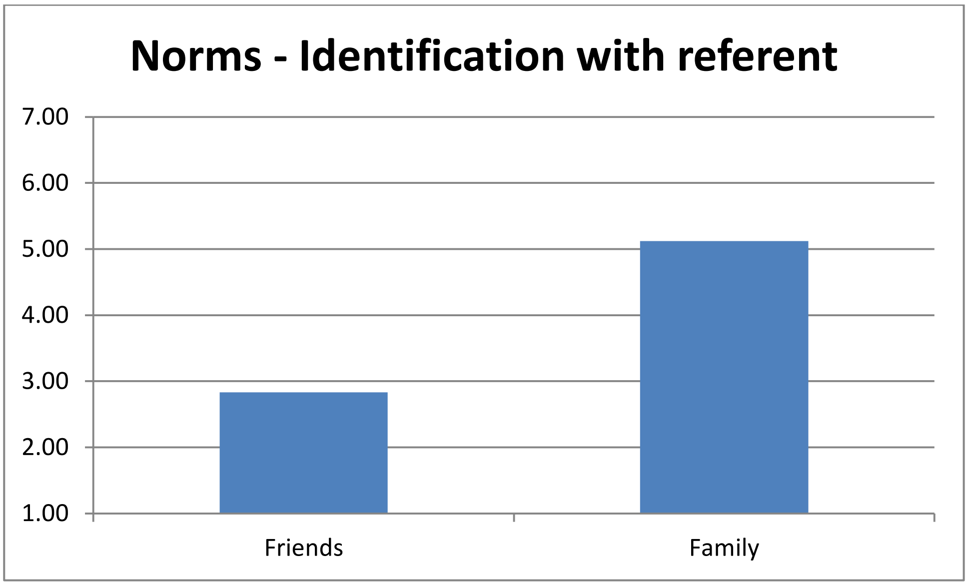


Figure 43 - Norms - Identification with referent – I like to cook the same way as my flatmates or university friends do / my family does: false (1) – true (7)

5.6.2.4 Perceived Social Norms – Total

When combining the descriptive norm of friends and family with the identification with both of these referents, it was possible to have a total score for a general perceived social norm, as can be seen on Figure 44. The values became substantially lower for all behaviours, comparing to the separated measurements of descriptive norms for friends and family. The behaviour to score slightly better than the others was the 'measurement of time for cooking', which was close to the median scale value of 50. The analysis of normative influence indicates that the low identification with university friends and flatmates made the overall score of social norms relatively low.

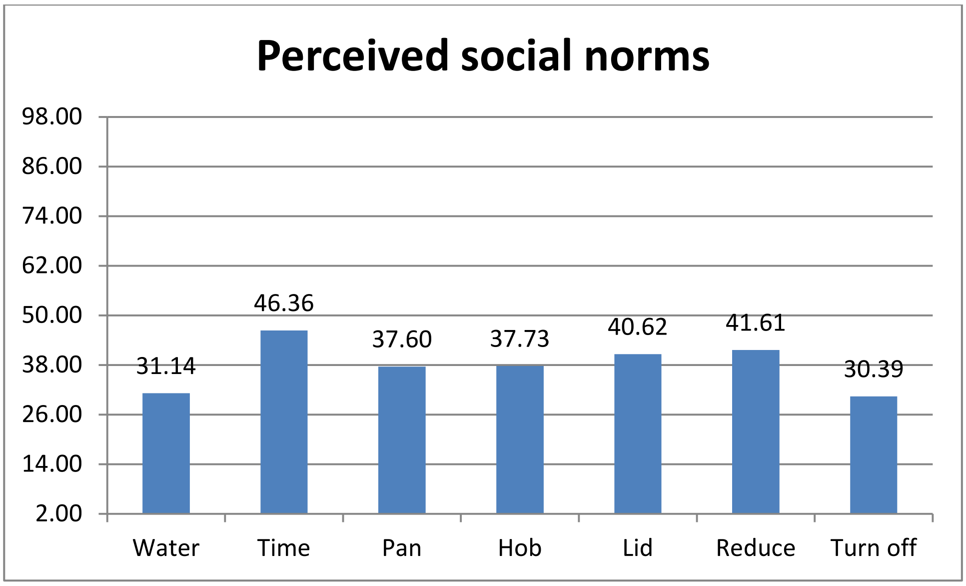


Figure 44 - Perceived Social Norms – Total Friends + Family

5.6.3 Perceived Behavioural Control

To understand how participants evaluate their level of control, a combination of questions were administered. One of them was related to their perceived capacity to perform the proposed behaviours. Other indirect measurements involved the modal salient beliefs reported during the elicitation study, being the ownership of adequate utensils, the amount of information they have and the fact that they do not pay for electricity directly – consequently not having the financial motivation to save energy.

5.6.3.1 Perceived Behavioural Control – Capacity

When asked 'if I want to, I can [perform the proposed behaviours]', the vast majority of students rated it at the maximum score across all behaviours. Figure 45 illustrate these responses, all above 6, on a scale from 1 (false) to 7 (true). It indicates that participants generally believe they have the capacity to perform the behaviour.

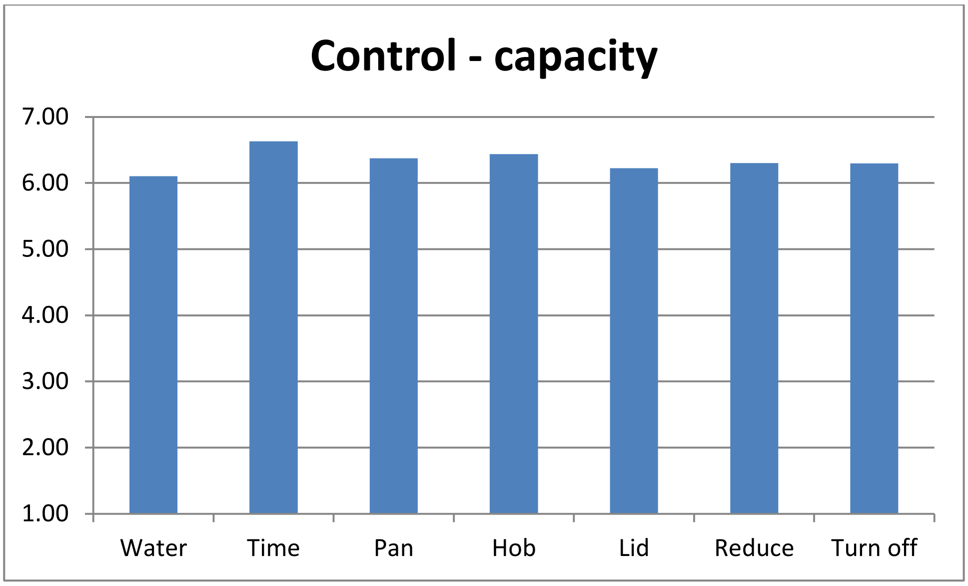


Figure 45 - Perceived Behavioural Control – Capacity – If I want to, I can perform the proposed behaviours: false (1) – true (7)

5.6.3.2 Perceived Behavioural Control – Utensils

The perceived ownership of the right kitchen utensils was another way to evaluate participants' beliefs regarding their control to perform the cooking behaviours. Figure 46 indicates that students generally believe they have the adequate kitchenware that enables them to execute the proposed techniques. However, it is possible to notice that the items related to the cooker (hob size, reduce the heat and turn off the hob) are rated higher than items related to individuals' utensils (water measurement container, small pan and lid for the small pan). Utensils for measuring time also presented high level of ownership, probably reflecting the high penetration of mobile phones nowadays.

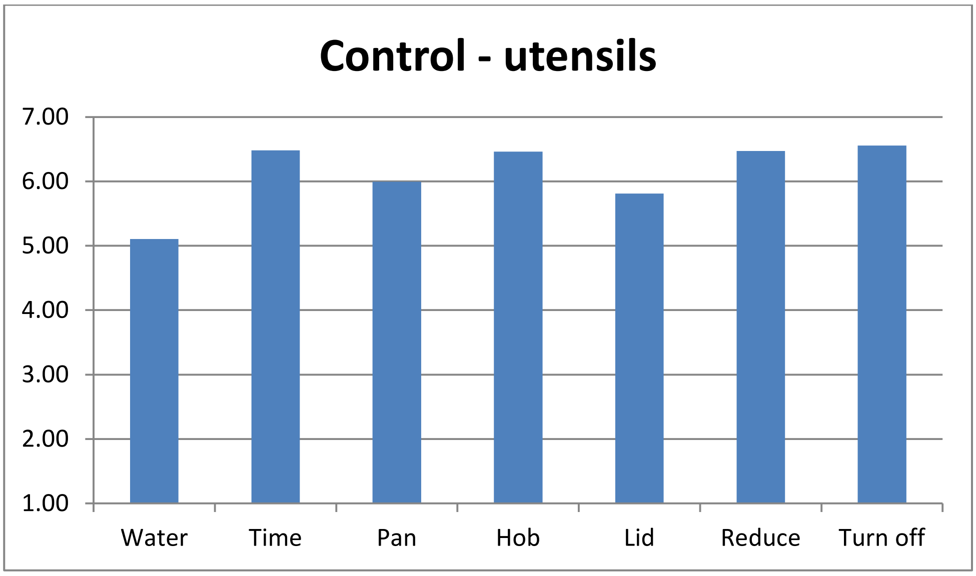


Figure 46 – Perceived Behavioural Control – Utensils – I have the correct utensils that enable me to perform the behaviour: false (1) – true (7)

5.6.3.3 Perceived Behavioural Control – Information

When asked if they have the right information to perform the given behaviours, the vast majority of participants marked 7 on the scale from 1 (false) to 7 (true). Consequently, all behaviours have average scores above 6, as demonstrated on Figure 47.

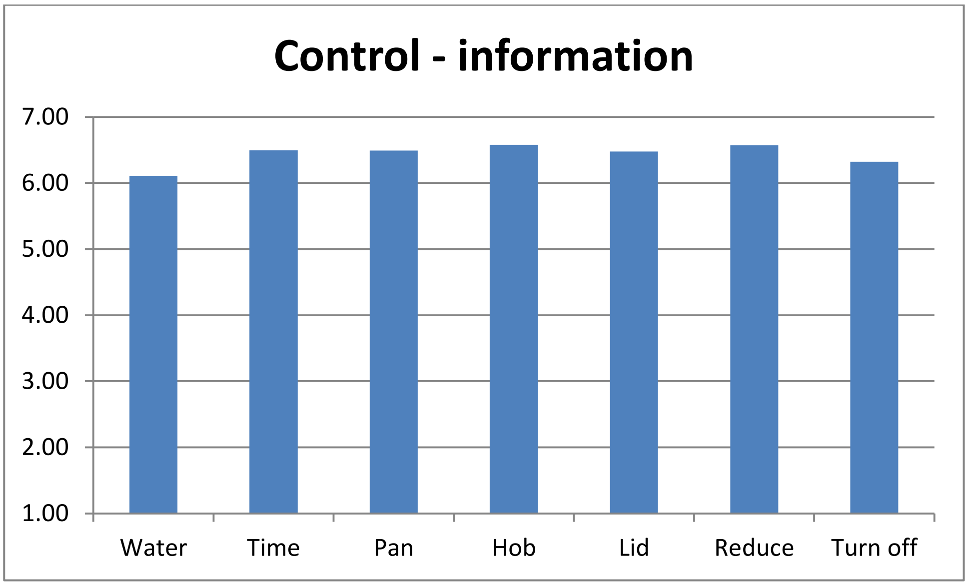


Figure 47 – Perceived Behavioural Control – Information – I have all the information that enables me to perform the behaviour: false (1) – true (7)

5.6.3.4 Perceived Behavioural Control – Pay

Participants were also asked if they would perform the behaviours if they had to pay for the electricity separately. This question had mixed responses and did not produce very conclusive results, with all behaviours having average scores slightly above the median scale value.

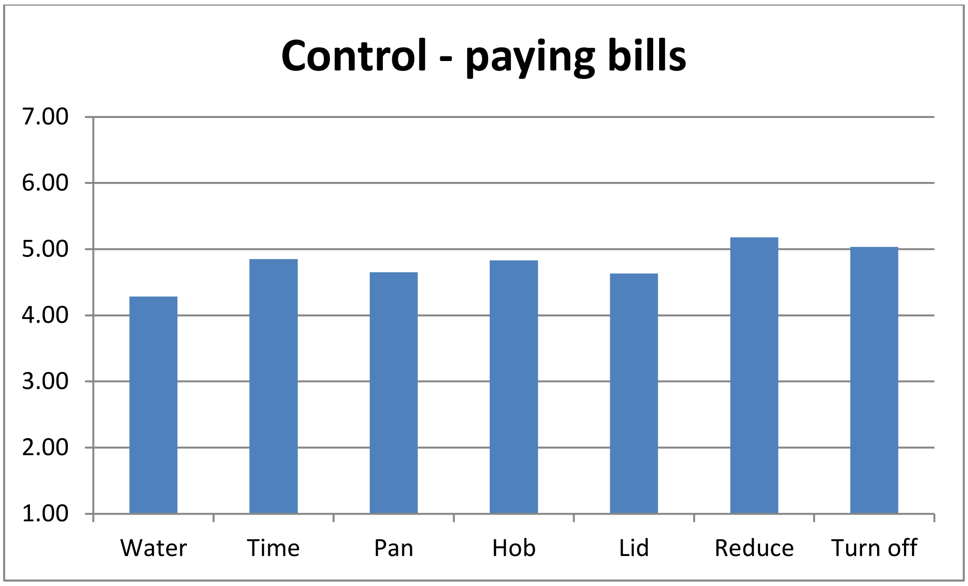


Figure 48 – Perceived Behavioural Control – Paying bills – Having to pay for electricity would motivate me to perform the behaviour: false (1) – true (7)

5.6.3.5 Perceived Behavioural Control – Total

By combining the 3 indirect perceived behavioural control measures it was possible to evaluate participants' general attitudes related to all measured salient modal belief factors (utensils, information and bills). Figure 49 shows that the average value for every proposed behaviour is significantly above the median scale value (12).

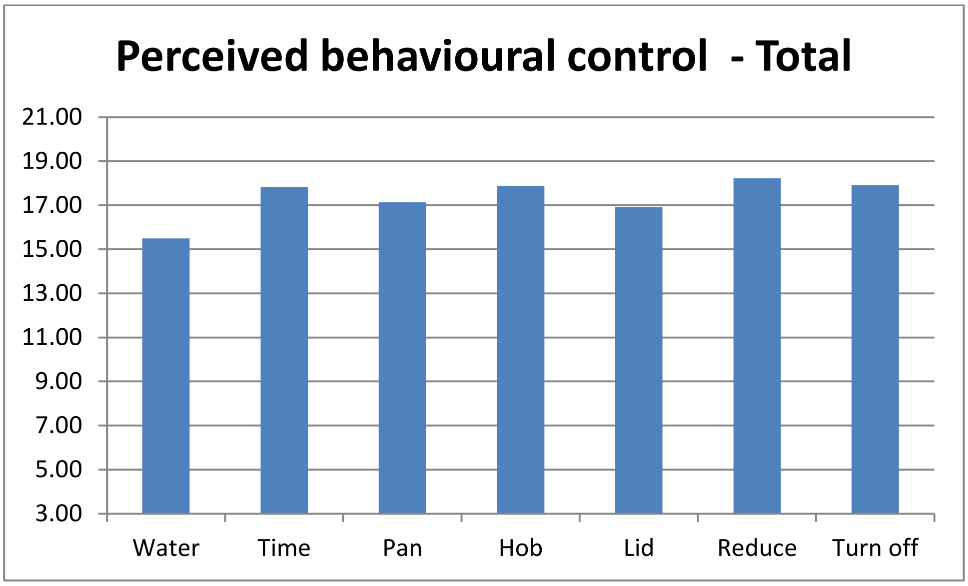


Figure 49 - Perceived Behavioural Control – Total – average: combined values of direct and indirect measurements of perceived behavioural control

5.6.4 Intentions

Participants were asked to rate their intentions to perform the suggested behaviours on a scale from 1 (never) to 7 (always). This question presented different results for different cooking behaviours. 'Measure the amount of water' scored a slightly negative intention (3) whereas 'use a saucepan lid' or 'turn off the hob before the end of the cooking time' had a median average value. 'Measure the time for cooking', 'use a small pan', 'use a small hob' and 'reduce the heat when the water is boiling' scored somewhat positive average values, as can be seen on Figure 50.

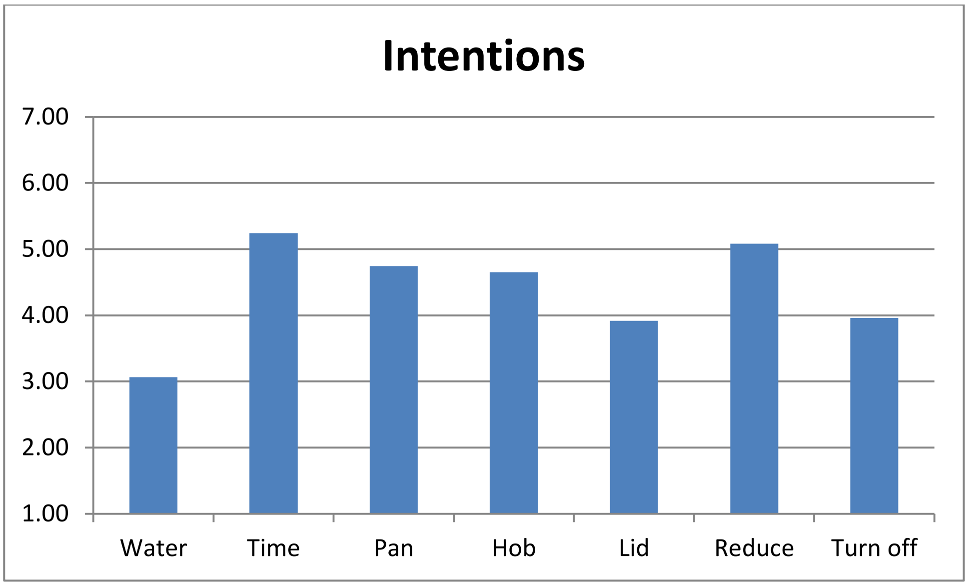


Figure 50 – Measurement of intentions – I intent to perform the proposed behaviours: false (1) – true (7)

5.6.5 Past behaviour

The question of "How often do you [perform the selected behaviour]" intended to measure past behaviour and by doing so obtain a self-report of these selected behaviours. As can be seen on Figure 51, these results are very similar to intentions. The average response is only slightly lower for past behaviours than for intentions, perhaps because participants understand that performing these behaviours is the good thing to do, hence indicating more positive intentions than actual past behaviours.

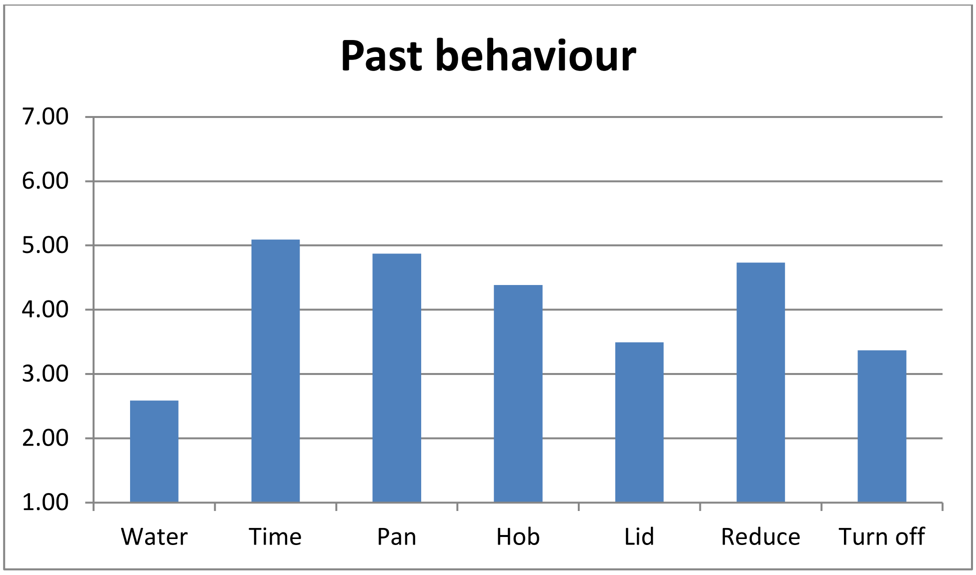


Figure 51 – Report of past performance of the proposed behaviours: never (1) – always (7)

5.6.6 Extra measurements

One question was added to the survey to understand if the participants had specific utensils needed to perform the proposed cooking behaviours. 32% (48) of the participants mentioned not having a proper measurement jug. 13% (20 participants) reported not having a small pan and 32% indicated that they do not have a lid for the small pan. This information can be compared with the question presented on item 5.6.3.2 (Perceived Behavioural Control – Utensils) above, where the equipment with lowest scores were also those for measuring the amount of water or using the saucepan lid for cooking.

5.6.6.1 Utensils

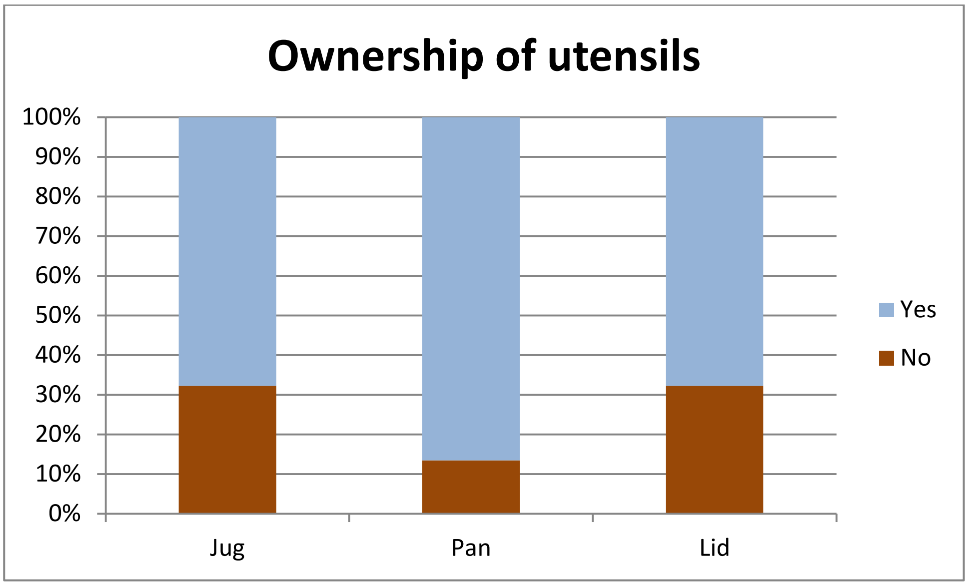


Figure 52 - Ownership of utensils

5.6.6.2 Age

The age of the participants ranged from 18 to 35, with the majority (38%) being 19 years old. It reflects the demographics of the selected halls of residence, which are specifically for undergraduate students, preferably *freshers*. Since this survey was sent at the end of the academic year, it was expected that most of the students would have turned 19. Those halls can also host *returners*, *finalists* and mature students, hence the relatively broad age range.

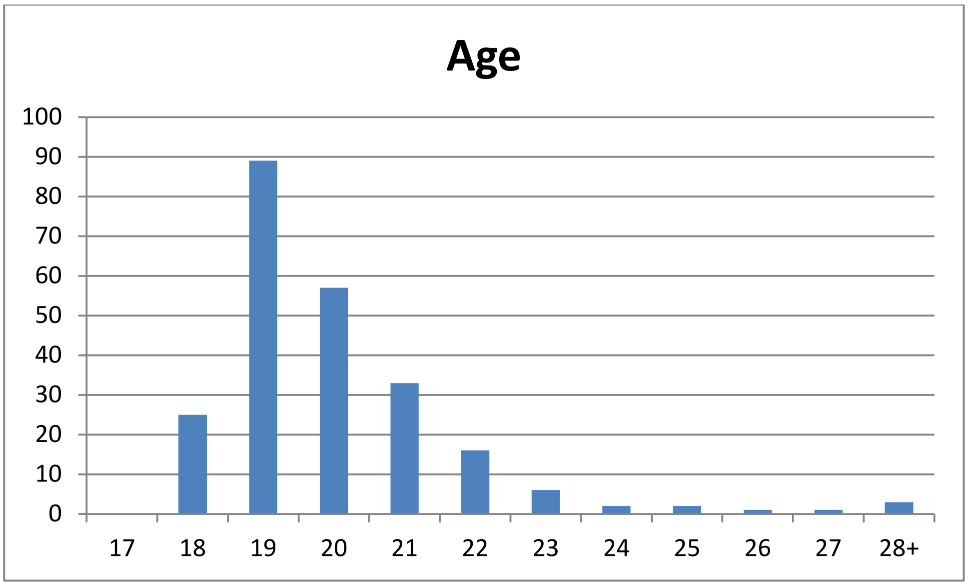


Figure 53 - Age of participants

5.6.6.3 Year at university

The majority of participants (63%) are on their first year at university. This figure reflects the nature of the selected halls of residence: they are mainly for *freshers*.

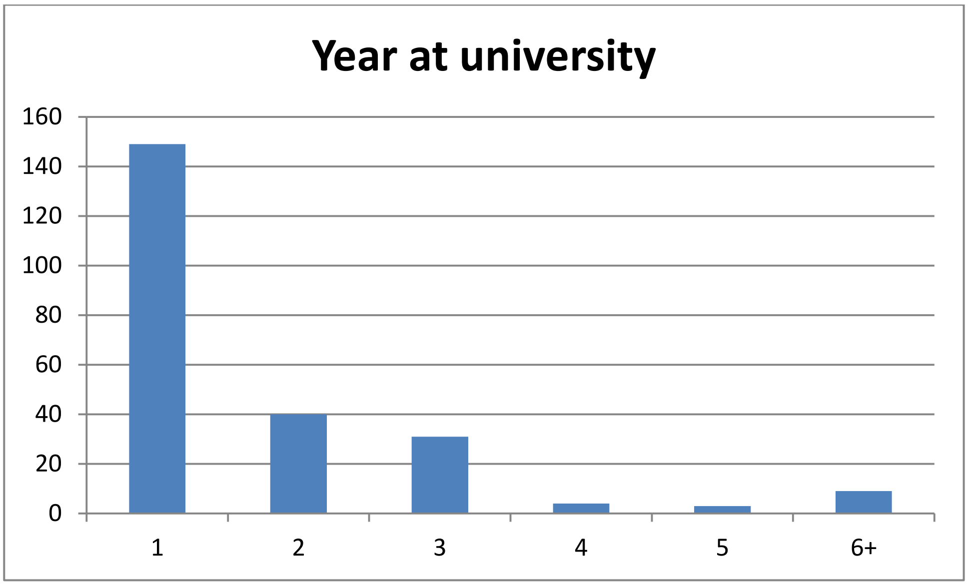


Figure 54 - Year at university

5.6.6.4 Gender

The gender distribution of the participants was relatively well balanced, with slightly more males answering the questionnaire than females. This tendency might be a reflection of the real distribution of the universe of students living in halls of residence. However, since the sampling strategy for this study involved invitations and voluntary participation, it was impossible to control this ratio.

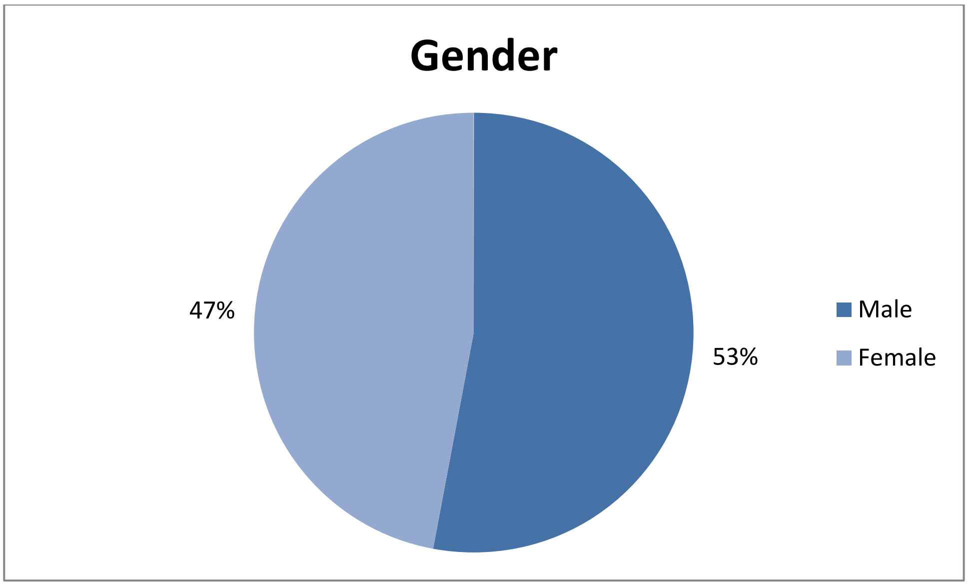


Figure 55 - Gender of participants

5.6.6.5 Cooking frequency

The vast majority of participants prepare hot foods at least daily. 66% (154 participants) reported cooking seven days a week whilst living in halls, as can be seen on Figure 56.

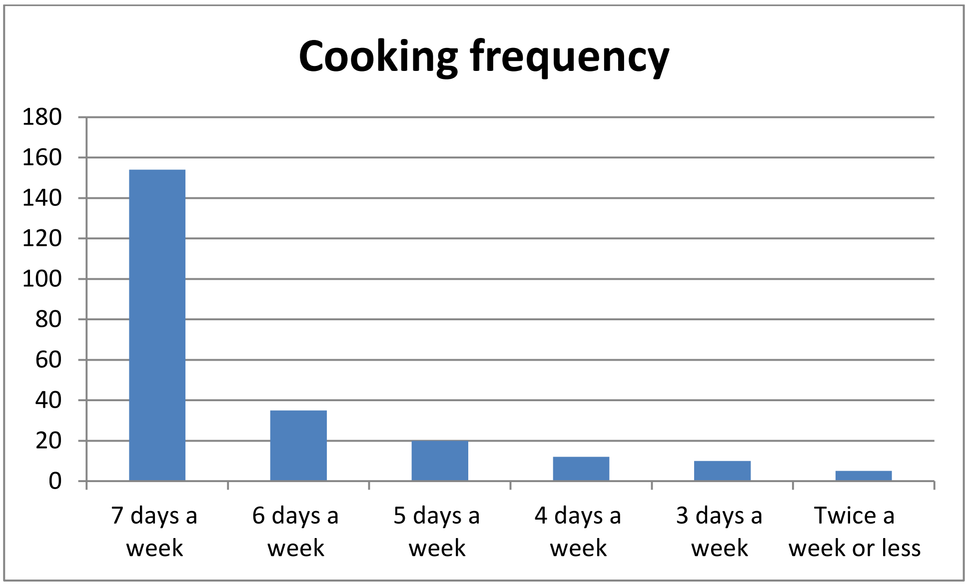


Figure 56 - Cooking frequency and number of respondents

5.7 Discussion

This study attempted to present a clearer picture of the acceptance of specific energy saving techniques to be used during cooking. The Theory of Planned Behaviour provided the tools and methods to gather this information. The extensive results presented here determined "the relative contribution of attitudes, subjective norms and perceptions of behavioural control to the prediction of intentions" (Ajzen 2006). Also, this study provided measurement of these beliefs and indicated which behaviours are more strongly affected by students' attitudes, perceived social norms or perceived behavioural control. This information can be of value because it indicates which behaviours are more likely to be changed, and which cognitive constructs have to be modified to produce a change in behaviour.

The first part of this study consisted of an elicitation study that gathered the salient beliefs among a sample of the target population. The majority of students mentioned that following the proposed techniques would increase time and effort for cooking. It indicates that there are limitations to the adoption of the techniques, since time and effort were one of the most frequent explanations for performing non-energy saving behaviours, as seen on the First Study. It shows that students must have a better understanding of the advantages of the proposed techniques in order to accept it. Not only from the sustainability point of view, but also for their personal advantages, like making the cooking process quicker and more efficient. Other students mentioned during the elicitation study concerns that the proposed behaviours could compromise the quality of food or make cooking take longer, especially if they were cooking for others. It indicates that, in order to make the energy saving techniques acceptable, it is necessary to make clear that it will not compromise the quality of the food nor increase the cooking time. When asked what would prevent them performing the proposed behaviours, the lack of time was the most frequent response. However, as demonstrated during the First Study, the energy saving techniques can in fact reduce the cooking time. It is understood that cooking using less electricity involves preparation and planning before the start of the process. But the trade-off must be considered, and the challenge is to introduce the concept of efficiency in the process of cooking, which will benefit the students towards their main concern that is to have a quick preparation time. The responses to the elicitation study gave important insights on participants' beliefs and intentions to perform the proposed behaviours. It was clear that students need to get a broader understanding of the advantages of the energy saving techniques, since it can not only reduce electricity usage (and consequently reduce bills for those who pay for it), but also reduce the cooking time whilst maintaining the quality of food.

Table 20 below provides a summary of the proposed behaviours and the respective weaknesses and strengths according to students' beliefs. This information was collected and aggregated from the results tables above, from the main phase of this study. The selection of indicators was based on two aspects: (1) the position of the average evaluation of the behaviour on the rating scale, and (2) the discrepancy between the evaluations. Specifically, a heuristic interpretation of the data was performed: when evaluations were remarkably negative or positive, those results were selected to compose the table below.

Table 20 - Behaviours, weaknesses and strengths

Behaviour	Weakness	Strength
Measure the amount of water	Inconvenient Increases time Adds effort People do not do it 32% do not have a measurement jug Low intentions	
Time the process	Adds effort	Convenient The right thing to do Reduces cooking time Other people do High control High intentions
Choose small pans for single meals	13% do not have a small pan	Convenient The right thing to do Reduces cooking time Reduces effort High intentions
Choose small hobs that match small pans	Increases time	The right thing to do Reduces effort High control High intentions
Use the saucepan lid	32% do not have lids Adds effort	The right thing to do Reduces time Family members do
Reduce the heat when the water is boiling	Increases time	Convenient The right thing to do Saves energy Family members do High control High intentions
Turn off the hob a few minutes before the end of the cooking time	Increases time Compromises quality People do not do it	High control

To measure the amount of water appears to be one of the hardest behaviours to instigate among students. Respondents indicated negative attitudes (it is inconvenient, increases time, adds effort), negative social norms (friends or family do not do it), lack of utensils (32% of them do not have a measurement jug) and they have low intentions to perform it. To increase the performance of this behaviour presents interesting challenges for intervention design. To turn off the hob a few minutes before the end of the cooking time is another tough behaviour to suggest to users. Even though students have high level of control (capacity, utensils, information) their attitudes towards this are rather low (participants believe that it can increase cooking time or compromise the quality of food) and social norms are unfavourable (they believe friends and family do not do it). The other proposed techniques present more strengths than weaknesses indicating that they may be more easily implemented and more likely to be accepted.

One surprising result was the fact that students seldom want to behave in the same way as their university friends and flatmates, but still consider their family members as a good example. These two specific groups scored fairly differently on the measure of 'identification with referent'. Students also described that their friends and flatmates do not perform the suggested cooking behaviours frequently, and this average is lower than their family members for all seven measured behaviours. The influence of social norms into people's behaviours can be found in diverse examples from the literature. One classic illustration is the use of a normative message in hotel bathrooms prompting people to reuse their towels since most of the guests do the same, leading to environmental conservation (Goldstein, Cialdini et al. 2008). Another large scale study indicates that "efforts to conserve energy are significantly related to one's belief about how often others conserve energy" and that "a behaviour is more likely to occur if it is believed to be commonly done by others" (Göckeritz, Schultz et al. 2010). However, as this study indicated, the descriptive norm for friends and flatmates (my friends do it), and the identification with this referent group (I want to do it like my friends) are both relatively low. Therefore, in the context of university students, social norms appear to be a weak strategy to motivate conservation behaviours. It indicates that interventions should not rely on modelling from other students as example, peer pressure or other social strategies in the attempt to influence behaviour.

5.7.1 Limitations of study

This study presented a few limitations, either regarding methods or execution. One limitation was noticed during the elicitation study. The statements used mentioned 'energy saving techniques', but this proved to bias respondents towards providing responses mentioning sustainability. For the main questionnaire, all statements were presented suppressing mention of energy saving, and only indicating that the proposed behaviours are cooking techniques. By doing so, the intention was to prevent a ‘sustainability bias’, and to allow students to provide their own opinions without being primed towards energy saving.

The length of a TPB / RAA questionnaire is a limitation per se, since dozens of questions need to be answered in order to provide meaningful and reliable results. The survey designed for this study had 25 main questions, and most of them contained seven behaviours to be analysed and seven options to be selected. It resulted in 114 checkboxes or dropdown selections to be clicked. It represents a daunting task for students, and required a rather long concentration span towards the completion of the online form. The length of the questionnaire can be one of the reasons for the 38% drop-out rate from the first to the last page of the survey (Figure 32).

Although this questionnaire was piloted and the language and semantics of the questions optimized, it was noted during the data analysis that two statements on one of the questions about attitudes were semantically inadequate to capture the exact meaning intended. The phrasing used was “taking time for cooking is bad – good” and “putting effort into what you are cooking is bad – good”. These questions probably lead to a more positive evaluation of these aspects than they have in reality, since people generally agree that they have to take a time to cook for themselves, and that they have to put some effort on it. A more effective phrasing could be “doing something that increases the time for cooking is bad – good” and “doing something that adds effort to the cooking process is bad – good”. This could lead to a stronger evaluation of the influence of the proposed energy saving interventions according to students’ perceptions. Another question that could have been phrased more effectively was the measurement of the influence of the billing system for the hall accommodation. Students have all bills included on hall fees, which might demotivate them to save energy. The question was displayed as “Having to pay for electricity would motivate me to [perform the behaviour]”. This is asking students to evaluate a hypothetical situation. However, individuals are much better at accounting for actions that they actually do instead of imaginary ones (Kuniavsky 2003). A better phrasing could be “Since I don’t pay for electricity, I don’t [perform the behaviour]”. Unfortunately these semantic inadequacies were noticed only after the data collection, when it was too late to make changes to the questionnaire.

This research is also prone to the limitations imposed by online surveys, when it is difficult to guarantee that every entry refers to a real person. A thorough validation process was implemented. By sorting the dataset by specific variables it was possible to see spurious values. The online survey service provides the start and finish timestamp for each participant. Short times were flagged and these responses were analysed in detail. There were five suspiciously repetitive entries with all responses on the same column inserted in a very short time, which suggested that the students did not fill the survey with their own opinions, and thus were removed from the dataset.

Another threat to validity is that this study relies on self-reports of behaviours and intentions. There is some debate on how accurately simple self-reports reflects actual behaviour (Verplanken, Orbell 2003). Social science researches often rely on self-reports of behaviour rather than direct observation (Fishbein, Ajzen 2010), and it presents limitations that have to be acknowledged.

Finally, and probably more importantly, the Theory of Planned Behaviour is prone to criticism itself. Even though the TPB "is the most extensively studied social cognition theory, and is relevant to both intention and behaviour change" (Hardeman, Johnston et al. 2002), authors should recognize its limitations. The TPB suggests that people take conscious decisions to form intentions and to perform behaviours. Most statistical analysis performed with TPB data applies the expectancy-value formula (Sparks, Hedderley et al. 1991, Hewstone, Young 1988), which attempts to determine attitude formation through a product of beliefs and values. Authors indicate that the TPB "focus on intentions but neglects role of objective situational constrains and facilitators as well as habits and personal norms" (Klöckner, Blöbaum 2010). The TPB is frequently used to predict intention or behaviour and evaluate outcomes of behaviour change programs. However, one alternative approach and use of the theory is the application of TPB as a guide to the development of interventions. Projects can use the TPB to identify cognitive targets for change to inform "effective interventions aimed at behaviour change" (Hardeman, Johnston et al. 2002). One of the initial stages of a TPB study involves the application of open ended questionnaires to elicit the salient beliefs among the population. Understanding the salient beliefs that are to be changed can provide additional support to the development of behaviour change interventions (Fishbein, Ajzen 2010). Acknowledging these limitations, this research used the TPB in combination to its elicitation study, aligned with a user observation study and semi structured interviews (First Study). To sum up, the TPB seems to be a useful tool, if combined with other forms of data collection to provide a richer dataset.

Even though it was possible to identify several limitations of this study, results presented an interesting picture of the acceptance of the selected behaviours for cooking. During this study, the TPB showed to be an effective method to understand people's intentions to perform the selected behaviours. The tools provided by the TPB were valuable to elicit salient issues among the population, evaluate the importance of each of the common issues and measure the acceptance of the proposed energy saving techniques.

5.8 Conclusion

This chapter presented how strongly students' beliefs influence their intentions and behaviours for cooking whilst living in halls. In order to have greater likelihood of success, interventions should be designed to tackle specific determinants of behaviours. The TPB study implemented here indicated the constraints to the performance of the proposed energy saving techniques, and which aspects of students' general attitudes, perceived social norms and perceived behavioural control most affect the performance of these behaviours. The results shown here gave a better understanding of the students' opinions about a set of proposed energy saving techniques, and it provides insights on different strategies that can be implemented to result in behaviour change.

Results demonstrated that the recommendation of measuring the amount of water for cooking was rated poorly towards most of the questions, indicating low intentions, unfavourable attitudes, weak descriptive social norms and low level of control to perform this behaviour. The other behaviour to have low scores according to students' judgement was the recommendation to turn off the heat before the end of the cooking time. Although they have a high level of control over this behaviour, the attitudes and intentions were low, and it was caused mainly because some students believe that it can increase the cooking time or may compromise the quality of food. Participants were more favourable towards the remaining desirable behaviours, such as to time the process (if it does not add effort), choose small pans for single meals, choose small hobs (if it does not increase time), use the saucepan lid (if they have a lid), and reduce the heat when the water is boiling (if it does not add time).

This study showed that students are not inclined to perform a behaviour that, according to their beliefs, increases cooking time. These include measure of the amount of water, choose a small hob, reduce the heat towards the end of the process and turn off the hob before the end of the cooking time. It indicates a tendency towards energy intense behaviours, in accordance to the results from the First Study. The design of interventions could benefit from this information in different ways. For example, it should target to reduce time to cook whenever possible, relying on the students' predisposition to perform activities that saves time during cooking. Another strategy could be to alleviate the feeling that the cooking process is taking long, therefore making individuals less likely to try to speed up the cooking process. This knowledge was aggregated with data from the First Study in order to inform the adequate behaviour change intervention to be introduced to this population. The next chapter presents how this knowledge informed the design of a behaviour change intervention to promote energy saving.

6 Third study – Intervention design and development

This chapter answers the fourth research question:

RQ4: How can the knowledge of user behaviours and determinants inform the design of new interventions to reduce electricity consumption while cooking?

6.1 Introduction

The design of behaviour interventions has been studied for many years across different disciplines (Fishbein, Ajzen 2010). The design of products and services can be used to motivate users to behave in a more sustainable way (Beale 2007, Bhamra, Lilley et al. 2011, Jelsma, Knot 2002). It is possible for designers to indicate a route they want users to take, via different methods and strategies. "Where users often make poor decisions, design can help counter this" (Lockton, Harrison et al. 2010). Information and communication technologies (ICTs) can be used to increase the sustainability of products and services in many ways. Several examples can be found in the literature, from visualizations of resource consumption, energy use feedback to persuasive applications (Goodman 2009, DiSalvo, Sengers et al. 2010).

In order to increase the chances of success, an intervention need to be created with a broad understanding of the behaviour to be changed, and also the determinants of these behaviours (Uitdenbogerd, Egmond et al. 2007, Abrahamse, Steg et al. 2005, Jelsma, Knot 2002). This understanding must take in consideration "the cognitive, motivational and structural factors and processes that threaten environmental sustainability, so that pro-environmental behaviours could be facilitated and emerge" (Steg 2008). This chapter will describe how knowledge of user behaviours and determinants was applied on the design of interventions which were tailored to address these specific determinants and attempt to change the behaviours in question.

The careful selection of adequate intervention methods is crucial for the design of effective behaviour change projects. Firstly, because each type of behaviour, determinant, context and target group requires specific instruments in order to produce the desirable results. Secondly, because poorly designed interventions might not only be a waste of time and resources, but also produce negative effects among the target population (Fishbein, Ajzen 2010). In addition, it is important to understand if the intervention is really wanted, and if the aspect of human life is indeed in need of change. Interfering with an already positive behaviour "may even negatively modify the existing state of affairs" (Grimes, Harper 2008). Some of these undesired outcomes include the ‘rebound effect’, where savings in one area result in increase in energy use in other domains, partially offsetting the gains (Henryson, Håkansson et al. 2000, Greening, Greene et al. 2000). Interventions can also trigger negative resistance against the appeal (Wood, Quinn 2003, De Young 2002, Brehm 1966), and even motivate protests from individuals who decide to perform exactly the opposite of the advocated behaviour (Sussman, Gifford 2011). From the different intervention design frameworks found in the literature, specific approaches may be more suitable to tackle the target behaviours. The researcher should evaluate different existing influences in order to decide which behaviour changing strategies to apply (Zachrisson, Boks 2010). It is also important to select the appropriate intervention methods taking in consideration the level of freedom that is most adequate for the behaviour in question (Pettersen, Boks 2008) to not over impose control over user’s lives (Brynjarsdottir, Håkansson et al. 2012). For these reasons, a cautious development process had to be executed in order to determine the interventions that are suitable to influence specific behaviours.

This chapter presents the design process behind the specification of an intervention method to be introduced and evaluated within this thesis. One of the steps taken during the creative process involved an extensive literature review. There are several different methods available and a vast literature regarding their application and effectiveness. Another part of the intervention definition was the analysis of the data obtained from the studies performed during this research. Qualitative and quantitative data exposed the determinants of participants’ behaviours, their preferences and recommendations, and thus provided indications of suitable methods to be used to address these determinants. User-centred design approaches were also used via idea generation sessions and will be explained below. The combination of a literature review, evidence from previous studies and user-centred design methods allowed the design and development of the behaviour change intervention as presented here.

6.2 Evidence from studies

Time issues and concerns about how long it takes to cook were recurrent aspects noted during this research. One frequent aspect observed and reported by the participants during the First Study was that they ended up using more energy than needed because they wanted a quick cooking process. As can be seen from the results in the section 4.8 above, students generally boiled the kettle, pre-heated the hob, used the bigger hob and used high heat marks to enable a quicker preparation of the food. Even though students wanted to cook quickly during the experiment, and usually wanted to avoid an extended preparation time, it was noted that most of them used more water than needed or did not cover the pan, eventually making the cooking process longer.

Some of the participants tried to improve the time management during the cooking process with an external aid. Although it was not requested during the briefing, those who decided to time the process used their mobile phones to check the time. Seven of the participants checked the cooking time on the device by just glancing at the screen, but none of them set a proper countdown timer or stopwatch to time the 2-3 minutes as recommended by the packet instructions. As a result all students let their noodles cook for longer than recommended on the packet. It was also noted that participants had to check the noodles visually or taste it after failing to time the process.

This flexible timing process increased the cognitive load as these students had to memorise the time they started and calculate the recommended cooking time. It was noted that even among those who checked the duration of the cooking, the timing process was loose, with participants not paying attention to the phone screen at the right time. Since it was used as a passive device, the user had to periodically glance at the display to know when to act in accordance with the suggested cooking time. The cooking activity, similarly to any other external activity, competes in terms of cognitive resources with the task of monitoring the mobile phone screen (Oulasvirta, Tamminen et al. 2005). Participants were noticing the time, calculating how much time has passed since the start, and comparing this value with the time recommended for the task at hand. A time on a clock forces people to calculate their own relative event spacing and durations in relation to activities at hand (Martin, Holtzman 2011). Previous research provides evidence that the cooking activity is prone to memory slips, which "are problematic for certain cooking tasks, and that many existing memory strategies people make use of can be faulty" (Tran, Calcaterra et al. 2005). Their results showed that utilizing a memory aid to help in the preparation task allows participants to concentrate more on the primary task, and that people consider an external assistant more accurate than their own memory.

As can be seen from the results of the First Study, all participants left the noodles cooking for longer than indicated on the food packet – from 2 to 3 minutes. Subjects left the appliances on for 9 minutes and 26 seconds on average, and some of them even had the kettle on whilst pre-heating the hob. It was shown during the 'model cooking' procedure that less than 3 minutes was enough for bring the water to boil on the hob and produce sufficient heat to cook the noodles for another 3 minutes, even when switching the hob off when the water starts to boil. However, to reach this level of efficiency other steps must be followed, namely measuring the amount of water, using a small pan and using the saucepan lid. If the participant uses more water, it will take more time to heat up. A bigger pan also takes longer to heat, and not using the lid means that the heat will escape through convection, requiring more heat and more time to bring the water to boil. Choosing the large hob whilst using the small pan might shorten this cooking process, but this option is not being encouraged since it can increase the energy usage.

After the indication of time pressure gathered during the cooking process observation, the issue of time was raised again during the Second Study via eight questions. It was noticed during the survey that students demonstrated concerns that some of the proposed energy saving techniques might increase cooking time. Results also show students reporting that they have a positive attitude and high level of intention towards measuring the time for cooking. However, they also revealed that they seldom perform some of the techniques that could reduce cooking time such as measuring the water or using the saucepan lid.

This evidence motivated a deeper understanding of time perceptions by individuals, temporal tensions (adverse reactions to time perception) and their relationship with behaviours. Sometimes a short actual time appears to last for a long time, when attention is focused at matters at hand, in a way that transforms the perception of reality. This transformation can occur through naturally occurring situations, or via designed strategies to change our perceptions of time (Flaherty 2000). Time perception manipulation, sometimes defined as 'time work' (Flaherty 2003) was then identified as one of the solutions for tackling wasteful behaviours and this is explained more fully below.

6.3 A question of time

The cooking activity presents special challenges for time management, and it reflects on the temporal perceptions experienced by cooks. The pace of time can vary according to the activities at hand and the amount of time available to perform them. Routine and repetitive demands can make a task seem tiresome and endless, whilst a job with different demands and challenges can energise people and 'make time fly' (Fine 1990).

Lewis and Weigert (1981) present a diagram illustrating the relation of two points (T) in physical time and the number of events between them. The higher the number of events between T_1 and T_2 indicate that the distance between these two points appears relatively shorter (a). Conversely, having fewer acts on the timeline will make the same temporal distance appear relatively longer (b).

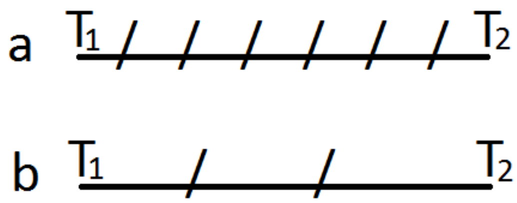


Figure 57 - Time and events (based on Lewis and Weigert 1981)

Individuals notice that the time is passing through changes in the environment. Estimates of time can be inaccurate, "depending on the purpose of the experience, especially during an emotionally coloured experience" (Holubar 1961). People are regularly exposed to changes, and with regularity, through conditioning, these changes influence the notion of time. The lack of changes in the environment can give the impression that time is dragging. In the context of cooking, there is little visual clue of changes. When boiling rice, pasta or noodles, their characteristics alter quite slowly. Consequently, there is no sensation of change in the environment, making time appear to pass slowly.

Fraisse (1963) introduces a broad overview of time perceptions and how stimuli influence the temporal orientation. During periods of emptiness and expectation people become more aware of the delay between now and the awaited moment, making the concept of time more painfully vivid. On the other hand, particularly tense or eventful circumstances (such as extremely busy periods) can bring intense attention, which will also make time seems to pass slowly. Between unusually slack times and extremely eventful circumstances sits the usual comfortable situation, when people experience routines and habitual times, which can make time pass relatively easily (Flaherty 2000).

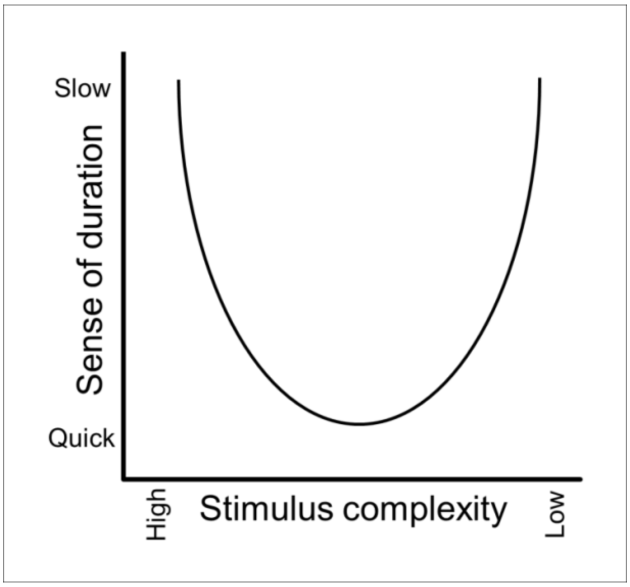


Figure 58 - Sense of duration of time x stimulus complexity (Based on Flaherty, 2000)

Figure 58 illustrates this paradox of time: Situations with extremely high stimulus complexity, such as those involving danger (a car crash, an assault) will demand high attention to self and situation, thus will be perceived as passing slowly. On the other extreme, situations with low stimulus complexity, such as when simply waiting during periods of boredom or when in stimulus depriving environments (empty waiting rooms, prisons) can also be perceived as passing slowly (Flaherty 2000). To make time appear to pass quickly, the situation must present neither high nor low stimulus complexity.

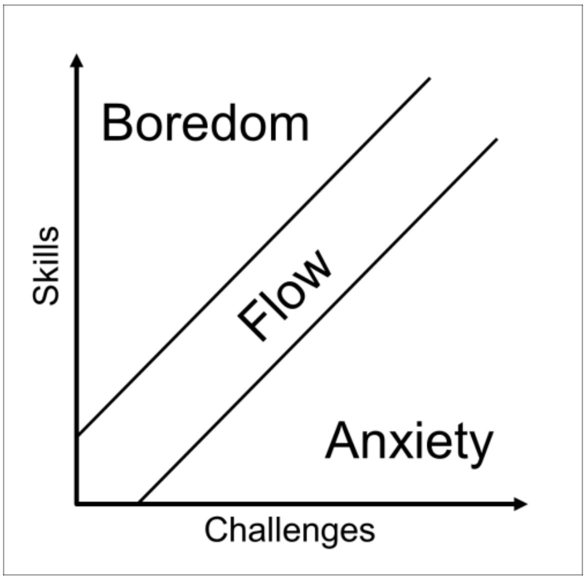


Figure 59 - Flow diagram (Csikszentmihalyi 2000)

Csikszentmihalyi (2002, 2000) presents a diagram that illustrates the relation between personal skills and the challenges from the environment (including time to complete tasks). In a state of flow individual's skills match the challenges of the environment (Figure 59). If the level of skills is high and there is not much challenge, this individual feels bored. If the challenges are higher and there are not enough skills to cope with these challenges, this individual will feel anxious. In a state of flow, an individual's attention is entirely focused on the task at hand – they tend to lose track of time and start doing things spontaneously and automatically without having to think (Csikszentmihalyi 2002).

6.3.1 Temporal tensions

It was observed that the interaction between students and appliances during the cooking process presented a few moments of tension regarding the use of available time in relation to the task requirements. The cooking activity could be divided in two main distinct phases. The first phase consists of the user preparing the utensils and ingredients to start cooking, and the second phase refers to when the user is waiting for the food to be ready. Participants' behaviours during these two phases and its relation to time indicate that both are rather distinct. The first phase includes activities like unpacking the food, selecting the pan and hob, pouring the water and setting everything ready to start the cooking process properly. The second phase constitutes basically of stirring and waiting.

It was noted that there were temporal tensions during both phases of the cooking process. Temporal tensions are defined as the psychological construct arising from assessing the availability of temporal, mental, physical and social resources (Oulasvirta, Tamminen 2004, Oulasvirta, Tamminen et al. 2005). The first phase is characterized by a *hurrying* feeling, when the time seemed to be short for the amount of preparation to be done. Some students performed different tasks at once, like pre-heating the hob whilst boiling the kettle, in the attempt to 'squeeze in' more actions – "to fit in a time frame" (Oulasvirta, Tamminen 2004). The second phase denoted a *waiting* tension, when participants wanted to avoid the boredom of waiting by trying to make the cooking process quicker. The relationship between time and action is stretched, with participants anticipating outcomes that are about to happen (Oulasvirta, Tamminen 2004), trying to find distractions such as chatting or listening to music on their mobile phones. These two phases indicate a problematic situation where the availability of time in terms of the overall cooking goal could be better managed in order to avoid temporal tensions. Technology can be used in such way that "stretches time and slow things down" instead of only trying to make users to perform their activities more quickly (Hallnäs, Redström 2001).

The series of diagrams below display the cooking timeline with the different steps undertaken during the cooking process. They introduce a visual representation of the process structure, in a simplified and less formal way than process modelling tools such as UML (Unified Modelling Language). The key interaction points and the specific actions of the user are displayed via a visual notation. These diagram designs were inspired by service design thinking, following practical guidance from the Service Design Blueprint technique (Bitner, Ostrom et al. 2008) and contributed to the definitions of the proposed behaviour change intervention. The diagrams facilitated a refinement of the cooking process and the creation of a comprehensive, visual overview of the activity.

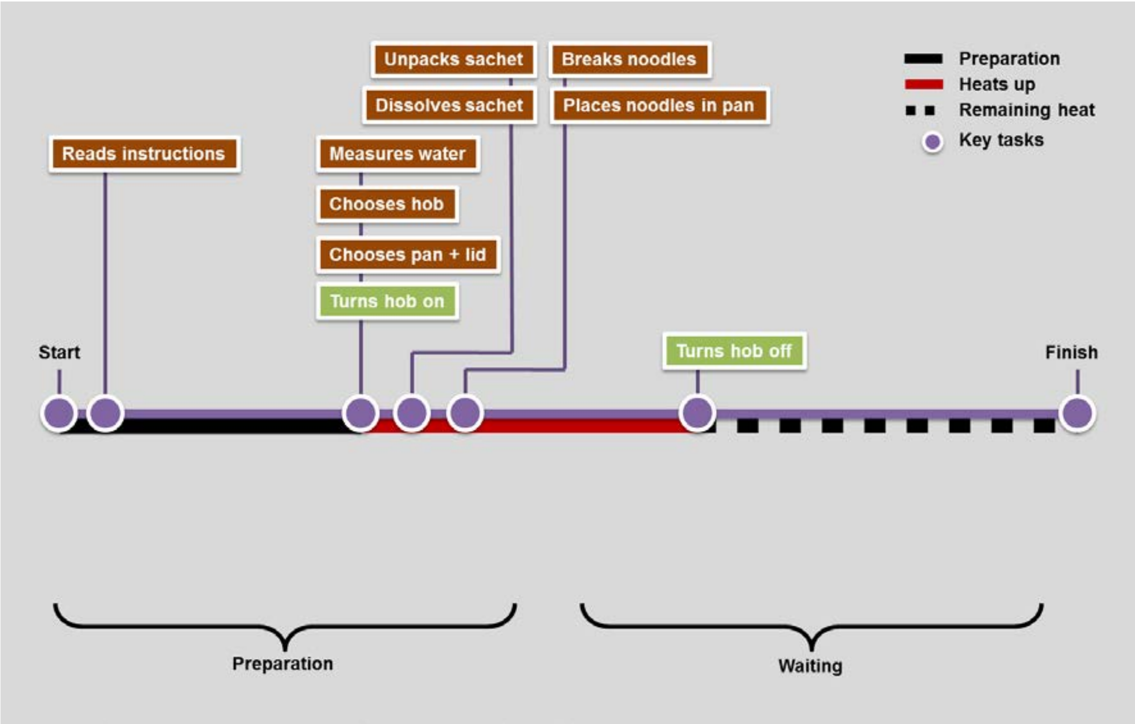


Figure 60 - Temporal tensions diagram 1

Expanding the ideal cooking process timeline presented during the First Study chapter (Figure 15), a stretched timeline for cooking noodles is displayed above (Figure 60). This timeline is not to scale, and it will comprise additional tasks, hence the apparent gaps. The preparation phase consists of a number of steps to start the cooking process according to the proposed ‘ideal’ method. The choices made during this phase will influence the energy consumption and the time taken to prepare the food. A careful selection of steps should be made in order to achieve the best final results in terms of the quality of food, effort, time and energy use. Evidence from this research showed that students rush into the cooking process without much consideration. The second phase of the cooking process is when the student has to wait for the food to cook. For boiling noodles or similar food like pasta or rice, it involves minimum interaction with the food, although students seemed to be tempted to do something to alleviate the waiting boredom.

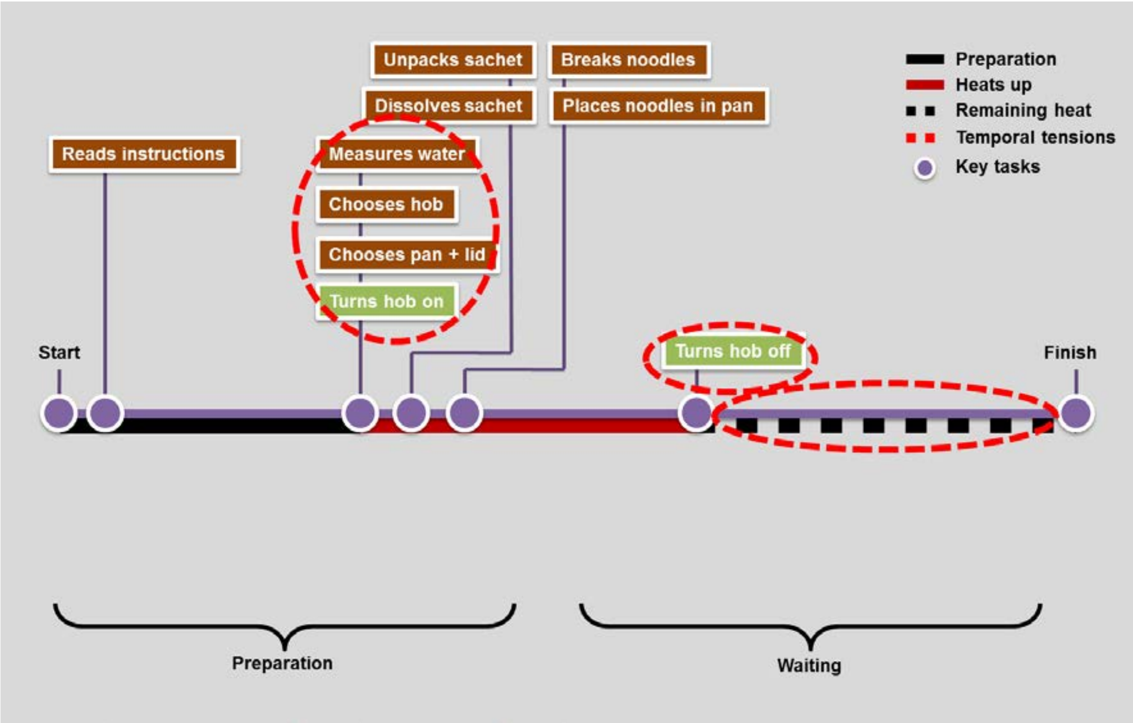


Figure 61 - Temporal tensions diagram 2

The diagram above displays the timeline of the ideal cooking process and indicates in the red dashed circles the areas where a temporal tension might occur. Evidence from the First Study showed that most participants failed to select the procedure that could result in quicker preparation time and less energy use. They also seldom turned the hob off before the end of the cooking process in order to use the remaining heat stored in the metal plate. Furthermore, evidence from the Second Study shows that students believe that turning the hob off before could increase the cooking time, indicating a temporal tension at the end of the process.

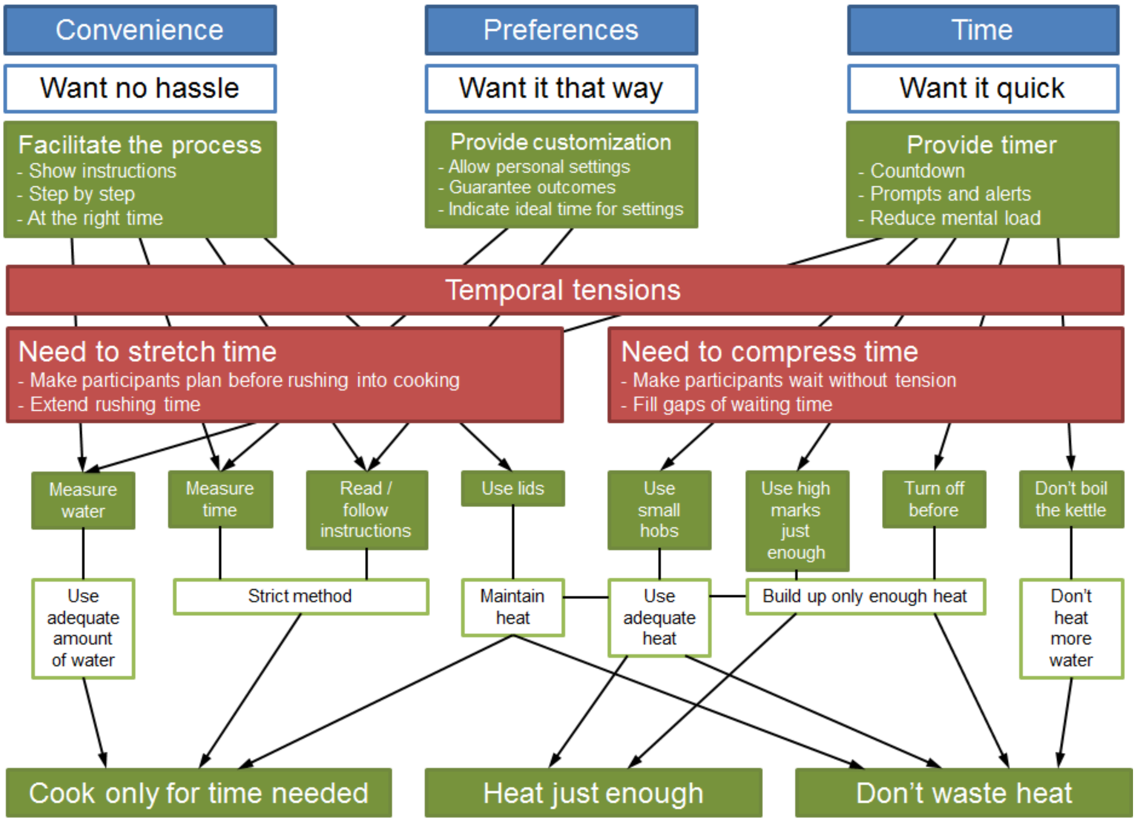


Figure 62 – Behaviours, determinants and proposed time perception manipulation

Figure 62 illustrates the concept of temporal tensions working to stretch time during the preparation phase, and compressing time during the waiting period. This diagram is a development of Figure 28 - Summary of behaviours and determinants. The difference here is that the three main determinants (convenience, preferences and time) that influence cooking behaviours are intermediated by the time perception manipulation to reduce the temporal tensions (in red boxes), resulting in new, desired behaviours. By introducing the manipulation of time perception it can be possible to leverage on users' need for convenience, personal preferences and desire for a quick preparation to promote sustainable behaviours that result in energy saving.

6.3.2 Reducing temporal tensions

The temporal tensions present during cooking could be avoided by optimizing the management of time during both parts of the process. During the first phase students need more time to prepare the activity, to plan their actions and to avoid rushing into cooking. During the second phase students need to just let it cook, stop worrying about the time it is taking to cook and avoid the boredom and the tension of waiting. The strategies to be implemented to reduce temporal tensions should be designed distinctively for both phases, firstly to make students pay more attention during the preparation process in order to follow the cooking instructions accordingly, and secondly to make them let the food cook normally without trying to speed up the process.

One of the key requirements of an intervention was to motivate users to perform all steps during the preparation phase, prior to start cooking. Tunnelling, one widely used strategy of Persuasive Technology (Torning, Oinas-Kukkonen 2009) seemed to fit the purpose of this study. Generally, tunnelling is used to support people accomplishing tasks, “by leading users through a predetermined sequence of actions or events, step-by-step” (Fogg 2003). A system can guide users in the process “by providing means for action that brings them closer to the target behaviour” (Oinas-Kukkonen, Harjumaa 2009). A system can lead users through the various steps during preparation by breaking down the instructions into separate stages, showing each step after completion of the previous one. The system could prompt the cook to unpack the ingredients, select the ideal pan, measure the amount water, choose the adequate hob, select the efficient hob marks and also time the process. The development of this and other strategies is explained on the next sections.

Providing some sort of distraction during the waiting phase of cooking could be one of the strategies designed to reduce temporal tensions. Introducing one activity that provides cognitive absorption (Agarwal, Karahanna 2000) during the second phase of the cooking process could work for this purpose, making time fly during an engaging activity. Nakamura and Csikszentmihalyi (2002) defend that it is possible to develop interventions to foster *flow*, an ideal state when the challenges of the environment matches personal skills. Flow could be promoted by shaping activity structures and environments to promote more enjoyable practices. These interventions are generally used to make regular work settings a better source of flow, with built-in goals, feedback, rules and challenges, without imposed demands or strict pacing. In a state of flow there is “a sense that one’s skills are adequate to cope with the challenges at hand, in a goal-directed, rule-bound action system that provides clear clues as to how well one is performing. Concentration is so intense that there is no attention left over to think about anything irrelevant, or to worry about problems” (Csikszentmihalyi 2002). Flow is much more likely to happen from a structured activity, and activities performed with flow can lead to a self-motivated dimension of behaviour (Csikszentmihalyi 2000). Although flow theory is generally applied to playful activities, previous research found correlations between measurements of flow and use of office software such as spread sheet and email tools (Webster, Trevino et al. 1993) or internet browsing (Novak, Hoffman et al. 2000).

Oulasvirta and Tamminen (2004) indicate the possibility of use of notifications as a form of reducing temporal tensions. Users could "delegate tasks to automatic devices that must somehow notify the user of important changes in the controlled task or process". The evidence that some students lost track of time during cooking, and the cognitive load associated with the task of calculating the duration of the cooking process (even a simple cooking task) indicates that electronic timers with prompts can improve the time management for the activity. "By creating a system that does not demand a continual awareness of time progression, opportunities for engaging in activities that reduce the time pressure may be increased" (Martin, Holtzman 2011). ICT interfaces can provide a better support for allocation of attention, via context-triggered audible or tactile alerts intervening at the right time and leaving the users to dedicate their cognitive resources to the cooking activity itself. This aid can be provided through a proper electronic timer with prompts programmed for the specific meal being cooked to alert the user at the end of each of the steps. Having the technology to provide timed hints and indicate the process stages suggests an appropriate allocation of function between user and system. "It is important to determine which aspects of a job or task should be handled by people and which can be handled by software and hardware" (Maguire 2001). Previous research also recommends that systems should minimize the attention required by technology by decreasing the need for visual attention. The user should be able to concentrate on the environment and receive multimodal feedback at an appropriate time (Roto, Oulasvirta 2005).

One negative aspect of measuring the time, according to participants' beliefs, is that it can add effort to the cooking activity. This was an issue reported by some participants during the First Study (section 4.8.3.10) and also during the Second Study (section 5.6.1.5). However, it can be seen as an opportunity to facilitate the process by presenting a timer embedded in an application. With the aid of a proper timer it might be possible to improve the cooking process resulting in benefit to the user of the application. For example, the participant could concentrate on the cooking while the device takes care of the timing. Also, participants would not need to rely on their senses for assessing when the food is ready, such as looking or tasting, as observed during the trials. Another evident advantage is that it may shorten the cooking process since prompts will remind participants of the end of cooking time, reducing the inclination to allow the food cooking for longer than necessary. Evidences from the previous two studies suggest that timers and alerts could enable users to reduce the electricity usage and behave in a more sustainable manner. It also indicates that participants need better time management in order to know when to switch the heat source off and use the remaining heat retained in the hob.

6.4 Mobile phones as the chosen media

Developing an intervention using an ICT-based application can exploit the potential of computers in persuading people to change their behaviours (Fogg 2003). With the characteristics of technology it is possible to implement resources that would be impossible to have on other media. This research indicates an avenue of research regarding better time management in the attempt to improve the experience during cooking and promote energy saving behaviour. Manipulation of time perceptions can be implemented using electronic devices, and mobile phones seemed to be the adequate choice for this purpose.

A mobile phone application was chosen as the way to portray the time perception manipulation to reduce temporal tensions during cooking. Electronic apps allow the implementation of the selected strategies whilst being in the hand of the user. An application working as a cooking assistant is indicated as the intervention method due to its possible features. Using computational resources enables an app to aggregate the list of ingredients and the preparation methods into a timeline that guides the whole cooking process. Messages can be shown from time to time indicating each step to be taken, sound and vibration can remind users of next procedures, and distractions can be provided to users while waiting for the meal to be ready. Having the mobile phone application as the scenario for implementing these concepts to the user, an experiment can be then designed to evaluate the effectiveness of this intervention.

The advantages of using mobile phone applications are evident by some of its inherent characteristics. Firstly, modern mobile phones are considered sustainable devices due to their hardware features: it combines in one single equipment the capabilities of several other devices that were used separately in the past, from camera, watch, geo-positioning system, compass, accelerometer, alarm clock and so on. This functionality can improve the *eco rating score* if the phone enables the user to embrace more sustainable behaviours, for example replacing the need for other hardware devices, providing software applications that enhance sustainable lifestyles, containing hardware innovations that have been proven to encourage direct sustainable behaviours (Forum for the Future 2010). Electricity consumption related to app usage is kept to a minimum since most users keep their phones switched on all day anyway (Dey, Wac et al. 2011). Another advantage of using a mobile phone application is that it runs on existing devices: Software does not create a new physical product, does not require a manufacturing process, does not use raw materials, does not require transportation or physical storage, and does not have an energy intense life cycle, all which would cause negative environmental impact (Bhamra, Lofthouse 2007). Software can also have a broader reach than physical products, since there is no limit on the number of copies to be produced and downloaded, there is no geographical limitation to obtain the application, and the financial costs of an app to the mobile phone user is rather smaller than of a physical product.

A number of examples in the literature demonstrate how mobile phone applications were used as part of a behaviour change intervention process. Gustafsson and Bång (2008) developed the *Power Agent*, a pervasive mobile game where teenagers could obtain information about energy saving techniques. Participants also had to perform some 'real world' challenges to reduce the actual overall domestic energy consumption, which was measured by a smart monitor. Bång, Svahn and Gustafsson (2009) presented another mobile phone intervention where users act as competitors and have to manipulate their real domestic electricity consumption in order to succeed in the virtual game (Bång, Svahn et al. 2009). Mobile phones can also be used to track users' eco-friendly self-reported behaviours and simulate an environment where the survival of the avatars (Shiraishi, Washio et al. 2009) or polar bears (Dillahunt, Becker et al. 2008) is related to participants' sustainable behaviours. These devices had even been studied regarding their use to control thermostat settings, provide temperature feedback and give rewards according to performance (Koehler, Dey et al. 2010).

It is possible to download and install several cooking applications into smartphones, and some of them provide more than just recipes, but also videos, essential kitchen equipment and a shopping list to help users buy what is necessary to prepare their selected recipes (for example http://www.jamieoliver.com/20-minute-meals/). However, a search on Apple Store (for iPhones) and Google Play (for Android devices) at the time of writing did not return cooking apps that provide information about how to save energy whilst cooking, whether this is explicit, or intended as part of a 'disguised' intervention.

The target population for this study is a group with relatively high use of mobile phones and also mobile internet. According to a report from the Office for National Statistics, 71% of youngsters from 16 to 24 years accessed the internet via a mobile device, demonstrating an increase compared to previous research (ONS 2011). In the United States, the share of Smartphones among adults under 24 years old is 62% (Nielsen Wire 2012). The use of mobile phones is not only growing, but individuals are also staying closer to their phones and for longer. One recent study demonstrated that users keep their smartphones within arm's reach or at least in the same room for about 90% of the time (Dey, Wac et al. 2011).

One of the limitations involving smartphones is the small available screen area that restricts the content that can be displayed. However, new devices are providing screens of reasonable sizes, and with increased image resolution. Other constraints are related the lack of a physical keyboard to facilitate data entry and lack of a pointing device to enable easy selection or access to contextual menus (Nielsen 2011). The design of mobile applications must consider device limitations to maximise the user acceptance and the effectiveness of the software. It is then crucial that the proposed design presents adequate information architecture, the right amount of text and images in a meaningful way, and also suitable interfaces in order to provide a fulfilling user experience (Rosenfeld, Morville 2002).

6.5 User-Centred Design

Results from previous studies indicated the need to develop strategies to reduce temporal tensions during cooking. However, prior to designing this system, it is advised to incorporate the user's perspective into the development process (Maguire 2001). It was necessary to generate new ideas that could contribute to the suitability and acceptance of such an intervention. For this purpose, a user-centred design study was implemented, which is described below.

A sample of the target population was selected to participate in an idea generation session. A group of 35 students participated on this study (12 females and 23 males). They were all undergraduate students registered for a module on research methods. The participation was voluntary and not related to their attendance records or grades, and they could work alone or in pairs.

Participants were made aware of the aims and objectives of this research during the briefing phase. They were presented with the main findings of this research via some images and graphs that can be seen in the previous chapters of this thesis. They were also presented with the cooking timeline diagrams to understand the temporal tensions observed during cooking. Finally they were prompted with the concept of a cooking assistant, a mobile phone application that could help during the cooking activity giving instructions for the preparation process.

6.5.1 Scenarios

To motivate a wider range of ideas, the concept of scenario was also introduced into the exercise. Scenarios of use are widely recommended methods for user centred design (Bevan 2003), and can be useful during early stages of developments "to provide examples of future use as an aid to understanding and clarifying user requirements" (Maguire 2001). Scenarios are "stories about people and their activities" (Carroll 2000), working as "narrative descriptions of interactions between users and proposed systems" (Potts 1995). During a technological development process, scenarios can help designers to identify user activities that are typical, inserted in specific situations of use. The intention when working with scenarios was to motivate students to consider the complexity of the cooking activity, elaborating on their own point of view but also simulating other experiences.

When building different scenarios, it is important to ensure that they cover different ‘stories’, as they “must have some ‘point’ that illustrates a design issue not raised previously by other scenarios” (Potts 1995). A scenario can be built considering 4 aspects involved in the situation (Carroll 2000):

1) **Setting:** the state and the background of the episode
2) **Agents or actors:** people involved in the episode
3) **Goals or objectives:** the changes that the agents wish to achieve
4) **Actions or events:** the plot, things that agents do and things that happen to them

For this study, three different situations of cooking were presented for students, and they were asked to evaluate the introduction of an electronic cooking assistant into these scenarios. Then they were asked to contribute with ideas for aspects of the application that would motivate them use it, follow the instructions and ultimately save energy for cooking. The proposed scenarios were:

A. **Cooking something quickly:** when the student is cooking his food as usual, when she just want to have food, to ‘fuel up’ when rushing between lectures, and having the kitchen as a routine space just to get things done.
B. **Cooking as a private moment:** when the student is more relaxed and experimenting with food, trying to be more creative and probably cooking something new, not particularly concerned about the time taken for cooking
C. **Cooking as a social experience:** when the student is cooking together with friends or flatmates, sharing the experience and the food, using the kitchen as a social space to enjoy the company, chat and eat.

Scenarios B and C were introduced to provide different situations of cooking, to counterbalance Scenario A, explored in depth during the First and Second Studies.

Table 21 - Scenarios

Scenario	A Cooking something quickly	B Cooking as a private moment	C Cooking as a social experience
Setting	Kitchen as routine space	Kitchen as creative space	Kitchen as a social space
Agents	Student	Student	Friends
Goals	Have food	Relax, enjoy and create	Interact, enjoy, share the experience
Actions	Cook food as usual	Experiment with food, take time	Chat, listen to music, cook, taste

6.5.2 Procedure

After a briefing of the aims of this exercise, students were asked to discuss among themselves to elaborate creative solutions to the problems presented. One sheet of paper was handed to each student in order for them to complete in a table with eight questions for each of the three scenarios. The questions were divided into two groups, corresponding to the two phases of distinct temporal tensions observed during the cooking process. The first group, related to the 'preparation' phase, had the aim of investigating the acceptance of the proposed mobile phone cooking assistant, and also to understand how to motivate students to take time to prepare the process before rushing into the cooking itself. The second phase, namely "waiting", was designed to understand how to make people wait without feeling bored during the process, and also what could a system suggest the user to do in order to avoid this boredom. The full questionnaire sheet layout can be seen on Annexe I. The questions used were:

1) In this scenario, do you think students will follow instructions from an app?
2) Why?
3) What would encourage students to follow a preparation procedure?
4) How to motivate them to think before acting?
5) In this scenario, do you think students will wait and follow the instructions?
6) Why?
7) What would encourage them to take their time, not rush and not feel bored waiting?
8) What could an app suggest them to do?

6.5.3 Data analysis

The dataset from this study comprised of 30 sheets with responses to these 8 questions shown above, for each of the three scenarios. A broad range of responses came from each one of these questions, and to organize them in themes, the software NVivo was used. It facilitated the categorization of responses and allowed a further qualitative data analysis. The software also enabled the researcher to build patterns from responses and provided a clearer picture for working with the data, following recommendations from Braun and Clarke (2006).

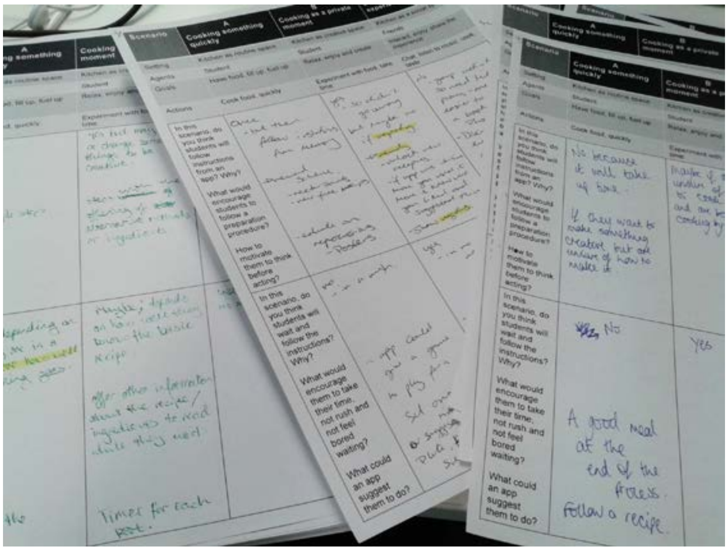


Figure 63 – Scenarios questionnaire

Preliminary analysis of the responses and familiarization with the data indicated that dozens themes were raised by the participants. Further examination of the data indicated that responses could be merged into a smaller number of categories. Participants mentioned frequently the need to obtain a ‘value’ from the experience, that it should be useful to them in some way. They wanted information, guidelines and knowledge acquisition in order to reach their goals more easily and more quickly. They also required ways to enhance the process, gain confidence, experiment with food, increase the quality, improve health and have more enjoyment during the task. Another category of responses indicated that participants want to have less effort and fewer distractions when cooking, and that a cooking assistant should be easy to use.

It was observed that these themes were falling into categories that match the ones from existing models for evaluation of technology acceptance and suitability. Since this study involved the evaluation of the acceptance of an electronic assistant, the Technology Acceptance Model (TAM) (Davis 1989) and its developments (Venkatesh, Bala 2008, Venkatesh, Davis

2000, Venkatesh 2000) provided a suitable framework to help in grouping and analysing participants' responses. TAM postulates that *perceived usefulness* and *perceived ease of use* are the fundamental determinants of user acceptance. Other factors were added later as influences on these main constructs, such as individual differences, social influence, system characteristics and facilitating external conditions (Venkatesh, Bala 2008).

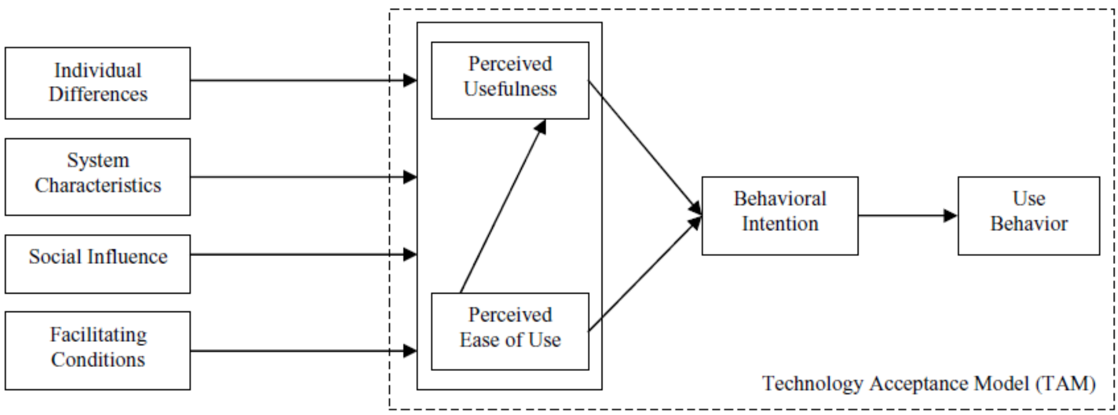


Figure 64 - Extended Technology Acceptance Model (Venkatesh & Bala 2008)

Four theoretical constructs, based on an extension of the original TAM (Figure 64 above) appeared to fit the results from this study. These are the perceived usefulness, perceived ease of use, social influence and external factors. These four categories were used to guide the coding system for this study. To define in which category each of the responses would fit, the grid presented below was used. This scheme was adapted from key references on TAM (Davis 1989, Venkatesh, Bala 2008):

Table 22 - Technology Acceptance Model - Four constructs

Perceived usefulness	Perceived ease of use	Social influence	External factors
• Helps do the job better • Enhances job performance • Provides advantage • Makes job easier • Makes job quicker • Saves time • Helps to be productive • Improves quality	• Is easy to use • Is simple to use, not confusing • Does not need effort to be used • Does not cause errors • Does not require mental effort for using it	• People think I should use it • It will improve my social status if I use it	• I have the resources to use it • I have control over using it

6.5.4 Responses

Responses to all the open ended questions were classified into one of these four categories: Perceived usefulness, Perceived ease of use, Social influence and External factors. The first table below (Table 23) presents the responses to the six open ended questions (excluding only the yes/no questions) separated in 3 columns, for each scenario: A (Cooking something quickly), B (Cooking as a private moment) and C (Cooking as a social experience). This table provides an overview of the scenarios and categories for the aggregated responses. Subsequently, responses were separated by specific questions and displayed in individual tables.

Table 23 - Scenarios results - overview

TAM x scenarios	A Cooking something quickly	B Cooking as a private moment	C Cooking as a social experience	Total	%
Perceived usefulness	107	102	61	270	63.38
Perceived ease of use	38	12	23	73	17.14
Social influence processes	1	2	32	35	8.22
External variables	21	16	11	48	11.27
Total	167	132	127	426	100.00

The majority of the responses from this study, aggregating all 6 open ended questions, fall into the category of perceived usefulness of the technology (63%). Previous studies also identify that perceived usefulness is indeed the best predictor of technology acceptance, since it correlates more strongly to usage than ease of use (Davis 1989, Venkatesh, Bala 2008). Perceived ease of use was the second most frequent item (17%), followed by external variables (11%) and social influence processes (8%).

This table does not show a total of 540 responses as it would be expected (from 6 questions * 3 scenarios * 30 participants), but only 426 because it was not mandatory to complete all questions. The three scenarios are displayed as columns, and the four TAM constructs are displayed as rows.

Table 24 - Q1 - In this scenario, do you think students will follow instructions from an app? Q2 - Why?

Scenarios	A			B			C			
TAM	Maybe	No	Yes	Maybe	No	Yes	Maybe	No	Yes	Total
Perceived usefulness	1	21	1	8	4	17	3	5	8	68
Perceived ease of use	2	8	0	0	0	0	1	7	0	18
Social influence processes	0	0	0	0	0	1	1	6	6	14
External variables	1	0	1	0	0	0	0	0	0	2
Total	4	29	2	8	4	18	5	18	14	102

Key: A: Cooking something quickly. B: Cooking as a private moment. C: Cooking as a social experience.

Table 24 presents all the responses for question 1, having the responses in one of the three columns (as maybe / no / yes), and question 2, having the responses counted and coded as items on the TAM scale. This table indicates that for scenario A (Cooking something quickly), when students are cooking in a hurry, they would not follow instructions from an app. Most of the responses were related to the (lack of) usefulness of the technology in this scenario. For example, one of the students mentioned that *"cooking something quickly normally is very easy, i.e. omelette or pancakes"*. Other complements saying that *"if want to make something quick will not experiment with new recipe, will cook something familiar which therefore don't need app"*.

For scenario B (Cooking as a private moment), on the other hand, most of the responses corresponded to "yes", students would follow instructions from an app, if they are experimenting with food. Almost all of the responses mention the usefulness of the technology in this scenario. For example, students said that *"they are experimenting so have time to read* *instructions and follow them"* and also *"want to experiment, try different techniques. Get it right as have time"*.

For scenario C (Cooking as a social experience), the responses are more frequently centred around "no": students would not use an app to help cooking with friends. The explanations are often related to the lack of usefulness. Other responses mention lack of ease of use, such as that there are *"too many distractions"* and they will be *"more focused on other activities such as conversing"*. There were also references to social influences indicating that technology is not appropriate in this scenario. For example, one student mentioned that they would *"rely on each other rather than an app. Also social setting may not want to seem like don't know what to do"*. Other considers that they *"will instruct each other if need to, and cook as a team with own knowledge"*. However, some positive responses also mention usefulness and social influence as motivators to use the technology: *"Depends on their cooking ability, confidence in creating a good meal"*. Also, students *"want to get recipe correct"*, they would be *"trying to impress friends with culinary expertise"*, and that they *"will want it to go well if entertaining friends"*, hence following instructions.

Table 25 - Q3 - What would encourage students to follow a preparation procedure?

Scenarios	A	B	C	Total
Perceived usefulness	17	13	8	38
Perceived ease of use	13	9	6	28
Social influence processes	1	1	7	9
External variables	4	4	2	10
Total	35	27	23	85

Key: A: Cooking something quickly. B: Cooking as a private moment. C: Cooking as a social experience.

The third question prompted participants to suggest ways to motivate students to follow a preparation procedure. According to their responses, it is necessary to provide a strategy that is useful for them, and also easy to implement. For example, for scenario A: *"If following instructions would be quicker and easier"*, and *"knowing that it would save time, if it would reduce washing up"*. They also suggested making the process easier with *"short, simple and easy methods / ingredients"* and *"instructions step-by-step"*, amongst others.

Table 26 - Q4 - How to motivate them to think before acting?

Scenarios	A	B	C	Total
Perceived usefulness	16	13	13	42
Perceived ease of use	5	3	3	11
Social influence processes	0	0	0	0
External variables	3	1	1	5
Total	24	17	17	58

Key: A: Cooking something quickly. B: Cooking as a private moment. C: Cooking as a social experience.

The fourth question also provided answers regarding the usefulness of the application as a way to make students think before acting. For example, for scenario C, students suggested the *"ability to focus in socializing while food cooks"* and *"inform of issues / disadvantages when not followed"* to help cooking with friends. Some external variables mentioned included *"decrease hunger"* as a way to avoid rushing, and give an *"introductory talk at start of academic year"*.

Table 27 - Q5 - In this scenario, do you think students will wait and follow the instructions? Q6 - Why?

Scenarios	A			B			C			
TAM	Maybe	No	Yes	Maybe	No	Yes	Maybe	No	Yes	Total
Perceived usefulness	0	12	1	4	0	9	1	0	2	29
Perceived ease of use	0	4	1	0	0	0	3	3	0	11
Social influence processes	0	0	0	0	0	0	0	0	3	3
External variables	0	9	1	3	0	7	0	1	4	25
Total	0	25	3	7	0	16	4	4	9	68

Key: A: Cooking something quickly. B: Cooking as a private moment. C: Cooking as a social experience.

When asked if students would wait and follow instructions, most students said "no" for scenario A. Their explanations included lack of usefulness since they *"just want to get the task done"* or that *"instructions perceived as more time consuming"*. However, they said "yes" to instructions considering scenario B. Examples of external variables here include *"more time means more concentration and better chances of looking at the instructions"* or *"want to achieve the best result and have more time to consider actions"*.

Table 28 - Q7 - What would encourage them to take their time, not rush and not feel bored waiting?

Scenarios	A	B	C	Total
Perceived usefulness	18	18	12	48
Perceived ease of use	5	0	0	5
Social influence processes	0	0	7	7
External variables	2	1	3	6
Total	25	19	22	66

Key: A: Cooking something quickly. B: Cooking as a private moment. C: Cooking as a social experience.

When asked what would encourage them to take their time and wait for the food to cook, they suggested, for example, *"reminders on app - bright and eye-catching. Change to maintain interest"* to increase the perceived ease of use. One student also mentioned that, for scenario C, *"they wouldn't feel bored if they had friends with them, so they may take* [time]*"*.

Table 29 - Q8 - What could an app suggest them to do?

Scenarios	A	B	C	Total
Perceived usefulness	20	16	9	45
Perceived ease of use	0	0	0	0
Social influence processes	0	0	2	2
External variables	0	0	0	0
Total	20	16	11	47

Key: A: Cooking something quickly. B: Cooking as a private moment. C: Cooking as a social experience.

The last question of this session was intended to gather suggestions for activities during the waiting period, so users would not feel bored or anxious during the cooking activity. Almost all responses involved ways of making the technology useful to the process. Examples in scenario A included *"suggest ways of speeding the process up (safely)"*, *"complete washing up in time when food is cooking"*, *"prepare another section of the dish"* or even provide a *"search engine for things to do in x minutes (however long the wait is) and come up with results"*. One example in scenario B is that *"an app could give different options of ingredients that they could experiment with so that they have choice and can engage"*. Students proposed for scenario C that the app could suggest *"witty / relevant conversation topics to discuss with friends (linked to Twitter or Facebook)"* and also to *"balance tasks with others"*.

6.5.5 Summary of responses

The semantic analysis of themes gathered during this study allowed the definition of the most important requirements in each scenario, for the two main phases of the cooking process. All responses given by the participants were clustered into a smaller number of themes and nodes to facilitate visualization and analysis. This data indicated that any proposed intervention should be useful by adding value to the cooking process. This value is perceived as any improvement in an aspect of cooking, such as increasing the speed of the cooking process, reducing mental workload or improving the user experience for cooking. These requirements are shown on Table 30 below.

Table 30 - Scenarios and requirements

Scenario	A	B	C
First phase – preparation How to make students use the app and follow instructions	Make it useful - Improve efficiency - Make the cooking process quicker, easier, and save energy - Improve quality, make healthier - Inform – benefits, how to be quicker, what can go wrong Make it easy - Easy to use - Quick to use	Make it useful - Instigate gourmet / experiment / creativity / skills - Guarantee quality - Save money - Inform - instructions on complex steps, show benefits, what can go wrong, feedback Make it easy - Improve visuals	Make it useful - Improve quality and health - Inform - benefits, instructions on complex steps Make it easy - Easy to use - Allow manage food whilst with friends Improve social aspects - Promote social interactions, engage friends to contribute - Impress friends with food
Second phase – waiting User requirements – how to make students wait	Make it useful - Concentrate on food – Suggest how to improve speed, health and quality - Give external distractions – read, work, quiz, games, tips on energy, cooking, relax - Multitasking – prepare other parts of the dish, wash up, set table	Make it useful - Concentrate on food – suggest ingredients, how to improve speed, health, quality - Give external distractions – read, work, other tasks, tips on energy saving, waste use and better cooking - Multitask – other part of the dish, wash up, clear up, set table	Make it useful - Concentrate on food – How to improve speed, health, quality - Guide multitasking – inform how to prepare other dishes simultaneously - Enhance social aspects – share tasks with others, involve, give conversation topics, use online social networks

Data gathered during this session indicates the primary need to consider the perceived usefulness of the application, and as a secondary consideration the proposed app needs to be perceived as easy to use in order to be adopted. Concepts of a richer user experience (UX) (Anderson 2011) were also suggested, including fun elements (games, quizzes, relaxing activities, social interactions) and improved visual appearance. Some external variables such as social factors can also influence the acceptance of technology, but to a lesser extent. In summary, participants required that the technology must fit the task they attempt to perform (Goodhue, Thompson 1995). In line with previous studies involving the Technology Acceptance Model (Davis 1989, Venkatesh, Bala 2008) students need to recognize the application as having the capability of helping them to accomplish the goal during the activity, preferably with added fun, otherwise the technology might not be perceived as useful, consequently failing to be really accepted.

6.6 Results – the proposed intervention

Data from the studies conducted during this phase combined with the literature review indicates that participants need to perceive a benefit from using the application. Often people want to see the rewards from specific behaviours, as if asking 'what is in there for me?' (Foster, Lawson et al. 2012). The strategies developed here focus on the results of the scenario analysis and previous studies by providing benefits to the user including a shorter cooking time, a convenient process, and the possibility to have the final meal prepared according to their preferences, in a facilitated way.

In order to design the application that delivers usefulness to cooks, reduces temporal tensions and promotes energy saving at the same time, diverse sources of inspiration were consulted. One of the sources that presents an array of strategies is persuasive technology (Oinas-Kukkonen, Harjumaa 2009, Fogg 2003). From their examples of common uses of persuasive technologies as tools, it is possible to select strategies that could be embedded within an intervention intended to influence people's behaviours whilst cooking. The selected techniques are listed below, followed by the intervention design strategy used, including the rationale behind the choices.

6.6.1 Tailoring

Tailoring is a strategy present when a system uses persuasion through customization. For example, the user can have access to a specific meal according to their preferences or past options, or can see tips on how to use their specific appliances more efficiently. The system can also allow personalization of the outcomes through a set of options which cause modifications to the processes. By providing options the system can make the user feel more in control of the process. Results from the First Study indicates that one of the reasons for students not following instructions was because they wanted one specific outcome. It suggests that customization can possibly increase user adherence with an app. Different options for final outcomes can be presented at the start, so the user can select the desired outcome according to his or her preferences, and the procedure is adjusted to these selections. By doing so, it is possible to have an application that will guide the cooking process to better fit user's preferences.

The initial interface of the application can provide the user with options to select the desired final outcome in relation to some customization. For example, with noodles, users can have choice regarding the consistency (soft, medium, *al dente*), the amount of water (soup, wet, sticky) and the time for cooking (slow, average, quick). When running the application, screens present each cooking step to be performed, taking in consideration the selected choices, the most efficient method to come up with the expected results, and at the same time setting the timers in order to have the lower possible energy use without compromising the specific user needs. By selecting his or her preferred method and outcome, a higher chance of adherence to the energy saving techniques (and consequently success in energy saving) is expected, since participants believe they will obtain the intended results. Having two-way interaction between the user and the system, a more precise targeting of tasks and personalization can be achieved (Midden, Kaiser et al. 2007).

6.6.2 Tunnelling

When the intervention presents a guided persuasion, it is said that the user enters the 'tunnel'. For example, by providing a timeline and the sequence of steps to prepare a meal, this guided method indicates the path to follow and does not allow much room for modification. Different steps can be separated via different screens, and the user can be presented with the instructions progressively as they accomplish each step then advances through the tunnel. Evidence from the First Study presented that students cooked their food following a 'loose' procedure, and it indicates that they may benefit from guidance that points to the ideal procedure. Tunnelling was selected as one of the persuasive strategies embedded in the app due to the possibility of reducing the temporal tensions observed during the preparation phase of the cooking activity. This intervention relies on the principle of tunnelling to prevent users rushing into cooking, and also provides some distractions in order to promote absorption and consequently reduce temporal tensions during waiting.

6.6.3 Suggestion and information

Suggestion is present when the system intervenes at the right time, for example by indicating when is a good moment to perform an energy saving action. It is common to attempt to change attitudes and behaviours through information and awareness-raising interventions. However, information alone is unlikely to be effective against powerful influences of attitudes and behaviours (Owens, Driffill 2008). Information should be part of a wider strategy, introduced timely when it could be more effective. Having the application to be used at the right moment in time, i.e., when the user is cooking, can increase its effectiveness (Gram-Hansen, Schärfe et al. 2012) and also the persuasive purpose. It happens because it does not rely on the transferability of skills (the user will not have to transfer the learned material to another situation) and also because it uses the technology at the right moment when the user needs it (Oinas-Kukkonen, Harjumaa 2009, Fogg 2003). The application can provide timers and alerts can that guide users to spend the right amount of time in each activity.

An intervention can indicate the exact amount of water necessary to cook and guide users into following the desired process. The main reason for not measuring the amount of water was the need for convenience and the lack of utensils for doing so, as can be seen in the results from the First Study. The Second Study demonstrates low scores on attitudes towards measuring the amount of water (it is inconvenient and adds effort), low descriptive social norms (friends and family do not do this very often), a lower perceived behavioural control and lack of intention to measure the amount of water in comparison to the other proposed behaviours. However, students want to cook quickly, and do not want to compromise the quality of food. Too much water can increase the cooking time and also reduce flavour. The Third Study indicates that students want assistance in making the cooking process quicker. It suggests that demonstrating the adequate amount of water to reduce the cooking time and at the same time preserve the quality of food, the application can increase the likelihood of acceptance of this recommendation.

The size of the pan used can influence the total time that food takes to cook, since larger pans take longer to heat up. By indicating that the small one is the quicker pan, an application can motivate sustainable behaviour by combining the need for quick preparation and an energy saving technique. Not all students used a small pan during the First Study. However, this behaviour is related to strong positive attitudes, as demonstrated in the Second Study. Students reported that using small pans is generally convenient, is the right thing to do, it does not compromise the quality of food, does not increase cooking time and does not add effort to the process.

The hob selected for cooking can influence the energy usage, as demonstrated on the First Study. The variation in electricity consumption differs among position and size of the hob, and also the heat mark used (Beko 2006). The application can recommend the best hob to be used in combination with the small pan, increasing the chances of adherence and consequently reducing the energy usage during the cooking process. The Second Study demonstrated that students have positive attitudes towards using small hobs and high level of control when choosing which hob to use. If the application manages to assure users that the cooking process will be short, it makes this strategy more likely to be accepted.

Using lids can reduce the energy usage and also the time that food takes to cook. The application can remind the user to put the lid on, and by doing so the user will have the benefit of a quicker cooking process and also reduced energy usage, without compromising the quality of food. The Second Study showed that students generally have the perception that lids can reduce the cooking time, do not compromise the quality of food and can help saving energy.

6.6.4 Reduction

Reduction is the use of technology to make activities easier to perform. Reduction can be implemented through simplifying, for example reducing the number of steps required to perform a desired behaviour. It is possible to develop recipes that convey the right procedure to cook a meal and at the same time provide instructions on how to measure the ingredients, control the appliances and time the process. With the aid of technology, the attention level required to cook using less energy might be reduced, through simplification and facilitation of the process.

It was observed that participants want to cook quickly, and cooking quickly can save energy, if following the proposed techniques. By combining the desire for a quick cooking process with the energy saving tips, it is possible to achieve both objectives. As seen in the First Study, users want quick preparation, but seldom measure the time for cooking, hence the use of instructions, timers and prompts to indicate the sustainable options for cooking.

One technique to reduce electricity usage consists of turning the hob off a few minutes before the end of the cooking time. The solid metal plate hobs found on some electric cookers stay hot for a few minutes after they are switched off. However, the Second Study demonstrated that some students believe that this behaviour can compromise the quality of the food or increase the cooking time. Furthermore, as seen on the First Study, users generally do not know when to perform this behaviour. Prompts and alerts can be presented to remind participants of the exact time when they can turn the appliance off. Participants must be assured that it will not compromise the quality of the meal nor make the process longer.

The proposed app relies on reminders of the activities to be performed during the cooking process. However, these strategies must be used only when necessary – when interruption is needed. It is important to not annoy the users with notifications, but only provide the time-sensitive information that is relevant to them (Clark 2010). If the application requires a lot of visual attention the user will feel it difficult to concentrate on the environment at appropriate times (Roto, Oulasvirta 2005).

6.6.5 Entertainment

Although entertainment is not one of the persuasive tools as described by the literature (Oinas-Kukkonen, Harjumaa 2009, Fogg 2003), it can use the power of technology when it works as media per se, as a distraction working as a persuasive strategy, without necessarily conveying a specific message through that media. During the second phase of the cooking process, students wanted to speed up the process to reduce boredom and consequently used more electricity, for example by using large hobs and high heat. By promoting cognitive engagement, an app could make users less worried about the activity and let the food finish cooking in the adequate time to save energy. Entertainment can be especially useful when proposing to turn the hob off before the end of the cooking time. During the Second Study students indicated that they were not inclined to perform this technique, even though the remaining heat can be sufficient to complete cooking.

As noticed during the scenario analysis and idea generation session, students suggested that an app can provide external distractions as things to do and forms of relaxation whilst waiting. The app can load YouTube videos which have the exact length as the time necessary to finish cooking. By providing an engaging activity, the app can foster the concept of flow, making users lose notion of time and consequently reduce the temporal tensions during waiting. This might make users more inclined to accept the suggestion to turn the hob off before the end of the cooking time.

6.7 Structure of the application

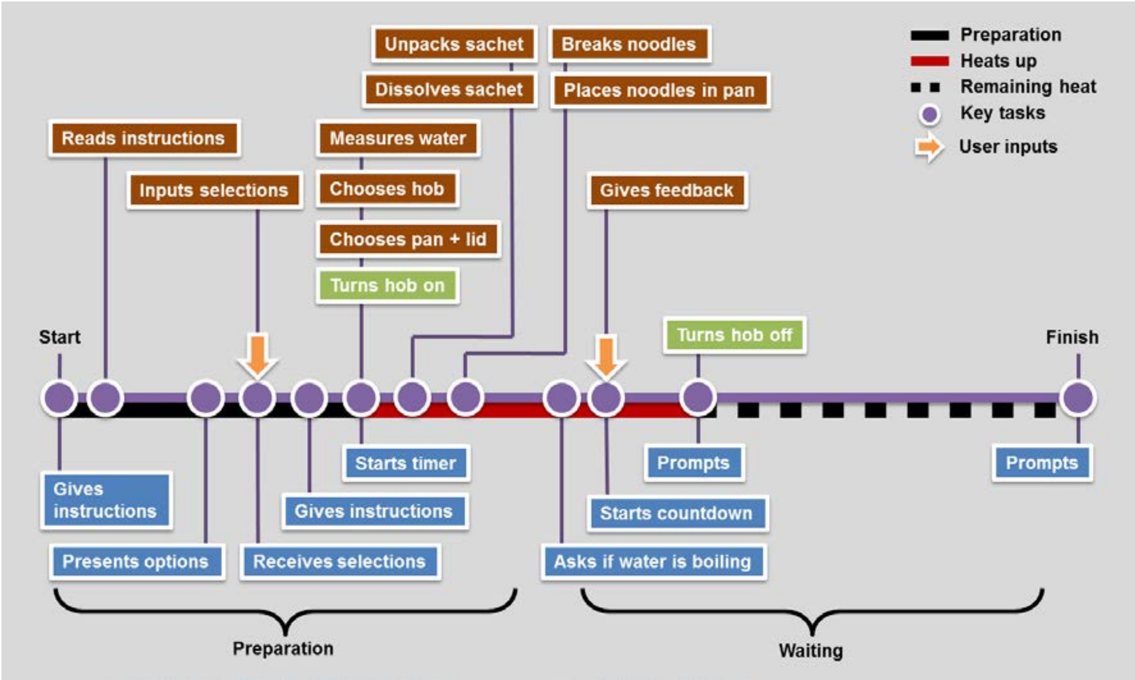


Figure 65 - Cooking timeline: user and app tasks

Continuing from Figure 60 and Figure 61, which presented the moments of temporal tension during cooking, Figure 65 above shows opportunities for a system to intervene during the cooking activity and ultimately reduce these temporal tensions. Based on the Service Design Blueprint (Bitner, Ostrom et al. 2008), this diagram includes the timeline, the physical evidences and inputs, the visible user actions, the 'checkpoints' and also the backstage actions that could be performed by the cooking application (in blue boxes). The roles of the user and a cooking agent are interrelated in order to produce an ideal process, aiming at energy saving, shorter cooking time, food quality, less effort and reduced temporal tensions.

The proposed interaction for cooking packet noodles consists of:

1- Upon starting, the user gets instructions regarding the activity so they can understand the activity.
   a. User reads the introductory instructions
2- The application presents options to the user in relation to a few aspects of the process:
   a. Cooking time
      i. Slowly

        ii. Average
        iii. Very quickly
    b. Amount of water
        i. Sticky
        ii. Normal
        iii. Watery
    c. Consistency
        i. Al dente
        ii. Medium
        iii. Soft

3- The user selects and inputs the desired options
4- The application responds presenting instructions tailored to achieve the desired results
5- The user then proceeds to measure the amount of water, choose the right hob, right pan with lid, then turns the hob on
6- Following instructions, the user adds and dissolves the contents of the sachet in the water
7- The user then breaks the noodles and adds it in the pan
8- The app then waits the user to input when the water is boiling
9- The user gives the feedback regarding the temperature of the water
10- The app starts counting down the time to finish the procedure. This length of time will be related to the previous selections the user made.
11- The application prompts the user to switch the hob off and to continue cooking for a few minutes more.
12- The application prompts the user that the food is ready.

6.7.1 App development for experimental testing

To better test the effects of an intervention it should be introduced and tested in an experimental situation (Robson 2002). Two different versions of the app were developed to allow the evaluation of a control condition against an experimental condition. This experimental condition introduced the manipulation of time perceptions, in line with the strategies above, in an attempt to reduce temporal tensions during cooking. The control version of the app was a more basic application without the specific features to change time perceptions or facilitate the control of time, but with an identical look and feel. The development of different versions therefore allowed the confounding effects of a mobile app per se to be reduced.

The images below present the structure of the application as a simplified schematic UML (Unified Modelling Language) diagram. It indicates the selection stages (diamonds) where the user inputs his preferences. These data will be stored by the system and shown on subsequent screens displaying the tailored instructions. The persuasion logic is represented here as a hierarchy chart, describing each step as a node in the diagram. The tunnelling aspect of the persuasive application is implemented here and shown in red arrows. The available options and settings are kept to a limited number of choices to reduce the cognitive load that the participant has to dedicate to the application (Iyengar, Florez-Arango et al. 2009).

6.7.1.1 Version A

The version A was designed to work as the control version, with some persuasive strategies embedded but neither time manipulation to reduce temporal tensions nor timers and prompts to facilitate control of the length of the process. Figure 66 presents the UML diagram of this simpler version. Upon start, users are presented with options regarding amount of water, speed and consistency of the final product (tailoring). This information will feed the next screen with the aggregated customized cooking instructions. The page containing the instructions displayed the text similarly to how it is found on the back of the food packet, in bullet points. This information was added with some items not present on the original instructions: which hob to use, which heat mark, which pan, to use the lid and to turn the hob off when the water starts to boil.

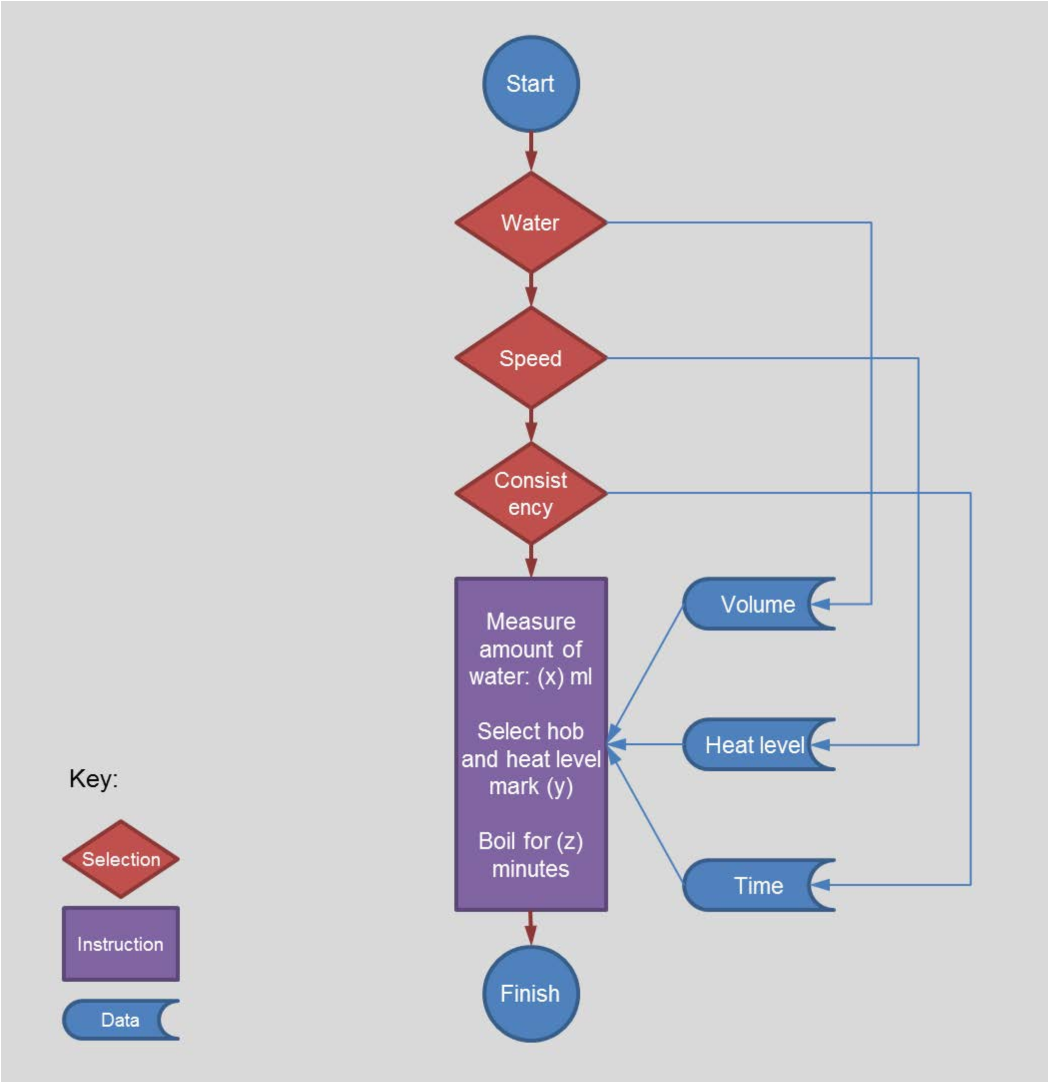


Figure 66 - UML diagram of the app, version A – control condition

6.7.1.2 Version B

Figure 67 presents the version B of the app, or the experimental condition. The app is working as the means to test the theory that it is possible to reduce temporal tensions during cooking and consequently promote energy saving through more optimum cooking behaviour. Similarly to version A, it enables tailoring of the experience and this data will feed the subsequent instructions. However, this information now comes in steps, in separated screens, constituting the tunnelling strategy. It is expected that users will dedicate more time to the preparation and not feel anxious to rush into cooking. Once the user measures the water they can 'tap' to continue to the next page that informs the hob and heat level to use. The following step indicates the length of the boiling process. The content of the text was, wherever possible, the same as the version A, but separated into different pages. One added feature during this step is the countdown timer as the reduction strategy. The system will count, display the time and alert the user at the end of the process. One parallel activity is the entertainment strategy. The user will have time fillers as cognitive engagement promoting flow, with the intention to reduce boredom when waiting for the food to be ready.

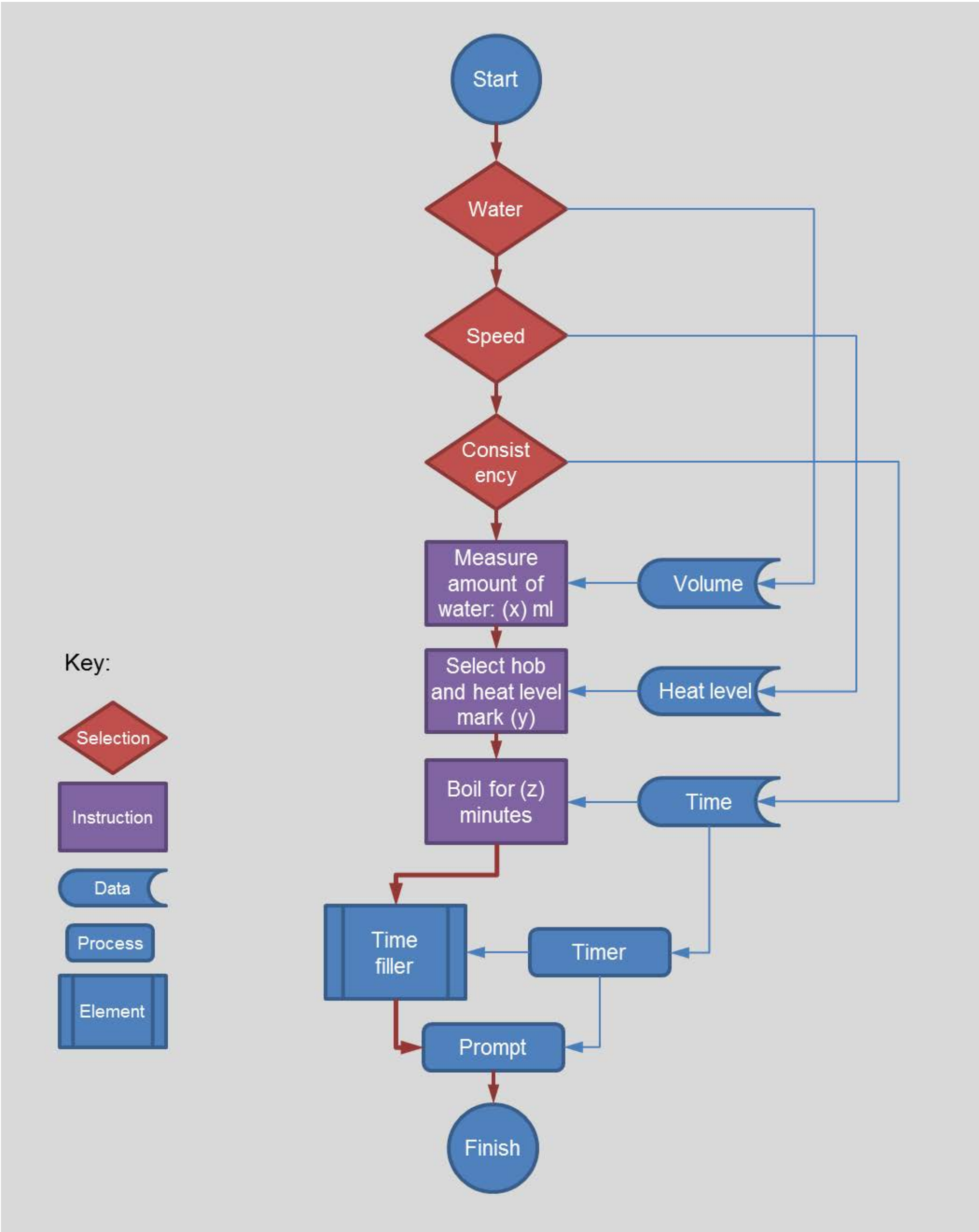


Figure 67 - UML diagram of the app, version B – incorporating time perception manipulation strategies

6.7.2 Layout and code principles

The layout of the app followed instructions from the Apple iOS Human Interface Guidelines (Apple Inc 2012) and Android Compatibility Definition Document (Android Open Source Project 2012). The user interface was kept as simple as possible, focusing on the idea of guiding users through the cooking process and doing the minimum to accomplish that. The mission in designing the user experience "is to make sure that every screen and every action delivers delight, efficiency, and results" (Clark 2010). The layout of the app tried to present only common user interface patterns, having only elements widely recognizable and frequently used on apps and mobile webpages. The intention was to minimize basic usability problems such as people having to learn how the interface works and what each element does. Usability flaws can also compromise the adherence to a system, even during research projects and prototype testing (Zwinderman, Shirzad et al. 2012). Furthermore, the aim of this study was to evaluate of the concepts and strategies embedded in the app and not the layout of the app itself.

The coding of the application was undertaken using Adobe Dreamweaver® and contained HTML, CSS and JavaScript files. The Mobile JQuery library was added to allow the calculations and creation of dynamic response pages according to user selections. Combining these languages made it possible to have an application that resembled an app. The files were accessed as a regular webpage but had the feel and look of a native app.

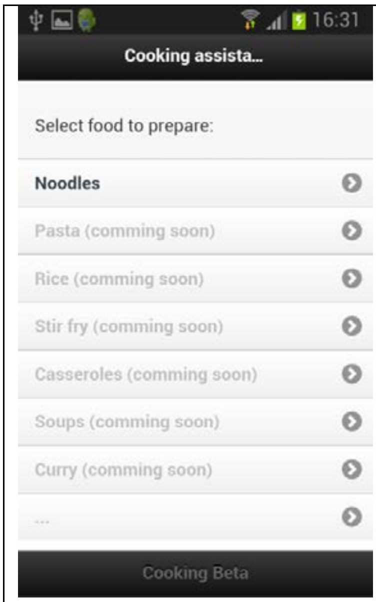
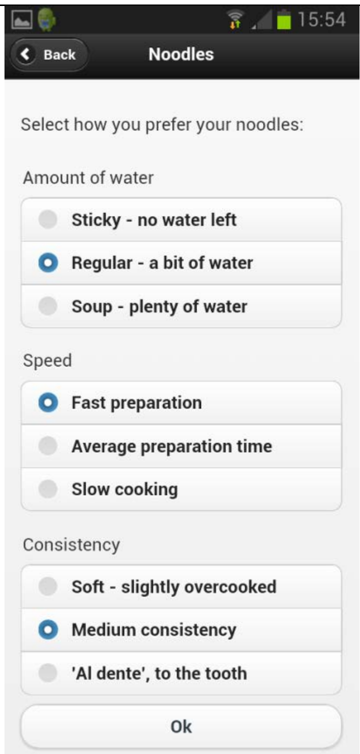
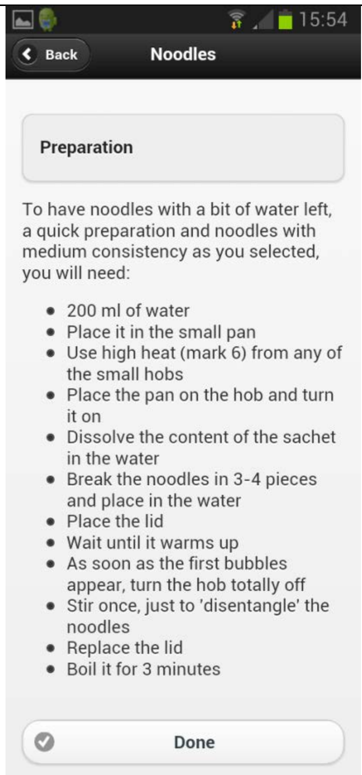
```
    <script>
    $(document).ready(function(){
      $(".c0").click(function(){
        $(".selectedconsistency").html("soft noodles");
        $(".selectedconsistency2").html("4 minutes");
        $(".selectedconsistency3").html('<option value="240"
selected>4:00</option>');
      });

      $(".c1").click(function(){
        $(".selectedconsistency").html("noodles with medium consistency");
        $(".selectedconsistency2").html("3 minutes");
        $(".selectedconsistency3").html('<option value="180"
selected>3:00</option>');
      });

      $(".c2").click(function(){
        $(".selectedconsistency").html("hard noodles");
        $(".selectedconsistency2").html("2 minutes");
        $(".selectedconsistency3").html('<option value="120"
selected>2:00</option>');
      });
    });
    </script>
```

Figure 68 - JQuery code example

The piece of code above exemplifies the programming behind one of the options presented to the user. If the user selected soft noodles as their desired outcome, the app would display on a subsequent page that they have to boil it for 4 minutes, and 240 seconds would be parsed as starting value to the countdown timer. If the student selected noodles with medium consistency they would be instructed to boil it for 3 minutes and 180 seconds would be sent to the timer. ‘Al dente’ noodles meant that only 2 minutes would be enough to produce the desired results, giving 120 seconds from when the water starts to boil until the final alert that the food is ready. Similar calculations are made for the amount of water left and the speed of the cooking process.

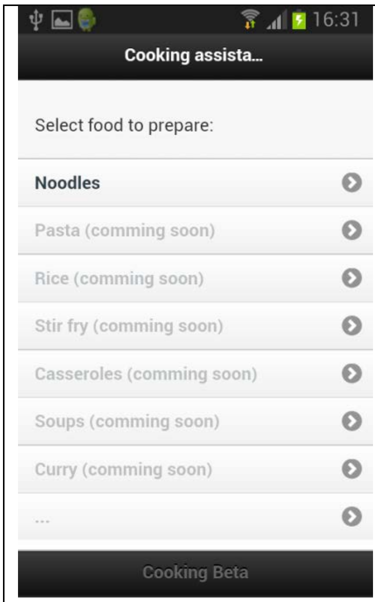
6.7.2.1.1 Version A – screenshots

Table 31 - Screenshots of the app - Version A – control condition

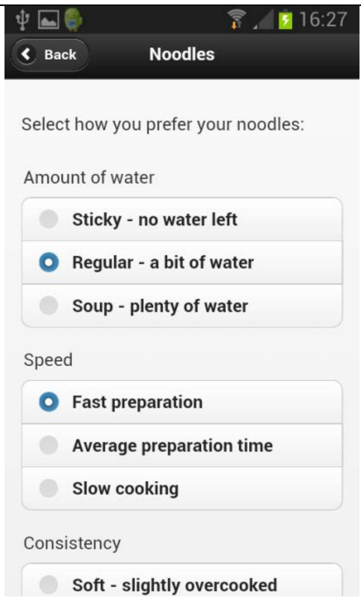
<table>
<tr>
<td>
</td>
<td>
</td>
<td>
</td>
</tr>
<tr>
<td>The first screen presents a list of food that could be cooked with the app. However, all but Noodles were greyed out indicating that they were disabled on the current version.</td>
<td>The second screen presents three groups of default radio buttons for the user to select the desired outcomes.
This content does not fit on one page of the mobile phone screen, so it is presented here as a taller than usual interface. The user had to scroll the page to see all the content on the screen.</td>
<td>The third screen presents all the information needed to cook noodles as selected, placing the amount of water, heat level and duration in their respective placeholders along the other items.
This image is also displayed here taller than on the mobile screen.</td>
</tr>
</table>

6.7.2.1.2 Version B – screenshots

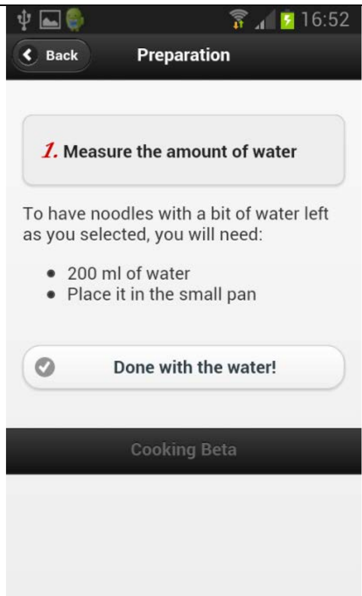
Table 32 - Screenshots of the app - Version B – experimental condition



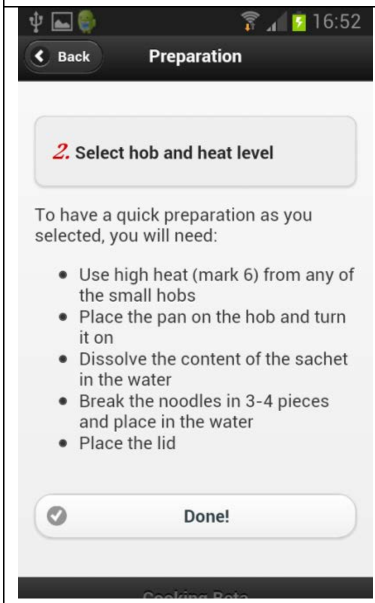
1) Identical to version A



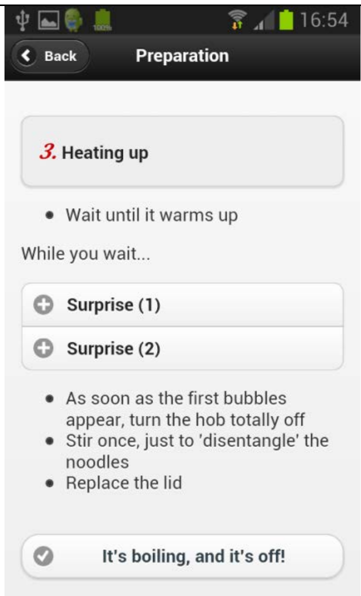
2) Identical to version A



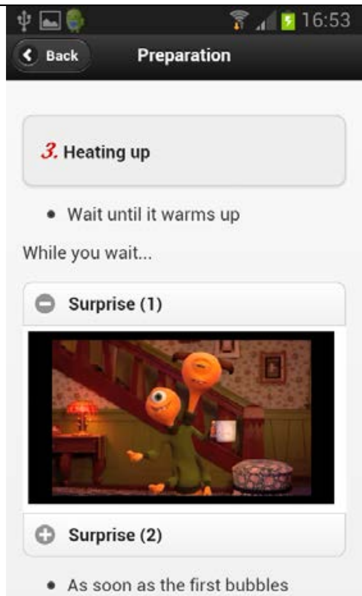
3) The first step of the tunnelling is presented: Users are asked to measure the amount of water and place it in the small pan.



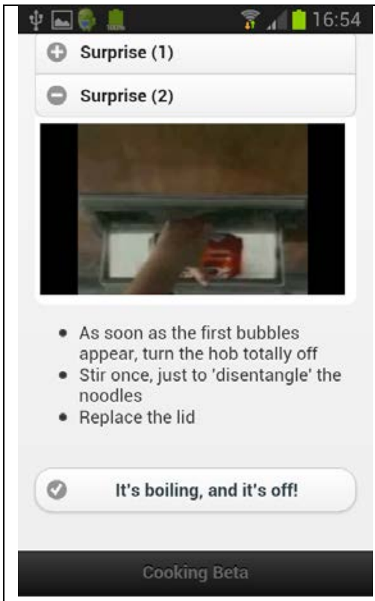
4) The instructions tell users to select the small hob and place on the lid.



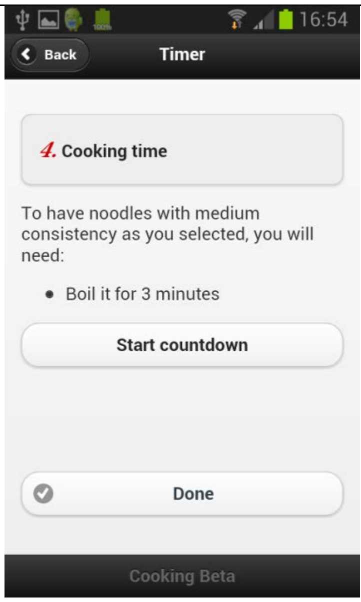
5) When heating up the user is presented with the instructions plus videos to pass the time.



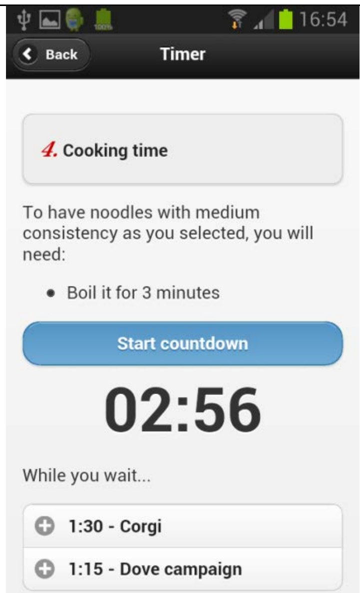
6) The selected videos are played by opening the collapsible menu.



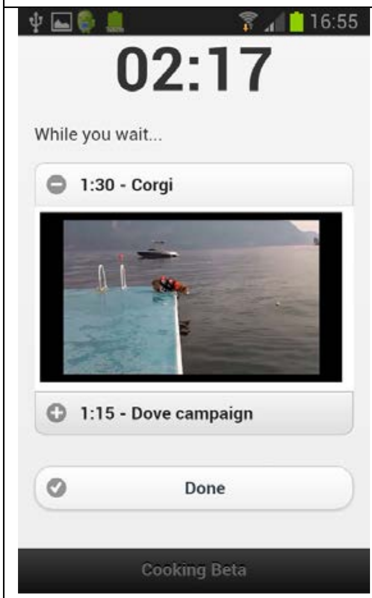
7) In this example, two videos are combined to distract the user for the duration of the warm-up phase.



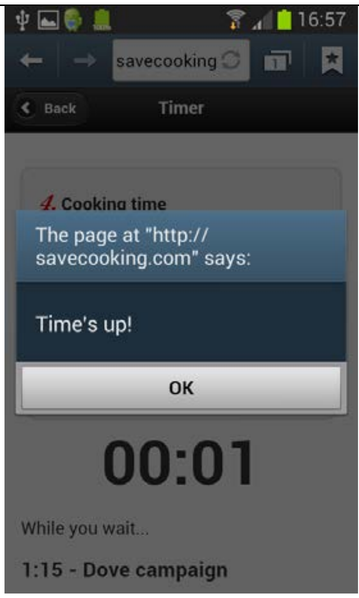
8) The next screen presents the actual cooking time.



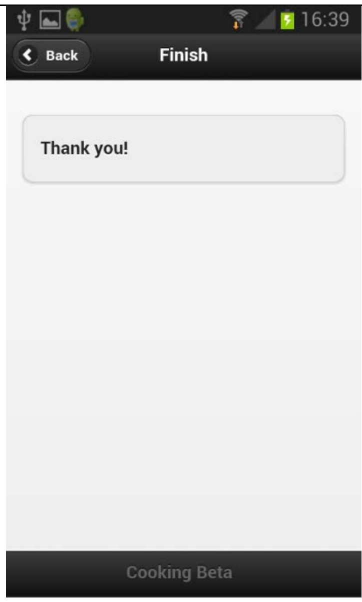
9) After starting the count down, more videos appear below with a total time slightly shorter than the cooking time.



10) Random funny videos are presented to the user.



11) One message pops up and a bell sounds indicating the end of the cooking time.



12) The last screen is a simple 'thank you' page indicating the end of the activity.

6.8 Discussion

The earlier studies performed during this research, combined with previous work in the field of behaviour change interventions, guided the design of the strategies to be introduced and tested with participants. The evidence relevant to the intervention design was described in this chapter, indicating how the knowledge of users' behaviours influenced the selection of the proposed methods. The understanding of the target population in their specific context was compared with the background from the literature review, and this combined knowledge indicated the development of the proposed intervention described here.

A general observation from the previous studies is that participants are worried about the time it takes to cook, and that they wanted to reduce the waiting time at the cost of extra energy usage, by boiling the kettle, using high heat marks, keeping high heat for longer or using large hobs. Although less frequent, some energy saving behaviours were also performed in the attempt to make the cooking time shorter, like using the lid or choosing a small pan. The waiting time was also filled with other activities like using the mobile phone for texting, listening to some music or chatting in order to balance the time tension caused by the stretched time (Oulasvirta, Tamminen 2004) during the waiting phase. This research proposes that minimizing these temporal tensions can in fact make it easier for people to reduce energy consumption.

One possible way to test the theory that time perception manipulation can encourage people to perform behaviours that save energy is via a mobile phone application. This app can aggregate information about how to prepare the food and at the same time tell people how to use the appliances and utensils in a more efficient way. The proposed application indicates all the steps necessary to reach the intended goals and simultaneously facilitate the procedure. It also attempts to reduce the temporal tensions – the effectiveness of this strategy is uncertain and is tested in the final study of this thesis, described in the following chapter.

The development of an application to assist the cooking activity represents an external interference to an often demanding process. Cooking is a manual process, and handing a mobile phone during cooking can be challenging and even dangerous. There is also the concern that electronic interventions do not fit the cooking activity since it is experimental and celebratory in essence (Grimes, Harper 2008). One of the requirements gathered from this study was that the task to be performed had to be kept as simple as possible because technology might not be suitable for complicated activities. Therefore, the relatively simple 'noodles cooking' task was chosen. Previous research showed that task characteristics explain more than 60% of technology utilization: the fit between task and technology "decreases as task requirements increase; that is, tasks can become too large and complex for IT to provide adequate support" (Dishaw, Strong 1999). In addition, the focus of attention can be disrupted when using a mobile phone and undertaking other activities at the same time. The competition for attention between mobile screens and the environment was subject of previous research: it has been shown that the amount of time dedicated to the device can be as short as four seconds, depending on the context of use, and attention-switches between the phone and the environment can occur more than eight times during a single page load (Oulasvirta, Tamminen et al. 2005).

Venkatesh and Bala (2008) suggest that the introduction of new technology can disrupt the user's performance or job satisfaction. The application characteristics can indicate how favourable individuals will be towards process changes and introduction of new information systems. Consequently, the amount of changes to the original task must be kept to a minimum. Wac et al (2011) describes that the use of applications can disturb the primary activity, but when the application in question is related to the primary activity that the user is performing, the user experience with the device tends to be positive. If a system permits customization, it might enhance the fit between a system and user's task. Webster, Trevino and Ryan (1993) showed that perceptions of flexibility and modifiability of a piece of software are directly related to the notion of flow: users appreciate the idea that they can tailor software to increase the level of engagement with a tool within the context of an activity.

It is understood that personal preferences and needs must be taken into consideration when trying to change user behaviours. First, because having control over individuals and limiting user freedom via an intervention raises ethical considerations (Pettersen, Boks 2008). Secondly, because evidence from the First Study show that trying to impose cooking methods onto the user group might not be very effective. Certain non-energy saving behaviours observed during the previous studies were performed because the participant wanted a specific outcome. The analysis of participants' determinants of behaviours shows that a simple imposition of a fixed cooking process might not bring about the changes needed to save energy, because it clashes with personal values and preferences. Proposing changes without considering personal predilections can cause negative reactance (Brehm 1966) among users and compromise the acceptance and effectiveness of interventions. The possibility of customization is then required, and it is proposed as one of the available features of the suggested intervention.

6.8.1 Limitations of study

This Third Study presented a few limitations that need to be acknowledged. Firstly, there are restrictions regarding the theoretical part of this chapter. The literature review on time perceptions and temporal tensions indicated an avenue for research in areas apparently not yet explored, linking anxiety and boredom with energy use. However, the theory constructed around this relation is relatively untested and further empirical research will be needed to confirm these suppositions. This research proposed that it is possible to deliberately reduce temporal tensions, and this can motivate people to behave more sustainably. It is not clear if the manipulation of time perceptions can be successfully performed in the context of energy use, if it will indeed reduce temporal tensions and if it will eventually result in energy conservation. These aspects will be discussed further in the next chapter.

Secondly, the suggested cooking behaviours might seem arbitrary. For example, the cooking process designed and embedded in the app recommended that students use cold water from the tap. This instruction is contrary to observations from the First Study when 16 out of 20 students boiled the kettle prior to cooking. It also challenges the default packet recommendations. The Tesco Value Instant Noodles used during this research says “Place 200 ml of boiling water in a saucepan”. But putting boiling water in the pan could result in energy waste if the user boils 500 ml of water in a kettle, considering that most kettles (and those available to students living in halls) have a minimum mark of 500 ml. Furthermore, kettles are filled with more water than needed most of the time (Energy Saving Trust 2006). Tesco Customer Service was approached by the researcher regarding the possibility of modifying the procedures found on the packet. They replied on a personal communication via telephone saying that “these instructions are recommendations only, and there is no problem if the user decides to change it, as long as the food is thoroughly cooked in the end”. Asking students not to use the kettle will probably be challenging, but this is a fundamental technique required to achieve the desired energy saving during cooking.

The proposed app also suggests techniques that are in conflict with external factors beyond students’ control. 32% of the participants do not own a saucepan lid for a small pan and 13% reported not having a small pan available whilst living in halls. For that reason they might have formed habits that will be difficult to counteract. All the other behaviours might also face resistance among the study population. This can compromise the testing of the app as platform for reduction of temporal tensions and behaviour change. However, the combination of persuasive strategies, especially tunnelling and tailoring, might encourage adherence and enable effective and valid testing of the hypothesis formulated during this study.

6.9 Conclusion

In this chapter it was explained how the knowledge of user behaviours and their respective determinants informed the design of interventions to potentially change people’s behaviours for cooking. By doing so, the fourth research question was addressed. This chapter reviewed the main findings from the First Study and Second Study, presenting them in an aggregated way that provided a clearer picture of the problems regarding time management during cooking. This knowledge was then aligned with a theoretical background on time perceptions and temporal tensions, which indicated the media and the content of an intervention to tackle wasteful behaviours. These propositions were presented to a group of students who analysed it according to specific scenarios. Their contributions confirmed the findings from previous studies reinforcing the message that an application should contribute to make the cooking process more efficient (reducing time to prepare, minimizing effort involved and providing better results) and improve the user experience. Participants also mentioned that an app could help users concentrate on the food preparation in order to follow a recommended procedure by providing guidance during the process. At the same time an app could provide a variety of distractions during the second phase of the cooking to minimize boredom during waiting, such as tips for better cooking, multitasking, quizzes, games and relaxing activities.

The qualitative data analysis from the requirements study showed that individuals are likely to be cautious in adopting a cooking assistant app because they do not want to spend additional time preparing the food, add effort or compromise the quality of food. However, if the application has a value, or is perceived as being useful and easy to use, then it is likely to be more accepted. This information contributed to the process of defining the design of a persuasive electronic intervention to change their behaviours for cooking.

The main hypothesis formulated after aggregating data from the previous studies is that providing a way to reduce temporal tensions during cooking can improve the user experience and promote energy saving. It was demonstrated that ICTs can provide the tools needed to manipulate time perceptions and therefore may be able to bring about changes in the specific behaviours that result in unnecessary energy usage. These tools were implemented via a mobile phone application, so that a prototype can be introduced and tested with participants. The interaction with the application is evaluated in the following chapter to understand its effectiveness in changing behaviours and also its acceptance among the target population.

7 Fourth Study – Intervention evaluation

This chapter answers the fifth research question:

RQ5: What is the role of persuasive technology and time perception manipulation in changing people's behaviours and reducing energy usage in the cooking context?

7.1 Introduction

This chapter presents the evaluation of strategies that attempt to manipulate time perceptions during the cooking activity. These strategies were implemented in order to assess the reduction of temporal tensions (Oulasvirta, Tamminen 2004) and how it affects people's behaviours. It is believed that by reducing temporal tensions it is possible to improve the user experience and promote energy saving at the same time. A mobile phone application, developed during the Third Study, was used as the platform to evaluate how persuasive technology and time perception manipulation can change behaviours towards energy saving during cooking.

The three previous studies performed during this research demonstrated that ICTs could provide the tools needed to produce changes in the specific behaviours that resulted in unnecessary energy usage. The First Study indicated that some students rushed into cooking without paying much attention to the procedure and also tried to shorten the cooking time and minimize boredom when waiting for the food to cook at the cost of extra energy usage. The Second Study pointed out the attitudes, social norms and behavioural control, according to students' beliefs, that more strongly affect the likelihood of adoption of energy saving techniques. Students believe that simply following the proposed techniques can increase time and effort required for cooking. Consequently, an intervention must provide personal advantages to users, for example making the cooking process quicker and more efficient whilst also promoting behaviours that lead to energy efficient cooking practices. During the Third Study, an idea generation session was undertaken with 35 students to explore ways of reducing the temporal tensions during cooking using a cooking assistant presented as a smartphone application. Participants described how such an app could help them concentrate during the preparation phase if it could provide the right information to reduce preparation time, minimize effort and provide better results through the cooking process. An app could also offer distractions during waiting to decrease boredom, such as things to read, play, interact and relax.

Strategies based on persuasive technology (Oinas-Kukkonen, Harjumaa 2009, Fogg 2003) represent interesting tools to be introduced into this context and evaluated. The concept of *tunnelling* was embedded in the app in order to provide the cooking instructions in steps and possibly make users pay more attention to the procedure. *Tailoring* was presented in the attempt to make users committed to the cooking process and also to increase acceptance of the intervention. *Suggestion* provided the right information when the user needed it. *Reduction* was implemented in the app to facilitate the activity, especially to help users to time the cooking process according to their preferences. *Entertainment* was introduced to provide a cognitive engagement (Agarwal, Karahanna 2000), foster *flow* (Csikszentmihalyi 2000) and consequently reduce the boredom during waiting.

This chapter presents the design of the Fourth Study consisting of a phase of observation of a controlled user testing (Maguire 2001), application of surveys containing rating scales to measure technology acceptance (Davis 1989) and flow in interactive systems (Fang, Zhang et al. 2012) followed by post-experience semi-structured interviews (Kuniavsky 2003, Sharp, Rogers et al. 2007). A two-stage experiment was designed to evaluate two different prototypes of a smartphone app, one control and one test condition. Thematic analysis was performed to consolidate results from the interviews, and this information was combined with the quantitative data to provide comparative evaluation of both versions of the application. Results present an account of user behaviours, energy usage, time to complete the task, assessment of acceptance of the technology, level of engagement with the app and an evaluation of each of the implemented techniques. Finally, a discussion section presents some aspects related to the introduction of an app into the cooking activity and the limitations of the study.

7.2 Methods

In order to better answer the research question proposed for this study, a mixed methods strategy was used, combining elements of fixed (quantitative) and flexible (qualitative) research. Quantitative data consisted of diverse measurements including energy usage, time to complete the task, specific aspects of the cooking noted on video, a checklist by the researcher (for example yes/no for using the lid or measuring the water) and also responses to a rating scale (described below). Qualitative data consisted of semi-structured post-experience interviews that took place at the end of the second trial. The questions, whenever possible, were neutral, nondirected and arranged in a specific sequence in order to extract the best answers without leading or biasing the responses (Kuniavsky 2003). Interviews were audio-recorded, transcribed and then analysed with the aid of NVivo. Transcriptions were made verbatim to avoid being decontextualized and lose meaning (Bazeley 2007, Miles, Huberman 1994). The coding process followed recommendations for thematic analysis, where a familiarization with the data is followed by an initial generation of codes, transformation of these codes into broader themes, a revision and further definition of these themes (Braun, Clarke 2006).

This study used a within-subjects design, having participants taking part in two different experimentally manipulated conditions at different times (Robson 2002). This study was designed containing two phases, one working as the control, or baseline, and the second working as the intervention which was actively introduced with a view to producing a resultant change in participants’ behaviours. However, the control phase was also likely to make people sensitized because it also contained a treatment condition. Even if using the simpler version, the app contains information that might influence people’s behaviours and attitudes. The introduction of the app during the first phase could prime users toward the desired behaviours, and this effect could be carried over to the second phase of the research. For this reason a counter-balanced design was used with two groups of participants: “Group 1 gets treatment 1 followed by treatment 2. Group 2 gets treatment 2 followed by treatment 1” (Robson 2002).

The trials consisted of a counter-balanced A-B / B-A design, with all 12 participants experiencing both versions of the app. The control version (A) and the test version (B) were allocated randomly to participants, such that four males and two females started using version A and later tested version B, whereas the other four males and two females were asked to start with version B and used version A during their subsequent trial. This alternation was used to minimize influences of learning and familiarization to the cooking process from A to B, which could influence the results.

The two phases of the test were performed on two different days, usually on consecutive days. This separation was chosen in order to avoid the boredom of performing the two trials in a row and minimize the chance of participants performing tasks or completing the rating scales automatically by memory. In addition, the two phases were not too far apart to minimize the effect of history: other external events could occur between the tests and influence participants’ behaviours, consequently threatening the validity of the results (Robson 2002). Nine participants had the second trial on the following day, whereas due to weekends or other commitments two students had the trials a couple of days apart, and one of them had the final trial four days later.

7.2.1 Demographics and sampling

All 12 participants of this study were undergraduate students from Loughborough University. Their ages ranged from 18 to 22 years old, eight males and four females. Although the gender distribution is unbalanced and does not correspond to the study population, data from the First Study indicated that gender did not influence the results. No strong correlation was found between gender and any of the measurements such as energy use, time or behaviours performed.

Students were recruited via their academic emails and in person in their halls of residence. A snowball technique (Robson 2002) also helped complete the sample, since three of the subjects were recommended by a previous participant. The invitation contained a brief description of the study, mentioned the use of smartphones and introduced the cooking task which candidates had to perform. The text indicated the main purpose of the study as being the evaluation of a cooking assistant designed as a mobile phone application. The content of the message was designed explicitly to not mention the introduction of time perception manipulation or the interest in energy saving behaviours.

To meet the inclusion criteria, all participants were required to be undergraduate students, be familiar with the cooker used during this research, and be used to cooking at least a few times a week. Having participants unfamiliar with cooking could affect the results in at least two ways: it could introduce errors, the measurement of which is not the object of this study, or it could make participants extra careful due to the novelty and lack of familiarity with the topic of study. The majority of students (nine) had been living the same hall where the research took place for at least eight months, consequently were familiar with the appliances. The other three had been living in other self-catered halls of residence using the same type of electric hobs or similar models. Consistent with the previous studies of this research, all participants were used to cooking hot food about once a day. Eleven participants were British, and one student, although born abroad, had been living in the UK for more than 7 years.

During the course of this study the researcher was a subwarden for the hall where the majority of participants were living, and it facilitated access and communication. It is understood that this relation can introduce bias to the study. Although there's a relation of power between subwarden and residents, the researcher made clear that participants were not being judged, and stated verbally that the purpose of the study was to understand the user interaction and not evaluate the user performance. The Participation Information Sheet also indicated that the objective was to know how people evaluate the app (Appendix 14.1).

7.2.2 TAM and Flow

A survey was implemented in order to evaluate the app and the usage experience, from the users' point of view. All participants completed a 27-item questionnaire after both trials, as can be seen in Appendix 13.4. The scale was divided in two parts, tapping into the acceptance of technology and the engagement with the application.

The first half of the survey used the widely used Technology Acceptance Model (Davis 1989) to measure participants' perceptions of ease of use and usefulness. The statements were based on the scales proposed by Moore and Benbasat (1991). Those statements not relevant to the cooking context were removed. The final selected constructs were:

- **Relative advantage** – to measure the usefulness of the app, or how the app enables the user to accomplish the task more quickly, improves the quality of food, makes it easier to cook, enhances the effectiveness during cooking or gives greater control over cooking
- **Compatibility** – To measure if the app is compatible with other aspects of cooking, if it fits well with the way participants like to cook
- **Image** – How participants rate those who use the app regarding prestige, and if the app is a status symbol or not
- **Ease of use** – to evaluate if the app is easy to use or if there is learning required
- **Results demonstrability** – if results of using the app are apparent, and if it is possible to communicate to others the consequences of using the app

The second part of the survey tapped into the temporal tensions of the cooking situation, the immersion, absorption and involvement with the app. The concept of flow comes from widely used propositions developed by Csikszentmihalyi (2002, 2000) and the constructs used on this instrument were based on a scale developed to measure the state of flow in computer game play (Fang, Zhang et al. 2012). Measurements not related to this research were removed. The remaining statements relevant to the cooking activity were the following:

- **Concentration on the task at hand** – to measure if the attention was focused entirely on the app and if the users were concentrating fully on what they were doing
- **The paradox of control** – to determine if the users felt in control over what they were doing in the app and if they felt comfortable with the controls
- **Immersion** – to measure the loss of self-consciousness, the merging of action and awareness, the transformation of time

- **Autotelic experience** – to understand if using the app was rewarding in itself, and if participants enjoyed the experience

7.2.3 Task

Similarly to the First Study, this time students were again asked to cook instant noodles. However, during this experiment the instructions came from a mobile phone application. A quick briefing introduced the participants to the task. Upon start they were asked to read the participant information sheet, sign the consent form, and were told that they could use any utensil available, and could also ask for any other item they needed.

The utensils available to the students were 2 different sized pans[3] with their lids on the side, a measurement jug, wooden spoons, scissors, a bowl and a fork. The noodles were unpacked and placed on a plate together with the seasoning sachet. This approach was taken to avoid participants using the packet instructions as source of information, which could interfere with the cooking process and confound the results.

A domestic energy monitor (The Owl) was used to record the electricity used during this experiment. This data was taken before and after each trial. The energy consumption from the cooker was isolated from the whole flat with the same technique used during the First Study: the clip sensor was installed around the live cable that feeds the cooker, inside the switch box. To avoid influences in the results, participants were not aware that the energy was being monitored.

At the beginning of each trial, students received a SMS message and were asked to access the link to load one of the versions of the app on their smartphones. Interferences from the researcher during the experiment were kept to a minimum. At the end of the cooking process, during both trials, participants were invited to complete the rating scale designed to measure the acceptance of the technology and the engagement with that version of the app. They could eat the noodles if they wanted to.

[3] During the First Study, 3 different sizes of pans were placed next to the cooker. However, none of the 20 participants used the larger one. For that reason, for this final study, the options were reduced to 2, small (which was the pan indicated by the app since it is the adequate size for a single meal and fits the small hob on electric cookers) and medium (in the case participants decided not to follow the instructions). All participants used the small pan though.

Figure 69 - Fourth Study – Setting

7.3 Results and discussion

Data from the observation checklist, the energy monitoring and the video footages recorded during this study are presented in this section. With this information it was possible to compare participants' behaviours during trial A and B, and also make some inferences about how effective the app was in changing these behaviours. These results indicate how successful the app was in attempting to create engagement with the instructions for better preparation of the cooking process and also in the attempt to reduce the level of boredom during waiting via time-based approaches.

7.3.1 Customization of cooking

The distributions of user selections are displayed below, showing that most students wanted noodles of medium consistency, with remaining water, and fast preparation time. Ten of the twelve participants used the same selections during both trials. One student changed from 'al dente' consistency to medium between phases. To obtain softer noodles they had to leave it cooking for an extra minute. The boiling period did not require energy input (it was only using the remaining heat), therefore choosing a different outcome would not directly affect energy usage on this type of hob. Another participant changed from fast to average preparation time. The instructions for both cooking procedures indicated the use of the small hob on mark 6. Consequently, choosing a different duration would not result in differences in energy usage. In agreement with the previous studies, the selections of speed reflect that students wanted a quick preparation time. Participants selected ‘Fast preparation’ 17 times out of 24 observations, representing 70.8% of occurrences.

Table 33 - App selection frequency, both trials aggregated

Amount of water	Speed	Consistency
Sticky – no water left 6	Fast preparation 17	Soft – slightly overcooked 2
Regular – a bit of water 18	Average preparation time 7	Medium consistency 21
Soup – plenty of water 0	Slow cooking 0	‘Al dente’, to the tooth 1

7.3.2 Commitment to the instructions

Most of the participants followed the instructions exactly as displayed on the app, either for trial A (control) or B (experimental condition). As can be seen on Figure 70 and Figure 71 below, the actions were rather similar for both phases of the cooking. All students used the small pan and covered the noodles with the saucepan lid provided. Only one student preferred not to measure the water, three students deliberately used bigger hobs and one student reduced the heat instead of switching it off completely. Two students used a larger hob unintentionally and two others used different marks because they misunderstood the instructions from the app (see section 7.4 - Limitations of study below for descriptions of mistakes by participants). The commitment to the instructions was notably higher than noticed during the First Study.

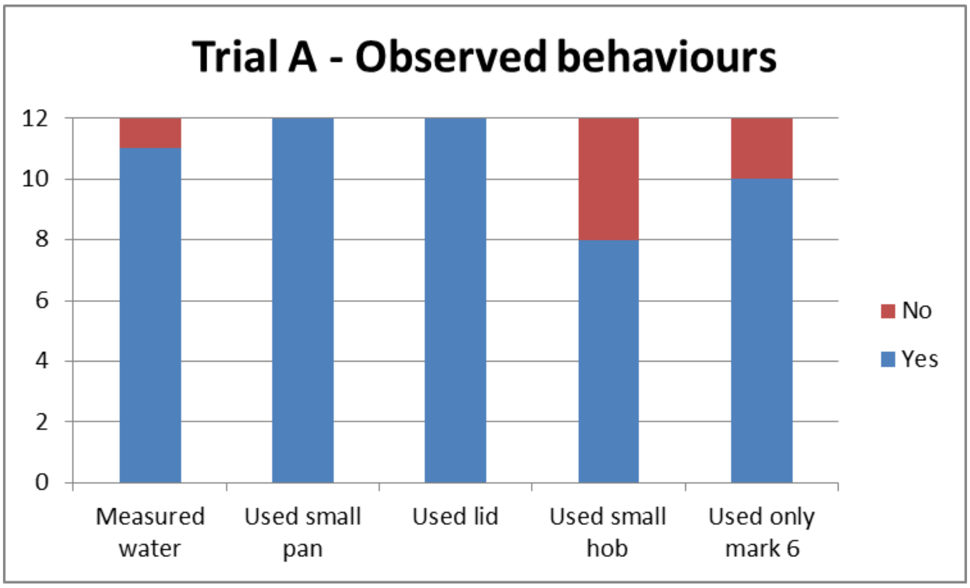


Figure 70 Trial A - Observed behaviours

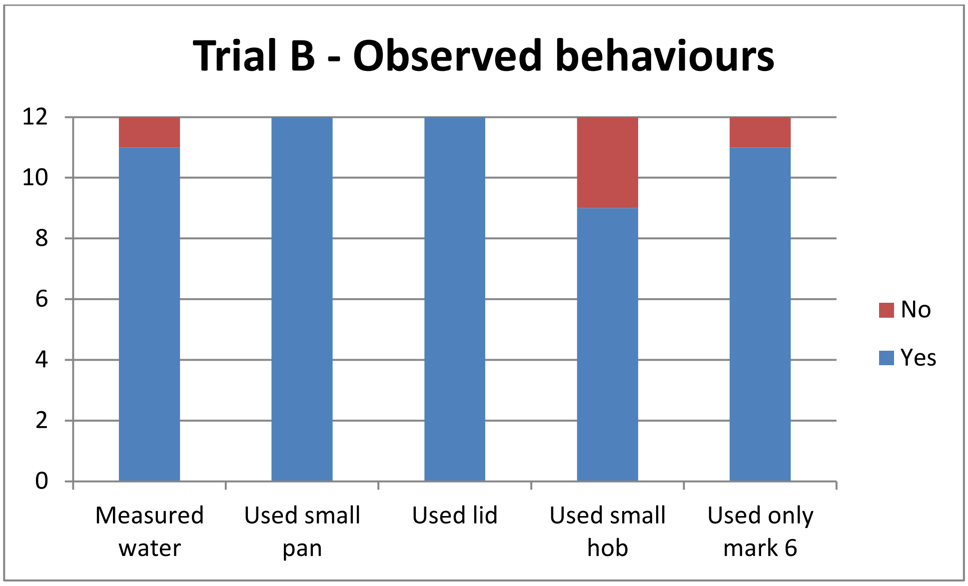


Figure 71 - Trial B - Observed behaviours

7.3.3 Survey on acceptance and flow

The results from the rating scales designed to evaluate the technology acceptance via a modified TAM scale (Moore & Benbasat, 1991) and the engagement with the app via a modified Flow measurement (Fang, Zhang et al. 2012) are presented below. Responses to the questionnaire items were aggregated to generate an overall score for each construct.

Participant's selections of Relative Advantage, Compatibility, Image, Ease of Use and Results Demonstrability were added to provide the TAM rating per participant. Results from Concentration on the Task at Hand, The Paradox of Control, Immersion and Autotelic Experience together gave the overall Flow score. The data gathered from these instruments provided means of comparison between both apps used during this study. The selection of the adequate statistical technique followed recommendations from Pallant (2007), after analysis of the characteristics of this study and the data obtained.

7.3.3.1 T-test

This study had a within-subjects, repeated measures design, where the same group of participants were measured on two occasions, under two different conditions. In this situation, parametric statistics may be applicable, as long as the statistics are undertaken on the aggregated score, and not on individual scores (Carifio, Perla 2007). The paired t-test can demonstrate "changes in scores for participants tested at Time 1, and then again at Time 2 (often after some intervention or event)" (Pallant 2007). One of the requirements to use t-tests is that the data should have a normal distribution. Figure 72 and Figure 73 present the box plot graph of data distribution for TAM and Flow measurements. No deviant value was found (i.e. TAM and Flow data met the normality assumptions for t-tests), meaning that a related sample t-test could be used for these variable pairs.

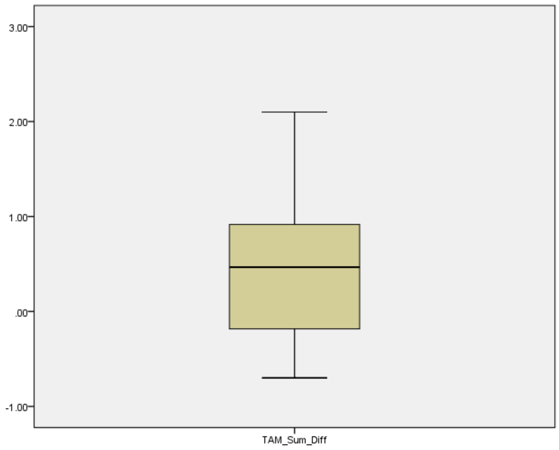


Figure 72- TAM analysis of distribution

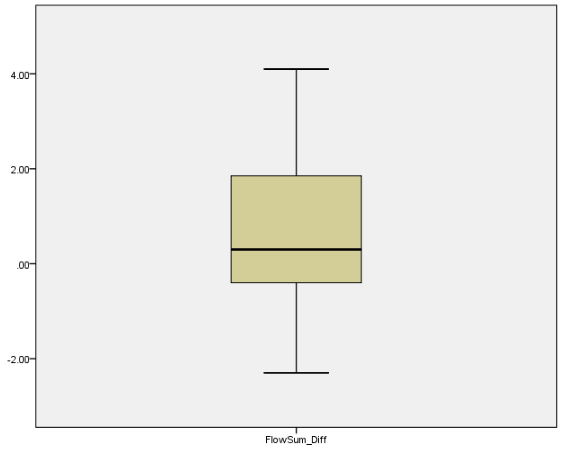


Figure 73 - Flow analysis of distribution

The paired sample t-test indicates whether there is a statistically significant difference in the mean scores for trial A and B. The paired sample correlation analysis (Table 35) indicates that the values for TAM and Flow are highly correlated between both tests, for TAM (r = .93, p

< .01) and Flow (r = .63, p < .05). However, considering a 95% confidence interval, the t-test analysis of the paired samples (Table 36) indicates that the difference between tests is non-significant for TAM (p = .074) and Flow (p = .223). The mean value for TAM increased slightly from 19.06 to 19.52. Flow rose from 15.12 to 15.86 (Table 34).

Table 34 - Paired Samples Statistics - TAM and Flow

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	TAM_SumA	19.05833	12	2.268142	.654756
	TAM_SumB	19.51944	12	2.264101	.653590
Pair 2	FlowSumA	15.12500	12	2.392080	.690534
	FlowSumB	15.85833	12	2.165623	.625162

Table 35 - Paired Samples Correlation Analysis - TAM and Flow

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	TAM_SumA & TAM_SumB	12	.936	.000
Pair 2	FlowSumA & FlowSumB	12	.632	.028

Table 36 - T-Test of TAM and Flow, paired between both trials (A and B)

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	TAM A – TAM B	-.461111	.809144	.233580	-.975217	.052994	-1.974	11	.074
Pair 2	Flow A – Flow B	-.733333	1.966692	.567735	-1.982910	.516243	-1.292	11	.223

7.3.3.2 Means

Figure 74 present the mean values gathered from the rating scales completed after both trials. It suggests that the acceptance of technology (TAM) tended to increase slightly from app A to B in almost all measurements, even though these changes were not significant at an overall level, as above. The mean value of 'relative advantage' increased by 3%, 'compatibility with cooking' rose by 6% and both the app image and 'results demonstrability' rising 2%. Ease of use remained the same at a high 4.79 average on a 5 point scale. From questions on prestige and status (for example "Students who use this kind of app have more prestige than those who do not"), the mean evaluation of the app image was 2.75.

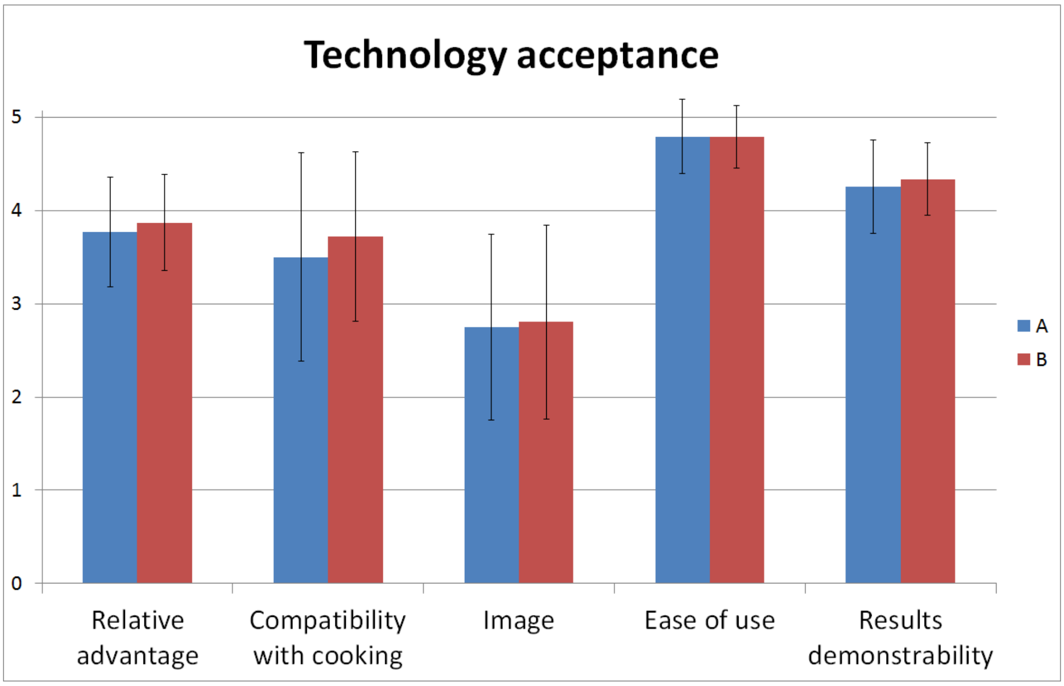


Figure 74 – Technology acceptance measurement – Means and standard deviation

Figure 75 presents a graphic visualization of mean values of measurements of Flow. It suggests a trend towards general improvements from the version A to B of the mobile app. The paradox of control stayed at a high 4.54 on a 5 item scale, in both phases of the study. The other individual constructs of flow showed a greater trend towards improvement than for technology acceptance, even though there was no significant difference at an overall level. Looking simply at the means, concentration on the task increased 9%, and mean immersion rose by 11% on the experimental version featuring the persuasive strategies and time perception manipulation. This result suggests a modestly enhanced engagement experienced during the interaction with the second version of the app, although there was considerable variability. It also provides additional evidence of the cognitive absorption illustrated by the body language presented below.

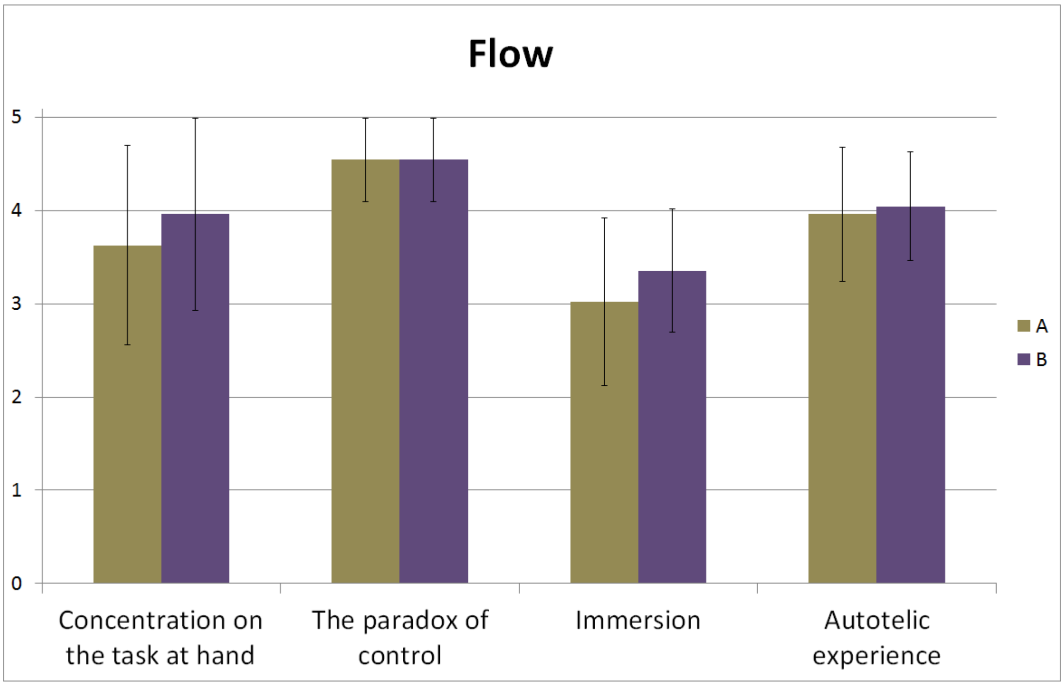


Figure 75 – Flow measurement – means and standard deviation

7.3.4 Time usage

From the video footages it was possible to measure how long participants had the hob on. This 'on' time is displayed on Figure 76 below. For most participants, the time effectively using energy was similar during both trials, and less than six minutes appeared sufficient to bring the water to boil and produce enough heat to continue the boiling process for 2, 3 or 4 minutes (depending on the noodles softness selection).

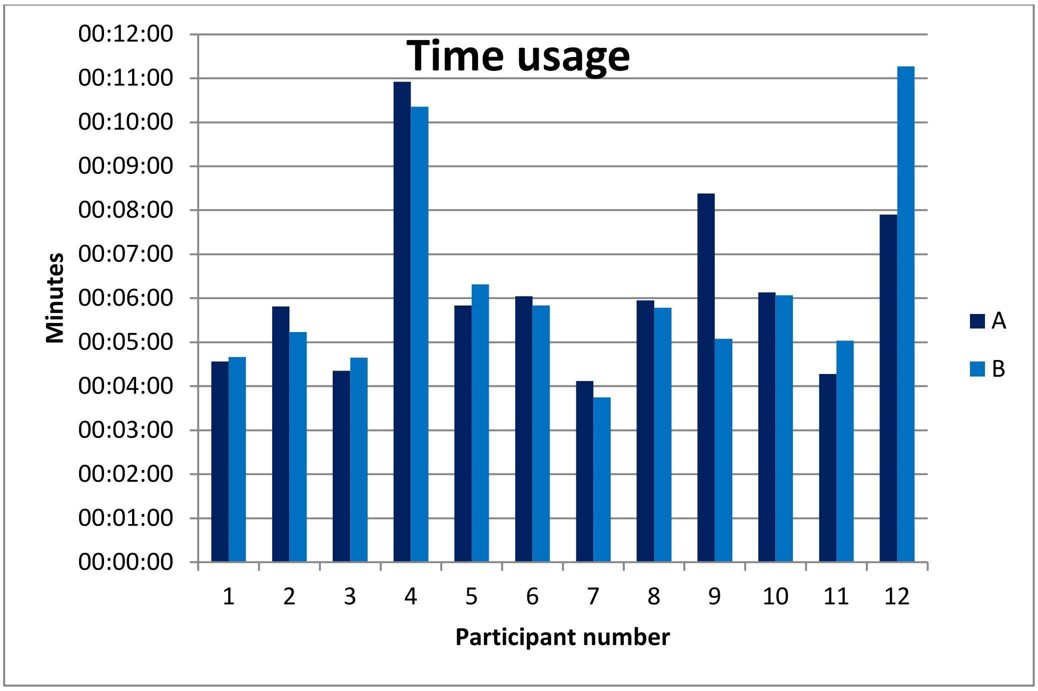


Figure 76 - Comparative time usage, trial A and B

On average, all participants kept the hob on for approximately the same time for both trials: 6 minutes and 11 seconds for trial A and 6 minutes and 10 seconds for trial B (Figure 77). The median values were 5 minutes and 53 seconds and 5 minutes and 30 seconds respectively (Table 37). However, means and medians must be taken with care, especially when there are outlying values in the dataset. Further statistical analyses and consideration on these are presented below.

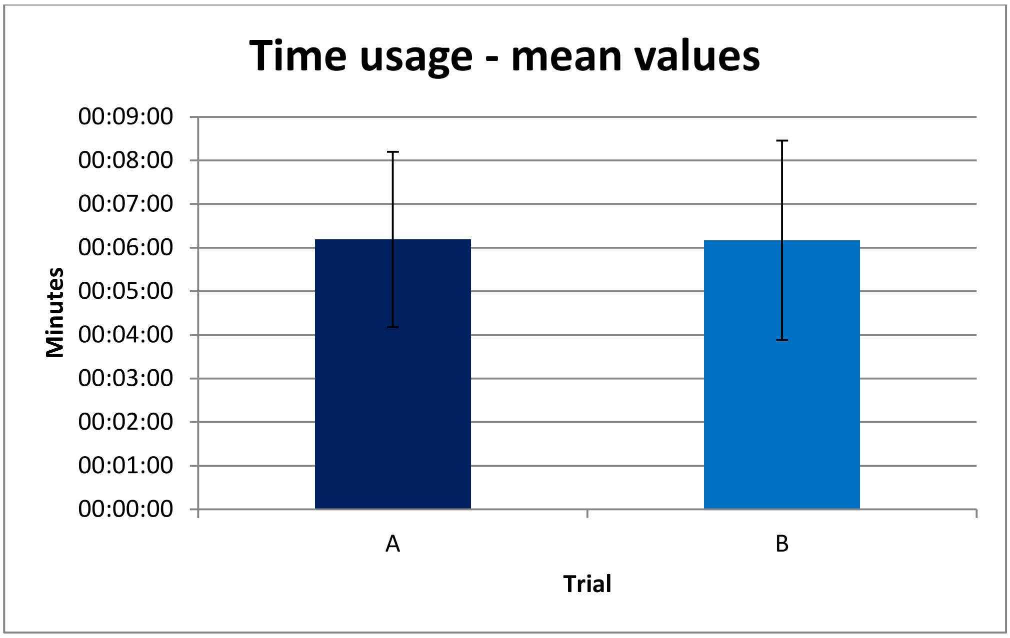


Figure 77 - Time usage - mean and standard deviation

Table 37 - Time usage - median

Descriptive Statistics

	N	Percentiles		
		25th	50th (Median)	75th
Time_A	12	0:04:24	0:05:53	0:07:27
Time_B	12	0:04:45	0:05:30	0:06:15

7.3.4.1 Statistical analysis of time usage

These particular behaviours performed by specific participants affected the time usage in ways that made it difficult to make statistical comparisons. Even though mean and median values indicate improvements in time to perform the cooking task, analysis of variation shows that results do not fall into a normal distribution. As can be seen on Figure 78, the differences in time usage for participant 9 and 12 are extremely outside the standard deviations (represented by the T lines at the top and bottom of the box plot).

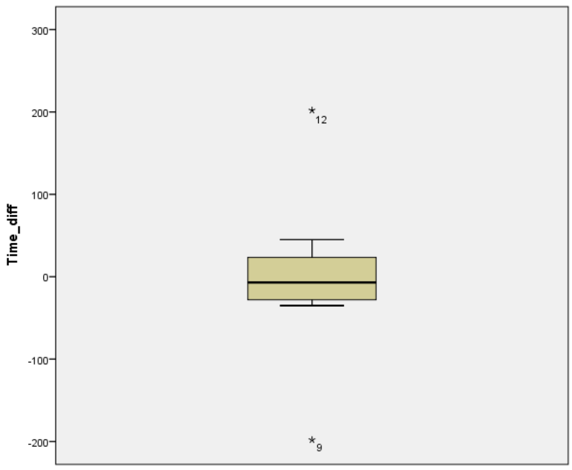


Figure 78 - Analysis of distribution – Time usage

Since the measurements of time had deviant data, it indicates that this dataset may not be fit for comparison using traditional methods such as t-tests and does not follow a normal distribution (Lowry 2013). Therefore, non-parametric analysis had to be performed. The alternative to t-tests, more adequate for these results, is Wilcoxon Signed Rank Test (Cohen, Manion et al. 2011). This test combines participants' both energy measurements, from phase A to B, compares these measurements, signals it (in terms of increase or decrease) and presents the significance of the differences (Lowry 2013). Table 38 below presents the ranks between measurements or time usage, calculating the product from trial B minus trial A, per participant. The first row of data indicates that the duration of use during trial B was smaller than trial A (negative ranks) for seven occurrences (N). The second row (positive ranks) indicates that five participants used more time during trial B than trial A. Matching each pair of observations provided a more detailed account of time usage, ranking individual cases instead of relying on averages. In summary, seven participants reduced their time use from app A to B, whereas five increased.

Table 38 - Wilcoxon Signed Rank Test, time usage

Ranks

		N	Mean Rank	Sum of Ranks
Time_B - Time_A	Negative Ranks	7[a]	6.00	42.00
	Positive Ranks	5[b]	7.20	36.00
	Ties	0[c]		
	Total	12		

a. Time_B < Time_A

b. Time_B > Time_A

c. Time_B = Time_A

Further analysis of significance level of the differences between time usage during trial A and B indicated that these results are not statistically significant, as would be expected from the similar mean values across both trials (Figure 77). Table 39 shows the level of significance *p* (Asymp. Sig.) for time usage compared between both trials using Wilcoxon Signed Ranks Test, which revealed a non-statistically significant reduction in time usage when using the app B, $z = -.235$, $p = .814$. The median score on time usage decreased from trial A (*Md* = 05 min 53 sec) to trial B (*Md* = 05 min 30 sec).

Table 39 - Analysis of significance for time usage - Wilcoxon Signed Ranks Test

Test Statistics[a]

	Time_B - Time_A
Z	-.235[b]
Asymp. Sig. (2-tailed)	.814

a. Wilcoxon Signed Ranks Test

b. Based on positive ranks.

7.3.4.2 Explanations for differences in time usage

Even though most participants had a regular and controlled cooking time, results in Figure 76 show a few notable differences. The causes of these differences are explained below. Two participants had the timing quite differently between trial A and B: participant 9 used energy for extra 3.5 minutes on trial A because he reduced the heat and left it on until the end of the cooking, instead of switching it off completely half way through the process. He reported that the instructions were not very clear: *"it's said turn the hob off, but then it said boil the water, boil the noodles, so I thought when it said boil the noodles I thought it meant turn the hob back on to boil the noodles, so that confused me a little bit"*. Participant 12 had a shorter trial A because he turned the larger hob on by mistake instead of the small one, whereas during trial B he used one small hob, reduced the heat half way through the process and left it on until the end of the cooking. In A he was able to produce more heat and heat up the pan quicker. But this speed came at a cost of extra energy usage, as can be seen on Figure 79 below. Even if having the hob on for less time during trial A, this student used more energy for trial A than B. His time usage for trial B is the longest one because he misunderstood (or did not pay much attention to) the instructions, similarly to participant 9: *"I reduced it to 1 when I put it back on, I didn't know if I was supposed to turn it off, or, completely like, when you detangle then, I just turned it down to 1, and then it was kind of bubbling up to the top so I had to kind of keep lifting* [the lid] *up"*.

Participant 4 had long 'on' times because he did not measure the amount of water, and consequently ended up filling the pan with more water than needed. He explains his motivations: *"I just did it roughly. I used less than yesterday though, because yesterday I realised I put too much water. If I had saw the beaker I'd probably use it, but I haven't noticed it. I was being maybe a bit blunt I guess."* He reports lack of habit of using a measuring jug: *"I haven't used it at all this year. But I just like, when I do spaghetti I just put this much and sort of, I won't do exactly, I would just put in, with the spaghetti under depth, so it's probably using more energy but I don't really care"*. Participant 7 had the shortest duration (and consequently the smallest energy usage) because she filled the measurement jug with hot water from the tap. She reports that it is her habit as a measure to save time: *"that's what I usually do, yes. It's quicker than boiling on the hob"*.

7.3.5 Energy usage

Figure 79 below shows the energy usage in Watt hours, according to the data provided by the hidden energy monitor. Most participants used about the same amount of electricity during both trials, indicating that there was little intra-subject variability. The only ones that show differences between trials are participants 4 (who did not measure the amount of water when using either of the apps), 9 (who kept the hob on towards the end of the cooking process only when using app A) and 12 (who kept the hob on until the end of the cooking process during interaction with app B, and used a large hob by mistake when cooking with app A). Participants 1, 8 and 11 used relatively more energy because they used bigger hobs deliberately, which can be quicker at the expense of more electricity consumption. Participant 1 explains that she wanted speed, hence using a big hob: *“it's good to, when I’m hungry, to cook quickly.* […] *I assume that it cooks quicker, that's why I do it”*.

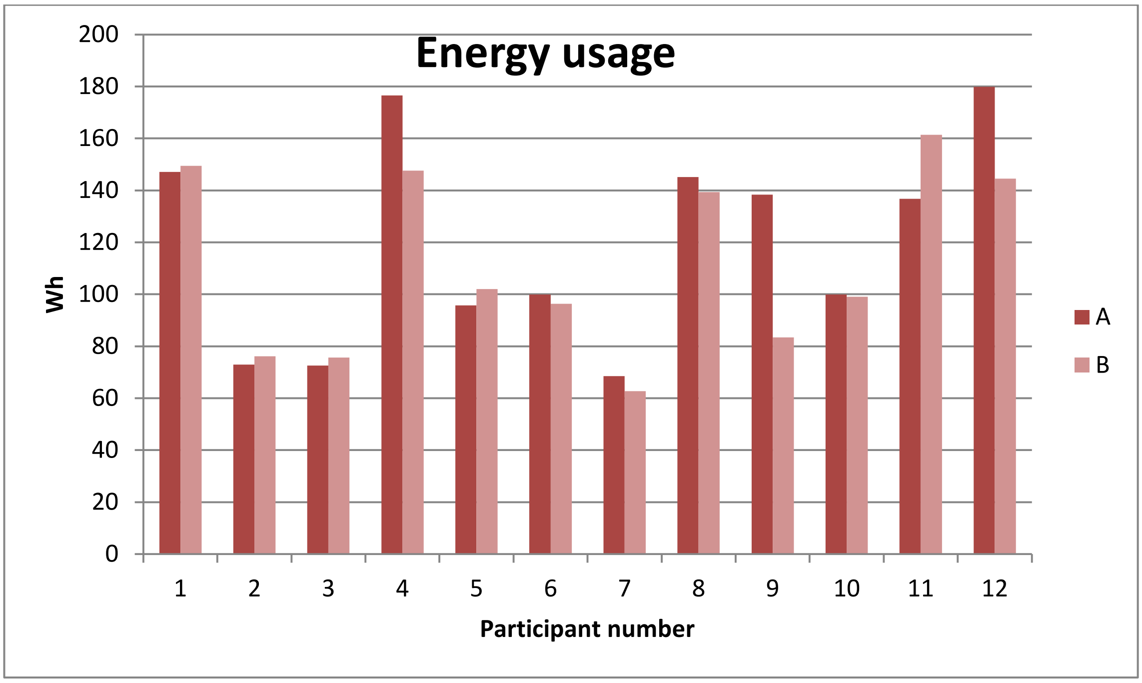


Figure 79 - Comparative energy usage, trial A and B

Figure 80 shows the average values of electricity usage for all participants during cooking when they were using app A and B. The mean values of energy usage for study A and B were 119.6 and 111.4 Watts hour, with a standard deviation of 39.6 and 34.7 respectively. The reduction of mean consumption from the simpler version of the app to the one featuring the manipulation of time perceptions can be considered modest: 8 Watts hour, or 6.7%.

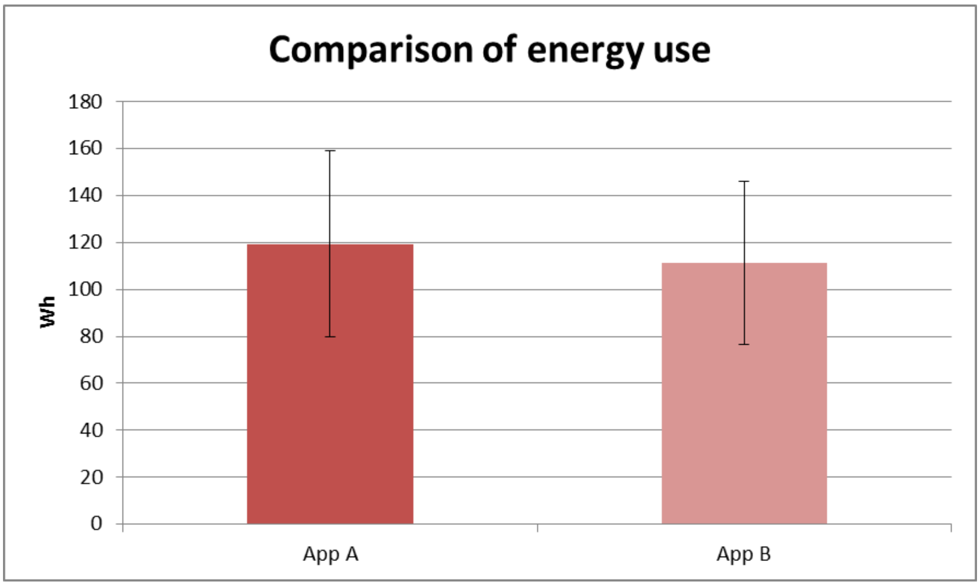


Figure 80- Comparison of energy use - app A and B - Means and Standard deviations

Table 40- Mean values - energy use

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
EnergyA	12	119.58333	39.553091	11.417994
EnergyB	12	111.41667	34.692043	10.014730

Table 41 shows that the median energy use also reduced from app A (*Md* = 118.5 Wh) to trial B (*Md* = 100.5 Wh). However, even though means and medians present positive results, they must be taken with care. The energy use during these trials was also influenced by factors other than by the manipulations of time perceptions embedded in the app. The unintentional use of larger hobs, wrong selection of heat level and other variations between trials caused different energy use. Further statistical analysis is presented below to provide additional exploration.

Table 41 - Energy use - median

Descriptive Statistics

	N	Percentiles		
		25th	50th (Median)	75th
Energy A	12	78.75000	118.50000	146.50000
Energy B	12	77.75000	100.50000	147.25000

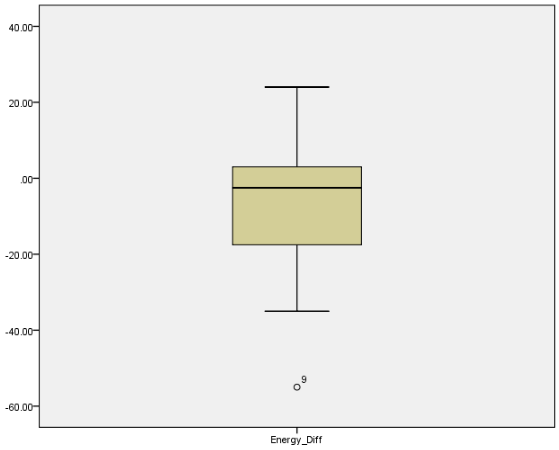


Figure 81 - Energy use - analysis of distribution

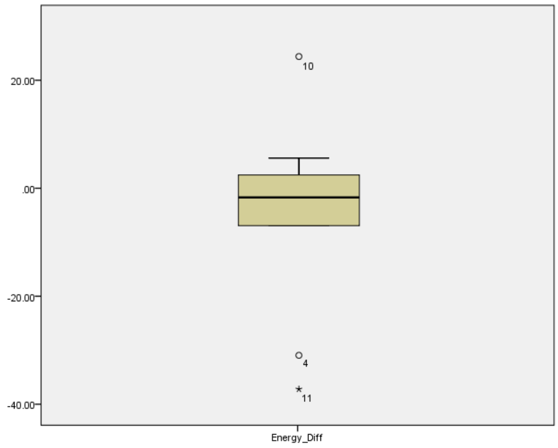


Figure 82 - Energy use - analysis of distribution, main outlier removed

Figure 81 present the analysis of normality of pairs of data. It can be seen that one value is clearly outlier (participant 9), outside the standard deviation area. When removing this main outlier pair of data, additional three are still present, as can be seen on Figure 82. It indicates that the data does not have normal distribution, and Wilcoxon Signed Rank Test should be performed (Cohen, Manion et al. 2011). Table 42 below presents the ranks between measurements or electricity usage, calculating the product from trial B minus trial A, per participant. The first row of data indicates that the energy use during trial B was smaller than trial A (negative ranks) for seven occurrences (N). The second row (positive ranks) indicates that five participants used more energy during trial B than trial A. Matching each pair of observations provided a more detailed account of energy usage, ranking individual cases instead of relying on averages. In summary, seven participants reduced their energy use from app A to B, whereas five increased.

Table 42 – Wilcoxon Signed Rank Test, energy use

Ranks

		N	Mean Rank	Sum of Ranks
EnergyB - EnergyA	Negative Ranks	7[a]	7.57	53.00
	Positive Ranks	5[b]	5.00	25.00
	Ties	0[c]		
	Total	12		

a. EnergyB < EnergyA

b. EnergyB > EnergyA

c. EnergyB = EnergyA

The diversity of energy use during these trials and influence of external factors can be seen on the associated level of significance *p* (Asymp. Sig), shown on Table 43. The *p* value for energy usage obtained during this study was .271. Similar to the results on time to complete the task, the test of significance level of energy usage makes it unadvised to make assumptions from these results. To sum up, a Wilcoxon Signed Ranks Test revealed a non-statistically significant reduction in energy usage when using the app B, $z = -1.100$, $p = .271$. The median score on energy usage decreased from trial A (*Md* = 118.5 Wh) to trial B (*Md* = 100.5 Wh).

Table 43 – Analysis of significance for energy use - Wilcoxon Signed Ranks Test

Test Statistics[a]

	Energy B – Energy A
Z	-1.100[b]
Asymp. Sig. (2-tailed)	.271

a. Wilcoxon Signed Ranks Test

b. Based on positive ranks.

7.3.6 Analysis and feedback on the app

During the post-experience semi-structured interview phase students were asked to comment on the different aspects of the human-computer interaction. Questions explored participants' opinions in order to rate the time perception manipulation and persuasive strategies embedded in the app. The five strategies implemented in the app were evaluated according to participants' opinions. The responses were classified as negative, neutral or positive attitudes towards each strategy following a thematic analysis of the statements (Braun, Clarke 2006).

With these groupings it was possible to link qualitative and quantitative data (Miles, Huberman 1994). Table 44 below lists these evaluations, displaying the number of mentions and, in brackets, the number of participants who evaluated that strategy. One mention is defined as one statement, as one entire response during the interview. Participants could have made more than one positive statement towards strategies during different parts of the interview, and they could evaluate these strategies in more than one category.

Table 44- Attitude toward strategies - number of mentions and participants count

Attitude toward strategies				
	Negative	Neutral	Positive	Total
Tailoring	0	0	15 (12)	15
Tunnelling	5 (3)	0	20 (10)	25
Instructions	12 (7)	11 (6)	40 (12)	63
Entertainment	10 (8)	2 (1)	23 (10)	35
Reduction	0	1 (1)	17 (12)	18
Total	27	14	115	156

From 156 extracts of participants' responses, 115 (69%) are positive towards the strategies implemented. Those are the mentions where there is clearly a positive attitude towards the strategy with adjectives such as good, better, useful, easy and right. Fourteen responses (8%) were neutral, not stating advantages or disadvantages, or mixing both evaluations on the same statement. Twenty seven negative mentions accounted for 16% of all responses. Examples of these extracts are listed below, ordered by the approximate sequence that the strategies were presented to the user on the app.

7.3.6.1 Tailoring

Both versions of the app gave the opportunity for the user to select the desired outcome. This feature was rated as positive by all students. Participant 2 evaluated the customization as positive *"because you're more likely to get what you like, if you choose what you want, as opposed of having a generic cooking guide"*. Similarly, participant 7 says that *"it's quite good, because so you can do it so it suits to your taste, because everyone is different. So on the packet there's only one saying 'cook this for 5 minutes'. It tells you like, everyone likes noodles differently. So I think it's quite good"*. Participant 9 mentions similar reasons:

> *I think that's a good idea because allows you to cook food in the style you want to and the way you'd like to eat it and in the way you enjoy to eat it. So, like, some people like the pasta quite hard, don't they, and some people like it quite soft, like, I like it really soft, so, it's good you can choose it towards your own preferences. Like, normally when you look at cooking instructions you normally only get one set of instructions to look at, so it's good to have like an option.*

The app calculated how to achieve the expected results by automatically changing the instructions to suit the selections made at the beginning of the interaction. This relationship was illustrated by participant 7, who said that she felt committed to the procedure *"because you gave your options, or how you wanted, then you still feel like, if you follow it, you'll get it how you wanted"*. Most students felt committed to the procedure and evaluated the guidance generally in a positive way. To follow the steps showed to be worthwhile for participant 6, since *"the results show, like, through my selections, the results are what I expected it to be, so the instructions were good"*. He later added that *"if I was using my eye with the pan I maybe would put in too much water or too little water. So then it affects how it tastes and how I want noodles or whatever the food"*.

7.3.6.2 Tunnelling

The version A of the app had all steps for cooking noodles in one page, similarly to what can be found on the back of the packet. The version B of the app presented a tunnelling strategy, to guide the user towards a path without much room for modification. This was made by having small steps on each page, where users had to perform one step prior to tapping 'Done!' and seeing the next step. Most mentions are related to the fact that it makes the process easier or safer: *"it goes through separate stages, so it's very easy, like, you can't forget to do anything"* [participant 1]. *"It's like separated, so once you've done one thing, you then move on to the next thing, rather than being faced with the whole page of instructions. That breaks it up and make it easier"* [participant 3]. *"I like that, because then you can see what you have done, like, then you can move to the next level once you've done it. Whereas, obviously you could have a list, you might get confused by what stage you actually are"* [participant 5]. The comparison with the food packet was raised by participant 7: *"sometimes you don't read the instructions properly, it's quite handy when it comes up step by step on the phone, it's more clearer rather than what you get from the packet"*. She continues adding that it can be easier with steps: *"Sometimes you can just skip a step if you're not reading it properly or if you're tired after a long day and you might not read every step. If it's sort of little bits and if you click next, next there's another little bit, I think that's probably more sort of easy to use"*.

Understandably, some students did not appreciate tunnelling since it constrained their freedom or prevented them of seeing the whole procedure in advance. Participant 2 preferred a single page of instructions *“[b]ecause I think you can read the whole sort of procedure before you do it, whereas the other one you had to, I thought I had to do one step, and then find out what the next step was. But I didn't like that* [laughs]*”*. The same opinion is shared by participant 4: *“in some ways I prefer the way it was yesterday, when you have all lined down in front of you, rather than clicks and then you see then next bit”*. Participant 8 felt the tunnelling threatened his freedom during cooking, since it put him into a path where he had little choice: *“I didn't like it because I wanted to read ahead in case I wanted to make my own decisions on how to change it”*.

7.3.6.3 Suggestion and Instructions

Students were asked about the contents of the app, on how they evaluated the instructions presented. The instructions were rated as positive on the majority of mentions. Participant 2 admits that she usually do not measure time or quantities, and for that reason she appreciates the idea of having it detailed on the app, which helps her with the final quality of the food:

> *I wouldn't measure anything, so I just use my eyes, 'is it enough water?'* […] *No measurement, no measurements at all, not even time measurement.* […] *I never think to turn off the hob, like, midway through the cooking, but I think that's also because, you don't know when to turn it off, and how long to have it on. So unless, like, unless you have like an app which tells you that, you can't do that, if you're just cooking free style, then you don't really know when to turn it off, so you're more likely to leave it on until you're sure that you finished cooking.* […] *The good thing about using like measurements is obviously you expect a certain outcome, so if it's good then you get that outcome, but with not measuring you can't really expect anything, you just hope that it comes out ok.*

The fact that the instructions help achieve better results was also pointed by participant 12: *“you'll never go wrong in your cooking. Like, everything will be fine”*. The instructions were also appreciated for how they facilitate the cooking process: *“it's easier, you get told what to do, and it's just, yes, a lot more easier than thinking about it yourself”* [participant 11]. The concept of convenience was shared by participant 9: *“it's just, it's straight forward, it's like simple and like, if the information is there in front of you and obviously you're gonna use it, because it's there and it's, and it's just easier to do”*.

When asked if he would trust the instructions from the app, participant 4 illustrated that the commitment to instructions in general should not be strict, advising users to challenge the guidance when appropriate:

> *I would trust them, but like I said, you use your instincts, if it doesn't look cooked you wouldn't eat it, for example, would you? It's like satnav, you sill, like these people who use a satnav and drive into the sea. It's like, oh, hang on a minute, you need a bit of common sense as well, don't you? They follow it, it says turn left and there's a hedge there, you don't turn left, do you? It's sort of, you need to use your initiative as well don't you?*

Part of the influence to follow the instructions noted during this study was due to the tunnelling strategy presented. Participant 8 indicated that he committed himself to the procedure due to *"the fact that I couldn't read ahead. So it might have had a consequence later on if I hadn't replaced the lid or if I hadn't used the small pan"*.

The cooking procedure presented on the app was somewhat limited and clashed with particular user preferences. Participant 8 would appreciate more freedom suggesting *"the option to add chicken or add something else. That would help. A little bit more, like, flexibility of not just how you want it, but what you want it with. So I may have put salt in the water or something beforehand but it didn't tell me so didn't do it"*. Participant 7 also mentioned that she likes a bit of flexibility, and that the app might be limiting possibilities: *"Sometimes I just throw, like, different things in to whatever I'm cooking, but if you're following step by step you might not sort of develop more.* She added that she was not very comfortable with part of the instructions: *"Maybe the timer was right, but the water, because it didn't cover the whole noodles. It might be how I broke it up, because some bits were a little bit higher"*.

7.3.6.4 Entertainment

Version B of the app presented short random videos with known lengths for the users as a distraction when waiting for the water to heat up or the noodles to cook. Participant 9 illustrated his engagement and how being entertained can make the time pass quicker: *"I like that, I very much like that. It's great, because it passes the time a lot quicker, 3 minutes went like that* [snaps his finger], *which is good"*.

Participant 2, who tested the app with the entertainment (B) first then used the simpler (A) version later, stated that she missed the videos on her second trial: *"I felt like, time was dragging, even though it was only three minutes like before"*. Participant 6 added a similar comment saying that *"yesterday obviously we had the videos that helped the time pass, whereas today I thought, like, nothing to do, sort of. So you're just waiting for the 4 minutes to pass or whatever"*. Participant 7 complements: *"sometimes it can get a bit boring, when you're sort of just waiting for the food to cook"*.

Having the entertainment embedded in the cooking assistant itself could make the time appear to pass more quickly and also perhaps make cooking safer, as participant 1 illustrates:

"Sometimes, when I'm at home, I go to watch TV when I'm waiting, then obviously I forget then it burns or whatever [laughs] *so yes that was good there, the right amount of time"*. Participant 8 adds saying that *"if it's just a small amount of time and you have nothing to do, then you may lose track of time and start texting and forget about what you're doing, so I like that"*.

The main negative points raised by participants regarding the entertainment strategy include concerns that the novelty might wear off. Participant 2 states that *"if it's an app that you use a few times, the distractions then get boring because once you know what it is, then you know what you've got every time, so it was good, the first few times, but I didn't miss it today"*.

This strategy proved to be generally appreciated but not free of concerns, as participant 1 indicates: *"I thought it was really good, on the first one I was worried that I was gonna forget to check the food or something because I was watching the video, but because it was the right amount of time it was good"*. Participant 9 was more vocal on the apprehensions over being over distracted by the app: *"When I was watching the videos I could have got distracted, because there was no timer, like I was watching the video and I wasn't really paying attention to the food, so that, that could actually be like, it could have been bubbling for about a while and I was still watching the videos and I could, if there was a problem I wouldn't have noticed because I might have got distracted by the video"*. This concern about 'forgetting' to check the food prompted participants to recommend making sure the videos are adequate for the cooking time to avoid risks. Participant 6, referring to the entertainments, said that *"I like it, but the thing is, you've got to be careful that it's not too distracting, because you don't wanna, you know, have your food burned or whatever, so you don't want it too long"*. Similarly, participant 10 adds that *"maybe if it's a different time scale, say if the video is long, you have to wait for 3 minutes on one of them, maybe if the video is longer than 3 minutes maybe you forget about the noodles and you're watching the videos, you know what I mean"*. The app was programmed to only load videos that were a few seconds shorter than the length of the cooking process selected by the participant.

Concerns about the technical aspects of connections speed were also raised by participant 3: *"I think sometimes we have a bad internet connection, then the video is quite slow to watch, so it's a disadvantage if the video is but... and that could be quite annoying because you're like 'oh there's a video' but you can't load it so..."*

Adding evidence to the usefulness of the entertainment when waiting for the food to get ready, participant 7 explains that she appreciated the distractions because with the videos people *"don't have to keep stirring it and keep, like, because if I just get bored I just stir it, have a look, move around, I don't know"*. Participant 6 verbalize the temporal tension when he reports how he felt during both trials:

> *I think that yesterday's was a lot better because it broke up a little bit more* [referring to version B]. *Whereas today obviously it's only one slide or one page so it seems a bit more tedious. I took more time sort of doodling about, that sort of thing. Rather than yesterday you were always engaged in the app, because of the videos and things like that, which was quite good.*

7.3.6.5 Reduction

One of the strategies embedded in the app included the possibility of attributing to the mobile device the task of timing the process, reducing the necessary mental load involved with keeping track of the duration of the cooking activity via a countdown timer followed by an alert. All participants mentioned that these resources were positive. For example, participant 3 said that *"that was good. And it came up when it was done so even if you aren't looking it still pop up saying that it's done"*. The concept of reduction is clearly illustrated by this quote from participant 9:

> *"It's very very good, especially because while I was watching the video it came up and said 'the cooking time has completed' so it didn't get distracted, you're not, like, because if it hadn't come up I would probably kept watching the video, it was very handy, it's very simple, because normally I use my watch and it's quite a lot of effort, because you have to turn the watch on and, like, unlock it, because it's a special runner watch, so it's a lot less effort to do it and turn, so I prefer that a lot.*

The timer embedded in the app can also improve safety, as the interviews illustrate. Students mentioned that burning their food is an issue that happens sometimes, mainly due to poor time management during cooking. Participant 4 presents an adequate anecdote on the issue of cooking time: *"I go into my room when I'm cooking, then I come out then 'oh shit I burned it'. Not very often, but just occasionally, I get distracted by a phone call or something.* […] *Occasionally, the phone has rung, and I answered it, and I had been on the phone for ¾ of an hour and 'oh shit' and when I come back my food is black, so the timer would be useful"*. He adds that the timer can reduce effort for checking when the food is ready. Usually he has to *"go back every 2 minutes or so, depending on how it looks, so if it's not quite done yet, I come back in 2 minutes. If I had an app that says go now, I'd use the timer rather than walking back and checking it"*.

7.3.7 Body language

It was noted during this study that participants' body language correlated with the content of the 2 versions of the app. There are a large number of studies focusing at how to identify moods through people’s movements and posture (Matthews, Jones et al. 1990). It is claimed that with video analysis of certain patterns of movement it is possible to classify the emotions fairly correctly (Wallbott 1998). This implies that it might be possible to identify people’s cognitive-affective state by the patterns of movement and postural behaviour. For this study, only a simple evaluation was undertaken, to categorize participants’ moods into two basic categories: engaged or waiting. After evaluating each key body postures, it was noted that when interacting with the first version of the app (A), students were generally in a *waiting* state, only observing the cooking. A few cues might indicate boredom, such as manipulating objects, holding on the counter, standing still or having low movement dynamics (Wallbott 1998). On the other hand, the second version of the app (B) indicates moments of absorption and immersion in the app. Students were generally focused on the screen, leaning over the phone or holding it in their hands. Table 45 and Table 46 below present several snapshots of these bodily expressions extracted from the videos of what can be considered boredom (version A) and engagement (version B).

Table 45 - Snapshots of body image, trial A (waiting)

Table 46 - Snapshots of body image, trial B (engagement)

7.3.8 Safety

One recurrent issue that emerged during the interviews is that participants are often concerned about safety during cooking, mainly regarding skin burns and burning the food. It is understood that introducing a mobile phone application into the cooking process can make it more dangerous. However, some risks can in fact be minimized when using the app. Participant 9 declared that together with the improved efficiency, safety can come as a bonus:

> *Especially with the hobs, turning it off, that's definitely more efficient for everyone. And it's less dangerous as well because the hobs aren't getting as hot, so, like, after, especially in Bakewell where hobs are very very hot afterwards and when someone has cooked and then you come in, it's quite easy to, like, burn yourself from the hob, and especially when you don't know they've been using it. So if it's not getting as hot it's a lot safer as well I think.*

The same participant reiterated that using the hobs at the back might be safer. This indication can be added to the app, and by introducing this habit among users, it can reduce the risk of burns associated with cooking:

> *I like to use the back ones because my mum always told me it's safer to use the ones towards the back. Because it's like, if it's at the front, and if you knock the pan, you can knock it off onto the floor and all onto your legs and stuff, but if it's the back it's safer, so it's less likely to spill, so that's why I've chosen the left back one.*

Participant 2 also mentioned that she selects the hob with safety in mind, because "*when you finish cooking the front hobs are hot, then I'm very careful of people going around there, but if it's at the back there's less worry that such things happening*".

7.3.9 Learning experience

Some of the participants reported positively that they experienced and learned new cooking procedures, and that it is possible to cook using less energy and still obtain the same results. The app provided an environment for 'enactive mastery experiences' to happen, consequently improving self-efficacy (Bandura 1994). Participant 9 explains how the procedure indicated in the app resulted in enactive experiences:

> [I learned that] *you can turn the hob off, and use the fact that the hob is already warm to use it and cook your noodles like, I never knew I could do that before. Because at the first time I did it I kept the hob on when I was boiling the noodles. And at the second time I*

> *realised you don't actually need the hob on, you can have it off and it's still hot and it still boils the noodles, and it doesn't need as much electricity, which is very handy.*

Participant 1 illustrates the learning aspect of the activity: *"I was quite surprised because I don't usually turn it off, I just leave it to boil, and I was quite surprised that it worked, so that was good"*. Participant 8 contribute to the notion of learning experience, indicating that the app demonstrated the possibility of slowing down and still providing good results:

> *If I would to cook noodles myself I would just boil the pan full power, put the noodles in, just blast it all the way through the amount of time it said, but, it might have turned out better than how they would normally have turned out, so, yes, maybe, actually follow the instructions. Slow down.*

The app proposed a few energy saving techniques that are not often followed by students. However, after trying those out themselves, participants mentioned, usually with surprise, that it is possible to follow those and still obtain the desired quality of food in the end. The suitability of those instructions is especially important taking in consideration the general lack of cooking skills among the students population (Blichfeldt, Gram 2013).

7.3.10 Regular distractions

It is understood that people often find their own entertainments to pass the time and alleviate boredom. Participants mentioned that they sometimes have their own distractions whilst waiting. The distractions often occur with the help of other ICTs, as participant 4 states: *"people who are cooking generally bring their laptops to the kitchen"*. Participant 5 adds that *"some people in their kitchens might have a TV anyway, so might watch that when they're cooking, or might listen to the radio, so just depends"*. Participant 7 exemplifies other tools to pass the time on her phone itself: *"Usually I'd probably just go on Facebook or Twitter or something like that on my phone"*. However, none mentioned having a tool to actively remind about the time.

For different target populations, especially more experienced cooks, and when cooking more complex dishes, an app with distractions to minimize temporal tensions might not be suitable. Participant 3 declared that she usually do not have to wait during cooking: *"I usually try and time it so that each part of my meal fit in slots, so I always have something to do and at the end I can just put it all together.* However, participant 8 illustrates that he was pleased to be distracted in a controlled way during the trial, *"with an advert or something to do that was inside that amount of time, because otherwise, if it's just a small amount of time and you have nothing to do, then you may lose track of time and start texting and forget about what you're doing, so I like that"*.

7.4 Limitations of study

This study presented some limitations inherent to experiments in the real world such as the lack of control over external variables (Robson 2002). One of these limitations regarded participants' knowledge of details concerning the experiment. It was assumed that participants were independent from each other. However, most of them were residents from the same hall on campus, meaning that they could have interacted and discussed aspects of the study among themselves. This limitation could contaminate the control and treatment variables and affect the results. During one occasion when the researcher noticed that participants knew each other, they were asked not to share information about the content of both apps with their friends. However, there is no guarantee that they kept it undisclosed.

It is known that subjects can perform differently during experiments because they know that they are being watched and they want to comply with the observer (Kuniavsky 2003). Participants of this study were asked if the instructions were different from their regular cooking, and why they followed the instructions. It helped to understand the motivation for performing that way, and if it was influenced by the experimental setting. Participant 2 was vocal on this issue. When asked why she followed the instructions she said that *"I think it's because I was doing, like, a study for you. If I was using it in, like, my kitchen or something, I think I would probably just make some decisions without being strict"*. Participant 11 were less outspoken on admitting influence of being in an experimental setting, but hinted at this interpretation, saying that he followed the instructions *"[b]ecause I thought I had to"*.

Another limitation is that the sample could have been contaminated by the knowledge of the aims and objectives of this research. Participants could have accessed information about previous phases of this research on academic publications online or on the researcher's webpage, which gives details about topics and interests. Particularly sensitive is the information about energy saving. Knowing that participants' performance was being measured or that the app was trying to persuade them to perform sustainable behaviours, it could have influenced results. In the attempt to measure this influence, one extra question was added at the end of the interview to understand participants' awareness of the strategies embedded in the app. When asked 'what do you think is the main purpose of this app', just one of them mentioned energy saving, but on a broader way. Participant 3 said that it would be to teach people who to *"turn the hob off, conserving electricity, I don't know, you're not using very much water as well, rather than boiling a whole kettle, I don't know"*. The most common responses were to make cooking easier, simpler or teach students how to cook, as participant 12 explains: *"Just to make cooking easier. Amn, easier to people. And like, to people who don't normally cook, give them the confidence to* *go and just cook a dish"*. The learning perspective was highlighted by participant 6: *"Help me cook? Cook in a way that maybe you might not be used to, or learn new ways to cook?"* Participant 4 gives his slightly stronger opinions regarding the purpose of the app: *"Just to make it easier, I guess. Easier for people who are morons and can't cook, full stop. For people who can cook, make it easier for stuff you haven't done before"*. His judgment on the usefulness of an app for cooking such a simple meal adds to the debate of the need to have technology that fits the task at hand (Goodhue, Thompson 1995) and the necessity of having challenges that match users' capabilities in order to guarantee engagement and enjoyment (Csikszentmihalyi 2000). If this was an app commercially available, it would benefit from strategies to keep interest in it, otherwise novelty wears off. Those could include game elements comprising different levels, planned progress, challenges, achievements and badges to earn (Anderson 2011, Koster 2010). However, the main objective of this study was not to retain users but only to provide the platform to test the persuasive strategies and the manipulation of time perceptions. One rather simple meal was presented on purpose to avoid complex activities which could make analysis of results problematic.

This research used observed posture and gestures to infer boredom or engagement. The limited position of the camera and the subjective nature of this method indicate that these results should be taken with care. Other studies in the literature mention the use of psychophysiological assessments of attention and emotion that involves more complex measures such as heart rate, facial electromyography, and electrodermal activity (Ravaja 2004). These methods might be more precise and reliable when testing attention levels and emotional factors in message processing. However, this type of measurements requires apparatus that would limit mobility, consequently compromising the cooking activity, and also would impose financial, temporal and complexity limitations to the study. Furthermore, an assessment of emotions with this level of detail sits beyond the scope of this study.

Even though the information and layout present on the apps were tested and improved during the design process, the interaction during the real experiment presented a few problems for some users. During one occasion the app crashed completely, making it impossible to continue. That trial had to be rescheduled to the following day after overnight improvements to the code and optimization of video files. The texts displayed on the app could also have had some improvements since 2 participants reported having misunderstood the instructions. However, changing the text halfway through the process could have influenced results of subsequent participants.

It was expected that the two versions of the app would present different results regarding energy usage. However, most participants used about the same amount of electricity from trial

A to B. One of the possible explanations is that participants followed the instructions from both apps and coped with the boredom when waiting for the noodles to cook because they were taking part in a research and were being video-recorded. Another explanation can be limitations with the apps themselves. Both apps contained the 'tailoring' strategy: users could select their desired outcomes and get customized instructions. On version B these instructions came separated in steps (tunnelling) at different times (suggestion), followed by distractions (entertainment) and a timer (reduction). Although substantially different, the presence of tailoring on the version A might have motivated users to follow instructions anyway, hence the lack of difference in behaviours and energy use. With hindsight it seems that the apps could have been more different from each other. Tailoring could have been removed to increase the differences on the apps, consequently maybe showing bigger differences on behaviours. However, it is important to have the balance right between the levels of differences on experimental conditions. Having several strategies on one condition and a control without any strategy makes it difficult to understand what motivated the observed change. Ideally, experiments should be designed with the introduction of one single treatment to be tested (Robson 2002). For that reason, only strategies that had the capacity to modify time perceptions were introduced on the experimental app (B).

It was noted that on certain occasions students did not follow the instructions by mistake and consequently ended up using more energy than expected. Participant 2, 9 and 12 heated up incorrect hobs after selecting the wrong switch. When noticing it, participant 2 switched the large hob off and started again from scratch with the small hob. As she stopped and started from scratch again, it was possible to exclude the energy consumption for the big hob and compute only the amount used by the small hob. Participant 9 turned on the large hob unintentionally for a few seconds when he tried to provide more heat halfway through the process but started heating a different hob than the one where the pan was. When he realised the mistake he corrected it and switched the right hob back on. Participant 12 started the process heating the big hob but put the pan on the small hob at the back. When he noticed it, he simply moved the pan to the hob that was already hot and continued on that. One participant used water from the hot tap and consequently gained a 'head start' during the process. Her results are surprisingly better than other students because she used one technique that was not part of the expected process.

Those mistakes and unexpected behaviours illustrate the diverse factors influencing results, and added more variables to the measurement of energy use within this experiment. For that reason, energy use data was 'contaminated' by external factors outside the app. The analysis of the benefits of the manipulation of time perception to promote energy must take in consideration factors other than energy monitoring. One review on strategies to evaluate technologies for behaviour change defends that it might be sufficient to assess the success of an intervention via the improvements that the strategies intended to promote (Klasnja, Consolvo et al. 2011). If the intention was to reduce temporal tensions, increase engagement and reduce boredom (or other factors influencing energy use), measuring gains in these psychological aspects can indicate success of the intervention. The advantages of the strategies implemented can be inducted from other data obtained during this study, for example the qualitative data gathered during the interviews.

7.5 Conclusion

This chapter presented the Fourth Study implemented during this PhD research. It detailed how mobile phone applications worked as the platform for testing the role of a HCI-based persuasive intervention. The two different versions of the app tested here allowed comparison between one simpler version and another working as a persuasive intervention attempting to reduce temporal tensions during cooking. This intervention was designed with the intention of manipulating time perceptions and consequently changing people's behaviours towards sustainable cooking. In order to evaluate the role of HCI-based persuasive interventions in the behaviour change process, this study combined diverse methods and instruments. These comprise the controlled user testing (Maguire 2001), the surveys on technology acceptance (Davis 1989) and flow in interactive systems (Fang, Zhang et al. 2012) and the post-experience semi-structured interviews (Kuniavsky 2003, Sharp, Rogers et al. 2007). Data gathered during this study consisted of user behaviours, energy usage, time to complete the task, assessment of acceptance of the technology, level of engagement with the app and an evaluation of each of the implemented techniques.

The results presented here made it possible to conclude that the selected persuasive techniques embedded in an HCI-based intervention helped reduce the temporal tensions previously observed during the two separated phases of cooking (as noticed during the First Study). The intervention also prompted the performance of behaviours that students are not very inclined to do, such as measuring the amount of water or turning the hob off before the end of the cooking time (as reported during the Second Study). When using both apps, participants were generally committed to the instructions during the preparation phase. However, students felt more engaged with the experimental app, which made the time pass more quickly when waiting for the food to cook.

This study combined qualitative and quantitative data that combined helped answering the fifth research question. A multi-strategy proved to be helpful since some of the statistical analysis were inconclusive. Even though mean and median energy use improved from trial A and B, t-tests indicated that the difference was non-significant for a 95% confidence interval. It was not possible to determine statistically whether the gains were due to the time perception manipulations implemented on the experimental condition, unexpected issues during the experiment or flaws on the measurements themselves. However, the thematic analysis of participants' responses to the interview indicated that they appreciated the strategies implemented to reduce temporal tensions.

Evidence from this study indicates that it was productive to manipulate the time perceptions during the cooking activity. A tool that helps people taking time to prepare the process according to instructions and pay attention to the steps can present a number of advantages. Separating the instructions into different screens makes the preparation easier to follow (the user knows where he is), guarantee the quality of food (the user does not forget ingredients) and knows what to expect (using measurements makes it possible to standardize). Likewise, an instrument that helps user keep track of time and minimize boredom during waiting can be beneficial during the cooking process. Providing controlled distractions in the form of embedded entertainment can improve the activity in a number of ways. These distractions prevent users from looking for time fillers that might distract them away from the kitchen, which could make them forget about the food being cooked. The distractions also made users less bored when waiting for the food to cook and manipulated the time perceptions so users perceived the same time as passing more quickly than during normal cooking. One enhancement to the time management was the introduction of a countdown timer. This feature eliminated the physical effort or mental load needed to keep track of time and reduced the probability of users forgetting when to switch the heat off.

Table 47 – Summary of themes on manipulation of time perceptions

	Preparation	Waiting
	Reduce rushing – To make users pay attention to the procedure through timely information	Reduce boredom – To present timers and distractions
	Tailoring, Tunneling, Suggestion	**Entertainment, Reduction**
Positive	• Less mistakes (User does not forget ingredients or steps) • Preferred results (Recipe adequate to personal taste) • Easy process (Separated steps) • Safe cooking (Cooking time indicated, hobs not overheating)	• Engaging content (User feels entertained) • Time is perceived to pass quicker (Reduction of temporal tension achieved) • Less effort (Cognitive load is reduced)
Negative	• Less freedom (Strict procedure) • Limited options (Not enough variety) • Different from usual cooking (Learning process)	• Can be too distracting (Cooking may need attention)

According to participants' evaluations, the strategies implemented to modify the time perceptions worked as intended, minimizing the temporal tensions present during the cooking activity. Students were generally more inclined to cook following the instructions when those came 'disguised' in the app. The majority of participants appreciated having the cooking procedure presented in steps with the instructions displayed at the right time, and it increased the likelihood of them paying attention to the procedure. They also enjoyed having entertainment when waiting for the food to cook combined with timers and prompts that tell when their food is ready. A few negative aspects were mentioned by participants, such as the reduction of freedom when they could improvise, the limited number of options presented by the app, and the concern that the app could be too distracting during the cooking process (Table 47). These remarks indicate where the app could be improved, but does not compromise the overall results. This study concludes that by minimizing temporal tensions it is possible to increase the likelihood of adoption of sustainable behaviours and consequently promote energy saving for cooking.

8 Discussion

This chapter answers the sixth and last research question:

RQ6: How can this knowledge contribute to the development of future HCI-based behaviour change interventions?

8.1 Introduction

This chapter presents discussions of results obtained during this PhD research together with the methodology rationale and comparison with similar studies. Results from the work performed during this research (literature review and four empirical studies) are combined here and discussed in terms of implications and limitations. This chapter also acknowledges that there are limitations to the methods implemented during this research and this section discusses what was done to minimize possible pitfalls from the methods used. This chapter helps address the sixth and final research question, which is also covered in chapter 9 (Conclusion).

This research started with a literature review to understand the challenges facing sustainability, the share of domestic energy use in CO_2 emissions and also the methods previously used in attempts to minimize impacts of people's behaviours on the environment. Previous studies indicate that behaviours play an important role in energy consumption (Verhallen, Raaij 1981, Gram-Hanssen 2011, Murray 2010). People living in similar houses, using the same type of appliances or performing equivalent tasks can present diverse patterns of energy use (Gill, Tierney et al. 2010, Morley, Hazas 2011, Crosbie, Baker 2010).

The evidence that individual user behaviours play an important role in energy consumption motivated studies to understand behaviours related to domestic energy use and what are the determinants of these behaviours (First Study – Understanding cooking behaviours). Interventions can be designed to change people's behaviours, and it indicates fruitful ways to promote energy saving and sustainability. The Second Study (Survey based on the Theory of Planned Behaviour) was designed to evaluate the enablers of and constraints to the performance of a set of energy saving techniques in relation to cooking. These techniques were designed to tackle the specific determinants of behaviours that caused additional energy use observed during the First Study. This knowledge informed the appropriate strategies, media and methods to be implemented as behaviour change interventions, designed during the Third Study (Intervention design and development). During the Fourth Study (Intervention evaluation), this intervention was subject to an experiment to assess its acceptance and effectiveness in relation to causing a change in behaviour towards energy saving. The next section presents the process of exploring the possible domains of energy use, tasks of interest, theoretical backgrounds, methods of data collection, intervention methods and strategies implemented.

8.2 Discussion of domain and methodology rationale

The Intervention Mapping Protocol (IMP) guided the development of this project (Kok, Lo et al. 2011, Bartholomew, Parcel et al. 2001, Uitdenbogerd, Egmond et al. 2007). It involves understanding behaviours, understanding determinants, finding the theoretical background to orient the project, designing interventions to tackle these determinants, and evaluating the effectiveness of the interventions. The process of definition of theoretical background and also the appropriate interventions to be designed considered the diverse options available. A literature review was undertaken, and in combination with findings from the performed studies, resulted in the most adequate intervention for the target population. Care was taken considering that “a poorly designed intervention not only squanders scarce resources but may be worse than no intervention at all” (Fishbein, Ajzen 2010).

8.2.1 The selection of cooking as the task of interest

From the different domains of energy use that could be examined, cooking was chosen to be the platform where the studies on behaviour change and energy use would take place. It is possible to see diverse studies on people’s behaviours and its relation to heating systems (Koehler, Dey et al. 2010, Verhallen, Raaij 1981, for example Crosbie, Baker 2010, Wilson, Bhamra et al. 2010) or energy monitors and other forms of feedback of consumption (Darby 2008, Yun 2009, Ueno, Sano et al. 2006, Darby 2001, Darby 2006). Other domains have been investigated in recent studies to understand how human behaviours affect consumption, for example washing machines (Stamminger 2011), personal computers (Chetty, Brush et al. 2009) and fridges (Tang, Bhamra 2009).

Personal cooking as the energy use domain during this research was chosen based on the high level of interaction between the user and cooking appliances and the amount of energy that can be saved by performing a number of techniques targeting energy saving (Wood, Newborough 2007). The literature review also indicated other aspects favouring cooking behaviours as the object of research. These include the lack of efficiency improvements to traditional cookers in recent years, slow replacement of old appliances, prohibitive prices of more efficient technologies, the role of people's behaviours in consumption and general lack of cooking skills.

8.2.2 User observation and video recording

A few issues need to be raised regarding the methodology used to gather data during this research. For the First and Fourth Studies, video observation was used in order to understand participants' behaviours during the cooking activity. It is understood that the physical presence of a researcher during the activity can influence the results due to the Hawthorne effect: people behave differently when they know they are being observed (Kuniavsky 2003). But video images needed to be produced in order to understand the multitude of actions performed during the cooking process, and also check the time spent during each action. Other research methods such as self-reported methods or diaries would miss the opportunity to gather the complexity of behaviours and richness of details seen in the results. One other possibility would be to use video cameras installed in the student's real kitchen. Martens (2012) report the use of 24/7 cameras in families' kitchens as "tools for enhancing knowledge of what people do in their kitchens" and also focused on other practices performed in the kitchen. Her methodology seems suitable for understanding social practices as a whole, including cooking, cleaning, ordering and socialising, and produced interesting results. However, in the case of one specific cooking task, a one-off video recording session as used during the First and Fourth Studies proved to be adequate. The context of shared student's cooking with up to 10 people using the same facilities made it difficult to use CCTV or other forms of video recording in their own kitchens. Flatmates use the kitchen as a social space for diverse activities and cook in various times of the day, often simultaneously, making it difficult to video record the occurrences, even if using motion detection technology. Additionally, interpreting video footage just by looking at it leaves room for errors or uncertainties about the meanings of 'doings' (Martens 2012). The methodology used during the First Study accounted for that by having post-experience semi-structured interviews following the trials, allowing for clarification over a conversation (Maguire 2001).

8.2.3 HCI as a tool for energy saving interventions

It is understood that the cooking activity places challenges for the use of technological assistants and electronic interventions. Researchers in HCI usually tend to focus on technological solutions for problems, and sometimes a digital intervention is not suitable or advised (Baumer, Silberman 2011). Human-food interaction is sometimes a *celebratory* experience, involving uncertainty, experimentation, creativity and fun. Grimes and Harper

(2008) suggest that people's interaction with food is positive, rich and delightful, and the introduction of *corrective* technology must be done with care. Sometimes there is not much to be 'fixed': users can enjoy a slow cooking process, for example. They suggest that researchers should carefully determine when to introduce technology, to make sure that it is indeed needed. This necessity can provide new ideas about how to design effective technologies "in situations where the introduction of technology makes sense" (Grimes, Harper 2008).

From the results obtained during the first three studies performed during this research, it was possible to envisage different energy saving intervention methods based on the research evidence. The specific needs of the cooking activity indicated that an electronic intervention was an adequate platform to be implemented and tested. Participants of the Third Study reported that during specific scenarios of food preparation, for example when they are cooking something quickly, the introduction of technology might not be adequate. In this scenario, technology can be seen as an obstacle that could make the cooking process longer or more complicated. However, it is possible to make technology more accepted if it brings value to the activity, for example making it more efficient, quicker and easier. The app developed for the experimental condition accounted for these requirements whilst disguising the strategies for reducing the temporal tensions. User interface patterns (Apple Inc 2012, Android Open Source Project 2012) and design best practices (Clark 2010) were followed in order to minimize usability problems and provide a simple and effective platform to be used during the experiments. The app could convey the persuasive technologies for evaluation of time perception manipulation, such as tunnelling, suggestion, entertainment and reduction. During the Fourth Study it was possible to evaluate the designed mobile phone application and gauge user behaviours, energy usage, time to complete the task, acceptance of the technology, level of engagement with the app and evaluate of each of the implemented techniques. Results made it possible to conclude that the selected persuasive techniques embedded in an HCI-based intervention helped reduce the temporal tensions previously observed during cooking and also motivated the performance of behaviours that students are not very inclined to do.

8.3 The rationale for basing the intervention on temporal tensions

The initial studies performed during this research were designed to provide an understanding of the cooking experience, and the barriers and enablers to more efficient cooking, from a student's perspective. This knowledge informed the design of the subsequent phases of this research, when the development and evaluation of the intervention took place.

The First Study [Understanding cooking behaviours] demonstrated that diverse determinants contribute to the wasteful behaviours observed during cooking. Various actions performed during the cooking activity included not measuring the amount of water, boiling the kettle, using high heat, using large hobs and keeping the heat on until the end of the cooking process. These all resulted in greater energy use than necessary. The loose management of time during the cooking process resulted in participants using energy for three times longer, on average, than the researcher undertaking the same activity using the same equipment, but incorporating energy saving techniques. Determinants of wasteful behaviours involved mainly user preferences, need for convenience and desire to cook quickly, and also included other observed and reported factors such as: habit, how flatmates behave, how their family expect them to behave, knowledge, skills, the available appliances, utensils, the absence of financial incentive. The Second Study indicated that participants do not want to increase the length of the cooking process in an attempt to save energy. They also expressed concerns about the energy saving techniques which they believe can take time to be implemented thus making the cooking process longer. Evidences from these studies indicated the influences of the notion of time, starting from the observation that students used more time than recommended to cook the noodles, even though they wanted a quick preparation process. The Third Study showed further arguments to complement to support the rationale of focusing on time for cooking. Students suggested that an electronic cooking assistant could help them make the cooking process quicker and more efficient.

This research demonstrated that temporal tensions (Oulasvirta, Tamminen 2004, Tamminen, Oulasvirta et al. 2004) appeared to be a strong determinant of energy intense cooking behaviours, affecting different phases of the cooking process, namely preparation and waiting. The First Study demonstrated that they rushed into cooking without much preparation, and tried to avoid boredom when waiting for the food to cook. It indicates a temporal tension characterized by the amount of time made available to the task in relation to the goal in question. The first phase of the observed cooking process consists of the user preparing the utensils and ingredients to start cooking. It was noted that students did not pay much attention to the process, as if they were busy with the activity, without time for deliberation. Previous research reported busy cooks rushing to have everything ready, and the problems that it could cause. “The pandemonium that occurs on a busy Saturday night provides direct confrontation with the reality that this is a space for *everyone*, even for the ethnographer watching and scribbling notes” (Demetry 2013). She reports one of the chefs saying that “the minute you start not thinking, or not thinking about food and your mind goes elsewhere and then you get busy, it’s really difficult to keep your mind in third gear”. The second phase of the observed cooking process relates to when the user is waiting for the food to be ready, and participants of the First Study were observed basically stirring and waiting. Studies with professional cooks indicate similar issues: “The inability to fill one's time with a productive activity generates frustration” (Fine 1990). Chefs were seen actively “working time”, manipulating the sense of duration by chatting during long breaks or partaking in small kitchen duties (Demetry 2013).

Previous research reports that “when consumers were stressed, they tended to hurry and were not as careful with the cooking system under investigation” (DeMerchant 1997). Participants of her study were classified in personas, and some of these groups were defined according to their relation to time. Cooks behaving patiently used the least energy to prepare a menu. Conversely, users in a hurry generally presented the highest energy consumption due to pre-heating saucepans, using high heat and not matching the diameter of heat source and cookware.

In certain situations, people deliberately invest efforts to influence perceived duration of events. One extensive study by Flaherty (2003) describes how individuals control, manipulate or customize their own experiences of time. Interviews with 398 participants indicated situations when they were “trying to make an interval seem longer or shorter than its objective length as measured by the clock or calendar”. The strategies described include diverse particularities determined by the situation, from how a student makes time pass quickly during a boring class, how another copes with homesickness by writing letters as a method of remembering the good moments with the family, or even how one participant multitasks in the shower whilst waiting the two minutes required for the conditioner “to work as it’s intended to”. There is also evidence that individuals may use ‘time work’ to manipulate the behaviours of other individuals. Therefore, this manipulation of time perceptions might not only be limited to internal, subjective pressures, but rather have real consequences outside individual experiences of time (Flaherty 2011). The time perception manipulation was presented as an activity typically “marked by purposefulness, regardless of its salience in particular circumstances” (Flaherty 2003), in the sense that individuals sometimes engage in these strategies of ‘time work’, however they are not always conscious of doing so.

It has been shown that individuals can actively engage in particular practices in order to have some experiences and not others, indicating ‘agency’, when behaviours may not be strictly determined by the environment. The idea of self-determinism is necessary to envisage the capacity of people deliberately manipulating the perception of time (Flaherty 2011). One participant in the First Study used the loudspeakers of her mobile phone to entertain herself with some music during the cooking activity, contributing to make the cooking process more enjoyable (Figure 83).

Figure 83 - Participant using the mobile phone loudspeakers to play some music

However, in some occasions, people are not naturally inclined to purposefully manipulate the notion of time, or do not have the resources (cognitive or structural) to engage actively in these activities. In this scenario, social agents or systems could work to provide the resources needed for individuals to perform ‘time work’ (Flaherty 2003). Some authors mentioned the possibility of using technology to manipulate time perceptions for different needs. For example, Oulasvirta and Tamminen (2004) indicate the possibility of use of notifications as a form of reducing temporal tensions, when a system notify the user of important stages of the process, minimizing the attention needed. Students seldom measured the time (First Study), believe that measuring time can add some effort to the process (Second Study) and suggest that timers and alerts can benefit the cooking activity.

Although studies mentioned the presence of time issues among the determinants of energy consumption, and others indicated the possibility of actively reducing temporal tensions, demonstration of an attempt to actively minimize these temporal tensions in relation to energy use were not found in the literature. The manipulation of time perceptions and its relation to energy use seemed to be an unexplored area of research and suggested an interesting and potentially effective approach to promoting sustainable behaviours. For that reason, the modification of time perceptions was proposed as the underlying strategy to be incorporated into the intervention and tested.

8.3.1 Time perception manipulation embedded in persuasive technology

Practical examples in the literature report the application of persuasive technology as platforms where behaviour change strategies are implemented. These studies make use of inherent features and possibilities of ICTs to convey the tactics that might motivate change. The selected tactics used during this research involve the manipulation of time perceptions, making participants dedicate more time to the preparation, and making time seems to pass quickly during the activity. A number of studies in the literature demonstrate strategies to modify perceptions of duration. For example, one study demonstrated that by showing participants beautiful images of desserts can make the time seems to pass quicker than displaying neutral images, and the contraction of the time interval is more pronounced if participants are hungry (Gable, Poole 2012). Another study investigated the effectiveness of filler interfaces presented during the wait for search results. Their results indicate that there is influence on users' perceived waiting time, which seems to be shorter with attractive distractions (Lee, Chen et al. 2012). These studies present evidence of the possibility of manipulating individual's perception of time in diverse settings. However, to the best of the knowledge of the researcher, there is no reports of interventions designed to evaluate the reduction of temporal tensions to promote energy saving.

This research provided interesting results supporting the use of persuasive technology to reduce temporal tensions and consequently reduce energy use. For example, tunnelling was very successful in having participants to dedicate more attention and time to the preparation process and follow the recommended steps. Observed behaviours and responses from participants show rather high adherence to the suggested cooking procedure, as expected. Leading the user through a 'tunnel' can help them achieve their goals by guiding the process, especially when a complex number of steps is involved (Fogg 2003). The adherence to the instructions (and consequently to the recommended energy saving techniques) was much higher during the Fourth Study than the First Study (when participants seldom performed the energy saving behaviours). As demonstrated during the Fourth Study, when the app presented a step-by-step guide, participants reported that it made the information processing and the task performance easier. The combination of observed data and thematic analysis indicated that the temporal tension present during the preparation phase was minimized through the tunnelling strategy. However, three participants complained about this same feature, stating that they would prefer to see the whole picture prior to proceeding. Making the user a captive audience can trigger negative reactance once it threatens personal freedom or choices (Brehm 1966). One of these participants added that the tunnelling process limited his freedom to make his own decisions.

‘Tailoring’ provided the possibility to customize the results according to users’ preferences. Previous research indicates that having tailored advices on a mobile phone showing tips to save energy at home “was well accepted and effective in supporting electricity conservation behavior” (Gamberini, Spagnolli et al. 2012). From the First Study it was determined that the cooking process, even when quick and simple, should account for particular preferences. All participants in the Fourth Study rated this feature positively. Some of them indicated the need for more recipes and more options, specifically allowing the addition or modification of ingredients. The customization of the cooking process improved adherence to the application, therefore facilitating the delivery of the other strategies that implemented the time perception manipulation.

‘Suggestion’ was implemented to provide the information at the right time. Participants from the Fist Study rarely read the packet instructions and consequently did not use measurements or followed a procedure. This research used the capability of this persuasive intervention to convey a message informing a desirable course of action at the right time and place. The strategy of suggestion is linked to the principle of *Kairos*, a Greek word meaning the right or opportune moment (Oinas-Kukkonen, Harjumaa 2009, Fogg 2003). Embedding this strategy in a mobile phone can increase the potential to persuade, since the cues can be given at a particular time, when the user is in a specific location and performing a given task. During the Fourth Study, participants mentioned that they appreciated the instructions, that it was convenient to have it during the cooking process and that it contributed to a better quality of food in the end. It is important to note that this research did not convey the information about energy use to participants. The literature presents diverse examples of studies on the role of energy monitoring and energy use feedback in the attempt to motivate savings (Ueno, Sano et al. 2006, Darby 2006, Riche, Dodge et al. 2010). The information presented in the app contained only the manipulations of time perceptions and energy saving techniques ‘disguised’ as regular cooking instructions.

‘Entertainment’ was implemented during the Fourth Study in the attempt to reduce the temporal tensions observed and reported throughout this research. During the First Study, participants tried to speed up the process to avoid boredom at the cost of additional energy usage. The presence of videos in the experimental version of the app proved to engage users with the application and promoted a cognitive involvement with the app. Participants in the Fourth Study reported engagement and being entertained, which made time pass quickly. Their reports are in agreement with the public notion that ‘time flies when you are having fun’, which was also suggested by previous research (Agarwal, Karahanna 2000). Participants who used the simpler version of the app (control) without the strategies to minimize temporal tensions reported that time was ‘dragging’, corroborating the adage that says ‘a watched pot never boils’

(Flaherty 2000). When individuals are waiting for something to happen and endure delay, they become conscious of the interval that separates them from the awaited moment, causing discomfort (Fraisse 1963). Consequently, it is possible to say that the app designed for the experimental condition fulfilled the objective of minimizing boredom when waiting during the cooking process.

The ‘reduction’ strategy embedded in the app included the possibility of attributing to the mobile device the task of timing the process (Maguire 2001), minimizing the necessary mental load involved with the cooking activity (Fogg 2003). Participants in the First Study seldom used a timer when cooking, usually resulting in a longer preparation time than was necessary. This strategy was implemented during the Fourth Study via countdown timers and prompts indicating the end of the cooking time. Most participants managed to turn off the hob at the ideal time to promote energy saving, and none of the students evaluated this strategy negatively.

It was noted, to some extent, an improvement in self-efficacy, as reported during the Fourth Study (section 7.3.9). The app provided an environment where ‘enactive mastery experiences’ took place. This is one of the core elements for constructing self-efficacy (Bandura 1994): Through difficulties and experience of success it is possible to build a resilient belief of self-efficacy. To foster self-efficacy, users should dedicate some effort into an activity, and most importantly, succeed in it. Participants reported, usually with surprise, that the experience of cooking following the suggested procedure proved to be beneficial to the cooking process, when they gained knowledge of efficient techniques whilst providing the expected (or even improved) outcomes. Usually students lack knowledge and skills relating to food preparation. Any opportunity to develop good practices will help them form “the habits that will hopefully make them succeed during this life stage” (Blichfeldt, Gram 2013).

8.4 Analysis of combined results

The initial and final experiments performed during this research, which featured energy monitoring, generated remarkably dissimilar results. Participants from the First Study performed the cooking task in diverse ways, consequently having diverse energy usage. On the other hand, most students followed a more controlled procedure during both phases of the Fourth Study, consequently having less variation in energy usage. Phase B of the Fourth Study was selected for comparison between these cooking activities due to being the experimental condition.

It is important to note that a cross study comparison should be taken with care due to a number reasons as follows: participants in the First and Fourth Studies were not the same; the Fourth Study was performed 2 years later; during the Fourth Study participants were asked to cook using the app whereas during the First Study they were asked to cook as they normally do; and the researcher was the subwarden of the hall where the Fourth Study took place. All these variables could have influenced the results providing data with different parameters, therefore the comparison between both studies presented here is for illustrative purposes only.

Non-parametric statistical analysis, more suitable for small samples and irregular distributions, were performed to determine any statistical differences between these studies, and the results are presented below. Mann-Whitney U test can be used when the researcher wants to compare differences between two independent groups on a continuous measure (Pallant 2007, Robson 2002, Cohen, Manion et al. 2011). This Mann-Whitney U test analysis revealed a significant difference in the median energy usage during the First Study (Md = 196.5 Wh, n = 20) and the Fourth Study B (Md = 100.5 Wh, n = 12), U = 23.5, z = -3.75, p < .01. This result indicates that participants in the Fourth Study, who followed instruction from a mobile phone application featuring time perception manipulations, used significantly less energy than participants from the First Study who cooked freely, having only the instructions from the back of the packet (Table 48 and Table 49).

Table 48 - Mann-Whitney U test statistics, First and Fourth Studies

Test Statistics[a]

	Energy use
Mann-Whitney U	23.500
Wilcoxon W	101.500
Z	-3.758
Asymp. Sig. (2-tailed)	.000
Exact Sig. [2*(1-tailed Sig.)]	.000[b]

a. Grouping Variable: Studies 1 and 4 (B)

b. Not corrected for ties.

Table 49- Median scores, First and Fourth Studies

Report

Energy use

Studies	N	Median
1	20	196.50
4 (A)	12	118.35
4 (B)	12	100.55
Total	44	147.00

Figure 84 presents the comparative graph across both studies, illustrating the reductions in mean energy use observed during the Fourth Study. It is important to note that the First and Fourth studies were undertaken with different participants. Differences in the sample population could have partially contributed to the variances in energy use observed across the studies. However, both experiments had undergraduate students living in halls of residence as participants, which made it more likely that they were from the same demographic group in terms of age and education level. The energy monitor used to collect energy use data was the same across all studies. Utensils used during both experiments were similar and the appliances of same type (electric metal plate hobs), although of different brands. To provide an evaluation of differences in energy resulting from appliances and utensil characteristics, the researcher performed the same cooking task using both configurations. The result of this was that the energy use was 63 and 75 Wh when using the settings of the First and Fourth studies, respectively. It indicates that the configurations used for the Fourth Study (e.g. the energy consumption of the specific cooker) were 19% more energy intense than those available during the First Study. For visualization purposes and to enable accurate comparison of the energy usage due to cooking *behaviours*, the results of the Fourth Study were reduced by 19% and a readjusted graph is presented in Figure 85.

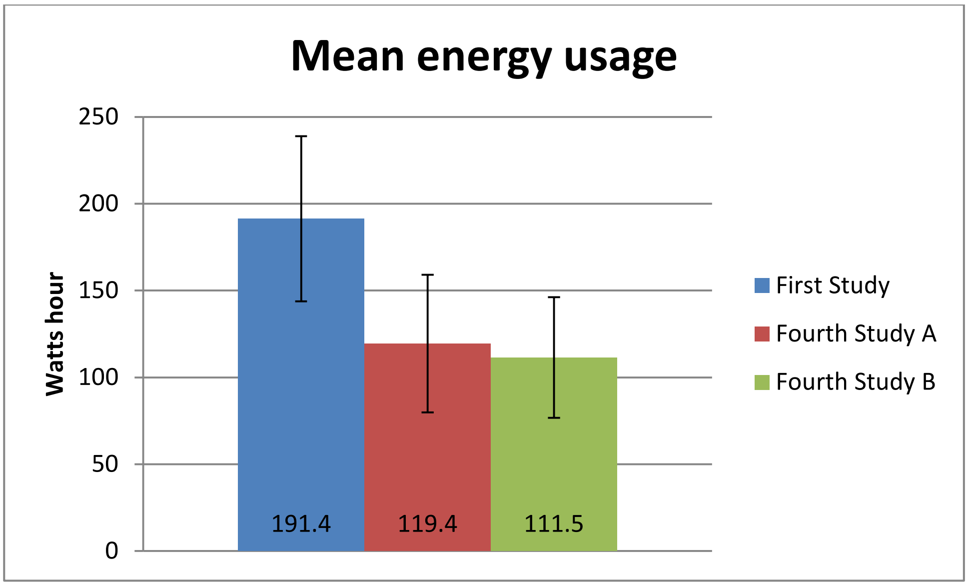


Figure 84 - Mean energy usage across studies, Watt hours and S.D.

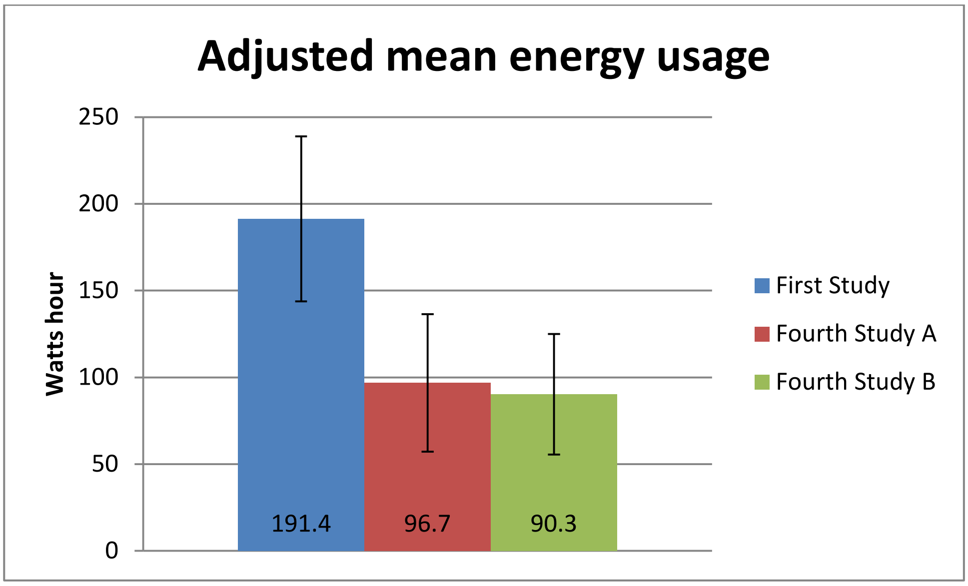


Figure 85 – Adjusted mean energy usage across studies, Watt hours and S.D.

8.4.1 Summary of results

The cross-study Mann-Whitney U test (Table 48 and Table 49) and comparison of mean values of energy monitoring data (Figure 84 and Figure 85) revealed that participants in the phase B of the Fourth Study used significantly less energy than participants from the First Study. The mean energy use from the Fourth Study was 2.11 times smaller than the First Study.

However, as described in the results section of the Fourth Study, the differences in energy use between phase A and B (within subjects comparison) are not significant. It was expected that participants would not follow the instructions precisely when using the control version of the app (A). Due to the lack of temporal tensions (Oulasvirta, Tamminen 2004, Tamminen, Oulasvirta et al. 2004) mitigation strategies, the expectation was that participants would jump into the cooking skipping the energy saving techniques present in the procedure, or try to actively speed up the process and avoid the boredom of waiting during the cooking phase. However, this behaviour was not clearly observed during the trial, and statistical analysis indicated that differences in energy use were non-significant. Students acted in similar ways when using both applications and the energy use during these trials was also influenced by the unintentional use of larger hobs, incorrect selection of heat level and other variables in addition to the manipulation of perceptions of time.

Nonetheless, it was noticed that participants felt bored during the use of the type A of the prototype (without the strategies to manipulate the perception of time). It could be observed by their coping strategies involving posture, gestures, bodily movements (Table 31) and a tendency to boredom. Observed cues included participants manipulating objects, holding on the counter, standing still or having low movement dynamics (Wallbott 1998). Conversely, the interaction with the version B indicated involvement and absorption (Csikszentmihalyi 2000), with evidence of this from the video footage analysis (Table 32) and also from a slightly higher mean evaluation of the *flow* of this experimental condition version (Figure 75). This video observation data was complemented with qualitative data from semi-structured interviews to provide a more comprehensive account of engagement with the app. Participants expressed clearly their appreciation of the design strategies employed to alleviate temporal tensions in the version B during the interviews. Students indicated that they experienced cognitive absorption (Agarwal, Karahanna 2000) and that the time perception manipulation strategies indeed made time seems to pass quicker when waiting for the food to cook (section 7.3.6.4). Even though the variation in energy use between trial A and B was not significant, the reduction in temporal tensions indicates that the intervention was successful in manipulating participants’ time perceptions. The strategies implemented during this study can play an important role in promoting behaviour change and energy conservation.

The comparison between the First and Fourth Studies indicates that there is potential for halving energy use during cooking activity merely through behaviour change, without the need to replace appliances or utensils. This is a remarkable finding especially considering that cooking activity accounts for 13.8% of the overall domestic electrical power demand (DEFRA 2012). Halving this figure represents an important step towards reduction of carbon emissions. Potentially, if the strategies presented in this research were applicable across the range of cooking tasks, it is possible to save about 7% of UK's domestic electricity consumption. Additionally, if the manipulation of time perceptions could be applied to other domains of energy use, these figures can be even higher. Some of these diverse fields that can benefit from the reduction of temporal tensions are presented in section 9.5 - Recommendations for future work.

8.5 Structure for the development of interventions

The structure of this research project was constructed partially based on the Intervention Mapping Protocol (IMP), with which researchers can guide the procedures of planning activities and methods for change (Kok, Lo et al. 2011, Bartholomew, Parcel et al. 2001, Uitdenbogerd, Egmond et al. 2007). The IMP consists of the following steps:

1. Problem analysis, with an analysis of energy relevant behaviour, the determinants and context factors;
2. Choose specific behaviours, determinants and target groups, resulting in program objectives;
3. Select theory- and evidence-based methods and practical techniques;
4. Develop the programme;
5. Make an implementation plan;
6. Make an evaluation-plan.

This research was designed loosely based on this procedure, but during the development of the activities, a few different routes were taken and some steps added to the process. Modifications were made to fit the specific characteristics and purposes of the studies performed. This section describes the research activities undertaken in relation to the IMP, and identifies were modifications may be made to the original protocol. This research started from a comprehensive literature review, where diverse studies were consulted to present the background of research that guided this PhD project. The relevant behaviours identified were associated with domestic energy use, more precisely those related to food preparation. Some gaps in the current literature where found in an area combining sustainable HCI (DiSalvo, Sengers et al. 2010), persuasive technology (Fogg 2003), temporal tensions (Oulasvirta, Tamminen 2004, Tamminen, Oulasvirta et al. 2004) and perceptions of time and duration

(Flaherty 2000, Agarwal, Karahanna 2000). The need for more research combining these specific areas of knowledge was identified.

A subsequent phase consisted of understanding users in terms of behaviours and respective determinants (First Study). Interventions can be more effective if they are based on a thorough identification of the behaviours to be changed and examination of the main factors underlying this behaviour (Steg, Vlek 2009). It is possible to increase the effectiveness of an intervention by targeting the determinants of energy use (Uitdenbogerd, Egmond et al. 2007, Abrahamse, Steg et al. 2005). This research identified that issues related to time, convenience and preferences were strong determinants of energy use. It was identified that more effort had to be invested in defining the wasteful behaviours to be changed and those to be promoted. A definition process to select the energy saving techniques to be explored (reported in section 4.6) was performed based on recommendations from Booth (1996). The selection process involved evaluation of the potential impact of behaviours on energy use, the existence of approximations to the ideal behaviour, the positive consequences, compatibility with cultural norms or current practices, costs to users and complexity to implement.

It emerged from the First Study that some wasteful behaviours were caused by issues surrounding the appliances used during the experiments. The heating rate of metal hobs, its thermal inertia, lack of feedback of energy use, among others, motivated the exploration of the appliance behaviours and characteristics in more detail (section 4.6). It was noticed that some energy saving techniques could be implemented in order to counteract issues related to the appliance (for example turning the hob off before the end of the cooking time).

The knowledge of user behaviours, the respective determinants and the appliance characteristics informed the design of a set of energy saving techniques that could promote energy saving for cooking. However, it was important to evaluate the acceptance of these proposed techniques prior to introducing it in the 'real world'. The Second Study was designed to understand, from participants' point of view, the acceptance of these techniques. An online survey based on the Theory of Planned Behaviour was chosen as the method of data collection (Ajzen 2006, Ajzen 2002, Francis, Eccles et al. 2004, Fishbein, Ajzen 2010). Results indicated which of the energy saving techniques were more likely to be accepted by the target population (section 5.6).

The methods to constitute the behaviour change intervention were developed during the Third Study of this research. They were selected based on the determinants of selected wasteful behaviours, appliance characteristics, desired behaviours to be promoted, context of energy use in question and the selected time perception manipulation elected as object of study. This phase also involved scenario analysis and idea generation sessions to contribute to the creative process of the HCI-based intervention. These requirements and suggestions indicated that a HCI-based intervention would provide the adequate test bed to be used during this research. Electronic devices offered the platform for time perception manipulation via persuasive technology strategies such as tunnelling, suggestion, entertainment and reduction (Oinas-Kukkonen, Harjumaa 2009, Fogg 2003). A mobile phone application was developed to encompass these strategies and be tested. The final phase of this research constituted of an evaluation study, when the application was tested during a two-phase experiment. Subsequently, the whole development process was subject to evaluation, when findings were reported and contributions defined.

The design process implemented during this research, although specific to the context of energy use chosen, might be useful in contributing to the development of future HCI-based interventions. A modified intervention mapping protocol can be suggested as following:

1. Problem analysis, with an analysis of specific domains of energy use, context factors and identification of issues to be addressed;
2. Understand the complexity of behaviours related to energy use and their respective determinants;
3. Understand infrastructure, appliances or context and how it affects behaviours;
4. Select specific determinants considering feasibility and impact;
5. Define the desired behaviours to be promoted;
6. Evaluate the acceptance of the selected behaviours and shortlist behaviours to be promoted (if needed);
7. Define the suitable strategies to be implemented and the adequate platform to present these strategies;
8. Develop the intervention;
9. Evaluate the intervention;
10. Evaluate and report findings and pitfalls of the program.

8.6 Limitations

This research presented individual limitations relative to each study in their respective chapters. However, the more general limitations of this research are aggregated in this section. These include the limitations of the use of persuasive technology as the strategy to motivate behaviour change. The ethical considerations relative to persuasive technology and other implemented research methods are presented at the end of this chapter. The Theory of Planned Behaviour, even though is the most widely used model for prediction of attitudes, intentions and behaviour, is often target of criticism. For that reason, special considerations were made to justify the adoption of this theoretical model of behaviour. This section presents also limitations in relation to the overall research methods implemented during the course of this research.

8.6.1 Limitations of persuasive technology

Persuasive technology has an established field of work, and numerous projects undertake scientific research using its tools and methods every year. Nonetheless, there are criticisms that must be taken in consideration, for example those highlighted by a recent literature review on 36 papers reporting the use of persuasive technology for sustainability (Brynjarsdottir, Håkansson et al. 2012). First, research on persuasive technology can be "based on a limited framing of sustainability, human behaviour, and their interrelationship". Also, often complex issues of sustainability are framed under simple metrics, and technology is placed incorrectly as objective of what would be rather complex issues. Frequently, the designer is "responsible for deciding what constitutes desirable behaviour change and how this is to be accomplished", and participatory design is rarely reported. They also indicate that often, studies focus on changing individual behaviour, but do not clearly define target behaviours: "users are given no specific direction on how to decrease their resource consumption or how much decrease is enough". Brynjarsdóttir et al. (2012) also analyse that studies on persuasive technology generally frame users as individuals, isolated from the social, cultural and institutional contexts where they live, consequently tending "to assume that individuals have a greater capacity for action than they actually do in practice".

This research tried to prevent these shortcomings through a number of methods. It is understood that human behaviours are complex and interrelated. User observation, in depth interviews and surveys were used to gather a broad understanding of users, their behaviours and respective determinants (First and Second Studies). Regarding the use of technology as solution to sustainability problems, it is acknowledged that it is not always the case. Sometimes persuasive technology is introduced when it is not welcomed or needed. However, for the challenges raised during this research, an electronic intervention was defined as the most suitable method, based on solid data and reasoning (Third Study). With regards to the definition of what constitutes the desirable sustainable behaviours, it was made following extensive literature research, after performing in-site experiments and with the help of a large scale survey to evaluate the acceptance of these proposed behaviours (First and Second Studies). During this research users were always at the centre of the design process, either by providing information on problematic behaviours and determinants (First and Second Studies), or by indicating how an electronic intervention could improve their cooking activity (Third Study). This research states clearly the behaviours to be promoted and indicates how technology is used to accomplish that. It also recognizes that contexts play an important role on people's behaviours. The studies performed during this research accounted for diverse external factors affecting students behaviours, from family, friends, appliance characteristics, ownership of utensils, the dynamics of student kitchens and also the disconnection between energy use and accommodation fees.

Hallnäs and Redström (2001) suggest that the objectivity of modern technology, in terms of efficiency, immediate 'visible' results and task orientation could be replaced by an intervention designed for thinking, where the users "reflect and think about it". The app designed during A recent literature review (Knowles, Blair et al. 2013) indicates that studies trying to promote sustainability often focus on the use of technology to foster environmentally responsible behaviour on an individual level, paying less attention to social, economic and environmental needs. They recommend more radical and comprehensive understandings of sustainability. Although powerful and problem-solving oriented, persuasive technology research must take in consideration a broader understanding of sustainability and the complexity of social problems in order to better deliver the solution to the problems it claims to solve. This research acknowledges these criticisms and indicates that measures were taken to minimize them. Persuasive technology was identified as one of the possible strategies to be implemented after three studies involving a combination of research methods, extensive data collection and thorough analysis. The complexity of user behaviours and the diversity of determinants of behaviours were evaluated during the decision making process. The set of desirable behaviours was defined after detailed analysis and intended not to conflict with user's determinants. For example, the cooking process takes shorter than usual by following the proposed techniques, in harmony with students' desire to have quick food preparation.

8.6.2 Limitations of the Theory of Planned Behaviour

In order to enhance the effectiveness of interventions, designers can make use of behaviour theories to inform the design of HCI-based behaviour change interventions. Established theories are often "used both to make decisions about which functionality to support and how to implement such functionality" (Hekler, Klasnja et al. 2013). It is believed that providing a solid base with theoretical explanations for design decisions could improve the success of interventions. The Theory of Planned Behaviour (TPB) is extensively used and tested, and can be relevant for intention and behaviour change programs (Hardeman, Johnston et al. 2002). TPB and its developments state that people behave according to their intentions, and these intentions are formed by their attitudinal beliefs, perceived norms and perceived behavioural control. A detailed measurement of the influence of each of these three constructs was performed during the Second Study, in order to evaluate the real impact of them on people's intentions to perform a set of desired behaviours. However, the relative contribution of these three constructs "is expected to vary from one person to another, from one group of individuals to another, and from one behaviour to another" (Fishbein, Ajzen 2010). Authors indicate that the TPB focus on intentions and do not evaluate the role other constrains and facilitators such as habits and personal norms (Klöckner, Blöbaum 2010). To counteract these limitations, this research used the results of the Theory of Planned Behaviour in combination with observational measures, actual behaviour accounts and qualitative data from semi-structured interviews. By doing so, it was possible to provide a wider dataset for further analysis and evaluation.

Diverse examples in the literature demonstrate that the TPB can contribute to the analysis of behaviours and intentions (Gill, Tierney et al. 2010), evaluate determinants of behaviours (Bamberg, Schmidt 2003), compare beliefs and intentions with actual observed behaviours (Nigbur, Lyons et al. 2010), provide suggestions to behaviour change programs (Tonglet, Phillips et al. 2004) and analyse barriers to energy conservation measures (Stokes, Mildenberger et al. 2012). The literature indicates that the TPB can be an efficient tool to understand behaviours, evaluate barriers and indicate directions to the design of effective behaviour change programs. The knowledge of barriers and facilitators of behaviours performed during the Second Study of this research suggested the adequate interventions to be implemented in order to result in energy saving for cooking (Ajzen 1991, Fishbein, Ajzen 2010).

There are diverse social-psychological models in the literature attempting to understand behaviours and determinants. From the analysed models, the Theory of Planned Behaviour (Ajzen 1991) was selected due to the fit to this research and to the explanatory power. Results from the First Study indicated that students were behaving as they did due to their attitudes, influence of their family members and friends, and to their internal and external levels of control to perform the cooking task (such as knowledge, skills, the utensils and appliances available and the billing system implemented in student accommodations. Previous research supports the idea that TPB can be a unifying framework to guide research on environmental attitudes (Kaiser, Wölfing et al. 1999), providing often a high explanatory power of people's behaviours (Bamberg, Schmidt 2003, Kaiser, Hübner et al. 2005).

The Theory of Planned Behaviour and its developments are sometimes challenged due to being limited to only three constructs (attitudes, perceived social norms and perceived behavioural control) to explain human behaviours. Fishbein and Ajzen (2010) defend their theoretical approaches indicating that these three constructs are indeed sufficient since empirical studies tested the inclusion of other measurements but failed to improve the explanation power of the theory. Another criticism is that the theory accounts for planned behaviour, consequently expecting people to be rational in their decisions. Psychological research defends that many decisions "are made by automatic, unconscious processes on the basis of information that our conscious, rational brains are hardly aware of" (Manning 2009). Their defence to this statement is that people form their beliefs through experiences in life. These beliefs are formed by diverse processes including inaccurate inferences, intuition, biased conclusions and also logical trains of thought. Attitudes, social norms, level of control and "ultimately their intentions follow spontaneously and inevitably from their beliefs. It is only in this sense that behaviour is considered to be reasoned" (Fishbein, Ajzen 2010, p. 301).

Another criticism of these models is that they do not take into consideration "behavioral practices, situated in time and space that an individual shares with other human agents" (Spaargaren 2003). A sociological and practice based approach to behaviours and lifestyles could provide more contextually rich insights into understanding how energy is used during cooking (Bates, Clear et al. 2012). These concerns are part of the wider debate between disciplines relating to the role of practice based and behaviour based approaches within sustainable design and in particular sustainable HCI (Shove 2010). This research had a broad user observation study (First Study), which provided rich and meaningful data from user behaviours obtained from video analysis of behaviours and semi-structured interviews. The TPB was used during a subsequent phase (Second Study), not to understand or predict behaviours but only to evaluate students' acceptance of a set of energy saving techniques. An elicitation study comprising open-ended questions and an online survey in the form of a TPB-based questionnaire was implemented. With this instrument, quantitative results from a large number of participants could be combined with the qualitative data from behaviour analysis and interviews, therefore providing a richer dataset, which informed the following phases of this research.

8.6.3 Some methodological limitations

An expressive part of this research was based on interviews which were later transcribed and analysed. The transposition of rich narratives from interviews into textual format certainly incurs losses. The richness of meanings delivered through a personal communication goes beyond the verbal content, presenting also subtle nonverbal expressions (Bazeley 2007, Miles, Huberman 1994). All efforts were taken in order to transcribe data 'verbatim', including every single word spoken and some manifestations such as 'hums', laughter and hand signals. However, even with this determination, some information might have been lost on the way.

The First and Fourth studies implemented during this PhD research analysed behaviours from single observations. The user observation studies framed a limited aspect of the cooking experience in a reasonably controlled environment. It is likely that participants could perform the cooking task differently next time around. Sociological and anthropological studies of behaviours place energy use in larger social, cultural and historical contexts, indicating that social networks, communities and families affect energy and behaviour (Lutzenhiser 1993). Social Practice research defends that more wide-ranging and prolonged studies can provide a better account of individuals' behaviours (Shove 2007). The restricted temporal and social nature of the studies is one limitation of the research design chosen. Other methods such as ethnographical analysis or practice theory could account for the diversity and complexity of influences on individual activities and provide richer data (Schatzki 1997).

Sometimes people might not clearly express what they mean, and will not always say what they believe. They might say 'yes' to avoid conflict when they mean no (Kuniavsky 2003). Participants are generally influenced by the pressure to respond positively to surveys or interviews or to sound politically correct. It requires a level of interpretation and discourse analysis to extract the meaning of what people express, and the results might not be accurate. For example, during Fourth Study, when participant 3 was asked if she would use the app again, she replied with a statement that is open to interpretation: *"Maybe, I think I would, if it had, like, different recipes, something a bit more substantial"*. Even if she said that she thinks she would use it again, she added a conditional word (if), and in fact she just avoided replying directly that she would not use again the app as it is. However, sometimes during this research students demonstrated strong opinions and admitted going against their hall of residence rules, for example when leaving cooking unattended.

It is important to mention that some of the studies performed during this research are sometimes referred as experiments. However, they cannot be labelled true experiments since they do not use randomized control trials (RTC). The scientific nomenclature of experiment requires participants being sampled randomly among the population, and randomly assigned to either the control or experiment condition (Robson 2002). Participants for all phases of this research were directly invited and some of those invited did voluntarily decide to take part in the study. It can inevitably bias the sample because those who were willing to take part in the research might be different in terms of values, beliefs, attitudes and behaviours from the rest of the population. However, as this research is dealing with human beings, it is rather difficult to achieve a truly representative sample due to ethical reasons. People have their free will, and it is not possible to simply randomize a sample from the study population and expect that every selected person will give their consent to participate.

8.7 Ethics

Persuasion is sometimes not seen with good eyes, likewise marketing or advertising. Similarly to probably any area of knowledge, its tools and strategies can be used for the good or evil. Understandably, using persuasive strategies embedded in technological apparatus is also often the target of criticism. Computers can be proactively persistent, can control the interactive possibilities, can affect emotions but cannot be affected by them, they cannot shoulder responsibility, and do not accept responsibility if things go wrong (Fogg 2003). Furthermore, the nomenclature of persuasive technology was challenged by Atkinson (2006). She argues that the relation between computing and persuasion would be more appropriately labelled as ‘computer-mediated persuasion’. The designer persuades, not the computer: “The computer is the tool of the designer”, only working as “the mechanism for conveying, or mediating, its designers’ intent”. The researcher acknowledges that computer-mediated persuasion could be more adequate phrase to describe this activity. This research is using technology as a tool to convey the strategies designed to change behaviours. However, to be in line with previous publications in the field, the term persuasive technology was used.

Whenever using methods to change what people think or do, it is important to make sure that no ethical rules are being broken. These concerns are especially important if working with persuasive technology. Computers can be stronger persuaders than human-human persuasion. According to Fogg (2003) computers have a rather positive reputation nowadays, but several characteristics can put these impressions at risk.

When designing interventions to be ethical, it is important that the content and information provided are “as accurate as possible, based on the latest scientific knowledge” (Fishbein, Ajzen 2010). The intervention has to guarantee that people are free to accept or reject the information provided, and the intervention should not attempt to change behaviours that are known to be detrimental to the individuals’ well-being or to the well-being of others or the environment (Fishbein, Ajzen 2010).

To better assess if a persuasive intervention is being ethical or not, it is important to review three main topics: intentions, methods and outcomes. These items, described by Fogg (2003), are detailed below. The intention of a persuasive application aiming to reduce energy use is highly ethical. The individual and the environment can both benefit from it. The methods designed for this research can be considered ethically sound because they empower individuals to make better decisions for themselves, guide users to better perform activities that they are already used to doing, and engage them with a fun interactive environment. Unethical methods such as deception or coercion were not be implemented in the system. The last item, the outcomes of the persuasive technology, can also help assessing the ethics of systems. As the intended outcome of this research is benign, there might be no ethical concern, but it is necessary to evaluate the possibility of unintended outcomes emerging during the course of the research.

Atkinson (2006) adds a pinch of criticism to Fogg's account of ethics in persuasive technology, which would be limited. She states that computer-mediated persuasion will only be ethical if the user is fully informed of the persuasive intentions. When asking the question 'is computer mediated persuasion ethical?', she answers it herself:

> It is ethical only if they are aware of the intention from the outset of their participation with the program. Anything that occludes this function is a form of manipulation which in turn can lead to coercion and be associated with propaganda and information that seeks to thwart and distort individual autonomy and even sound reasoning. […] Persuasion that operates without the user being aware of the programmers' intent, it could be argued, might be ethical if the change in attitude, behaviour or belief is motivated from the perspective of wisdom, benevolence and genuine care for others. But would not this sort of benevolent intent be better constructed and represented by the sound reasoning we know as advocacy or even education, where intent is exposed at the outset or revealed through simple inquiry about course content?

Not many forms of persuasion would pass this stricter framing of ethics. Diverse examples of online persuasion would be inappropriate, such as those frequently used shopping recommendations, scarcity announcements, or authority endorsements (Kaptein, Eckles 2010). Furthermore, there is always the likelihood that by disclosing persuasive strategies the target attitude or behaviour change will reduce. Participants in the Fourth Study could behave differently if they were told that the tunnelling strategy was implemented for them to pay attention to the energy saving instructions, and that the entertainment was presented to make them more comfortable turning the heat off to save energy a few minutes before their food is ready.

Oinas-Kukkonen & Harjumaa (2009) also suggest that "persuasion through persuasive systems should always be open". They suggest that the designer bias behind the strategy should be revealed. One omission during this research was that, during the observation studies, energy consumption was monitored without participant's knowledge. This might raise ethics concerns, but as it is a vital part of the research, it was chosen to keep this information secret, as the awareness of this data collection might strongly influence the participant's performance. One of the "ethical principles of persuasion" states that "[t]he creators of a persuasive technology should disclose their motivations, methods, and intended outcomes, except when such disclosure would significantly undermine an otherwise ethical goal" (Berdichevsky, Neuenschwander 1999). If energy saving and sustainable behaviours are to be considered ethical goals, then it seems justifiable to omit the nature of the persuasive strategies embedded in the app used during this research.

One of the 'ten questionable practices in social research' described by Robson (2002) refer to revealing what the experiment is about. He argues that researchers should try not to withhold information about the true nature of the research. However, in particular studies, these methods can be considered if "the benefits accruing outweigh the costs". In a research setting, the intentions and measurements often cannot be revealed. That's the case when the research was designed specifically to measure the effect of one experiment condition: Experimenters usually provide a cover story to disguise the true measurements (for example Gable, Poole 2012). If researchers tell participants that they are testing the effect of placebos, it will probably influence results. If during the Fourth Study participants were primed that one app was simpler and the other designed to make them adhere to the instructions and relax when waiting, that would probably bias them to do exactly that. This research had to deliberately omit the purpose of the studies in order to be able to evaluate the effect of the intervention unbiased.

One concept used recently is "benevolent deception", which often exist in HCI and researchers and practitioners might choose to use it (Adar, Tan et al. 2013). Persuasive system present opportunities for improving our understanding and ability to craft useful systems, and this deception can and should be used "*for* rather than *against* users". In conclusion, this research implemented strategies that could benefit users (for example through a shorter cooking time and a more enjoyable experience without boredom or anxiety) and that the aim of the persuasion is ethical per se (promoting energy saving and sustainability). This research made sure that the 'Golden Rule of Persuasion' was followed: "The creators of a persuasive technology should never seek to persuade a person or persons of something they themselves would not consent to be persuaded to do" (Berdichevsky, Neuenschwander 1999).

8.8 Conclusion

This chapter presented discussions of the contents and results of this thesis. It also indicated the methods rationale undertaken during this research. The research motivations were demonstrated and linked to the choices presented during this research. These choices included domestic energy use, cooking behaviours, time-related issues as determinants of energy use, persuasive technology as the strategies implemented and mobile phone as the platform to present these strategies. This chapter also presented the evidence that led to the design of interventions to change temporal perceptions, and discussed the influence that temporal tensions and time perception manipulation can have on energy use. Limitations of the research methods used during this PhD project were also presented, in addition to the sections present at the end of each of the study chapters. A combination of results from the four empirical studies performed during this research was presented and discussed. It made possible to have an overview of how data from the initial studies fed subsequent phases, and how the aggregated data informed the design of the behaviour change intervention tested during the Fourth Study. Furthermore, a cross-study comparison indicated how different the energy use was between students cooking freely and those using the mobile phone application containing strategies to manipulated perceptions of time. The discussion of these findings led to the conclusion that having the strategies to reduce the temporal tensions observed during the cooking activity can promote energy saving. The next chapter, which concludes this thesis, draw from the discussions presented here to inform the general conclusions from this PhD research.

9 Conclusion

This chapter answers the sixth and last research question:

RQ6: How can this knowledge contribute to the development of future HCI-based behaviour change interventions?

9.1 Introduction

This chapter presents the research conclusions of this PhD research. It describes how the aims were met and the objectives accomplished, indicating the results that contributed to these conclusions. The six research questions are placed here with the corresponding answer extracted from the individual chapters. This conclusion chapter then presents the contribution to knowledge and indicates areas where further research is needed.

9.2 Achievement of research aims and objectives

The overall aim of this research was to design and evaluate an intervention that introduces modification of time perceptions as one of the solutions to promote sustainable behaviours. The literature review and the two initial empirical studies provided the knowledge that informed the design of the selected intervention. The two subsequent studies involved the development and evaluation of this intervention containing the manipulation of time perceptions. The knowledge produced during this research indicates that manipulation of time perceptions can contribute to sustainable behaviours, hence indicating the achievement of the overall research aim. Specific objectives were developed to provide a breakdown of the main research aim. These objectives are described below, following each research question that guided this project.

9.3 Research questions

The following research questions were answered during the course of this PhD:

RQ1: What is the current background of research related to energy use, and how does it indicate possible strategies to guide the design of behaviour change interventions?

Chapter two answered the first research question by presenting a comprehensive literature review. It demonstrated examples of previous research related to energy use in general, domestic energy use and more specifically what aspects influence energy usage for cooking. It presented the role of people's behaviours in energy consumption, and the existing challenges to promote sustainability. A number of studies presented protocols, models and strategies that could be used to promote sustainable behaviours. The studies also demonstrated the existence of a gap in the literature, where studies involving HCI, persuasive technology and time perception manipulations could be merged into one research project.

RQ2: What are the key energy related behaviours and what are the determinants of these behaviours associated with cooking?

In order to answer the second research question, the First Study [Understanding cooking behaviours] provided a detailed view of the energy related behaviours for cooking and domain-specific factors that were identified as determinants of these behaviours. A combination of methods was used to provide these results, including observation of actual behaviours, energy monitoring, questionnaires, rating scales and qualitative data from semi-structured interviews. The behaviours that resulted in additional energy usage for cooking noodles were identified as follows:

- Not reading the packet instructions
- Boiling the kettle
- Not measuring the amount of water
- Using large pans
- Using large hobs
- Not using the saucepan lid
- Pre-heating the hob
- Using high heat towards the end of the cooking process
- Not measuring the time

These behaviours affected energy use since participants needed longer cooking time than needed, overheated hobs and wasted heat. The main determinants of these behaviours were identified as following:

- User preferences
- Need for convenience
- Desire to cook quickly
- Habit

- The influence of how flatmates behave and how their family members behave
- Knowledge and skills
- The characteristics of the available appliances and utensils
- The absence of financial incentive to save energy

RQ3: What is the acceptance of a set of energy saving techniques for cooking among the target population?

The Second Study [Theory of Planned Behaviour Survey] investigated how strongly students' beliefs influence their intentions to perform a set of energy saving techniques, therefore answering the third research question. Results indicated which aspects of students' general attitudes, perceived social norms and perceived behavioural control most affect the performance of these behaviours. The results provided insights into different strategies that can be implemented to result in behaviour change.

This study also showed that students are not inclined to perform a behaviour that, according to their beliefs, increases cooking time. It indicates a tendency towards energy intense behaviours that can reduce cooking time, in accordance with the results from the First Study. These results provided insights into the design of behaviour change interventions. The main recommendation from this study is that an intervention should target to reduce cooking time whenever possible, since students have the predisposition to perform activities that save time during cooking, and an intervention should try to alleviate the feeling that the cooking process is long, therefore making individuals less likely to try to speed up the cooking process through unnecessary use of energy.

RQ4: How can the knowledge of user behaviours inform the design of new interventions to reduce electricity consumption while cooking?

The Third Study [Intervention design and development] addressed the fourth research question combining a literature review (especially on time perceptions and temporal tensions), results from the two previous studies and a user-centred design process. Results from this research indicated the media and the content of an intervention to tackle wasteful behaviours in the cooking context. It was proposed that providing a way to reduce temporal tensions during cooking could improve the user experience and promote energy saving. It was demonstrated that ICTs can provide the tools needed to manipulate time perceptions and therefore be able to bring about changes in the specific behaviours that result in unnecessary energy usage. These tools were implemented via a mobile phone application using a user-centred design process, and a prototype was developed.

RQ5: What is the role of persuasive technology and time perception manipulation in changing people's behaviours and reducing energy usage in the cooking context?

The Fourth Study (Intervention evaluation) addressed the fifth research question. It detailed the mobile phone applications designed to work as the platform for testing the role of an HCI-based persuasive intervention. The two different versions of the app were tested, enabling comparison between one simpler version and another working as a persuasive intervention attempting to reduce temporal tensions during cooking. This intervention was designed with the intention of manipulating time perceptions and consequently changing people's behaviours towards sustainable cooking. The strategies targeted wasteful behaviours in two separated phases of cooking: preparation and waiting. The evaluation of the designed intervention consisted of a controlled user testing with energy monitoring and video recording. Additional data included surveys on technology acceptance and *flow* in interactive systems, and post-experience semi-structured interviews. Data gathered during this study comprised of user behaviours, energy usage, time to complete the task, acceptance of the technology, level of engagement with the app and an evaluation of each of the implemented techniques.

The results presented here made it possible to conclude that the selected persuasive techniques embedded in an HCI-based intervention helped reduce the temporal tensions previously observed during the two separated phases of cooking. The intervention delivered via an app also prompted the performance of the desired energy saving behaviours. Students felt more engaged with the experimental app (incorporating manipulation of time perceptions), which made the time appear to pass more quickly when waiting for the food to cook. Thematic analysis of participants' responses to the interview at this stage indicated that they appreciated the strategies implemented to reduce temporal tensions. According to participants' evaluations, the researcher concludes that the strategies implemented to modify the time perceptions worked as intended, minimizing the temporal tensions present during the cooking activity. However, the experimental app conveying temporal tensions did not in itself result in increased performance of energy efficient behaviours – instead it increased engagement with the app, which contained energy efficient cooking instructions. The majority of participants appreciated having the cooking procedure presented in steps with the instructions displayed at the right time, and the intervention increased the likelihood of them paying attention to the procedure. They also enjoyed having entertainment when waiting for the food to cook combined with timers and prompts that tell them when their food is ready. This study concluded that by minimizing temporal tensions it is possible to increase the likelihood of adoption of sustainable behaviours and consequently promote energy saving for cooking.

RQ6: How can this knowledge contribute to the development of future HCI-based behaviour change interventions?

This sixth and last research question is answered in the next section where the contribution to knowledge is stated.

9.4 Contribution to knowledge

A few literature reviews mention the need for more research on sustainable HCI and persuasive technology interventions (DiSalvo, Sengers et al. 2010, Goodman 2009, Lilley 2009). Interesting examples of uses of ICT to promote sustainability can be found (Zapico, Turpeinen et al. 2009) and the field of sustainable HCI has been growing fast in recent years. However, there is demand for more research in the area, especially regarding success evaluation (Huang 2011). Silberman and Tomilson (2010) recognize the importance of research on understanding users and their relationship with technology. They list diverse studies where the knowledge of user behaviours informs the design of technologies which facilitates more sustainable practices. However, they suggest that “well intentioned interventions often lead to unexpected – and sometimes undesirable – consequences”. They argue that principles, heuristics and indices that broaden the evaluative scope and not use single measurements can help sustainable HCI to become more scientific. Studies try to understand how the information potential of ICT can be used towards sustainability, and how technology can be used to change attitudes and behaviours towards a low-carbon lifestyle. The common conclusion is that more research is needed: “doing a series of cases with real users of particular applications, tracking their carbon dioxide emissions and behavioural change would be beneficial” (Zapico, Turpeinen et al. 2009).

The overall contribution from this research is the development of the link between time perception manipulation (Flaherty 2003) and sustainable behaviours. The empirical studies demonstrated that an element of unnecessary energy use was caused by temporal tensions (Oulasvirta, Tamminen 2004, Tamminen, Oulasvirta et al. 2004). This research proposed that it is possible to deliberately reduce temporal tensions, and this can motivate people to behave more sustainably. The studies found in the literature are usually focused on one aspect only, for example understanding how individuals manipulate their own notion of time (Flaherty 2000) or testing how distractions can alter individual’s perception of time (Lee, Chen et al. 2012). No studies were found investigating how time perception manipulation can promote sustainability.

Individual outcomes from this research proved to be unique, building on previous research or presenting new results in an unexplored field. The First Study performed during this research demonstrated how students cook one specific meal, which behaviours influence energy use and what the determinants are of these behaviours. Only a few descriptive studies were found in the literature investigating cooking behaviours and energy use: one study was implemented to explain the user's influence on energy consumption using electric cooking appliances and define *personas* based on users' characteristics and appliance operating time (DeMerchant 1997). Another study was designed to understand the impacts of energy use and embodied greenhouse gases (GHG) due to food preparation. They combined observations in real kitchens with life-cycle analyses, estimations of GHG emissions and qualitative data of motivations behind the practices observed. The outcome was "a range of design interventions that might be applied to reduce the impact of these food practices" (Clear, Hazas et al. 2013). However, the design of these interventions is not yet reported. The Second Study evaluated the acceptance of a set of energy saving techniques using a survey based on the Theory of Planned Behaviour. Although diverse studies use TPB to measure intentions and influences on sustainable behaviours (Gill, Tierney et al. 2010, Tonglet, Phillips et al. 2004, Nigbur, Lyons et al. 2010), no study was found in the literature taking in consideration cooking behaviours. The Third Study demonstrated the user centred design and development of a mobile phone application containing persuasive strategies to minimize temporal tensions observed during the cooking activity. This approach seems to be unique since no previous research was found evaluating the role of technology to motivate energy saving for cooking. Diverse cooking assistants can be found in the literature. However, they are generally designed to promote other aspects such as cooking skills (Mennicken, Karrer et al. 2010) or improved interfaces (Buykx, Petrie 2012). The Fourth Study presented the evaluation of the persuasive strategies designed to minimize temporal tensions, and provided indications of its influence on changing behaviours and ultimately on promoting energy savings.

9.5 Recommendations for future work

This research presents a new approach connecting diverse disciplines with behaviour change and sustainability. From the results presented here, it is possible to envisage a few recommendations for future work. Some of them relate to methodological limitations observed during these studies. Researchers from different fields could bring their expertise to build on this work and perform further investigations. The first suggestion would be to evaluate the minimizing of temporal tensions in a more controlled environment, using lab-based methods to assess attention and emotion. These measurements could involve heart rate, facial electromyography, and electrodermal activity (Ravaja 2004) to assess mood, evaluate the temporal tension and correlate it with actual energy use. On the opposite spectrum of controllability, studies could use non-intrusive measures and evaluate the manipulation of time perceptions ‘in the wild’. Users could be presented with the interventions to minimize the temporal tensions in their natural settings, inserted in their social practices (Shove 2010) and habitual behaviours (Verplanken, Wood 2006). Ethnographical analysis or practice theory (Schatzki 1997) could be used to evaluate the introduction of these interventions, especially in relation to long term effects of the proposed interventions. Other researchers could also perform the elicitation of behaviours to be investigated using different theoretical frameworks, to counteract the frequently used Theory of Planned Behaviour (Ajzen 1991, Fishbein, Ajzen 2010) and its rational-choice-based approach (Kaiser, Hübner et al. 2005). Researchers could also perform as future work explicit comparisons of different theoretical frameworks in terms of understanding and predicting sustainable behaviours and the role of HCI in changing these behaviours. Also, studies can use both traditional social cognitive theories and social practice theories in a way that they together inform the design and evaluate the acceptance and effectiveness of HCI-based behaviour change interventions.

This research only started to indicate the possibility of use of time perception manipulation to promote energy saving and sustainability. One specific domain of energy use was chosen to be investigated. Further research on how temporal tensions affect energy use could be implemented across a wide range of human activities. In the cooking context, the heat input turned out to be one fundamental component of the proposed energy saving techniques. After understanding the rate of heat and the cooling process it was possible to calculate the ideal time for the cooking activity for energy saving. The process of timing and heat conservation can be compared to other scenarios, for example domestic heating systems. Homes can stay warm after the heating is switched off. Previous research shows that “home heating can be predictively turned off in advance of occupants’ departure, using this inertia to keep the house warm while saving energy” (Ellis, Scott et al. 2012). Using inertia can also save fuel depending on how people drive cars. A driver can anticipate when he will need to brake, in order to brake less (Siero, Boon et al. 1989). One technique to save energy is defining when to remove food from the freezer, leave at room temperature and not require energy to defrost. Peak demand of electricity in the evening is a problem with difficult and expensive solutions (MacKay, Hafemeister 2010). Avoiding doing the laundry during peak demand hours will require a certain degree of time management, and manipulation of people’s anxiety and boredom can make this process easier. Delaying the use of energy is also extremely important in the context of renewable generation: “when the wind blows (supply) does not necessarily match when people want to use electricity (demand)” (Higginson, Thomson et al. 2013). The promotion of flexible demands that match peak supply will benefit from the reduction of temporal tensions. All these energy intense examples entail time management, which could be improved by technological interventions to make people less anxious when trying to manage it without the adequate resources, or bored when waiting for the process to finish. Evaluation of attempts to modify these temporal tensions in different context of energy use could provide interesting results.

9.6 Conclusion

It is possible to draw some conclusions from the results presented here. Firstly, the HCI-based intervention containing strategies of persuasive technology made the mobile phone application more acceptable and engaging to the participants in the trial. Secondly, using a mobile phone application incorporating the energy saving techniques resulted in actual energy saving behaviours. Therefore, the persuasive technology can be seen as an indirect tool to promote sustainable behaviours which are targeted through a technology-based intervention. The persuasive strategies embedded in the app were purposefully designed to manipulate the time perceptions, and were successful in reducing the temporal tensions observed during the cooking activity and creating a positive attitude towards using the app. Participants felt less rushed during the initial preparation stages and less bored while waiting during the cooking process due to the strategies implemented. Through increased engagement in the app, they generally took the time to follow efficient cooking procedures and did not try to speed up the process, then performing the recommended energy saving techniques as desired. Therefore this research concludes that an intervention designed to bring modification of time perceptions can be one of the solutions to promote sustainable behaviours.

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11 Appendix 1 – First Study – support material

11.1 Informed consent form

Cooking practices observation study

Loughborough University

(to be completed after Participant Information Sheet has been read)

The purpose and details of this study have been explained to me. I understand that this study is designed to further scientific knowledge and that all procedures have been approved by the Loughborough University Ethical Advisory Committee.

I have read and understood the information sheet and this consent form.

I have had an opportunity to ask questions about my participation.

I understand that I am under no obligation to take part in the study.

I understand that I have the right to withdraw from this study at any stage for any reason, and that I will not be required to explain my reasons for withdrawing.

I understand that all the information I provide will be treated in strict confidence and will be kept anonymous and confidential to the researchers unless (under the statutory obligations of the agencies which the researchers are working with), it is judged that confidentiality will have to be breached for the safety of the participant or others.

I agree to participate in this study.

Your name ____________________________________

Your signature ____________________________________

Signature of investigator ____________________________________

Date ____________________________________

11.2 Participant Information Sheet

Cooking Practices observation study

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What is the purpose of the study?

This study investigates user behaviour while cooking. You are invited to cook a specific meal as you are used to. The interaction will be video recorded to be analysed later. We are undertaking this study to know how people cook and understand their different behaviours.

Who is doing this research and why?

This study is performed by Luis Oliveira, under the supervision of Val Mitchell and Kevin Badni from the Design School. This study is part of a Student research project funded by the Loughborough University.

Are there any exclusion criteria?

The participants must be British, Butler Court residents, familiar with electric cookers and must be used to cook regular meals at least once a week.

Once I take part, can I change my mind?

Yes! After you have read this information and asked any questions you may have we will ask you to complete an Informed Consent Form, however if at any time, before, during or after the session you wish to withdraw from the study please just contact the main investigator. You can withdraw at any time, for any reason and you will not be asked to explain your reasons for withdrawing.

Will I be required to attend any sessions and where will these be?

The only session you have to attend is the cooking session, at the Subwarden's Flat, Block A, ground floor, Butler Court, on the Loughborough University campus.

How long will it take?

The entire session is expected to last about 30 minutes.

Is there anything I need to do before the sessions?

No!

Is there anything I need to bring with me?
No!

What type of clothing should I wear?

You are advised to wear your normal clothes, but as you are going to cook, spillage may occur, so avoid white or expensive clothes. For health and safety reasons, avoid wearing flammable materials.

What will I be asked to do?

You will be asked to cook noodles. If you want, you can eat them afterwards.

What personal information will be required from me?

You will just have to provide your basic contact information and socio demographic details such as age, gender, etc.

Are there any risks in participating?

The risks are the regular danger related to cooking: burnt, spillage and fire.

Will my taking part in this study be kept confidential?

Yes! The data will be used only for the purpose of this study. All information will be analysed in conjunction with other participants, and the study will never reveal the name of any participant. Video or sound will never be published without your consent. These data might be kept stored up to 10 years and will be later destroyed.

What will happen to the results of the study?

The results of this study will inform the design of future intervention methods.

What do I get for participating?

Food vouchers

I have some more questions who should I contact?

Luis Oliveira, l.oliveira@lboro.ac.uk

What if I am not happy with how the research was conducted?

The University has a policy relating to Research Misconduct and Whistle Blowing which is available online at http://www.lboro.ac.uk/admin/committees/ethical/Whistleblowing(2).htm. Please ensure that this link is included on the Participant Information Sheet.

11.3 Experiment check list

Date ________/________/____________ Participant code _____________

Have you cooked noodles before? How many times approximately?

Time start ________________________ Time finish__________________________________

Energy data start ___________________ Energy data finish ___________________________

Water volume start ________________ Water volume finish ___________________________

Measured the amount of water? ( ) Yes ( ) No

Pan: ( ) Small ( ) Medium ( ) Big

Lid: ( ) Yes ( ) No

Hob ( ) Small front ( ) Big front ( ) Small back ( ) big back

Marks sequence ____

Read the information on the package? ( ) Yes ( ) No

Followed the instructions? ( ) Yes ( ) No

Checked the time? ( ) Yes ( ) No

Why did you use this amount of water / this method to measure the water?

Why did you choose this pan?

Why did(n't) you use a saucepan lid?

Why did you choose this hob to use?

Why did you use these energy marks to cook?

Why did(n't) you read and follow the package cooking instructions?

Why did(n't) you keep track of the time it took to prepare?

Comments

Practices

1. Where do you usually get instructions about how to cook?

( ) Recipe books – Examples ____

( ) Family book

( ) Food package

( ) Internet – which websites ____

How do you use it?

( ) print

( ) take notes

( ) leave the computer on with the recipe on screen

( ) bring the computer to the kitchen

( ) Other____

2. Have you ever heard about the website studentcooking.tv? (If yes) Have you used it? How useful did you find it?

3. Do you follow recipe instructions exactly?

( ) Yes ( ) No ( ) Depends on the meal – Why?______________________________

4. How often do you prepare hot meals?

( ) Daily ( ) A few times a week ( ) A few times a month

5. What do you cook generally?

6. Do you like to learn to cook new things?

7. What would make you try a new recipe?

8. When cooking, how important are these aspects to you?

	totally important	High importance	Medium importance	Low importance	Not important
The quality of the final meal (flavour, consistency)	5	4	3	2	1
The time it takes to cook (quick preparation)	5	4	3	2	1
Simple to prepare (easy preparation)	5	4	3	2	1
The amount of electricity used (low energy consumption)	5	4	3	2	1
How many pans, lids and dishes I'm using (less washing up)	5	4	3	2	1
Nutritional facts (healthily meals)	5	4	3	2	1

9. These are a few tips that can improve cooking in general. Would you do this next time you cook? Why?

	Would you do this next time you cook?	Even if it's different from the way you generally cook? If maybe / no, Why? Comments
Use small pans for small quantities. It makes cooking quicker as bigger pans takes more time to heat	( ) Yes ( ) Maybe → ( ) No →	
Choose the hob plate to match the pan size. Bigger hobs waste energy to the air	( ) Yes ( ) Maybe → ( ) No →	
Use lids on every pan. Lids help keep the heat in and also retain moisture and preserve flavour	( ) Yes ( ) Maybe → ( ) No →	
Use the minimum amount of water possible. Heating more water adds to the cooking time	( ) Yes ( ) Maybe → ( ) No →	
For liquids, switch down the heat level when it starts to boil. Boiling water stays at 100ºC, no matter how much more energy is put in	( ) Yes ( ) Maybe → ( ) No →	
Use low heat. High heat can make your food stick to the bottom of the pan and burn, compromising flavour, consistency and also health.	( ) Yes ( ) Maybe → ( ) No →	
Turn off hobs 2 or 3 minutes before the end of the cooking time. Solid plate hobs maintain the heat for a few minutes after the heat is switched off	( ) Yes ( ) Maybe → ( ) No →	
Keep track of time. Too short or too long cooking times can compromise health and the quality of food	( ) Yes ( ) Maybe → ( ) No →	

10. Do you know any other tips?

11. Would you like to have these tips on hand so you could follow them whilst cooking?

( ) Yes

( ) Maybe, It depends on ______________________________

( ) No, why? ______________________________

12. What would be a good way to present these tips to you?

____

13. Would you like to have a food recipe showing these tips along with the ingredients and preparation?

( ) Yes

( ) Maybe, It depends on ______________________________

( ) No, why? ______________________________

14. Would you follow these tips if they were placed in the recipe?

( ) Yes

( ) Maybe, It depends on ______________________________

( ) No, why? ______________________________

15. Would you use a recipe with these kinds of tips if it was presented as a mobile phone application?

( ) Yes

( ) Maybe, It depends on ______________________________

( ) No, why? ______________________________

16. All of these tips can reduce the energy use during cooking. Did you notice that?

( ) Yes ( ) In some of them ( ) No

17. Would you follow these instructions knowing that the main goal is to save energy?

( ) Yes

( ) Maybe, It depends on ______________________________

( ) No, why? ______________________________

During your trial you used _____ watts of electricity, as we can see using this energy monitor. The other participants used from 100 to 200 watts.

But following these techniques it is possible to cook the same food using about 63 watts.

One of the aims of this research is to find ways to motivate people to use less energy whilst cooking by following these techniques.

18. What do you think that would motivate you to use these energy saving techniques next time?

____

19. I'm developing some recipes which include these tips. Would you like to try to cook here again using this recipe, in a few months, and see how much electricity you use?

( ) Yes

( ) Maybe, It depends on ____

( ) No, why? ____

20. How do you like your noodles?

Consistency ____

Amount of water ____

Seasoning ____

____

11.4 New Ecologic Paradigm scale

Listed below are statements about the relationship between humans and the environment. For each one, please indicate whether you STRONGLY AGREE, MILDLY AGREE, are UNSURE, MILDLY DISAGREE or STRONGLY DISAGREE with it.

Statements	Strongly agree	Mildly agree	Unsure	Mildly disagree	Strongly disagree
1. We are approaching the limit of the number of people the earth can support	5	4	3	2	1
2. Humans have the right to modify the natural environment to suit their needs	5	4	3	2	1
3. When humans interfere with nature it often produces disastrous consequences	5	4	3	2	1
4. Human ingenuity will insure that we do NOT make the earth unlivable	5	4	3	2	1
5. Humans are severely abusing the environment	5	4	3	2	1
6. The earth has plenty of natural resources if we just learn how to develop them	5	4	3	2	1
7. Plants and animals have as much right as humans to exist	5	4	3	2	1
8. The balance of nature is strong enough to cope with the impacts of modern industrial nations	5	4	3	2	1
9. Despite our special abilities humans are still subject to the laws of nature	5	4	3	2	1
10. The so-called "ecological crisis" facing humankind has been greatly exaggerated	5	4	3	2	1
11. The earth is like a spaceship with very limited room and resources	5	4	3	2	1
12. Humans were meant to rule over the rest of nature	5	4	3	2	1
13. The balance of nature is very delicate and easily upset	5	4	3	2	1
14. Humans will eventually learn enough about how nature works to be able to control it	5	4	3	2	1
15. If things continue on their present course, we will soon experience a major ecological catastrophe	5	4	3	2	1

11.5 Participant demographic information

Code: ______

Name:____

Telephone: ____

Email: ____

Block / flat / room: ____

1. Age: _______ years old

2. Gender: ( ) Male ( ) Female

4. Course / department / year: ____

____

11.6 Experiment procedure

Previously

1. Clean the cooker, sink, area
2. Clean table
3. Position pans and lids
4. Position measurement jug
5. Provide wooden spoon
6. Provide a plate, knife and fork
7. Weight jar with water and take note
8. Check energy monitor data and take note
9. Position camera

Before trial

1. Introduce myself
2. Present the ‘information sheet’
3. Present the ‘consent form’ and collect signature
4. Present ‘personal data sheet’ and collect signature
5. File ‘consent form’ and ‘personal data sheet’
6. Give a code to the participant
7. Write code on every sheet of the questionnaire
8. Re-inform about the testing and performance

During trial

1. Start camera
2. Start recording saying participant code
3. Ask participant to start
4. Check time and take note
5. Take notes using the checklist

At the end of trial

1. Check time and take note
2. Check electricity consumption and take note
3. Check if food is thoroughly cooked
4. Reposition camera to table to work as microphone
5. Apply questionnaire
6. Ask participant to fill the importance scale
7. Ask participant to fill the NEP scale
8. Thank participant
9. Stop camera
10. Give voucher
11. Feed the diary
12. Organize papers – file questionnaires

12 Appendix 2 – Second Study – support material

12.1 Elicitation study – Open-ended questionnaire

We are conducting a research project about cooking behaviours among students from Butler Court. This study is part of a PhD research supported by Loughborough University. Your answers will remain anonymous and your data will be protected. You are free to withdraw from taking part in this survey at any time.

If you need more information about this research, feel free to contact me (Luis Oliveira l.oliveira@lboro.ac.uk) or my supervisors (Val Mitchell v.a.mitchell@lboro.ac.uk and Kevin Badni k.s.badni@lboro.ac.uk).

We are interested in the reasons why students do or do not follow energy saving techniques whilst cooking. We would appreciate your responses to some questions about this. There are no right or wrong answers. Please take a few minutes to list your thoughts about the following questions and tell us what you really think.

To answer all the 9 questions below, consider these energy saving techniques:

- Measure the amount of water
- Time the process
- Choose small pans for single meals
- Choose small hobs that match small pans
- Use the saucepan lid
- Reduce the heat when the water is boiling
- Turn off the hob a few minutes before the end of the cooking time

1. What do you think are the advantages of following these energy saving techniques for cooking?

____

____

____

2. What do you think are the disadvantages of following these energy saving techniques for cooking?

____

____

____

3. What are your personal opinions about these energy saving techniques for cooking?

____

____

4. Are there any individual or groups who would approve of your following these energy saving techniques for cooking?

5. Are there any individual or groups who would disapprove of your following these energy saving techniques for cooking?

6. Are there any other people who come to mind when you think about these energy saving techniques for cooking?

7. What factors or circumstances would enable you to follow these energy saving techniques for cooking?

8. What factors or circumstances would make it difficult or impossible for you to follow these energy saving techniques for cooking?

9. Are there any other issues that come to mind when you think about following these energy saving techniques for cooking?

Your university e-mail: ____@lboro.ac.uk

12.2 Theory of Planned Behaviour Online Survey

Cooking behaviours survey

Cooking behaviours survey

Thank you for taking the time to fill out this questionnaire.

You are contributing towards a study being carried out by researchers at Loughborough University, looking at how students cook, and what are the major influences on cooking behaviours.

This questionnaire is aimed at Loughborough Students who live in self-catered halls of residence, and should take around 15 minutes to complete.

The answers you give will be completely confidential, and the University will not have access to them. Any information reported in the final research will be anonymous and aggregated, and it will not be possible to trace answers back to individual respondents. Your contribution is voluntary, and you can withdraw at any time.

The research is being conducted by me, Luis Oliveira, as part of the work towards a PhD in the Design School at Loughborough University. The results will inform the design of behaviour change interventions and will be reported in academic papers. If you have any questions about the study, or would like to be informed about the outcomes of the research, please contact me on the details below.

Many thanks for your contribution.

Luis Oliveira
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PhD office 2.22
Loughborough Design School
Loughborough University

***1. What is your age?**

[ ]

***2. What is your gender?**

○ Male ○ Female

***3. Which year at University are you in?**

[ ]

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Cooking behaviours survey

***4. In which University Hall of Residence do you live?**

- ◯ Butler Court
- ◯ Falkner Egginton
- ◯ Forest Court
- ◯ Harry French
- ◯ Hazlerigg Rutland
- ◯ John Phillips
- ◯ Robert Bakewell
- ◯ Telford
- ◯ The Holt
- ◯ William Morris
- ◯ WM - Somerton
- ◯ Other (please specify)

***5. How often do you prepare hot foods whilst living in halls?**

Cooking techniques

The questions below are related to cooking everyday meals that involve boiling water, like:

- pasta
- rice
- noodles
- etc.

Some of the cooking techniques relevant to this study are:

- To measure the correct amount of water prior to filling the pan
- To measure the time according to what you are cooking
- To use a small pan, if the amount of food fits in it
- To choose a small hob that matches the pan
- To use a saucepan lid to cover the pan
- To reduce the heat when the water is boiling or the content is hot
- To turn the heat off before the end of the cooking time when using electric cookers with metal plates

To answer all questions, consider your cooking activity whilst living in halls, using the cooker from your flat kitchen.

The questions in this survey make use of rating scales with seven places. Just select the one that best describes your opinion.

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Cooking behaviours survey

***6. What is your personal opinion about these cooking techniques (when cooking single meals in hall)?**

	1 - inconvenient	2	3	4	5	6	7 - convenient
Measuring the amount of water is	○	○	○	○	○	○	○
Measuring the time is	○	○	○	○	○	○	○
Using a small pan is	○	○	○	○	○	○	○
Choosing a small hob is	○	○	○	○	○	○	○
Using a saucepan lid is	○	○	○	○	○	○	○
Reducing the heat when the water is boiling is	○	○	○	○	○	○	○
Turning the heat off before the end of the cooking time is	○	○	○	○	○	○	○

***7. What is your personal opinion about these cooking techniques (when cooking single meals in hall)?**

	1 - the wrong thing to do	2	3	4	5	6	7 - the right thing to do
Measuring the amount of water is	○	○	○	○	○	○	○
Measuring the time is	○	○	○	○	○	○	○
Using a small pan is	○	○	○	○	○	○	○
Choosing a small hob is	○	○	○	○	○	○	○
Using a saucepan lid is	○	○	○	○	○	○	○
Reducing the heat when the water is boiling is	○	○	○	○	○	○	○
Turning the heat off before the end of the cooking time is	○	○	○	○	○	○	○

***8. If I want to, I can...**

	1 - False	2	3	4	5	6	7 - True
measure the amount of water.	○	○	○	○	○	○	○
measure the time for cooking.	○	○	○	○	○	○	○
use a small pan.	○	○	○	○	○	○	○
choose the small hob.	○	○	○	○	○	○	○
use a saucepan lid.	○	○	○	○	○	○	○
reduce the heat when the water is boiling.	○	○	○	○	○	○	○
turn the heat off before the end of the cooking time.	○	○	○	○	○	○	○

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Cooking behaviours survey

*9. How often do you...

	1 - Never	2	3	4	5	6	7 - Always
measure the amount of water?							
measure the time for cooking?							
use a small pan?							
choose a small hob?							
use a saucepan lid?							
reduce the heat when the water is boiling?							
turn the heat off before the end of the cooking time?							

*10. How often do your flatmates or university friends...

	1 - Never	2	3	4	5	6	7 - Always	I don't know
measure the amount of water?								
measure the time for cooking?								
use a small pan?								
choose a small hob?								
use a saucepan lid?								
reduce the heat when the water is boiling?								
turn the heat off before the end of the cooking time?								

*11. How often do your family members...

	1 - Never	2	3	4	5	6	7 - Always	I don't know
measure the amount of water?								
measure the time for cooking?								
use a small pan?								
choose a small hob?								
use a saucepan lid?								
reduce the heat when the water is boiling?								
turn the heat off before the end of the cooking time?								

Intentions

The questions below are related to cooking everyday meals that involve boiling water, like:

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Cooking behaviours survey

- pasta
- rice
- noodles
- etc.

Some of the cooking techniques relevant to this study are:

- To measure the correct amount of water prior to filling the pan
- To measure the time according to what you are cooking
- To use a small pan, if the amount of food fits in it
- To choose a small hob that matches the pan
- To use a saucepan lid to cover the pan
- To reduce the heat when the water is boiling or the content is hot
- To turn the heat off before the end of the cooking time when using electric cookers with metal plates

To answer all questions, consider your cooking activity whilst living in halls, using the cooker from your flat kitchen.

The questions in this survey make use of rating scales with seven places. Just select the one that best describes your opinion.

***12. For the next time I'm cooking in halls, I intend to...**

	1 - False	2	3	4	5	6	7 - True
measure the amount of water.	○	○	○	○	○	○	○
measure the time for cooking.	○	○	○	○	○	○	○
use a small pan.	○	○	○	○	○	○	○
choose a small hob.	○	○	○	○	○	○	○
use a saucepan lid.	○	○	○	○	○	○	○
reduce the heat when the water is boiling.	○	○	○	○	○	○	○
turn the heat off before the end of the cooking time.	○	○	○	○	○	○	○

***13. For the whole remaining time that you are living in halls, how often do you intend to...**

	1 - Never	2	3	4	5	6	7 - Always
measure the amount of water?	○	○	○	○	○	○	○
measure the time for cooking?	○	○	○	○	○	○	○
use a small pan?	○	○	○	○	○	○	○
choose a small hob?	○	○	○	○	○	○	○
use a saucepan lid?	○	○	○	○	○	○	○
reduce the heat when the water is boiling?	○	○	○	○	○	○	○
turn the heat off before the end of the cooking time?	○	○	○	○	○	○	○

Cooking behaviours survey

***14. The cooking process will take longer if I...**

	1 - False	2	3	4	5	6	7 - True
measure the amount of water.	○	○	○	○	○	○	○
measure the time for cooking.	○	○	○	○	○	○	○
use a small pan.	○	○	○	○	○	○	○
choose a small hob.	○	○	○	○	○	○	○
use a saucepan lid.	○	○	○	○	○	○	○
reduce the heat when the water is boiling.	○	○	○	○	○	○	○
turn the heat off before the end of the cooking time.	○	○	○	○	○	○	○

***15. It will compromise the quality of food if I...**

	1 - False	2	3	4	5	6	7 - True
measure the amount of water.	○	○	○	○	○	○	○
measure the time for cooking.	○	○	○	○	○	○	○
use a small pan.	○	○	○	○	○	○	○
choose a small hob.	○	○	○	○	○	○	○
use a saucepan lid.	○	○	○	○	○	○	○
reduce the heat when the water is boiling.	○	○	○	○	○	○	○
turn the heat off before the end of the cooking time.	○	○	○	○	○	○	○

***16. It will take more effort if I...**

	1 - False	2	3	4	5	6	7 - True
measure the amount of water.	○	○	○	○	○	○	○
measure the time for cooking.	○	○	○	○	○	○	○
use a small pan.	○	○	○	○	○	○	○
choose a small hob.	○	○	○	○	○	○	○
use a saucepan lid.	○	○	○	○	○	○	○
reduce the heat when the water is boiling.	○	○	○	○	○	○	○
turn the heat off before the end of the cooking time.	○	○	○	○	○	○	○

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Cooking behaviours survey

***17. I will save energy if I...**

	1 - False	2	3	4	5	6	7 - True
measure the amount of water.	○	○	○	○	○	○	○
measure the time for cooking.	○	○	○	○	○	○	○
use a small pan.	○	○	○	○	○	○	○
choose a small hob.	○	○	○	○	○	○	○
use a saucepan lid.	○	○	○	○	○	○	○
reduce the heat when the water is boiling.	○	○	○	○	○	○	○
turn the heat off before the end of the cooking time.	○	○	○	○	○	○	○

Cooking techniques

The questions below are related to cooking everyday meals that involve boiling water, like:

- pasta
- rice
- noodles
- etc.

Some of the cooking techniques relevant to this study are:

- To measure the correct amount of water prior to filling the pan
- To measure the time according to what you are cooking
- To use a small pan, if the amount of food fits in it
- To choose a small hob that matches the pan
- To use a saucepan lid to cover the pan
- To reduce the heat when the water is boiling or the content is hot
- To turn the heat off before the end of the cooking time when using electric cookers with metal plates

To answer all questions, consider your cooking activity whilst living in halls, using the cooker from your flat kitchen.

The questions in this survey make use of rating scales with seven places. Just select the one that best describes your opinion.

***18. I have the correct utensils that enable me to...**

	1 - False	2	3	4	5	6	7 - True
measure the amount of water.	○	○	○	○	○	○	○
measure the time for cooking.	○	○	○	○	○	○	○
use a small pan.	○	○	○	○	○	○	○
choose a small hob.	○	○	○	○	○	○	○
use a saucepan lid.	○	○	○	○	○	○	○
reduce the heat when the water is boiling.	○	○	○	○	○	○	○
turn the heat off before the end of the cooking time.	○	○	○	○	○	○	○

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Cooking behaviours survey

***19. I have all the information that enables me to...**

	1 - False	2	3	4	5	6	7 - True
measure the amount of water.							
measure the time for cooking.							
use a small pan.							
choose a small hob.							
use a saucepan lid.							
reduce the heat when the water is boiling.							
turn the heat off before the end of the cooking time.							

***20. Having to pay for electricity would motivate me to...**

	1 - False	2	3	4	5	6	7 - True
measure the amount of water.							
measure the time for cooking.							
use a small pan.							
choose a small hob.							
use a saucepan lid.							
reduce the heat when the water is boiling.							
turn the heat off before the end of the cooking time.							

***21. Which of these kitchen utensils do you have available in your hall kitchen?**

	No	Yes
Measurement jug		
Small pan		
Saucepan lid for the small pan		

***22. Please indicate how you evaluate the following statements:**

	1 - bad	2	3	4	5	6	7 - good
Putting effort into what you are cooking is							
Doing something that reduces the quality of food is							
Taking time for cooking is							
To cook in a way that saves energy in halls is							

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Cooking behaviours survey

***23. I like to cook the same way as:**

	1 - Disagree	2	3	4	5	6	7 - Agree
my flatmates or university friends do.	○	○	○	○	○	○	○
my family does.	○	○	○	○	○	○	○

Thank you for filling in this questionnaire.

Thank you for taking the time to fill out this questionnaire. The answers you have given will be very useful for this research.

If you have any questions or concerns regarding this questionnaire, or any other aspect of this research, please do get in touch by emailing l.oliveira@lboro.ac.uk

If you want to be informed about the outcomes of this research, just insert your email address below.

Also, if you want to be contacted in a few weeks time for a quick follow up (only 2 questions, I promise!), just indicate below.

Privacy: Your email address will be used only for the communication process, and will be totally separated from your questionnaire answers.

24. Interaction:

- ○ I would like to fill in a follow up survey and see the outcomes of this research
- ○ Follow up only
- ○ Outcomes only
- ○ None

25. Email address

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13 Appendix 3 – Third Study – support material

13.1.1 Scenarios analysis questionnaire

Scenario	A Cooking something quickly	B Cooking as a private moment	C Cooking as a social experience
Setting	Kitchen as routine space	Kitchen as creative space	Kitchen as a social space
Agents	Student	Student	Friends
Goals	Have food, fill up, fuel up	Relax, enjoy and create	Interact, enjoy, share the experience
Actions	Cook food, quickly	Experiment with food, take time	Chat, listen to music, cook, taste
In this scenario, do you think students will follow instructions from an app? Why? What would encourage students to follow a preparation procedure? How to motivate them to think before acting?			
In this scenario, do you think students will wait and follow the instructions? Why? What would encourage them to take their time, not rush and not feel bored waiting? What could an app suggest them to do?			

14 Appendix 4 – Fourth Study – Support material

14.1 Participant Information Sheet

Cooking Practices observation study

Loughborough University

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What is the purpose of the study?

This study investigates user interaction with a mobile phone application while cooking. You are invited to cook a specific meal as you are used to, following instructions from an app. The interaction will be video recorded to be analysed later. We are undertaking this study to know how people evaluate the app.

Who is doing this research and why?

This study is performed by Luis Oliveira, under the supervision of Val Mitchell and Andrew May from the Design School. This study is part of a Student research project funded by the Loughborough University.

Are there any exclusion criteria?

The participants must be living in the UK for the recent years, familiar with electric cookers and must be used to cook regular meals a few times a week.

Once I take part, can I change my mind?

Yes! After you have read this information and asked any questions you may have we will ask you to complete an Informed Consent Form, however if at any time, before, during or after the session you wish to withdraw from the study please just contact the main investigator. You can withdraw at any time, for any reason and you will not be asked to explain your reasons for withdrawing.

Will I be required to attend any sessions and where will these be?

Two sessions are scheduled, at the Subwarden's Flat, B Block, ground floor, Robert Bakewell, on the Loughborough University campus.

How long will it take?

The entire session is expected to last about 30 minutes.

Is there anything I need to do before the sessions?

No!

Is there anything I need to bring with me?

No!

What type of clothing should I wear?

You are advised to wear your normal clothes, but as you are going to cook, spillage may occur, so avoid white or expensive clothes. For health and safety reasons, avoid wearing flammable materials.

What will I be asked to do?

You will be asked to cook noodles following instructions from an app. If you want, you can eat them afterwards.

What personal information will be required from me?

You will just have to provide your basic contact information and socio demographic details such as age, gender, etc.

Are there any risks in participating?

The risks are the regular danger related to cooking: burnt, spillage and fire.

Will my taking part in this study be kept confidential?

Yes! The data will be used only for the purpose of this study. All information will be analysed in conjunction with other participants, and the study will never reveal the name of any participant. Video or sound will never be published without your consent. These data might be kept stored up to 10 years and will be later destroyed.

What will happen to the results of the study?

The results of this study will contribute towards my thesis.

What do I get for participating?

Supermarket vouchers

I have some more questions who should I contact?

Luis Oliveira, l.oliveira@lboro.ac.uk

What if I am not happy with how the research was conducted?

The University has a policy relating to Research Misconduct and Whistle Blowing which is available online at http://www.lboro.ac.uk/admin/committees/ethical/Whistleblowing(2).htm. Please ensure that this link is included on the Participant Information Sheet.

14.2 Experiment Procedure

Previously

1. Clean the cooker, sink, area
2. Clean table
3. Position pans and lids
4. Position measurement jug
5. Provide wooden spoon
6. Provide a plate, knife and fork
7. Check energy monitor data and take note
8. Position camera

Before trial

9. Introduce myself
10. Present the 'information sheet'
11. Present the 'consent form' and collect signature
12. Present 'personal data sheet' and collect signature
13. File 'consent form' and 'personal data sheet'
14. Give a code to the participant
15. Write code on every sheet of the questionnaire
16. Re-inform about the testing and performance

During trial

17. Start camera
18. Start recording saying participant code
19. Ask participant to start
20. Check time and take note
21. Take notes using the checklist

At the end of trial

22. Check time and take note
23. Check electricity consumption and take note
24. Reposition camera to table to work as microphone
25. Ask participant to fill the importance scale

Second trial

26. Interview participant
27. Thank participant
28. Stop camera
29. Give voucher
30. Feed the diary
31. Organize papers – file questionnaires

14.3 Experiment check list

Date _______/_______/________ Trial 1 2 Study A B Participant code __________

Time start ________________________ Time finish ______________________________

Energy data finish ___________________

Energy data start ___________________

Measured the amount of water? ( ) Yes ( ) No

Pan: ( ) Small ( ) Medium

Lid: ( ) Yes ( ) No

Hob ( ) Small front ( ) Big front ( ) Small back ( ) big back

Marks sequence____

Followed the instructions?

Checked the time?

Set a timer?

Dissolved sachet first?

Selections:

- Amount of water
- Speed
- Consistency

Have you cooked noodles before?

How many times approximately?

How often do you cook hot food?

Have you used a mobile phone app for cooking before?

Comments

14.4 TAM and Flow Likert scale

Questionnaire ( ) 1 ( ) 2 ( ) A ( ) B Participant __________

Question	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1- Using this app enables me to accomplish the task more quickly	1	2	3	4	5
2- When using this app, I was totally concentrated on what I was doing	1	2	3	4	5
3- The results of using this app are apparent to me	1	2	3	4	5
4- Students who use this kind of app have more prestige than those who do not	1	2	3	4	5
5- Using this app makes it easier to cook	1	2	3	4	5
6- I think that using this app fits well with the way I like to cook	1	2	3	4	5
7- I feel comfortable with the controls of this app	1	2	3	4	5
8- Using this app enhances my effectiveness during cooking	1	2	3	4	5
9- Using this app is compatible with all aspects of my cooking	1	2	3	4	5
10- Students who use this kind of app have a high profile	1	2	3	4	5
11- Overall, I believe that this app is easy to use	1	2	3	4	5
12- Using this app fits into my cooking style	1	2	3	4	5
13- Learning how to operate this app is easy for me	1	2	3	4	5
14- I believe I could communicate to others the consequences of using this app	1	2	3	4	5
15- My attention was focused entirely on the app that I was using	1	2	3	4	5
16- When using this app, I felt in control over what I was doing in the app	1	2	3	4	5
17- When I used the app, I feel I am in a world created by the app	1	2	3	4	5
18- Using this app is rewarding in itself	1	2	3	4	5
19- I kind of forgot about myself when using this app	1	2	3	4	5
20- Using this app improves the quality of food	1	2	3	4	5
21- I lost the consciousness of my identity and felt like "melted" into the app	1	2	3	4	5
22- Using this app gives me greater control over my cooking	1	2	3	4	5
23- I enjoyed the experience	1	2	3	4	5
24- When I used this app, I sometimes felt like things were happening in slow motion	1	2	3	4	5
25- Having this kind of app is a status symbol in halls	1	2	3	4	5
26- When I used this app, I tended to lose track of time	1	2	3	4	5
27- I would use this app for other dishes	1	2	3	4	5

14.5 Topics for interview

The app presented the instructions, on screen.

- What do you think about that?
- Did you like to follow it from an app, instead of from the packet?

How different would be your regular cooking? Would you use this hob? These heat marks? This duration? Kettle?

What made you follow the instructions?

- Did you feel committed to the procedure?
- Trust?

At the beginning we presented options for you to select desired outcomes.

- What do you think of that?
- Why?

The instructions came in steps, separated into different pages.

- What do you think about that?
- Did it make you pay more attention to the steps?

The app provided a timer

- What do you think about that?
- Did you trust that amount of time suggested?
- Would you like to cook for more or less time than suggested?

You were provided with some distractions whilst waiting (watching videos)

- What do you think about that?
- Did you enjoy watching the videos?

Did you feel bored or anxious during cooking?

What are, in your opinion, the advantages and disadvantages of using this app?

Did you learn anything from this experiment?

Would you perform with some of these methods next time? Which ones? Why?

What do you think is the main purpose of this app, from the designer's point of view?

- Learning
  - Cooking in general
  - Techniques
- Efficiency
- Less effort
- Less time
- Less energy

14.6 Voucher receipt

I confirm that I received a £15 ‘thank you’ gift card for taking part in the *mobile phone app research* conducted by Luis Oliveira.

Student’s name	Signature