The Stroppy Kettle: An Intervention to Break Energy Consumption Habits

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Abstract
Changing human behaviours using persuasive technology has been a focus of the CHI community in recent years. Much of this research aims to change behaviour through feedback of information. This is predicated on the fact that raising awareness will drive changes in behaviour, but psychological research shows that in the case of highly habitual behaviours this form of intervention is unlikely to be effective. We present a prototype device, the Stroppy Kettle, a targeted behavioural intervention aiming to break users' habitual kettle overfill behaviours, by breaking the link between habitual behaviour and goal attainment.

Author Keywords
Sustainability; technology driven behaviour change; habitual behaviours; energy saving; intervention

ACM Classification Keywords
H.5.m. [Information Interfaces and Presentation (e.g. HCI)]: Miscellaneous

Introduction and related work
The reduction of consumption and the drive for more sustainable patterns of behaviour paired with the ability of technology to influence, shift and change behaviour has recently been a focus of the CHI community (e.g. [5]).

The main research approach has been on providing information and feedback to consumers through visualisations, termed eco-feedback (see Pierce for a review [12, 13]). As highlighted by this review, most interventions focus on providing feedback in order to inform or motivate conscious decision making [12]. Interventions such as the Power Aware Cord [9] and more generally home energy monitoring systems [14] assume that through generating more awareness of consumption people will change their behaviours towards being more sustainable. In other words, these interventions assume that filling an information gap will give the user the ability to act on such information and change their behaviour.

This information gap hypothesis seems more of a fallacy if we take the perspective that energy consumption behaviours may be habitual [14, 13]. Recent habit research has discussed that information alone is unlikely to change habitual behaviours significantly [17]. Indeed a recent review of interventions to reduce energy consumption highlights that information alone is not an effective long term behaviour change intervention [2]. Although habitual components to energy behaviours are mentioned in the CHI literature [7, 13] little of it considers habit and more specifically the utilisation of technology to change habitual behaviours.

A habit is defined in the behavioural psychology literature as a learned sequences of acts that have become automatic responses to specific cues [15]. They are seen as behaviours that are repeated frequently, have achieved significant automaticity and where a stable contextual factor acts as a cue to enact a behaviour to attain a goal [16]. Domestic energy behaviours are strong candidates for habituation due to their frequent execution in a consistent environment.

We present a prototype device called the Stroppy Kettle ("Stroppy" is a UK slang term for being ill-tempered or awkward), focusing specifically on impacting the habit of boiling more water than needed when using a kettle (kettle overfill). Although this adverse behaviour represents a significant cost in energy consumption [1], our aim is to identify whether such an intervention philosophy is successful in changing habitual behaviour.

Design Philosophy

Whilst the kettle behaves normally when it is filled appropriately, our design aims to alter the performance of the device for those who overfill, thus breaking the link between habitual behaviour and goal attainment, a critical part of habit setting and maintenance [11]. Through the kettle being "stroppy" in its operation the user is punished for undertaking bad behaviours as opposed to a user being rewarded for good behaviour.

Although people may intend to fill the kettle appropriately the habituation of overfill behaviour means that users are still likely to overfill in the long term, even if a reward is used to influence intentions. Habits are hard to control and are not significantly influenced by conscious intent [17]. Using the habitual response to reach the end goal of having sufficient quantities of boiled water is not hindered in the reward scenario and thus the habit would still be the most easily activated behaviour to achieve the goal.

A barrier to goal attainment when executing the bad habit in the form of a punishment task was therefore felt to be more appropriate and effective. This breaks the habitual procedure and therefore forces interaction with the kettle to become more considered and conscious. Importantly, those who exhibit "good" filling behaviours will experience a normal kettle interaction.

The philosophy of negative consequences to bad energy related behaviours is similar to the Nag-baztag [10] and Power Ballad [7] interventions, designed to deliver negative consequences and social feedback for environmentally unfriendly behaviours. Our approach is more nuanced in terms of our aims to make a behaviour difficult to execute rather than using nagging and embarrassment as user punishment. Based on captology principles [6], our device also focuses on one specific behaviour rather than attempting to bring behaviour change in general in terms of energy reduction across a specific room or home. The design of the device has two key aspects that are core in its development:

Create a barrier to habit execution
Whilst previous research emphasises feedback through visualisation of consumption information [12], habitual behaviours imply a limited scope for feedback to support behaviour change. When designing we must take into consideration the nature of habits as being automatic, learned actions that are affected by specific cues. Habits lead to lower information search and reduced deliberation and consideration in decision making [17]. For successful habit change, these habits need to be disrupted. This could be through changes in the environment or context (as suggested by [17]) or disrupting the process of the habitual interaction. With the Stroppy Kettle, the disruption is created using a punishment task (see the Punishment Task section) similar to the principle of anti-usability described in [4]. To make the kettle work, the user cannot ignore the intervention and thus this intervention breaks the flow of the boiling behavioural process. It means that users must therefore reassess how to execute the behaviour and reach their goal or successfully execute the punishment task each time the kettle is overfilled at a significant time and effort cost. In either case the user will likely re-evaluate the necessary process for successful, low time cost, barrier free interaction in the future. This barrier cannot be too entertaining, otherwise people will engage in the negative behaviour in order to activate the very task that acts as punishment (an issue highlighted by [3, 13]). The barrier used in this intervention was therefore a boring activity whereby users had to spin a wheel on the display at a certain speed, and the worse their behaviour (i.e. the larger the overfill), the longer this task had to be conducted.

Immediate and targeted intervention
By challenging specific actions, habitual or not, at the time at which they are happening, it is much more likely that users will reconsider their approaches and either alter their habits or make a more appropriate choice based on a specific behaviour. Such an approach is advocated in much of the captology literature with the the emphasis on timeliness and having clearly defined behaviours upon which to target technological behaviour interventions [6]. In relation to the kettle the intervention occurs when the habitual behaviour is being executed. Therefore the design makes it clear that the intervention is related to their actions and in turn they are forced to consider them at the time they are being performed.

Technical Specification

The kettle used is an electrically powered cordless design common to most domestic kitchens. The appearance and function of the kettle are not altered ensuring that the perceived affordances and thus the users expectation of the operation of the kettle remain the same as any normal kettle. One unique requirement was to ensure that the kettle could safely boil a relatively small amount of water (300ml) that might be required by a single person.

Figure 1: The stroppy kettle in situ

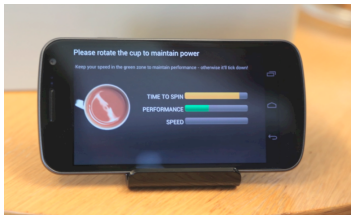

Figure 2: The stroppy interaction embodied by a punishment task delivered through a mobile device

The Water Fill Monitor component continuously measures the amount of water contained within the kettle by weigth rather than measuring the water level directly. This is advantageous since it is robust to the form and function of the kettle and does not alter the appearance or function. Weight is determined using a load cell and then broadcast over a bluetooth modem in real-time. Figure 1 shows the kettle and water fill monitor in situ. The base of the kettle is attached to the top of the water fill monitoring equipment so that users cannot power the kettle without using the water fill monitor setup.

Power Control and Monitoring utilises a wireless control system in order to control and monitor the power consumed by the kettle. The system consists of a plug-through device which monitors and switches power to the device and a wireless hub which receives commands from a remote server and uploads monitoring data. This includes specific interaction events captured through the mobile device such as login, removal and replacement of the kettle, the water level as well as power consumption and power management events.

The Punishment Task in an expression of the device's "stroppiness". Upon a user initiating an interaction (either by clicking on the screen or picking up the kettle) the device asks the user to identify themselves and then asks them about their requirements for boiled water (for example the number of cups required). Once the user fills and replaces the kettle the device calculates the difference between water added and water required to determine the level of overfill. Any overfill quantity is then used to determine the "stroppiness" of the device. The punishment task requires the user to undertake a boring and costly (in terms of time and effort) pacing wheel task. As mentioned this task was chosen above other options (such as a puzzle or game) so as to minimise the chance that users will engage in overfill solely to gain access to the punishment task, an issue mentioned in [3, 13]. The user is required to rotate an object on the touch screen with their finger. If the user rotates too quickly or too slowly the performance bar goes red and after a small period of time spinning the object at the wrong speed, the user fails the task. When the task is failed a signal is sent to the power control system and the power to the kettle is cut leading to the kettle not boiling. The user is then asked if they wish to continue or to give up. If the user gives up then the kettle does not boil the water and the system returns to its initial state. The length of time that the user is required to complete the task directly reflects the level of overfill. The punishment task is implemented using a mobile device placed near the kettle.

Discussion and Future Work

The primary intent of this work is to investigate the role of habituation in the context of technology driven behaviour change and explore how technology can be designed to break and, in the long term, reform negative energy related habits. The authors acknowledge that there may be existing ways in which water can be boiled on demand more efficiently, yet our device looks to show how behaviour change technologies can break and rebuild wasteful energy habits. Our planned future work is based on incorporating behavioural psychological methodology in the evaluation of how the stroppy kettle technologies impact overfill behaviour. Very little of the established, more controlled and quantitative methods in behavioural psychology and conservation psychology have been applied in relation to evaluation of device effectiveness in changing behaviours in the CHI domain. When designing to impact habits, only such long-term, longitudinal trials will highlight quantitatively the effect our intervention has

on such a habit, and such a long term experiment forms a major part of the next stage of our research.

This longitudinal experiment, as well as identifying the effectiveness of breaking habits with this technology, will incorporate conditions to identify the effect of other aspects of the intervention on behaviour. For instance a condition will be added that only includes users identifying the number of cups they wish to boil so that the causal impact of this activity on overfill can be identified. However, we hypothesise that this activity alone will not impact overfill in the long term as there will be no significant barrier to habit execution achieving the user's goal of boiling water.

We also aim to improve on the design of our intervention, using feedback from short pilot tests with UK households. A critical element of this will be interviews with the households to gather ideas in terms of improvements. The interviews will look to assess user views on the kettle design, its behaviour and the design of the punishment task and how these can be improved. Part of this work will look at how people might circumvent the system and how we might avoid this in future prototypes.

Some initial evaluations have been performed with 6 households with the intent of identifying technical and design issues with the prototype. While the number of participants was too low, and their exposure too limited, to infer any significant outcomes we were able to identify some shortcomings with our design. In particular, the data logging performance is susceptible to poor quality and intermittent wireless network connections. Any future deployment will need to be more robust in terms of network connectivity.

Although our device is likely to break overfill habits, there is also the question as to how and whether a new habit is built to replace it. We aim to do this over the long term by effective punishment (or 'stroppiness') leading the user to a habit of filling their kettle correctly. After demonstrating whether the intervention breaks habits effectively, we would look at how to incorporate other intervention mechanisms. Recent research efforts have looked at using social pressure and social norms to affect energy related behaviour. Technology such as the Power Ballad, Power Agent and the Shower Calendar look to harness this social embarrassment to change consumption behaviours. The catalysts for change in these technologies are to either embarrass the user [10] or display ranking of the user compared to others and use visual feedback to create a social motivation to act [8]. Although there is to date no specific evidence to suggest the designs mentioned lead to long term behaviour change, there is evidence to suggest that social feedback and social pressure can be a powerful catalyst to consumption reduction and continued engagement (see [2] for a review).

The findings of the longitudinal study will allow us to identify whether our design achieves this goal. It may be that, once habits are broken, the device must change to be more considerate and supportive to positive habit formation and that in fact information based interactions or rewards could impact behaviour as it becomes more considered. It may also be the case that the behaviour of filling a kettle with only the required amount of water is, in itself, less prone to habituation.

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