Pers Ubiquit Comput (2013) 17:1197–1210
DOI 10.1007/s00779-012-0587-1

ORIGINAL ARTICLE

Designing beyond habit: opening space for improved recycling and food waste behaviors through processes of persuasion, social influence and aversive affect

Rob Comber · Anja Thieme

Received: 7 November 2011 / Accepted: 17 February 2012 / Published online: 13 July 2012

Abstract Disposing of waste is a common part of our everyday life, yet we do not pay much attention to the process. For many it can be considered a habitual, unconscious process. Disposed goods and materials, however, do not simply disappear. This issue has been approached widely and in a variety of disciplines and arenas, including HCI. We add to this growing literature by considering recycling and food waste as habitual behavior and investigate the potential to design toward conscious reflection on waste disposal intentions and behaviors through social influence and aversive affect. That is, we aim to design beyond habitual performance of waste disposal behavior in two phases of (1) awareness raising and (2) supporting subsequent intentions for behavior change. We present results of a rich qualitative and explorative evaluation of the BinCam system, a two-part persuasive technology, which replaces an everyday waste bin with one enabled to capture and share images of disposed of waste on an online social network. Findings suggest that awareness raising leads to self-reflection and re-evaluation. The re-evaluation causes feelings of shame, where individuals perceive a disparity between their attitudes and their behaviors. Results also highlight the importance of a person's perceived behavioral control (e.g., a person's recycling competences or facilities) for enabling behavioral change and confirm the significance of providing "signal triggers" to individuals to remind them about performing the desirable behavior in its required context. Furthermore, as the present research extends its focus beyond the lone individual, it contributes to our understanding and study of social influence processes and group movements.

Keywords Persuasive technology · Behavioral change · Social persuasion · Aversion · Sustainable HCI

R. Comber (✉) · A. Thieme
Culture Lab, School of Computing Science,
Newcastle University, Newcastle upon Tyne, UK
e-mail: robert.comber@newcastle.ac.uk

A. Thieme
e-mail: anja.thieme@newcastle.ac.uk

1 Introduction

Disposing of waste is a common part of our everyday life, yet we do not pay much attention to the process. For many it can be considered a habitual, unconscious process [36, 52] where waste disposal behaviors occur without much thought. True to the motto "Out of sight, out of mind," disposed-of items fall into oblivion; with the closure of a bin's lid, they escape our awareness. Disposed goods and materials, however, do not simply disappear. In the UK alone, individuals discard 5.3 million tons of consumable food each year and improperly dispose of 4.9 million tons of recyclable packaging [55]. As this is a global problem, environmental sustainability has been one of the fastest growing research fields in HCI in recent years. This research examines the potential of using technology to promote environmentally sustainable behavioral and ecological awareness in individuals [13, 14]. To this end, information [30] and persuasive technologies [17] are commonly regarded as valuable sources for behavioral change [14, 16], as they provide users with information on how their behavior impacts on the environment and enhance the desirability of ecologically friendly actions [13, 41, 47].

We present an analysis of the BinCam system, a two-part persuasive technology to facilitate sustainable lifestyles. The system integrates personal informatics

techniques [29] for awareness raising, with social influence [8] and aversive affect [43] by capturing waste disposal behaviors and sharing those in an online social network. We design to raise awareness and break the habits of inappropriate recyclers and to support new and improved behavior through: (1) the provocative nature of the system itself and (2) evoked processes of social influence and self-reflection. While the first achieves its goals at the individual level, the second targets change at the collective level. HCI research and design on behavioral change largely focuses on motivating the lone individual [14] and has paid little regard to the study of powerful social persuasive strategies [17, 51], such as informational and normative social influence [9, 12]. Likewise, the use and study of social media to motivate change is still relatively under-explored (for exceptions see [19, 32]). Therefore, in designing beyond simply drawing attention to habitual behavioral performances, we suggest that the processes of social influence and aversive affect can be employed to support change and shape attitudinal and behavioral responses in relation to ecological sustainability.

The remainder of the paper will firstly discuss the automaticity of habitual recycling and food waste behavior and how technologies can challenge a lack of conscious reflection in individuals' performance of waste disposal behaviors. We examine this as a process of awareness raising. In considering the transition from unconscious, habitual behavior to conscious, planned action, we then explore the role of social influence, perceived behavioral control and attitudes in the performance of recycling behavior. In contrast to persuasive techniques that often rely on the reduction in cost to the individual in performing behaviors, we argue for the role of aversive affect in response to the performance of habitual behavior. We continue to describe a number of persuasive technology designs that compliment and inform the design of the BinCam system, which is subsequently outlined. Findings from an evaluation of the BinCam system are presented, and the system is discussed as a tool for raising awareness, for the provision of social influence and in light of changes in perceived behavioral control. From this, implications for the design of persuasive technologies for habitual behavior are drawn out. We conclude by highlighting the need to consider an array of persuasive techniques in challenging and supporting behavior change beyond habitual behavior.

1.1 Waste disposal as habitual behavior

Many classic approaches to examining human decision-making and behavior assume that individuals behave rationally at all times, cf. [25]. In this light, presenting individuals with information about their own behavior and the context in which it occurs is theorized to improve the quality of rational decisions and resulting behaviors [29]. However, there is increasing evidence suggesting that much behavior occurs outside our awareness and without conscious evaluation [52]. Such behaviors incorporate automatic processing of relevant and available information, which significantly reduces the effort expended by the individual to perform a task or action. Subsequent automatic behavior becomes habitual when performed unconsciously *and* as a routine [52]. Thereby, the performance of the behavior makes efficient use of attentional resources and is perceived to be out of the control of the individual [5]. Habitual behavior occurs when there has been a high-frequency history of the behavior, a stable context in which the behavior occurs and has become an automatic response to that context [36, 52]. Given that waste disposal behavior occurs at high frequency, often in the same contexts (e.g., at home), and people do not spend much, if any, time thinking about it, it is likely that it can become habitually enacted.

1.2 Challenging habitual behavior

Recently, significant research has been carried out in HCI into the potential of technology to change people's beliefs, to shape their attitudes and to influence their behavior [18]. Persuasive technologies [17] are now applied in many domains, including health care [34], education and training [18], and environmental sustainability where it has been used to promote reductions in energy consumption [19, 24, 26, 37, 44], water usage [4, 29] and greener transportation habits [20, 21]. In most cases, the techniques of persuasive technologies [16] can be used to improve the performance of particular behaviors by increasing the ease of performing the behavior and by reducing costs and increasing rewards related to a behavior. For instance, Chetty et al. [10] conclude that simplifying the quantification of home energy to meaningful measures (e.g., bags of coal instead of kilowatt/hours) may make it easier for consumers to reduce energy waste. Thus, simplification of the knowledge and actions associated with a behavior can increase the likelihood that the behavior will be performed [15].

One alternative to this is to nudge individuals toward certain behaviors by making the desired behavior more salient [33, 46] (e.g., making a healthier food option the "default" meal for school children). Like simplification, nudging suggests that automatically performed behaviors are more likely to be performed. However, for many people, habitual waste disposal does not include a history of recycling cf. [55]. The effort required to separate recycling from general waste is enough to make inappropriate waste disposal an easier option. Thus, addressing habitual waste disposal behaviors and motivating individuals to move beyond the "easiest" option and make "more effortful"

evaluations of the appropriateness of their waste management poses a significant design challenge for BinCam.

The fact that habitual behavior is performed outside of conscious awareness indicates a need for the conscious re-evaluation of potentially inappropriate habitual behaviors. Awareness raising has been identified as a key stage in the processes of behavior change [39]. It stimulates reflection allowing for the cognitive and affective evaluation of whether certain changes are desirable to the individual (e.g., reduced food waste, savings in money, reduced carbon emissions). Generally in early stages of behavioral change, methods of self-observation, confrontations or interpretations are used successfully. These methods have been mirrored in HCI research in terms of personal informatics [30], provocative systems [19, 26] or technology probing [37]. Moreover, research on home energy management [10, 44, 45] has shown not only the necessity to attend to the automaticity of disposal behavior but also the context in which it occurs to achieve long-lasting and effective behavior change.

1.3 Intention, efficiency and control: ecological sustainability as reasoned action

If we wish to support individuals beyond awareness raising, we must also support the emerging *conscious* decision-making processes of waste disposal behaviors. For this purpose, we examine waste disposal behavior as a form of reasoned action. When actively reflecting on their actions, individuals can make conscious evaluations of the outcomes of their waste disposal, how much they feel in control of their behavior [31] and to what extent they are influenced by subjective norms, cf. [2, 31, 39]. The greater the intention and the perceived ability to engage in the behavior, the more likely it will be performed [18]. Thus, we examine intentional disposal behavior in terms of the Theory of Planned Behavior (TPB, see Fig. 1) [2]. The TPB has previously been applied to the study of recycling behaviors and is well supported by empirical evidence, cf. [23, 27].

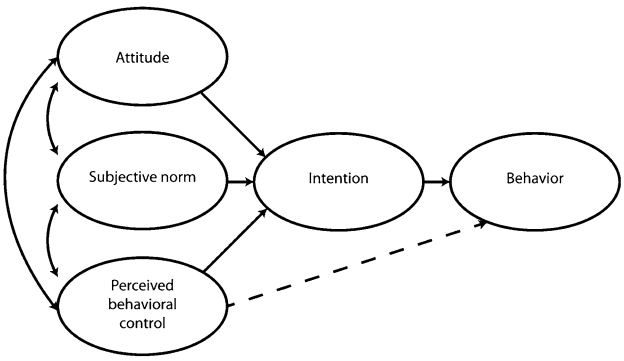

Fig. 1 The theory of planned behavior [2]

For recycling, we may posit that the intentions to carry out environmentally friendly behavior is linked to attitudes toward ecological sustainability, perceptions of the responsibility to act in an ecologically friendly way, and the acquisition of the knowledge and ability to do so. To date, a person's attitudes, as opposed to subjective norms, have often been found to more strongly predict intentions [3], suggesting that people with strong attitudes toward ecological sustainability are more likely to recycle. However, this also depends on other factors including the habitual nature of the behavior and the salience of group membership. As habitual behavior is less likely to be intentional, the relationship between attitudes and intentions is considerably weaker than when the behavior is non-habitual [36].

Ybarra and Trafimow [53] also suggest that increasing a person's sense of group membership, rather than attitude, leads to higher correlations between social norms and behavioral intentions. Such changes in individual behavior can be understood in terms of "social influence" [8, 16]. This influence can operate in one means, as social informational influence [12], where other people are regarded as a significant information source for one's own behavior, particularly in situations in which individuals' are uncertain as to how to behave [9]. Resulting changes in a person's behavior or attitudes are usually motivated by the desire to behave appropriately in the situation and can be deep-seated, private and enduring [12]. Behavioral change also occurs through normative social influence, where the individual is motivated by the desire to obtain social approval and avoid rejection by others [9]. This influence to conform to the positive expectations of others is stronger the more important these people are to the individual [12]. To comply or conform with social norms, individuals tend to agree on the values, beliefs, attitudes or behaviors of others [9], meaning that displayed changes in attitudes or behaviors may not reflect an actual internal change and thus can be regarded as superficial, only publicly shown and transitory. These behaviors may only appear when the individual is under social surveillance [8].

In terms of recycling, McCarty and Shrum [35] suggest that the greater importance of collectivism to the individual, the less likely the individual is to perceive recycling to be inconvenient. Additional factors have been proposed to influence recycling behavior as reasoned action, including the perception of the moral obligation to recycle [10], past recycling and perceived habit [27], and the perceived inconvenience as well as perceived effort of recycling [35, 42]. Even though the relative importance of the three central determinants of intention can vary across situations and behaviors [2, 31], each needs to be supported to increase the frequency of the target behavior.

1.4 The potential of aversive affect

Research into coercion—as the use of force, pressure or even pain—to change a person's behavior is ethically questionable, meaning that strategies to threaten or intimidate a person for not behaving in a desired manner have rarely been applied in the design of persuasive technologies, cf. [19]. Fogg et al.'s [18] understanding of persuasion in fact excludes the use of force to enable change. They claim that persuasion should neither be coercive, nor manipulative or deceitful, but allow individuals to remain in control of their own actions. Thus, persuasive technologies primarily reward individuals for performing desirable behaviors while avoiding the providence of negative feedback for "misbehaviors," with few exceptions (e.g., [19, 26]). Consolvo et al. [11] assume that individuals would simply stop using a system if being punished or blamed by it.

Kirman et al. [26], however, argue that behavioral change technologies should employ both appetitive and constructive aversive feedback to support the learning and maintenance of a desired behavior [43]. Although rewarding a desirable behavior is assumed to increase the likelihood that a behavior will be performed again, behavior can also be negatively reinforced, meaning that performing the behavior prevents or removes a negative response (e.g., avoidance of social disapproval for non-recycling). Similarly, Foster et al. [19] have shown that a light form of punishment in the form of aversive feedback, if carefully and playfully presented, does not necessarily disengage users but can valuably support behavioral change. Whenever the energy consumption of a user's household increases, their "Power Ballads" application automatically posts a public message about the excessive and undesirable energy behavior to the person's facebook profile, together with a playful yet aversive stimulus (here, a link to popular UK chart music that is knowingly disliked by the person). Contesting the assumptions of Consolvo et al. [11] and despite being shamed, users regularly engaged with the application and reflected about their energy consumption. As such, the powerful motivation to avoid social rejection or disapproval may act as a resource to engage, rather than disengage, users from a persuasive technology.

Thus, we position such aversive affect as an additive factor to the design beyond habitual behavior. Through the interaction with BinCam, it is hoped that participants become more aware of their own and other people's behavior, including their misbehaviors. This may, together with social normative influence, evoke feelings of "guilt" or "shame." Evoking such aversive emotions may be successful in supporting an individual's motivation to change for the better.

1.5 Related work

Persuasive technologies and design concepts addressing people's waste management have begun to emerge. These include the augmented Trashcan [37], Cleanly [40], TrashTrack [50], the World's deepest bin [48], Bottle Bank Arcade Machine [47] and Weigh Your Waste [22].

The augmented Trashcan [37] is a public city trashcan that projects a flow visualization of collected trash items to urban dwellers on the street. The system is not designed to raise environmental awareness, but to prompt wonderment on urban life and to provoke storytelling on the visualized trash. Cleanly [40] is a system that focuses on educating citizens to avoid environmental pollution through misplaced trash. It tracks people's interactions with various bins and displays these on wearable smiley badges, in monthly personal reports and on public displays. However, this design concept does not specify the type of information to be collected or how data would be aggregated and presented, nor has the concept been evaluated.

In the Trash Track [50] project, 3,000 small tags were attached to different types of trash, monitored and visualized in real time to make the typically invisible journey of trash visible. Results not only increased the visibility of the waste removal system, but also invited individuals to reflect on the impact of their disposal behavior on the environment, and thereby promote behavioral change.

The World's Deepest Bin [28, 48] uses an audio cue to prompt reflection on waste disposal. When waste is put into the bin, the bin plays a sound emulating an item falling a great distance. Resulting surprise and fun engages the individuals in reflections on their waste disposal. Likewise, the Bottle Bank arcade machine [47] engages individuals in the playful use of a bottle bank. The bottle bank incorporates elements of an arcade game whereby the individual is rewarded with points for every recycled bottle, increasing use and fostering long-term environmentally friendly behavior [40].

In contrast to these *public* means of engaging individuals in reflection on waste, Weigh Your Waste [22] is an interactive disposal bin with an integrated scale to weigh the amount of waste produced in a *private* household. The weight of the waste, its financial costs and information on how general waste can be reduced are visualized to the users to highlight the financial benefits of producing less waste and thereby to motivate environmentally friendlier actions. Although a promising design concept, the impact of this waste-weight monitoring device on people's pro-environmental behavior has again not been evaluated.

Most of these concepts and designs aim at affecting long-term change in individuals' behavior through promoting self-reflection. They draw attention to the often mundane activity of waste disposal and hope to encourage reflection.

2 Design of BinCam

BinCam is a two-part system consisting of an augmented bin and a custom BinCam application (short "App") on facebook (www.facebook.com). The system and its design rational are described in detail in [49]. Here, we position the design of our persuasive system around two distinct approaches to behavioral change. On the one hand, we examine the notion that a large part of everyday behavior is not intentional, but unconscious and habitual. On the other hand, assuming that the habitual behavior can be raised to conscious performance, we also examine a person's food waste and recycling behavior as an intentional, reasoned action, designing for the direct route for persuasion. The BinCam system is therefore also designed as a response to both the unconscious and conscious processes of waste management behavior. We explore the impact of various techniques for persuasion and influence, as well as coercion, on behavior change.

2.1 The BinCam bin

Seeking to design BinCam as a minimal intervention and considering that recycling facilities in UK households range from having at least one, and up to five, recycling container, we found the refuse bin to be the only standard among all. Thus, the BinCam bin simply replaces an existing kitchen refuse bin. To address the lack of interest in one's own waste activities—particularly for young adults (cf., [55])—and the time required to gather information on the users' part, the process of data collection with BinCam is entirely automated. To this end, the BinCam bin automatically captures images with a smart phone installed on the underside of the bin's lid (see Fig. 2). The phone's accelerometer triggers the camera each time the lid is closed. Using a wireless connection, the phone uploads images to the BinCam application on facebook where they are immediately visible to all BinCam members. This system-driven capture of individuals' waste-related behavior significantly eases the collection of personal data [30].

2.2 The BinCam application on facebook

The BinCam system is employed on the facebook platform as a means to leverage participant engagement and social influence. Facebook is widely and regularly used by the target population, fitting into their everyday communication and technology use practices. Importantly, facebook users most often engage with known others and, as such, have a strong desire to be accepted [15]. Positioned within the practical and social dynamics of this engagement, the BinCam App provides the user with "BinPictures" and a "BinLeague" to enable social informational and normative influences.

2.2.1 BinPictures

The BinCam app publishes the images captured by the BinCam system to a continuous photo stream on facebook, each of which can be enlarged to allow for inspection of individual items in the bin (see Fig. 3). The owners of the bin ("Bin Responsibilities") are displayed alongside the images as a means to encourage reflection on and as well as responsibility for household waste. To further leverage social influence, the app also presents images of people who have recently viewed the contents of the bin ("Bin Spy"). To increase discussion and the potential for influence, the pictures taken by each bin are visible to all BinCam users.

As images are captured and uploaded, they are processed by Amazon's Mechanical Turk crowd-sourcing

Fig. 2 A BinCam bin augmented with a Sony Ericson Xperia™ X10 mini smart phone

Fig. 3 Part of the BinCam interface showing an enlarged and tagged bin picture in the *middle*

service (AMT, www.mturk.com), where workers are asked to identify the *total number of items*, the *number of recyclable items* and the *number of food items* in each image. This crowd-sourcing technique allows for the robust identification of food and waste items even if squashed or semi-covered. The tagged data are presented to BinCam users alongside the respective picture. Images and tags can be manually edited if items are incorrectly identified and, to facilitate privacy, can be deleted should participants wish.

Inevitably, the display of personal data on a public platform raises privacy and ethical concerns. Disposed of items are normally objects that individuals do not want to be identified with anymore, and the publication of these pictures poses a risk to the individual of being publicly humiliated. As such, the BinPictures may act as an aversive force that requires the individuals to adjust their behavior to avoid public disapproval. To address potential privacy concerns related to personal waste, BinCam is only deployed in shared houses, where the contents of a bin cannot be directly attributed to any particular individual. The BinCam bin replaces the shared kitchen bin in households of 5–7 participants. Participants also retain their personal bin in their rooms for disposal of personal refuse. We therefore assume that personal objects would not find their way in the BinCam bin. However, such decisions are part of a design trade-off, as the aggregation of waste disposal behavior also makes the impact of individual's behavior less visible and as a consequence may lead to a reduction in the social influence effects described earlier.

2.2.2 *BinLeague*

The BinLeague provides visualizations of the crowd-sourced scores for two elements of waste disposal: (1) *recycling achievements* visualized as "leaves on a tree"; and (2) *prevented food waste* displayed as "gold bars." *Recycling achievements* are achieved through a decrease in recyclable materials in the bin, visualized through the growth of leaves on the tree. A reduction in food waste increases a household's quantity of gold. Each week, the percentage change from the previous week is calculated for each score (see Fig. 4). We chose relative feedback, as opposed to an absolute presentation of food waste, due to an unequal number of participants in each household (between 5 and 7 members). It allows for tracking of improvements per household per week (e.g., 10 % improvement equates to one leaf on the tree or one additional gold bar) and, unlike absolute data, comparison in relation to improvements to other households. It was expected that improvement over the course of the study

Fig. 4 The BinLeague displaying all households' recycling achievements (leaves on a tree) and food waste savings (*gold bars*) in comparison to other households over time (color figure online)

would be a strong and easily appropriated indication of behavior change as the population was identified as being poor on recycling [55]. The tree and gold images draw on common metaphors used in eco-visualizations and were chosen as abstractions of each household's performance on recycling and food waste behaviors. Holmes [24] for instance uses the image of a tree to reflect the amount of consumed carbon. He argues that "trees are considerably easier to picture as opposed to 533-kilowatt hours" and that "most individuals maintain positive feelings toward trees" (p. 160). Fröhlich et al. [20] also employ the tree metaphor in their Ubigree transportation application. Here, their tree accumulates leaves, blossoms and finally apples, the more the individual engages in green transportation activities. Financial consequences of producing general waste have also been emphasized in the Weigh Your Waste [22] concept. With BinCam these consequences are highlighted for food waste. While abstract visualizations can help reduce the complexity and increase accessibility of collected data, particularly for a layperson, they carry the risk of being misunderstood [7].

Apart from visual feedback on each household's waste performances, the BinLeague aims to motivate competition between the BinCam households. While supporting one's household achievements makes normative social influences more salient, a comparison of one's own efforts with the progress of other households presents a social informational influence [8, 12]. The element of competition can foster desirable behaviors by providing a positive outlook on winning, described by [2] as the "*incentive value of success*" (p. 184), but also motivates individuals to avoid feelings of failure [15]. Comparisons with others who may share similar environments, but perform better on target behaviors, can also highlight the achievability of that behavior.

3 Method

To gain insight into how individuals interpret the BinCam system and how they relate to its different features in everyday life, we conducted an explorative study with 22 young adults (*females* = 11), ranging in age from 18 to 35 ($M = 23$), who live together in four shared households of 5–7 occupants. Three households were recruited by one member of the research team, who knew one person in each flat. This contact person then introduced the idea of the project to her housemates. A fourth household declared interest after attending a presentation of the project to students through the waste manager of the university and collaborator of the research. With all four households we arranged an introductory meeting in their flats, allowing the researcher to assess the kitchen modalities (e.g., recycling facilities, available WiFi and power plugs) and to discuss the research with potential participants. All households were appropriately equipped for deployment and agreed to take part. Two weeks later, we sought informed consent from participants, deployed the BinCam bin in their kitchens and handed out pre-study questionnaires.

Of all the participants, 16 were students and six were self-employed or unemployed. The households did not know each other from the outset of the study. In each household, we replaced the existing refuse bin with the BinCam bin. Each household had one recycling bin for

cardboard and plastic, three households had an additional recycling bin for glass and jars, and one household had an extra bin for compost. Refuse waste for each household is collected weekly and recycling every 2 weeks.

All participants were given access to the BinCam App, yet their engagement with the App during the five-week period of the study remained voluntary. To facilitate appropriation of the BinCam bin and to foster collaboration between members of each household, participants were asked to name their bin. To enable engagement with the BinCam App, participants were also required to be regular and active facebook users. In the pre-study questionnaire, participants were therefore asked about their general facebook usage habits by answering the Facebook Intensity Scale [15]. Participants had on average 372 friends (SD = 251.4) and spent on average 86 min on the Web site per day. In addition, participants were asked about their general attitude and behavior related to recycling and food waste. Question items were informed by [54]. On a 5-point scale ranging from 0 (*not at all important*) to 4 (*very important*), participants indicated that recycling is quite important to them with $M = 3$ (SD = .8) and that they are fairly concerned when they have to throw away food ($M = 3$, SD = .8).

At the end of the five-week study, focus groups were held with participants in their residences. Post-study questionnaires were handed out prior to the focus group. Participants who were not available to attend the focus group were left with an envelope containing the questionnaire. We chose focus groups as a method to capture rich and insightful data evolving from interactive group discussions about their experiences and opinions of BinCam. All participants were invited to participate, and almost all participants were able to attend the interview (18 of 22 participants attended the focus groups). The focus groups followed a semi-structured interview approach with open-ended questions asking about participants' thoughts on the project, what they liked and disliked about it, their opinions on the different features of the BinCam App, whether there has been any impact of the bin on their waste management, whether they talked about the project with their flat mates and whether they would recommend the project to friends. Visits took on average an hour and were audio recorded. Although participation in the project was voluntary, each participant was remunerated for filling out questionnaires and taking part in the focus group with £10. The study was approved by the institutional review ethics committee at Newcastle University.

The audio recordings from the focus groups were transcribed and analyzed using a thematic analysis approach [6]. The researcher familiarized themselves with each transcript, generated initial codes and highlighted subsequent elicited interpretations. Through a continuous review of the generated codes, we developed initial themes that were reformulated to encapsulate all the data, until the final themes were decided. To ensure the data reflected the view of participants, the analysis followed an inductive approach and an attempt was made to attend openly and equally to all responses to minimize potential interference of prior expectations and speculations of the researchers. All names of participants have been changed.

4 Results and discussion

In the pre-study questionnaire, participants reported that they were either already good recyclers or at least contemplating improving their waste management. It is therefore not surprising that in the focus groups and post-study questionnaires, they did not report changes in their attitude toward recycling and food waste. Although the BinCam system did not appear to have an effect on individuals' attitudes toward recycling, it was shown to have an impact on their awareness of their own and others' recycling behavior. This awareness prompted self-reflection and re-evaluation of the facilities and abilities available to the participants for recycling. Below, we outline the three primary changes observed, namely awareness raising of local behavior, re-evaluation in light of social influence and re-evaluation of behavioral control.

4.1 Awareness raising of local behavior

The design of the system was aimed at a particular target group, namely those aged 18–35, who are typically unaware of recycling issues [55]. However, in this case, it appears that the participants were already recycling aware and held positive attitudes toward recycling. One participant claims: "*Well I think we all sort of recycled before.*" The participants therefore did not perceive the system as a whole impacting on their behaviors. For instance, one participant states that: "*I think this is possibly not the best…because I think we all recycle as much as we can and we don't really waste food because we're all quite poor.*" This suggests that the BinCam system may have been inappropriate for the purposes of behavioral change within this sample. The participants believe that their recycling behavior was as good as it possibly could be and that, as such, a persuasive system could not impact on their attitudes or behaviors. However, despite the belief that the system did not change their behavior outright, the participants do express a change in their awareness of their recent behavior. This appears to be first associated with a noise emitted from the bin when it captures images:

Tom: "*it makes you more aware because you hear the click and you think about it a second time. Was it really right that I put it in there or wasn't it?*"

The noise emitted by the BinCam bin occurs five seconds after the bin lid has closed. The trigger acts within the unconscious behavioral pattern associated with waste disposal and breaks the unconscious processing of the behavioral pattern. While it was expected that the presence of the new bin and the phone inside the lid would serve as a visual cue for reflection, the auditory cue proved more effective, serving as a timely trigger for self-reflection. From this, participants begin to question their own behavior and particularly the accuracy of their recycling decisions and habits.

Barbara: "*It is, it's interesting that you like, that you suddenly become really aware about your bin habits… Like you just don't realize how many times you put something in the bin every day… I mean that is interesting. It makes you analyze what you do much more I think.*"

Barbara expresses the perspective of many of the participants. The auditory trigger from the bin was a new and unexpected addition to their waste disposal habits and drew attention to what was otherwise an unconscious process. However, this does not always mean that they change their behavior:

Tom: *You don't like change your decision. You don't take the garbage out again after checking it was wrong*

However, it does mean that they are thinking more about their waste disposal. In many cases, this did lead to better recycling behaviors:

James: *I've seen a lot of paper in that bin actually that's one thing we are quite bad at … You know I think we're quite poor for that and I've certainly now noticed there's more paper in our, erm, I took out the recycle bin yesterday there was so much more paper in it. All the junk mail we get … you did chuck it in the bin but what we tend to do now is taking that plastic off and you know breaking it down to all recyclables and non-recyclables. So that is something I did see and I think has improved*

Individuals were prompted to reflect on their own behavior and then made a conscious decision about whether recycling was a worthwhile activity. Thus, although from the outset participants expressed positive attitudes toward recycling in general, these attitudes are not necessarily linked to actual recycling behavior. When prompted to reflect on their attitudes to specific behaviors, individuals could be seen to make more considered evaluations of personal, social and contextual factors, including perceived behavioral control.

Although BinCam raised awareness of individuals' local waste disposal behavior, participants' opinions of BinCam features such as the BinLeague were mixed. On the one hand, the league with the "tree" and "gold bar" images was described as a *nice* and *easy* visualization for tracking a household's progress in improving recycling habits and money savings on food waste. On the other hand, the opacity of how the league is calculated and how changes can be achieved was not entirely understood, leading to confusion among participants.

4.2 Re-evaluation in light of social influence

While the auditory trigger promoted an immediate and localized effect, there was also a strong and more persistent effect from social influence. For the participants, their re-evaluation of their own recycling behavior was influenced by the perceived presence of observers, including co-presents, imagined others and the system itself. These included housemates, an online public audience and the bin as a social actor. Two participants express such feelings:

David: "*I'm more aware because this is gonna be on the internet what you put in this bin*"

Regina: "*And it felt like the bin was watching you… because you are like, oh yeah I shouldn't have put this in, I cooked that.*"

Although they reported that they were not overtly blamed or shamed by others for their waste disposal, participants reacted to this on a number of levels, including a personal level, where individuals were forced to re-evaluate their perceptions of their own behavior, and on a within-household level, where individuals perceived their housemates as potential evaluators of their behavior. Yet, although participants were aware of the public nature of the facebook app, it was not reported that individuals felt that others outside their household exerted a direct influence on their behavior. In fact, many participants felt that the presence of others was a normal part of facebook use, common in practices such as "facebook stalking." The system itself also takes on characteristics of an observer. Participants felt that, through the system, their waste disposal became more visible to others. In response to this, participants experienced both social pressure and personal feelings of guilt. For two participants, this was perceived in relation to the BinLeague and the social responsibility to ensure the house did well.

James: "*Or if we did really bad in recycling that would be awful you know. So for me, for me it was, it*

was, there was a bit, you know, all of us together and I really know what my friends would say…"

Elaine: "*Yeah you don't want to let your house down.*"

This social influence acted as a normative influence, giving each house an idea of what "really bad in recycling" could mean, and as a coercive force, where it is unacceptable to "*let your house down.*" Although the participants claim not to be concerned with the competitive element of the BinLeague, they nonetheless use the information to evaluate their own behavior.

Katie: "*It honestly gets…like to see other bins, see other people how they're doing because it's like "Oh I'm not doing that great" so it's just like I'm trying to do better.*"

4.3 Re-evaluation of behavior control

For Katie's housemate, the guilt also results from reflections on his ability to perform the behavior in contrast to others. As such, it reflects an element of perceived behavioral control:

James: "*I think even if we're not interested in the composition of other people's bins or not looking at photos of other people's bins like Katie said was really interesting was to see how we're measuring up…Against people who are just like us, most of them, you know, all students you know or have a busy lifestyle. So it's no excuse when you see yourself coming sort of down the bottom [of the Binleague]. You know it's a competitive sort of feeling that you get, it's a bit of a feeling of guilt and you do think "Right okay", you know it just improves your behavior. Yeah it definitely does while you want to do better.*"

When James compares himself to others, he notes that, like him, they are busy, but unlike him they are more active in recycling. This discrepancy reflects poorly on James, particularly because he holds strong positive attitudes toward recycling. This is experienced both as a feeling of guilt and as a resolution to improve behavior.

Although the participants claimed to have positive attitudes toward recycling, it became clear that they often did not have the full knowledge or facilities required to recycle certain items. As they became more aware of their waste disposal behavior, they began to rethink their recycling knowledge.

Tom: "*And yeah, I think it makes you more aware and I noticed for myself that I'm not completely sure about recycling particularly here in Newcastle because I'm new here so I wasn't sure "Do I really have to clean that" because for me it's a strange thing as well.*"

Participants found themselves reading packaging labels and learning about different recycling techniques. Two participants discuss this issue:

James: "*I think at first it was, erm, I wasn't sure if it would make me feel more aware or not, erm, simply because I thought "It's just a camera in the bin" and it doesn't you know, erm, I thought I was pretty good anyway. Erm, and then you sort of get to read the back of the package and stuff like that and start looking what is actually recyclable—recyclable definitely and what isn't and then, erm, I find I took more time to differentiate between what was recyclable and what wasn't recyclable. It was useful for me.*"

Katie: "*Yeah I was like even aware of composite plastic and just break up where it is recyclable or it's not and I just feel before that I probably wouldn't like be aware of what it is actually going to recyclable bin you know.*"

This has different effects for different participants. Some participants consider removing items from the bin, while others stated that even after reflection they would not.

Apart from individual skills, participants also reflected about their waste management facilities. Despite being willing to recycle, participants felt that there is no good way of managing the large amounts of "bulky" cardboards and plastic containers in their kitchen. In addition, they complained that their recycling container outside the house fills up to quickly, sometimes within a day, while only getting emptied biweekly. In one household, participants also said that they tried to compost their food waste, yet found it very impractical. They describe the handling of *moldy* bits and *smelly* items as *disgusting* and did not find it desirable to be having a composting container in their kitchen, next to the food they eat.

5 Implications

Habitual behavior presents a significant challenge to society. It may be an important factor in continued harmful behaviors including smoking, drinking and poor dietary habits. It is also a significant barrier to environmentally friendly behavior. Critically, it appears that many people do not recycle and create waste food, despite being aware of environmental issues and even holding positive attitudes toward recycling [27]. This has led to the development of

numerous strategies and technologies to motivate behavioral change. Within HCI, these have often focused on the notion of reasoned action [2], where individuals are proposed to make rational and informed decisions regarding their action. It is expected that providing individuals with information on their behavior will improve the quality of their decision-making [30]. Participants in the study reported positive attitudes toward recycling from the outset. From a reasoned action perspective, this should have been associated with positive recycling intentions, and subsequently behavior. Therefore, persuasion that relied on the strength of pro-environmental attitudes may have been ineffective. However, it appears that for many of the participants, recycling behavior did not occur as a reasoned action, but rather as part of a habitual behavioral pattern of general waste disposal. In these cases, behaviors occur automatically, outside awareness and without intentionality [52], meaning that additional information may not be processed. This led to some inaccuracies in recycling behavior, where individuals relied on their assumptions [44], for instance, about the suitability of materials for recycling. Thus, techniques other than the provision of personal behavioral information are required. We suggest that techniques of persuasion, influence and aversive feedback may be used to design beyond habitual behavior. Here, we discuss the implications of these findings for the design of persuasive technologies to challenge inappropriate habitual behaviors and to support subsequent behavior change.

5.1 Activating and appropriating awareness

The BinCam system was designed as a provocative system to draw attention—for the individual, among a household and across a social network—to the inaccuracies of waste disposal behavior. The BinCam system was effective in drawing attention to the habitual waste disposal behavioral pattern and, in doing so, afforded participants opportunities to reflect on their behavior. This self-reflection led to the realization that the participants lacked recycling knowledge and access to facilities. We consider this two-phase activation and consequent appropriation of awareness as a significant feature of designing beyond habitual behavior.

Unintentionally in the design of BinCam, the click sound of the camera upon image capture was most readily recognized by participants as a challenge to their habitual performance of waste disposal. This post-behavioral prompt occurred within the continued automatic performance and was sufficiently unexpected to draw attention to itself and the waste disposal behavior. By being positioned after the performance of the action, the audio cue does not impose any additional effort on the individual in the performance of the behavior. While it may not have prompted individuals to change their decision about inappropriate waste disposal, it became a signal trigger to reconsider the decision. This critical reflection was coupled with the other post-behavioral resources provided by and around the BinCam system, including the BinPictures, BinLeague and other household members' knowledge, as participants began to re-evaluate aspects of the perceived control over recycling behavior. That persuasive systems are employed in a complex cultural context that constitutes a continuous dialogue between the system, the individual, one or more communities of users (both online and offline) affords that they are study in this richness [44, 45]. Thus, we suggest that while persuasive technologies must draw attention to the habitual performance of inappropriate behaviors, they must also draw on and influence the social contexts in which those behaviors are performed.

5.2 Social influence and aversive feelings of guilt or shame

In the context of the BinCam system, the appropriation of the facebook platform provided a means to leverage social influence and impart change in the network. The BinLeague suggested that group norms facilitated a local influence not to let the household down in competition. When individuals perceived their behavior and that of their household as below this norm, they experienced feelings of guilt and resolution to perform better. This relied both on the provision of the social information and also on the perceived observation by others, including local and networked publics and a system as social actor [17]. Although subjective norms are typically less salient in behavioral change techniques [3], it is clear that when attitudes are held constant, the power of social influence should not be underestimated. In this case, individuals were led to feel shame about their behaviors in light of the presence of others. This suggests that not only can system-led feedback lead to behavioral change (cf., [26]), but that research should extend on underexplored yet promising and potentially powerful strategies of social influence. In particular, it is necessary to investigate the use of influence through emotion, values and perceived social obligation. This may be supported using increased communication between individuals who share recycling responsibilities and through the development of shared activities for the creation and sharing of recycling knowledge.

Although the system was not designed specifically to induce shame, this was one of the outcomes. In each case, the feelings of guilt or shame could be framed as a coercive force; it is an influence that the participants would not have experienced without the presence of the BinCam system. However, it is an internal force, rather than an external force. That is, rather than feeling that others were, by

observing them, applying pressure, the participants felt guilty about their own behavior and the discrepancy between their perceived and ideal behavior. We suggest that such internal reflection and evaluation can lead to behavioral change [10] and therefore deserve consideration as a potential component of persuasive systems. While the design should avoid making people feel unduly bad about themselves, it is clear that certain aversive feedback can motivate individuals, cf. [19]. Fears of social disapproval (as negative reinforcement) may be necessary to support often hidden behaviors that impact on society. However, such motivation should be positioned as an internal force, where individuals move beyond habitual behavior and reconsider their own actions.

In moving beyond inappropriate habitual behavior, it would also be important in future designs to more strongly include positive reinforcements for appropriate recycling behavior to promote the formation of new habits through external motivators, such as positive feedback, social support and expert or referent power associated with performance of appropriate behavior. Although individual behavior is not recognized explicitly in the BinCam system, the provision of household rewards, micro-achievements and other elements that support a gamification of the system may further help in reinforcing positive behaviors and strengthening group identity and subsequently enhance the influence of group norms.

5.3 Study limitations

We have to point to some limitations in the study and in our approach to behavioral change in general. First, although our data suggest an increase in awareness of and recycling behavior, it does not necessarily follow that this marks an improvement in recycling behavior. That is, it is not enough to simply motivate individuals to recycle, but also to educate them in how to properly dispose of all waste. In this study the individuals relied on their own motivations and inquisition to increase their recycling knowledge. While this may have provided an intrinsic motivation for engagement with recycling issues, it may also lead to further inappropriate behaviors where incorrect information is assumed to be true. Therefore, future designs must also improve the provision of knowledge to support self-reflection, education and the sharing of information between individuals. This self-education should not interfere with, but support, self-reflection as a meaningful engagement with environmental sustainability.

We also note that the persuasive strategies applied did not work for every individual and that a "one-size-fits-all" approach to behavior change may be inappropriate, cf. [1]. In some cases individuals were persuaded to improve their recycling behavior, while others were not [7]. Although recycling was brought to their attention, these latter individuals still maintained that recycling was either too effortful, beyond their control or that issue of recycling particular items was not important. Thus, when individuals make conscious decisions not to engage in desired behaviors, additional mechanisms for change may be necessary. We suggest that an approach combining both system-led persuasive techniques and influences of social acceptance and desirability may best achieve behavioral change. As evidenced with the BinCam system, the application of a robust aversive social influence may be beneficial, though it is not always desirable.

Moreover, while the abstract images in the BinLeague were liked by some of our participants, for others they made it difficult to unpick how their behavior relates to the resulting visualization. A numerical and more frequent presentation of the amount of waste items identified in the BinPictures may have been more comprehensible to them. This finding reiterates results of Broms et al. [7], who experienced that interpersonal difference between participants and their past experiences of other feedback systems influences how they understand and appropriate the system and its design.

5.4 Conclusion

Following from the findings above, we suggest that persuasive technologies for sustainability should aim at self-reflection that responds to the changing attention and cognition of habitual behavior. Although individuals rated themselves highly in relation to ecologically friendly attitudes, they did not engage in these activities mindfully and as a result may have carried out inappropriate waste disposal behaviors. If a person has both the abilities and the facilities as well as the intention to perform the target behavior, then it depends on the attentional resources, contextual factors and personal norms of the individual to what extent persuasive strategies can come into play to support the behavior. The less the individual pays attention to the behavioral process and the more he/she follows a unconscious habitual route, the more the technology has to raise awareness, providing triggers, social pressure or other forms of light influence to promote the individual. When called to reflect on their own behaviors, participants were led to feel shame, to change their behavior and to try to self-educate about recycling and food waste. This self-reflection provides opportunities for social and aversive motivation, where individuals examine the relationship between their values and behaviors. This addresses a gap between the intentions of individuals, their ability to carry out recycling behaviors and the awareness of their pro- or non-recycling behaviors. Such awareness challenges the automaticity of habitual non-recycling that coexists with

contradictory positive recycling attitudes. The impact of the persuasive techniques employed, particularly the timely trigger for self-reflection, and the provision of social influence through competition, served to motivate individuals toward environmentally friendly behavior. The role of signal triggers and reminders to occur at the "right" moment as well as processes of social influence and coercion through persuasive design deserves more future research.

Acknowledgments We gratefully thank all households participating in this research, and for their contributions to the research, Jack Weeden, Julia Miebach, Nick Taylor, Isaac Teece, John Vines, Daniel O'Connor, Nicole Kraemer, Shaun Lawson and Patrick Olivier. We would further like to acknowledge the contribution of the reviewers through their insightful comments. This work is in part supported by Marie Curie Action under the European 7th Framework Program Balance@Home project and the RCUK Digital Economy Research Hub SiDE: Social Inclusion through the Digital Economy.

References

1. Ai He H, Greenberg S, Huang EM (2010) One size does not fit all: applying the transtheoretical model to energy feedback technology design. In: Proceedings of CHI 2010, pp 927–936. doi:10.1145/1753326.1753464
2. Ajzen I (1991) The theory of planned behavior. Organ Behav Hum Decis Process 50:179–211. doi:10.1016/0749-5978(91)90020-T
3. Armitage CJ, Conner M (2001) Efficacy of the theory of planned behavior: a meta-analytic review. Br J Soc Psychol 40:471–499. doi:10.1348/014466601164939
4. Arroyo E, Bonanni L, Selker T (2005) Waterbot: exploring feedback and persuasive techniques at the sink. In: Proceedings of CHI 2005, pp 631–639. doi:10.1145/1054972.1055059
5. Bargh JA (1994) The four horsemen of automaticity: awareness, intention, efficiency, and control in social cognition. In: Wyer RS, Srull TK (eds) Handbook of social cognition, vol 1. Erlbaum, Hillsdale, pp 1–40
6. Braun V, Clarke V (2009) Using thematic analysis in psychology. Qual Res Psychol 3:77–101. doi:10.1191/1478088706qp063oa
7. Broms L, Katzeff C, Bång M, Nyblom Å, Ilsted Hjelm S, Ehrnberger K (2010) Coffee maker patterns and the design of energy feedback artefacts. In: Proceedings of DIS 2010, pp 93–102. doi:10.1145/1858171.1858191
8. Cialdini RB (2009) Influence: science and practice. Pearson Education, Boston
9. Cialdini RB, Goldstein NJ (2004) Social influence: compliance and conformity. Annu Rev Psychol 55:591–621. doi:10.1146/annurev.psych.55.090902.142015
10. Chetty M, Tran D, Grinter RE (2008) Getting to green: Understanding resource consumption in the home. In: Proceedings of UbiComp 2008, pp 242–251.doi:10.1145/1409635.1409668
11. Consolvo S, McDonald DW, Landay JA (2009) Theory-driven design strategies for technologies that support behavior change in everyday life. In: Proceedings of CHI 2009, pp 405–414. doi:10.1145/1518701.1518766
12. Deutsch M, Gerard HG (1955) A study of normative and informational social influence upon individual judgment. J Abnorm Soc Psychol 51:529–635. doi:10.1037/h0046408
13. DiSalvo C, Sengers P, Hrönn B (2010) Mapping the landscape of sustainable HCI. In: Proceedings of CHI 2010, pp 1975–1984. doi:10.1145/1753326.1753625
14. Dourish P (2010) HCI and environmental sustainability: the politics of design and the design of politic. In: Proceedings of DIS 2010, pp 1–10. doi:10.1145/1858171.1858173
15. Ellison NB, Steinfield C, Lampe C (2007) The benefits of facebook "friends": social capital and college students' use of online social network sites. J Comput Mediat Commun 12(4):1143–1168. doi:10.1111/j.1083-6101.2007.00367.x
16. Eslambolchilar P, Wilson ML, Oakley I, Dey A (2011) PINC: persuasion, influence, nudge and coercion through mobile devices. Ext Abstr CHI 2011:13–16. doi:10.1145/1979742.1979586
17. Fogg BJ (2003) Persuasive technology: using computers to change what we think and do. Morgan Kaufmann, San Francisco
18. Fogg BJ, Cuellar G, Danielson D (2002) Motivating, influencing, and persuading users. In: Jacko J, Sears A (eds) The human-computer interaction handbook: fundamentals, evolving technologies and emerging applications. L. Erlbaum Associates Inc, Mahwah
19. Foster D, Linehan C, Lawson J, Kirman B (2011) Power ballads: deploying aversive energy feedback in social media. Ext Abstr CHI 2011:2221–2226. doi:10.1145/1979742.1979944
20. Fröhlich J, Dillahunt T, Klasnja P, Mankoff J, Consolvo S, Harrison B, Landlay JA (2009) UbiGreen: investigating a mobile tool for tracking and supporting green transportation habits. In: Proceedings of CHI 2009, pp 1043–1052. doi:10.1145/1518701.1518861
21. Fröhlich J, Findlater L, Landay J (2010) The design of eco-feedback technology. In: Proceedings of CHI 2010, pp 1999–2008. doi:10.1145/1753326.1753629
22. Gartland A, Piasek P (2009) Weigh your waste: A sustainable way to reduce waste. In: Ext Abstr CHI 2009, pp 2853–2858. doi:10.1145/1520340.1520414
23. Godin G, Kok G (1996) The theory of planned behavior: a review of its applications to health-related behaviors. Am J Health Promot 11(2):87–98
24. Holmes T (2007) Eco-visualization: combining art and technology to reduce energy consumption. In: Proceedings of C&C 2007, pp 153–162. doi:10.1145/1254960.1254982
25. Hersh MA (1999) Sustainable decision making: the role of decision support systems. IEEE Trans Syst Man Cybern C Appl Rev 29(3):395–408. doi:10.1109/5326.777075
26. Kirman B, Linehan C, Lawson S, Foster D, Doughty M (2010) There's a monster in my kitchen: using aversive feedback to motivate behavioral change. In: Ext Abstr CHI 2010, pp 2685–2694. doi:10.1145/1753846.1753852
27. Knussen C, Yule F (2008) "I'm not in the habit of recycling": the role of habitual behavior in the disposal of household waste. Environ Behav 40(5):683–702. doi:10.1177/0013916507307527
28. Langley J, Yoxall A, Reed H, Kulhmann S (2011) Is green a grey area? Sustainability and inclusivity; the ageing population and recycling. http://include11.kinetixevents.co.uk/rca/rca2011/paper_final/F382_2261.pdf. Accessed 8 Oct 2011
29. Laschke M, Hassenzahl M, Diefenbach S, Tippkaemper M (2011) With a little help from a friend: a shower calendar to save water. In: Ext Abstr CHI 2011, pp 633–646. doi:10.1145/1979742.1979659
30. Li I, Dey AK, Forlizzi J (2010) A stage-based model of personal informatics systems. In: Proceedings of CHI 2010, pp 557–566. doi:10.1145/1753326.1753409
31. Maio GR, Haddock G (2010) The psychology of attitudes and attitude change. SAGE, London, pp 67–77
32. Mankoff JC, Matthews D, Fussell SR, Johnson M (2007) Leveraging social networks to motivate individuals to reduce their ecological footprints. In: Proceedings of HICSS 2007, pp 1–10. doi:10.1109/HICSS.2007.325
33. Marteau MT, Ogilvie D, Roland M, Suhrcke M, Kelly MP (2011) Judging nudging: can nudging improve population health? Br Med J 342:263–265. doi:10.1136/bmj.d228

34. Matthews M, Doherty G (2011) In the mood: engaging teenagers in psychotherapy using mobile phones. In: Proceedings of CHI 2011, pp 2947–2956. doi:10.1145/1978942.1979379
35. McCarty J, Shrum LJ (1994) The recycling of solid wastes: personal values, value orientations, and attitudes about recycling as antecedents of recycling behavior. J Bus Res 30(1):53–62. doi:10.1016/0148-2963(94)90068-X
36. Ouellette JA, Wood W (1998) Habit and intention in everyday life: the multiple processes by which past behavior predicts future behavior. Psychol Bull 124(1):54–74. doi:10.1037/0033-2909.124.1.54
37. Paulos E, Jenkins T (2005) Urban probes: encountering our emerging urban atmospheres. In: Proceedings of CHI 2005, pp 341–350. doi:10.1145/1054972.1055020
38. Petersen D, Steele J, Wilkerson J (2009) WattBot: a residential electricity monitoring and feedback system. In: Proceedings of CHI EA'09, pp 2847–2852. doi:10.1145/1520340.1520413
39. Prochaska JO, DiClemente CC, Norcross JC (1992) In search of how people change: applications to addictive behaviors. Am Psychol 47(9):102–1114. doi:10.1037/0003-066X.47.9.1102
40. Reif I, Alt F, Hincapié Ramos JD, Poteriaykina K, Wagner J (2010) Cleanly—trashducation urban system. In: Ext Abstr CHI 2010, pp 3511–3516. doi:10.1145/1753846.1754010
41. Reitberger W, Tscheligi M, de Ruyter B, Markopoulos P (2008) Surrounded by ambient persuasion. In: Ext Abstr CHI 2008, pp 3989–3992. doi:10.1145/1358628.1358974
42. Schultz PW, Oskamp S (1996) Effort as a moderator of the attitude-behavior relationship: general environmental concern and recycling. Soc Psychol Q 59(4):375–383. doi:10.2307/2787078
43. Skinner BF (1974) About behaviorism. Random House, New York
44. Strengers Y (2008) Smart metering demand management programs: challenging the comfort and cleanliness habitus of households. In: Proceedings of OZCHI 2008, pp 9–16. doi:10.1145/1517744.1517747
45. Strengers Y (2011) Designing eco-feedback systems for everyday life. In: Proceedings of CHI 2011, pp 2135–2144. doi:10.1145/1978942.1979252
46. Thaler RH, Sunstein C (2008) Nudge: improving decisions about health, wealth, and happiness. Yale University Press, New Haven
47. The Bottle Bank Arcade Machine (2009) The fun theory. http://www.thefuntheory.com/bottle-bank-arcade-machine. Accessed 18 Oct 2011
48. The World's Deepest Bin (2009) The fun theory. http://www.thefuntheory.com/worlds-deepest-bin. Accessed 18 Oct 2011
49. Thieme A, Comber R, Miebach J, Weeden J, Krämer N, Lawson S, Olivier P (2012) "We've bin watching you"—designing for reflection and social persuasion to promote sustainable lifestyles. In: Proceedings of CHI 2012, pp 2337–2346
50. TrashTrack (2011) MIT researchers map the flow of urban trash? Last retrieved 1 Mar 2012, http://senseable.mit.edu/trashtrack/downloads/trash-track-nsf.pdf
51. Tscheligi M, Reitberger W (2007) Persuasion as an ingredient of societal interfaces. Interactions 14(5):41–43. doi:10.1145/1288515.1288538
52. Verplanken B (2006) Beyond frequency: habit as mental construct. Br J Soc Psychol 45(3):639–656. doi:10.1348/014466605X49122
53. Ybarra O, Trafimow D (1998) How priming the private self or collective self affects the relative weights of attitudes and subjective norms. Pers Soc Psychol Bull 24:362–370. doi:10.1177/0146167298244003
54. WRAP (2011) Research guidance: monitoring and evaluation guidance (annex 3). http://www.wrap.org.uk/local_authorities/research_guidance. Accessed 27 June 2011
55. WRAP (2010) Waste and resources action programme. http://www.wrap.org.uk. Accessed 29 Dec 2010