Cooking behaviours: understanding energy use to design persuasive applications

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ABSTRACT
Electric cookers and kettles are often the highest electricity consumers amongst household appliances. Cooking requires several interactions with these appliances, and furthermore people's behaviours play an important role in the energy consumption. This research is seeking to understand people's behaviours whilst cooking and also identify the determinants of these behaviours. Energy monitoring, video recording and semi-structured questionnaires were used to gather this information. This knowledge will inform the development of an intervention aiming at reducing energy expenditure.

Categories and Subject Descriptors
J.4 [**Social and Behavioral Sciences**]: Psychology H.5.2 [**User Interfaces**] Evaluation/Methodology, User-Centered Design; D.2.2 [**Design Tools and Techniques**]: Miscellaneous;

General Terms
Measurement, Performance, Design, Experimentation, Human Factors, Verification

Keywords
Persuasive technology, behaviour change, cooking appliances, energy saving, mobile phone application

1. INTRODUCTION
Global warming is nowadays one of the greatest concerns of societies. The UK government made commitments to reduce CO2 emissions, which are believed to make the planet warmer due to the greenhouse effect. Most of UK energy is produced by thermoelectric plants, which are responsible for most of the carbon emissions. The housing sector accounts for a big share of the total energy use, and if people manage to reduce the expenditure in their homes, it will contribute enormously to the country's carbon objectives.

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Cooking appliances are one of the highest energy consuming pieces of equipment in the home, specifically electric hobs. The cooking context provides a number of opportunities to save energy [15]:

- The user is in close proximity to the appliance during use
- There is a high degree of interaction between the user and the appliance during use
- There are several energy saving behaviours that the user can apply when interacting with the appliance

People's behaviours play an important role in electricity consumption. Observing how people interact with cookers is a good way to understand social practices, and this knowledge can inform the development of interventions aimed at reducing energy expenditure. If an intervention manages to increase energy use awareness and lead to more environmentally friendly behaviour, it will result in energy saving and consequently a reduction in CO2 emissions. One important aspect of this research is that it is trying to reduce energy use on existing appliances. It is understood that there are more efficient cookers and kettles available, but the challenge is to make people reduce the expenditure whilst using the hardware actually present in their homes.

Information about the most energy efficient techniques whilst cooking is scattered across journal articles, conference papers, organization reports, websites and Physics books. For that reason, understanding the best practices is difficult for the average user. Misguidance is often obtained from family tips to recipe books, commonly resulting in energy waste. Aggregating and introducing energy saving techniques to users in an organized way might facilitate energy use awareness and behaviour change.

2. METHODS
This research is using as a starting point the Intervention Mapping Protocol [1], a well-established methodology that guides behavioural change projects. This model was first designed to influence health related behaviour such as smoking and dietary behaviour. It consists of methods that can be applied to different fields of human behaviours, and it had been adapted to study interventions targeting energy saving [12]. The Intervention Mapping Protocol suggests that the first stage of a project must consider the specification of the behaviours to be changed and the determinants of these behaviours.

The main proposition made for this research is that a persuasive intervention can motivate people to use less energy whilst

cooking. To explore this proposition, it is be necessary to address the following questions:

- When cooking using an electric cooker, what are the key energy related behaviours and what are the determinants of these behaviours?
- How can knowledge of users inform the design of information and communication technology (ICT) based interventions that provide instructions regarding energy use and aim to reduce electricity consumption whilst cooking?
- Will users be able to save energy whilst using a recipe designed to motivate them to save energy?
- Will this intervention result in behavioural change when the energy saving advice is not present, and whilst cooking different meals?
- Will this intervention method influence behaviours in the long term?

This research is divided into 3 main parts. The first study aims at getting information about actual user behaviours before any intervention. It will help in understanding how users perform at the moment and also what are the determinants of their behaviours. With this knowledge it will be possible to design a specific intervention targeting these determinants. During the second study an intervention will be developed to try to encourage people to cook using less energy. This phase will require an iterative process involving users in a participatory design process. The third study will consist of testing the effectiveness of the intervention. Users' performance will be assessed before and after the intervention, including energy monitoring.

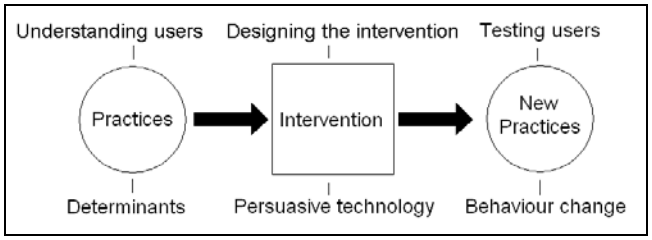

Figure 1 - Research diagram

University students are the target study population for this research, and especially those living in a self-catered university hall of residence. The motives for selecting this group can be listed as follows: high concentration of potential participants living in the same area (354 beds); subjects from around the same age (18-22); and same educational level (undergraduates). One important reason for choosing this group is the possibility of easy access and the availability of quick communication between researchers and population. An extra motive for choosing this group can be defined as receptivity and timing. For most of the students living in self-catered halls of residence, this will be the first time they are away from home, and consequently they will have to learn how to prepare their own meals. This could be an important moment to introduce and present best practices, as habits are not yet well formed [13].

It is understood that this population might not be a receptive audience to an energy saving intervention. Students living in University halls are not motivated to save energy as they do not pay bills directly. Due to contract and building characteristics, all bills are included in fees. Consequently, there is no financial motivation to use electricity reasonably, and in certain cases the residents take it for granted and abuse energy provision, especially because they know that there will not be any extra charge for doing that. The overall outcomes of the intervention must benefit them in some other way. The designed intervention must provide other benefits to the participants, for example improved cooking results. The arguments should not leverage on monetary gains or pollution reduction [3]. Instead, they will focus on creating an improved cooking experience.

In order to understand actual practices and preferences, a user observation study was designed. 20 participants have taken part in the trial aging 18-22 years, 10 male and 10 female. A regular kitchen in their hall was set as the laboratory. The cooker was equipped with a hidden energy monitor. Three different sized pans and lids were made available to participants as well as a measurement jug. Participants were asked to cook simple noodles as close as possible to the way they would normally cook such foods. To help with the observation study, a checklist of energy-saving techniques was produced for the observer, based on the literature about how to cook using less energy [4][14][6] and also based on specific on-site energy measurements. These recommendations include: read and follow the package instructions, keep track of time, measure the amount of water, use the smallest pan, use the lid, choose the smallest hob, reduce heat when it starts to boil, and turn off the heat 2 minutes before the end of the cooking time. A questionnaire followed this observation study to understand why the participants acted as they did. Each session was video recorded and later analysed using the software NVivo.

Figure 2 – Regular kitchen set up as lab [11]

3. RESULTS

Data analysis from the trials showed surprisingly diverse user behaviours, time to complete the task and electricity use. Qualitative analysis of the video data enabled non-energy saving

behaviours and a correspondent list of determinants to be developed.

The main non-energy saving behaviours observed were as follows:

- All participants left the noodles cooking for longer than stated on the packet (it says 2-3 minutes)
- Just 5 participants measured the 200 ml of water as recommended on the packet while the others used more water than needed
- 4 participants used the medium sized pan instead of the small one, which would have been adequate for a single meal
- 12 participants used a small pan on a big hob resulting in wasted energy to the air
- Just 4 participants used the lid
- Only 3 students turned the hob off before the end of the cooking time in order to use the remaining heat
- 16 participants boiled the kettle, but as it has a minimum mark of 500 ml, they ended up heating more water than needed.

When asked why they undertook each of these behaviours, their explanations were mainly to have a quicker preparation; due to habit; convenience (for example when they decided to check visually instead of measuring properly the amount of water or preparation time); and personal preferences. The observations also demonstrated a lack of knowledge on how the available appliances behave. These results were compared with best practices showing that the average user expends 3 times more energy than one following a few simple recommendations. Figure 3 shows the amount of electricity used by each participant, compared with the researcher (participant 0) who implemented the entire set of recommended energy saving techniques.

Although a big concern reported by the participants was about the preparation time, the analysis of the video data showed that they spent from 5 to more than 15 minutes to cook the noodles, as can be seen on figure 4.

Rating scales were used to gather data from participants relating to the relative importance of different aspects of the cooking experience. Results show that the quality of the meal was rated of highest importance, followed by the easiness to prepare, the nutritional facts and the time it takes to cook. The amount of pans, lids and dishes used was rated as medium importance. The item that scored the lowest importance was the amount of electricity used during cooking.

This knowledge can inform what would be a suitable intervention method and gives clues about designing an intervention focusing on these determinants to lead to behaviour change.

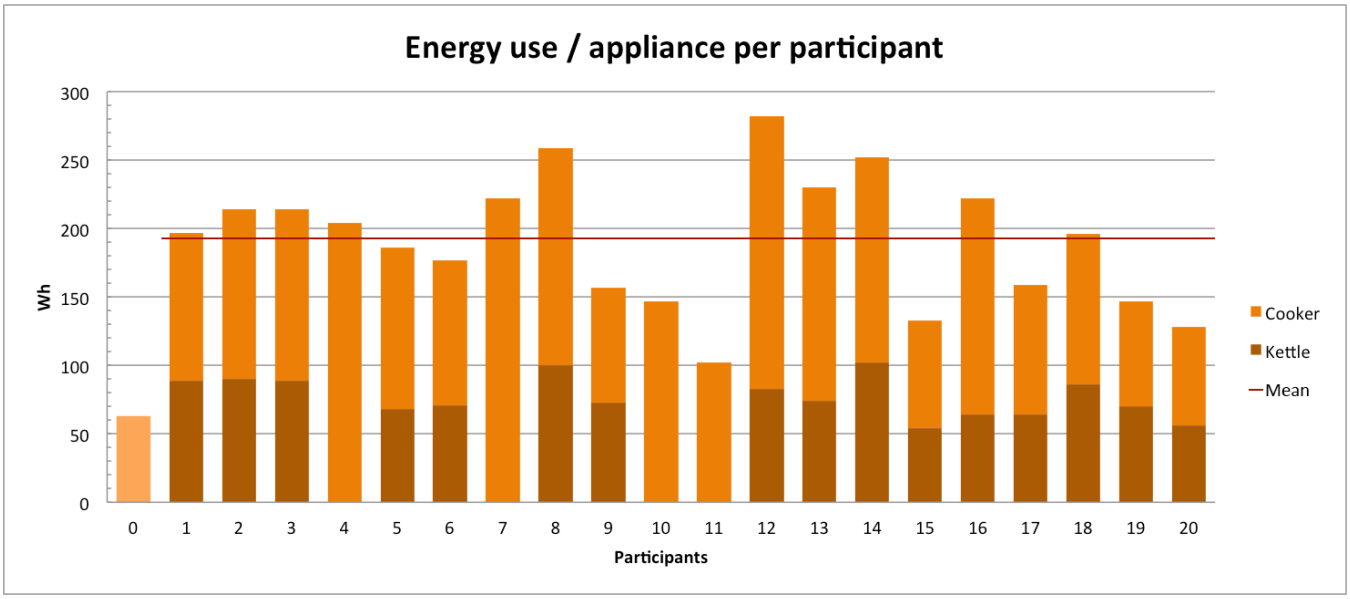

Figure 3 – Watts used per participant combining cooker and kettle (when used). The researcher (participant 0) cooked the same meal using 63 Watts, about 1/3 of the average of the other participants (191 Wh) [11]

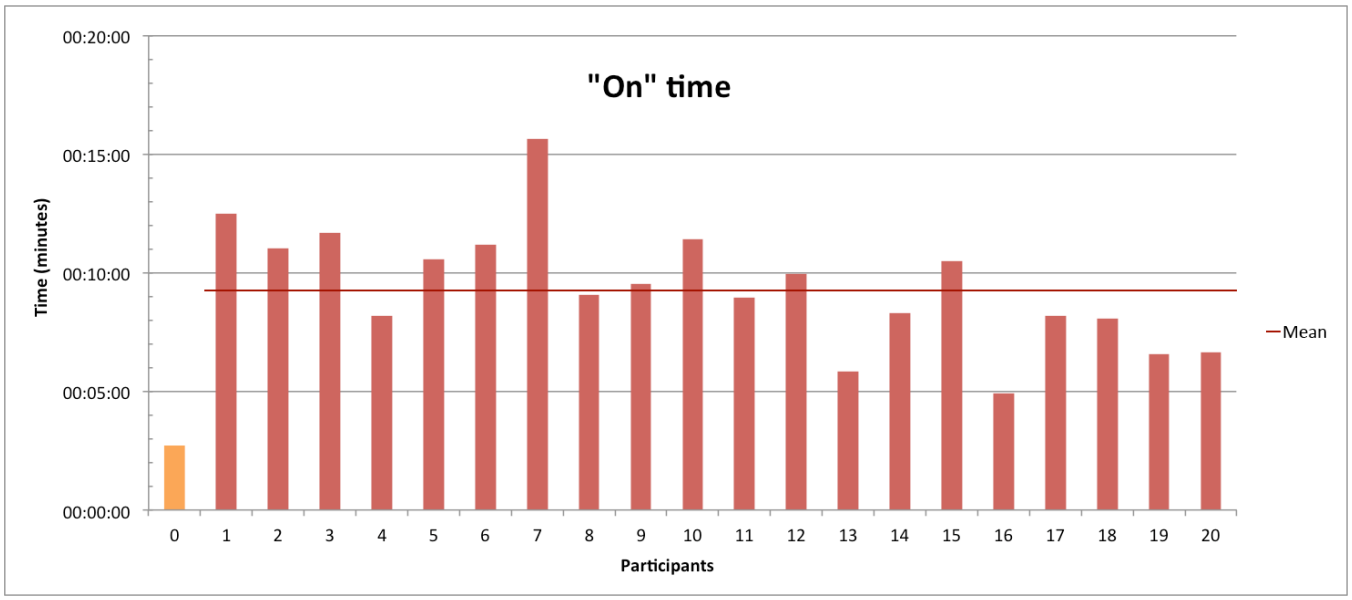

Figure 4 - Time effectively using electricity. The researcher (participant 0) left the hob on for less than 3 minutes. It was enough to bring the noodles to boil and have remaining heat to boil the water for another 2.5 minutes [11]

4. THE PROPOSED INTERVENTION

ICT 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 [8][5]. From Fogg's [7] list of seven common uses of persuasive technologies as tools, it is possible to exemplify how they could be embedded within a persuasive intervention intended to influence people's behaviours whilst cooking:

Reduction – When it persuades through simplifying, for example reducing the number of steps required to perform a desired behaviour. It's possible to develop recipes that inform the best procedure to cook a meal and at the same time give instructions on how to control the appliances.

Tunnelling – When the intervention presents a guided persuasion. For example, by providing the 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 modifications.

Tailoring – When it uses persuasion through customization. For example, the user can be presented with a specific meal according to their preferences or past options, or can see tips on how to use their appliances more efficiently.

Suggestion – When the system intervenes at the right time, for example by indicating when is a good moment to perform an energy saving action. Timers and alerts can guide users to spend the right amount of time in each activity.

Self-monitoring – When the intervention facilitates keeping track of activities, for example by calculating the amount of time spent and comparing with past performances.

Surveillance – When the observation stimulates change. If people know they've been watched, they behave differently. Sharing performance and results can motivate people to perform better. For example if the application facilitate users to upload pictures of the meal and performance data to social network websites, it might be an added motivator.

Conditioning – When the system reinforces target behaviour using periodic reinforcements such as praise, positive reinforcement and punishment. It is possible to reward or praise users if they chose to perform in a more energy efficient behaviour.

The exact kind of intervention to be used during this study is still under investigation, but at the present, one possible way to encourage people to save energy is using an electronic recipe as a mobile phone application. This recipe can aggregate information about how to prepare the food and at the same time tell people how to use the appliances in a more efficient way. By informing each step to be taken during the preparation of a regular dish, it could lead to a reduced use of electricity.

Developing an intervention using an ICT based application can exploit the potential of computers in persuading people to change their behaviours [7]. With the characteristics of technology it's possible to implant resources that would be impossible to have on other medium. 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 healthy physical activities [2]. 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. Most of the participants managed to improve their activity levels while using the application. Gustafsson and Bång [9] 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.

A mobile phone application might be chosen as the intervention medium due to its inherent characteristics. It allows the

implementation of all 7 items above whilst being in the hand of the user. An electronic recipe is indicated as the intervention method due to its possible features. Using computational resources it can 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 even a game can be provided so users can doodle while waiting for the meal to be ready. The Persuasive System Design model [10] will help during this development process.

It is possible to download and install several cooking applications into smart phones, 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, none of the cooking apps available from the Apple Store at the time of writing provide information about saving energy whilst cooking.

5. CONCLUSION

During this research it was observed that participants behave in diverse ways, even if cooking a rather simple meal. Consequently, the electricity usage and the time to complete the task vary remarkably. Another observation is that participants rarely followed recommended best practices, often because of lack of knowledge, because they wanted to cook quickly, due to convenience or habit. For these reasons a persuasive intervention would be extremely helpful to steer their behaviours towards a more efficient way, leading ultimately to energy saving and sustainability. Further work is being performed to develop this intervention, with which participants will hopefully have a fun and engaging user experience. The effectiveness of such an application in addressing the research questions will be later assessed, specifically regarding the actual energy saving, the transferability of behaviours to other contexts and the maintenance of the practices in the long term. This research also hopes to contribute to the knowledge base of persuasive system design development.

6. ACKNOWLEDGEMENTS

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