"We've Bin Watching You" – Designing for Reflection and Social Persuasion to Promote Sustainable Lifestyles

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ABSTRACT

BinCam is a social persuasive system to motivate reflection and behavioral change in the food waste and recycling habits of young adults. The system replaces an existing kitchen refuse bin and automatically logs disposed of items through digital images captured by a smart phone installed on the underside of the bin lid. Captured images are uploaded to a BinCam application on Facebook where they can be explored by all users of the BinCam system. Engagement with BinCam is designed to fit into the existing structure of users' everyday life, with the intention that reflection on waste and recycling becomes a playful and shared group activity. Results of a user study reveal an increase in both users' awareness of, and reflection about, their waste management and their motivation to improve their waste-related skills. With BinCam, we also explore informational and normative social influences as a source of change (e.g., socially evoked feelings of 'guilt' for non-recycling or food disposal), which has to date been underexplored in persuasive HCI. Design implications for reflection and social persuasion are proposed.

Author Keywords

Persuasive; technology; social persuasion; reflection; behavioral change; social networks; sustainable HCI.

ACM Classification Keywords

H.5.m [Information interfaces and presentation (e.g., HCI)]: Miscellaneous;

General Terms

Design, Human Factors.

INTRODUCTION

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 [12]. Persuasive technologies [11] are now applied in many domains, including healthcare (e.g., motivating users to exercise, to make healthier food choices or monitor their mood states [22]), education and training [12], and environmental sustainability where it has been used for instance to promote reductions in energy consumption [17] and greener transportation habits [14].

This paper aims to contribute to an understanding of how technology can promote ecological awareness and environmentally sustainable lifestyles in individuals [7]. Numerous previous approaches collect information about an individual's behavior and present it back to the individual to increase their awareness and understanding of such behavior and its environmental impact through processes of self-reflection [1,8,18]. Such approaches often seek to foster a 'personal morality' and consider individuals as responsible actors who make rational decisions when they can draw on accurate information about themselves. Typically they ignore possible restrictions in a person's abilities and opportunities to choose freely as well as other costs for change [e.g.,7,8,22,27].

In practice, self-reflection is a non-trivial activity that requires both considerable effort on the part of the user and an interest in the particular behavior or topic [cf18]. Engaging individuals to reflect on information that might not be of general interest to them, such as waste disposal, requires the use of effective motivational strategies. Furthermore, HCI research and design on behavioral change largely focuses on motivating the lone individual [8] and has paid little regard to powerful social persuasive strategies [11], such as informational and normative social influence. Likewise, the use and study of social media to motivate change is still relatively underexplored [13,21].

BinCam explores these issues through a social persuasive system that provides users with a display of pictures of their own, and others', refuse bin contents on the social network site Facebook to passively invite *reflections* on their own, as well as other peoples' recycling and food waste behaviors. Facebook has the potential to support engagement with BinCam, but can also be leveraged to realize various forms of social influence to motivate change. Since the management of waste is often a shared

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effort between several members of a household, we embedded a BinCam bin in the kitchen of 4 households of 5-7 people living together. Placing the system within the existing social structure of the household extends our understanding of behavior and behavior change beyond aspects of 'personal morality'. In addition, the collective use of BinCam can foster a sense of group membership in each household to facilitate processes of social persuasion.

Although we address with BinCam environmental issues related to recycling and food waste, the present work does not research sustainability per se but instead uses it as an application area to explore strategies borrowed from social psychology to facilitate reflection and behavioral change through digital design [4,11]. As such, our account of the design and evaluation of BinCam reveals: (1) a new way of engaging individuals in reflections on their waste management behaviors; (2) the potential for employing strategies of social persuasion – using the social network site Facebook – to motivate and improve environmentally friendly behaviors; and (3) how a close incorporation of such a system within individuals' everyday lives may support engagement with, and adherence to, interactive systems designed to promote behavior change.

PERSUADING CHANGE IN BEHAVIORS

Persuasion is the *purposeful* attempt to change a person's attitude or behavior [12]. To this end, the Theory of Planned Behavior (TPB) [2] provides a useful conceptual framework by which we can explain and predict behavior. It has previously been applied to the study of recycling behaviors and is well supported by empirical evidence [16].

Determinants of Human Behavior

The TPB (see Figure 1) identifies a person's behavior as having three conceptually independent determinants: attitude toward the behavior, subjective norms and perceived behavioral control. *Attitudes* are informed by a person's expectations of a favorable behavioral outcome and the values attached to this outcome (e.g. important contribution to the environment). *Subjective norms* relate to the degree to which a person perceives social pressure to perform the behavior, including normative beliefs about what important others expect of the person (e.g. would they approve the behavior), and a person's motivation to comply with these expectations [2,20,24]. The third component, *perceived behavioral control*, refers to whether or not a person feels able to perform the behavior; for instance if the resources (e.g. recycling facilities), opportunities or skills required for a particular action are available [20].

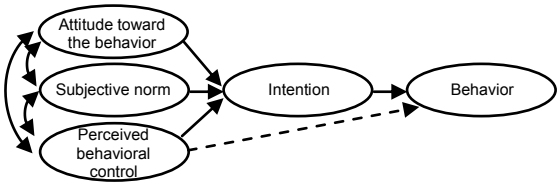

Figure 1. The Theory of Planned Behavior [2].

All three components contribute to the behavioral *intentions* that inform later actions. The greater the intention and the perceived ability to engage in the behavior, the more likely it will be performed [2,12]. To date, a person's attitudes, as opposed to subjective norms, have often been found to more strongly predict intentions. Research by Ybarra and Trafimow [30] however, shows that increasing a person's sense of group membership, rather than attitude, leads to higher correlations between social norms and behavioral intentions. Even though, the relative importance of the three determinants of intention can vary across situations and behaviors [2,20] each needs to be supported to increase the target behavior.

Strategies for Behavioral Change

While valuable in identifying the determining factors of human behavior, the TPB does not address important procedural aspects of performing a specific behavior. Prochaska et al.'s [24] transtheoretical model (TTM) provides stage-based strategies to support the individual in gradually achieving change. It regards intentional behavioral change as a process encompassing five stages: precontemplation, contemplation, preparation, action and maintenance. In *precontemplation*, individuals are unaware or under-aware that a particular behavior needs changing and often only modify their behavior because they are pressured by others. During *contemplation*, people are aware and seriously consider changing their behavior but are not yet ready to commit to it. The *preparation* stage is characterised by the intention to change and making the first small changes. The actual behavior modification occurs during the *action* stage and is *maintained* if the change is sustained.

Our research targets young people between the age of 18-35, who were identified by [28] to be either recycling unaware or are not seriously contemplating becoming active in this regard. Early stages of change require specific promotion strategies not only to overcome common barriers to change, such as reluctance or inadequate motivation, but also to raise a person's *awareness* about themselves and their behaviors, and increase the possibility to *experience positive emotions* related to a target behavior. These strategies allow for a *re-evaluation* of a person's cognitive and affective values towards a behavior, which can promote intrinsic motivation and facilitate change [20,24].

Social Persuasion and Behavioral Motivation

While the suggested strategies for behavioral change meaningfully inform persuasive designs, it has to be kept in mind that the TTM presents an ideal. Individuals may find themselves in various stages of change at different times and may not proceed continuously from one stage to the next [1]. Further, the TTM is aligned to individual processes of behavioral change, in which social processes to support change are interwoven. Thus, the next sections expand on how behavior can be regulated through social influence and other forms of behavioral motivation.

Considering that a person's feelings, thoughts and behaviors are influenced by the presence of others, Deutsch and Gerard [6] distinguish two forms of social influence: informational and normative.

Informational Social Influence

Other people can serve as a valuable source of information to accurately evaluate one's behavior. This is particularly relevant in situations where people are uncertain about how to behave. To overcome the natural need for information, they communicate with others, but also tend to observe and copy the actual behavior of others [4]. Resulting changes in a person's attitudes or behaviors can be *deep-seated*, *private* and *enduring* [6], as they are motivated by the desire to behave appropriately in the target situation.

Normative Social Influence

Human beings also have a fundamental need to belong to others [10]. Thus, in order to develop and preserve meaningful relationships and to be socially accepted, people have a tendency to agree on the values, beliefs, attitudes or behaviors of others [4]. The normative social influence arising from conforming to positive expectations of others is stronger the more important these people are to the self (e.g., friends, family) [6]. Changes in the expressions of attitudes or behaviors as a result of obeying to normative influences, however, do not necessarily reflect an internal change, but instead can be *superficial*, only *publicly* shown and *transitory*. They are motivated by the person's desire to obtain social approval and avoid social rejection by others, and usually persist only while the person is under a certain level of social surveillance.

Behavioral Motivation

People generally engage in behaviors that are either intrinsically rewarding (e.g. satisfaction about contributing to the environment) or extrinsically rewarding (e.g. a reduced bill on waste), but also tailor their actions towards avoiding adverse experiences such as feelings of guilt or shame [10]. While strategies for rewarding desirable behaviors are often applied in persuasive computing systems, strategies of aversion or punishment are typically criticized as being inappropriate, not only for ethical reasons [11,12], but also because users are assumed to simply stop using a system if they are nagged or blamed by it [cf.,5]. Foster et al. [13] however, have shown that aversive feedback, if carefully and playfully presented, does not necessarily disengage users, but functions as a valuable tool for behavioral change.

Related Work

To date, a number of designs have been proposed which address people's waste management and sustainability behavior. Gartland and Piasek [15] describe with their *Weigh Your Waste* system, an interactive disposal bin with an integrated scale to weigh the amount of waste produced by a household. Both the weight of the waste and its financial cost are then displayed on a touch screen, together with further information on how general waste can be reduced. It was hoped that visualizing the financial benefits of producing less waste would motivate environmentally friendlier actions. Although a promising design concept, its impact on people's behavior has not been evaluated.

Jetsam [23] is a public city trashcan, augmented to project a visualization of collected trash items to urban dwellers on the street. The system is not designed to raise environmental awareness, but to prompt personal and collective sense of wonder as to aspects of urban life and to provoke storytelling around the visualized trash. The idea to stimulate reflection on both the personal and communal level also informed the design of the Cleanly system [25] which focused on educating citizens to avoid environmental pollution through misplaced trash. For this purpose, it tracked people's interactions with various bins and displayed these on wearable smiley badges, in monthly personal reports and on public displays. Even though both Jetsam and Cleanly consider that the community and the individual inform a person's behavior, they do not explicitly consider the community as a source for social influence. They also have not been evaluated in terms of their impact on people's pro-environmental behavior.

THE DESIGN OF BINCAM

BinCam is a two-part system consisting of a BinCam bin and a custom BinCam application (short 'App') on Facebook. Based on theories of behavioral change, the system is designed to provide users with the opportunity to evaluate their own, as well as other people's, bin related behavior through information contained in the pictures taken from a household's rubbish bin. The BinCam system facilitates normative social influence on three levels: (i) within households; (ii) between BinCam households; and (iii) amongst a potentially wider circle of friends on Facebook. The strategies that aim to motivate and engage users with the system are introduced below.

The BinCam Bin

Information about one's own waste activities are of little interest to most people, in particular young adults [cf.,28], and this poses a significant design challenge for the collection of waste related data [cf.,18,24]. To address the lack of motivation, and the time required, to gather information on the users' part, the process of data collection in BinCam is entirely automated. In addition, 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 containers, we found the refuse bin to be the only standard amongst all. It provides rich data about individuals' waste behavior, as it generally captures landfill waste, food waste as well as misplaced recyclables. Thus, the BinCam bin simply replaces an existing kitchen refuse bin and automatically captures thrown away items through digital images taken with a smart phone installed on the underside of the bin's lid (see Figure 2). The phone's accelerometer senses movement of the lid and triggers the camera each time the

lid is opened and then closed. Using either a 3G or Wi-Fi connection, the phone uploads captured 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 [18] compared to existing methods such as 'waste diaries' [19].

The BinCam Application on Facebook

There are several motivations for using Facebook as BinCam's platform for reflection on personal, as well as other people's, behavior. Facebook is easy to access, self-instructing and widely used and accepted by our target user group. It provides a well-established social network structure which enables not only the formation and preservation of connections to relevant others but also leverages individuals' strong self-interest to be socially accepted [10]. By embedding the BinCam application within Facebook, we aim to engage individuals in regular use of the system, but also to promote behavioral change through the social dynamics within the network itself. To foster day-to-day engagement and to enable social informational and normative influences, the BinCam App includes functionality, which we termed 'BinPictures' and the 'BinLeague'.

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

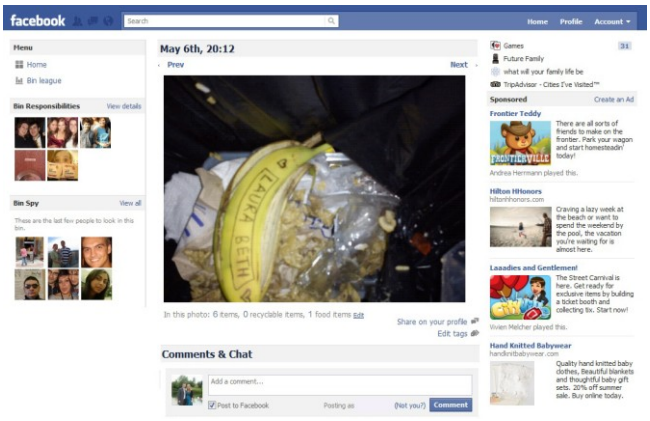

Figure 3. Part of the BinCam interface showing images of the bin responsibilities and bin spies to the left, and an enlarged and tagged bin picture in the middle, with a message of participants written on a banana skin.

BinPictures

On Facebook, pictures from the BinCam bin are presented as a continuous stream of photos which can each be enlarged to furnish a better view of individual items in the bin (see Figure 3). The interface also displays the owners that are responsible for the bin and its contents ('Bin Responsibilities') as well as other people who recently viewed the pictures ('Bin Spy'). As new pictures are added to the photo stream, they are simultaneously sent to Amazon's Mechanical Turk crowd-sourcing service (AMT, www.mturk.com), an online labor market where 'workers' are paid small amounts of money to complete micro tasks (in our case $0.02 per image). These 'tasks' are created automatically for each bin picture and require workers, who are given clear instructions, to identify the *total number of items*, the *number of recyclable items* and the *number of food items* in each photo. Particularly the measurement of food waste is a novel aspect that none of the previous work touched upon, and which is considerably difficult, i.e. when compared to measures of energy consumption. Thus, the crowd sourcing technique endeavored to help detect and distinguish recyclable, non-recyclable and food waste items in the pictures, if even squashed or semi-covered – a problem considered too complex for an automatic computer-vision based solution. Once tagged by the workers, the resulting data is presented alongside the respective picture. Bin owners can manually edit the tags if items are incorrectly identified, and they can delete photos.

As suggested by the TTM [24], the display of the BinPictures aims to increase awareness of an individual's waste management. To further facilitate normative social influences, the pictures taken by each BinCam bin are not only visible to all members of one household, but to all BinCam users. Although access to the App is provided to BinCam users only, they can share BinPictures with their wider circle of friends by linking selected pictures to their own Facebook profile. Inevitably, the display of such personal data on a public platform like Facebook raises privacy and ethics issues. 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. This risk, however, is ameliorated by the deployment of BinCam only in shared houses, in that the contents of a bin cannot be directly attributed to any particular individual. However, such decisions are part of a design trade-off, as this aggregation itself 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.

BinLeague

The numeric values generated by AMT contribute to weekly calculations of the BinLeague. This league visualizes two scores for each bin: (i) for *recycling achievements* visualized as 'leaves on a tree'; and (ii) for *preventing food waste* displayed as 'gold bars'. A decrease of recyclable materials in the bin leads to a growth of leaves

on the tree, and a reduction of food waste increases a household's amount of gold. Each household starts at a baseline of 5 leaves and 5 gold bars (of a range of 0-10). From one week to the next, the percentage change is calculated and visualized for each household (see Figure 4). The tree and gold images draw on common metaphors used in eco-visualizations [cf.,17] and were chosen as abstractions of each household's performance on recycling and food waste behaviors. They may also compensate for what Dourish [8] outlines as the problem of scalability, in that the consequences of an individual's contribution to the overall environment are difficult to visualize.

The BinLeague aims to motivate competition between the BinCam households to support behavioral change. On the one hand, supporting one's housemates and one's household achievements makes normative social influences more salient, while a comparison of own efforts with the progress of other households presents a social informational influence [4,6]. On the other hand, the element of competition can foster desirable behaviors in providing a positive outlook on winning, described by [2, p.184] as the "*incentive value of success",* but also motivates individuals not to lose, and thus, to avoid feelings of failure [10].

EVALUATION OF BINCAM

In order to understand their potential and effectiveness, HCI research on sustainability [e.g.,8,27] emphasizes the importance of designing technologies to be used and studied in everyday life. Thus, to gain insight into how individuals interpret the BinCam system and how they relate to its different features, we conducted a case study with young adults (18-35 years), living together in shared households (5-7 occupants). To facilitate engagement with the BinCam App, participants were also required to have a Facebook account, which they access and use regularly.

Method

22 participants over the age of 18 were recruited (age M = 23, SD = 4.6, females = 11) through posters, flyers and personal contacts of a member of the research team. In all but one of the four chosen households, gender was mixed. Of our participants, 16 were students and 6 were self-employed or unemployed.

Assessing their recycling facilities in an initial visit, we found that all households had a recycling bin for cardboard, plastic and metal, 3 of them had an additional recycling bin for glass and 1 had an extra bin for compost. Refuse waste for each household is collected weekly and recycling biweekly. In a second visit two weeks later, we replaced their existing kitchen bin with the BinCam bin, handed out questionnaires and provided participants with the URL link to the BinCam App. Their engagement with the App during the five-week period of the study however was voluntary. To facilitate appropriation of the BinCam bin and to foster collaboration between members of each household, participants were asked to name their bin. The households did not know each other from the outset of the study.

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

In a pre-questionnaire, participants were asked about their general Facebook use habits by answering the Facebook Intensity Scale created by Ellison et al. [9]. Results revealed a strong use of the social network site. Participants had on average 372 friends (SD = 251.4) and spent on average 86 min on the website per day. As part of the self-report data, participants further indicated that Facebook had become part of their daily routine, that they used the platform to learn about others, to stay in touch with people they know or met socially and that they would be sorry if Facebook closed down.

Before the start of the BinCam deployments, participants were also asked about their general attitude and behavior related to recycling and food waste. Question items were informed by [29]. In contrast to [28] which identified young adults as recycling unaware, our participants indicated on a 5-point scale ranging from 0 (*not at all important*) to 4 (*very important*) 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). These more global statements were supplemented by a 36-item pre- and post- study questionnaire on participants' recycling and food waste attitudes and behaviors. Findings of this quantitative data, however, did not reveal significant changes over time and therefore are not presented.

At the end of the five-week study, we arranged focus groups with participants in their residences, lasting on average 51 min (*min* = 40, *max* = 77). We chose this method to capture rich and insightful data evolving from interactive group discussions about their experiences of BinCam. We found post-study focus groups to be less intrusive than regular observations or diary keeping, while very suitable for our research purpose to study BinCam in shared households of individuals' living and experiencing the system together. Focus group sessions were audio recorded, transcribed and analyzed in-depth using thematic analysis [3]. Although participation 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 ethics committee at Newcastle University. All names of participants have been changed.

Results of the Focus Groups

Overall, participants liked the BinCam system, appraised it as a *good idea* and would recommend it to friends. The system was described as a *useful* way to raise an individual's reflection on waste management while being experienced as *fun*; turning recycling into a more *exciting* activity than it usually is. Yet, three participants stated that they dislike the idea to be monitored in every aspect of their life and although they generally did not mind if somebody saw pictures of their waste, they wouldn't want the council to see them. These privacy concerns, however, were not associated with their temporary participation in the BinCam project, which was both self-chosen and liked.

Integration of BinCam in Everyday Life

All participants appreciated that using the BinCam bin was effortless and that they *didn't have to change their routine.* They felt that the bin was well integrated into their everyday life. The majority of our BinCam users were also very committed to Facebook and valued the incorporation of BinPictures on this website. In one household, participants described themselves as less engaged Facebook users and were critical of a number of qualities of Facebook itself, describing the platform as an *ugly website* that is *boring*, *uncreative* and *user unfriendly*. These criticisms are also applied to the BinCam App. Although they proposed to replace the App with an external webpage they admitted that they then "*might have never looked at it"* (Jill).

Exploration of Own and Other Household's BinPictures

Despite reporting that the App was well-integrated into existing routines, participants only looked at the pictures taken of their own bin a few times (log file: *min* = 0, *max* = 27, *M* = 3.2) and mainly at the start of the study. At that time, curiosity about BinCam was highest and participants were motivated to identify items disposed of by themselves and their housemates. Jill states for instance: "*Oh well, I tried to find things I've thrown away. I was like 'Where is that item'*", and as Anna describes: "*You could identify different food packages belonging to a different member in the household*." Yet, after the first two weeks, participants either forgot about the BinCam App or simply lost interest in using it. Jim explains: "*I guess it's still important but I mean I kind of get bored looking at rubbish after a while*". Although participants admitted to have been a little *nosy*, and *curious* about exploring other households' BinPictures, this *voyeuristic* opportunity was hardly ever taken (log file: *max* = 6). Participants stated that pictures of other people's rubbish were not of much interest to them and focused mainly on those activities of their own bin and household.

The BinLeague and the Element of Competition

Participants' opinions on the BinLeague were mixed. On the one hand, the league with its 'tree' and 'gold bar' graphics was described as a *nice* and *easy* visualization for tracking a household's progress in recycling and money savings on food waste. On the other hand, the uncertainty as to how the league positions were calculated and how changes could be achieved led to confusion among participants. This was in part due to the fact that we found the tags delivered through AMT to be largely incorrect. Of a random picture sample of 20, only 5 images were correctly tagged. Participants also expressed the wish to receive feedback more frequently, or immediately, when they dispose of items. Similarly mixed were also the results for the element of competition stimulated through the BinLeague. While some participants indeed compared league achievements with other households and felt empowered and encouraged to improve, others were less keen on the competition. Sara explains: "*The competition sounds interesting in theory but I don't know, that's a competition on Facebook, and I don't think I ever really got into it. I wouldn't particularly try and get a bin award."*

Behavioral Change through BinCam

Confirming our pre-study questionnaire results, participants reported in the focus groups to either be already good recyclers or at least contemplated improving their waste management. It is therefore not surprising that they did not report changes in their attitude towards recycling and food waste. Yet, findings show interesting social group effects as well as an increase in individuals' awareness, reflection and perceived behavioral control related to their waste behavior.

The Role of Group Coherence in Collective Tasks

While the disposing of waste is in general an activity to be performed by an individual alone, participants reported that they sometimes looked at BinPictures together, named their bin collectively, and talked with each other about the project. They exchanged recycling tips and made plans for funny engagements with the bin such as leaving a message on a banana skin in the bin (cf., enlarged BinPicture in Figure 3) or talked about dismantling the phone of the bin to capture outdoor events to surprise each other. However, the coherence of group efforts with regard to the system differed greatly between households. In one house, we found that only half of its members had a real interest in the project, while in another household all members felt equally committed to the project. That there have been, in part, effects of local group coherence is apparent in the following statements: Tess: "*You don't want to let your house down";* and Kate: *"Yeah, I felt like we were a team."*

Social Surveillance

Moreover, in each household, participants reported having felt *guilty* or *ashamed* if they disposed of recyclables incorrectly or had to throw food away. For example, as Ben explains: "*Looking at food waste that you're guilty of and your items that you're guilty of and then thinking I've done that and I've done that and this shouldn't be in there."*; and Beth says about BinCam: "*It does make you feel guilty like you did something wrong"*. Such feelings of guilt were found to be evoked by (i) the visibility of one's own behavior to oneself; (ii) the potential visibility of one's own behavior to housemates; (iii) unfortunate results of one's household on the BinLeague; and (iv) the perceived presence of the BinCam bin.

In this context, participants also expressed feelings of being observed and controlled. Dave: "*I think like every person individually felt a bit more like controlled in their behavior*." In one household which exhibited stronger group coherence participants even perceived their bin as a social entity itself. For them, their bin "*felt like a little flat mate sometimes*" (Mia). They also used personifying attributes in their bin descriptions, such as the bin *thinks*, *judges* or *cares*. Lily expounded on this: "*When I hid the jar it wasn't that I was worried that these guys would go to judge me for it. It was more like the BinCam was going to judge me for it. I don't care if these guys saw that I threw away a jar because I knew that they wouldn't care but it was like Osama [their name of the bin] would care."*

Awareness, Reflection and Perceived Behavioral Control

The strongest effect of the BinCam system on participants is related to raising their awareness, and stimulation of reflection, about recycling and food waste. This awareness was sometimes simply triggered through a quiet, yet audible, simulated camera shutter carried out each time the BinCam bin took its picture. Dave tells: "*It [the bin] 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? And yeah, I think it makes you more aware."* Being reminded about one's disposal behavior led participants to reflect on their recycling skills and abilities. Participants became more aware that they had a lack in knowledge as to what is recyclable and what isn't. Jodi states: "*And you like question yourself if you could actually recycle what you just put in the bin.";* and Sara says: "*It's alright to sort of recycle but it's very easy to recycle wrong*." This uncertainty as to how to recycle properly encouraged self-education among the young adults. Participants reported that they started to read the labels on the back of packages or asked their housemates for recycling advice. Ben explains: "*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 (...) I find I took more time to differentiate between what was recyclable and what wasn't recyclable. It was useful for me*."

Despite the low usage of the BinPictures and BinLeague, participants were still persuaded to reflect on the relationship between their 'food waste' and 'money savings'. Tess explains: "*I think it's a money thing because you see the food you put in the bin and it makes you shocking like 'If I had just planned better I could have saved for another meal'. But now I have to go and spend more money to get more food."* Apart from the simple awareness about food and one's recycling skills, participants also reflected about their waste management facilities. Although willing to recycle, participants felt that there is no good way of managing large amounts of bulky cardboards and plastic in their kitchen, and that the container outside their house fills up quickly, sometimes within a day, while only getting emptied every two weeks.

Other Anecdotal Evidence for Behavioral Change

Although participants' attitudes towards sustainable waste management were positive from the outset, and their recycling knowledge and facilities not ideal, participants tried to improve their waste behavior by creating less food waste, said that they started sharing food left-overs with their housemates, were trying to cook more appropriate meal portions and sometimes simply *ate more* instead of disposing the food. Anna says for instance: "*I kind of make sure I didn't cook too much like, erm, I'm better in judging portions than I was before."* Regarding food left-overs, Beth states: "*Because there's lots of food in terms of like I don't want to dispose so I just put it out and then people can eat it because it's too much, (...) instead of chucking it in the bin straight away"*.

Participants also reported having recycled *more* and *better*, for example, jars and tins were rinsed and washed out before they were put in the bin, and composite packages broken down into their recyclable and non-recyclable components. Mia describes: "*Since we had like the BinCam project bin, erm, we've recycled a lot more than we normally would, like generally as a flat*."; and Ben explains: "*I am much more aware of making sure that everything I rinsed wasn't just, erm, I didn't put just water on it. I rinsed it - I made sure there's no food residue or anything like that*." One participant, Lily, even took out items from the BinCam bin that didn't belong in it. She says: "*I think it was like I wouldn't have given it a rough thought before the BinCam project, like there was no way I was going to our bin and fishing out something filthy and stuff. That, like, yeah, it was just the fact that I was more aware about recycling and I was like, well if we gonna have to recycle at least we do it properly*."

DISCUSSION & LESSONS LEARNED

BinCam was intended as a social persuasive system that provides a playful non-intrusive opportunity for young adults to engage in reflections on their waste management behavior. Findings of our user study indicate that it raised individuals' awareness of their recycling and food wasting behaviors. Invited reflections however did not to seem to impact on participants' already well-established attitudes and intentions to improve their behavior, but instead made more salient their perception of how much they control the performance of the target behavior. This led participants to view their disposal facilities to be insufficient and to identify deficits in their knowledge about what is or is not recyclable. As a result, participants started to educate themselves about recycling properties, exchanged recycling expertise with others, and improved the planning and sharing of their food. Moreover, participants responses towards BinCam were highly heterogeneous and indicated various motivational influences on both an individual and group level. These are outlined in Table 1 and discussed below along with proposed implications for the design of systems aiming to invite reflection and to promote change through social media and strategies of social persuasion.

Table 1. Persuasion in BinCam.

Identified individual, social & motivational influences in BinCam	
Individual self-reflection	▪ Feedback about one's own waste behavior
Informational social influence	▪ Feedback about waste behavior of others ▪ Discussions and exchange of knowledge with flat mates
Normative social influence	▪ Social presence of others offline & online ▪ Social presence of the bin
Extrinsic motivation	▪ Competition ▪ Social surveillance ▪ Signal trigger (BinCam camera sound) ▪ *(Potentially: notifications & reminder)*
Intrinsic motivation	▪ Avoidance of feelings of guilt ▪ Fun experience ▪ Attitudes & desire to behave appropriately

Informational Influence on Self and Others

To facilitate interaction with BinCam, the system is carefully designed to fit into daily routines such as user's regular Facebook and bin use. They are left with the choice whether they engage with the BinCam App. While this voluntary access makes it easy to ignore the App, it turns the act of looking at captured images into a conscious and not externally enforced activity. Overcoming the natural need for information, user can access the App to receive feedback about their behaviors and those of others [cf.,4].

Reflection on Behavior & Learning vs. Immediate Feedback

Although participants were presented through the App with general information about their and other household's waste performances, they expressed the desire for practical guidance and information as to *how* they can improve their behavior. BinCam was not designed as a system to educate its users, but presents individuals with an engaging and playful platform for reflection and self-education in order to break routines of non-recycling and food waste. To support this purpose and to increase engagement with the App, future designs should enable users to exchange their recycling advice and creative ideas with one another.

Our participants expressed the wish to receive immediate feedback from their bin about whether their disposal behavior was correct. Although this functionality is likely to simplify the recycling process [10it would remove both the need for self-motivated in-depth reflection and their efforts to inform themselves and learn about the recycling properties of their waste items. Changes in attitudes and behaviors through reflection can result in an internal change and be long-lasting [cf.,24]. It has to be acknowledged, however, that reflection is not only motivated by the factors outlined in Table 1, but evoked through the provocative character of the system itself. In foregrounding waste, something that usually falls in oblivion once it is discarded, it increases awareness and invites reflection. In addition, BinCam has been designed as a collaborative project exploring social processes of influence, whereas immediate feedback only functions at the individual level.

To promote informational social influence, we suggest that designs provide frequent feedback (e.g. daily instead of weekly) as well as diverse visualizations and opportunities for comparisons of own and others' behavioral data.

Other Invite Reflections: Abstract Visualizations and BinCam

While captured information about a person's behavior should be *accurate* and *reliable*, their presentation design seems equally important for it to be *understandable* to users. The BinLeague presents through tree and gold graphics an abstract and highly simplified view of users' collective recycling achievements and food savings, both further limited due to incorrect taggings of collected BinPictures using AMT. This explains why some users were confused or dissatisfied about the league and its visualizations. Yet, others were still able to make sense of the league. They reflected and discussed with their housemates how the graphics relate to their behavior, and felt motivated to improve. We assume that a less abstract visualization of the tagging results would not have allowed for the same fortunate interpretational scope [cf.,26].

Normative Social Influence

Overall, the normative social influence in BinCam was not as salient as expected. This may be explained by a lack of group coherence in the participating houses and their little engagement with the BinCam App. It may also relate to the fact that an individual's contribution to the household's waste was not perceived to be associated with the receipt of social rewards nor to pose a real threat from housemates for non-compliance (i.e. as compared to the council).

Social Presence of Others in the House – Group Coherence

Normative social influence is motivated by a person's desire to obtain social approval from others while avoiding being socially rejected. The influence is stronger the more important other people are to the individual [6]. Although BinCam was perceived as a collective activity, only the members of one household reported true commitment to each other and felt responsible for household-related activities. A feeling of group coherence can facilitate normative social influences [4,6]. We therefore believe that a strong sense of group coherence, the sharing of a persuasive system between users and a meaningful connection between them – through their actions and commitments – has the potential to shape a collective movement towards the desirable behavior [cf.,8]. Thus, to support group coherence, the interaction with the systems should be more strongly designed as a group activity. How can design facilitate the creation of a team identity around each bin? How would the social dynamics in BinCam change if participants of all households knew each other from the outset? These issues deserve more attention in future research, in particular in terms of motivating group commitment, social support or social movements [21].

Social Presence of Others on Facebook

Facebook was found to be an appropriate access channel for the BinCam App, as it is used regularly and well integrated in the existing routines of young adults. Yet, participants did not engage significantly with the BinCam App itself.

Although participants looked at the BinPictures for their own household and tried at times to identify individual 'misbehaviors', the normative social influence was not very strong. To increase engagement with the App and to give users reason to explore the BinPictures, we suggest designing challenges. Users could be instructed to place an object in the bin to be discovered by other households or take over the task of tagging the BinPictures as a collaborative activity. This would allow for more social control and transparency as to users' bin-related contributions, open up space for playful or competitive engagements and social opportunities to trick and cheat.

Feelings of Guilt & Social Presence of the BinCam Bin

Participants did not report feeling threatened by others regarding their behavior, but mentioned feeling 'guilty' or 'ashamed' when disposing of food or recycling incorrectly. It remains subject to future research whether these feelings are primarily evoked by the presence of the BinCam bin itself, participant's awareness about their behavior being potentially visible to their housemates or the wider BinCam community online. In one household, it was remarkable that participants perceived their BinCam bin as a "social actor" [11], and described a related influence on their behavior. We believe that the presence of the bin and its 'monitoring' of what a person discards facilitate individuals to perform more socially desirable behaviors, in ways similar to having a housemate in the kitchen watching the person's actions [12]. Despite certain inscrutability about the source of authority, we confirm findings of [13] that evoking aversive feelings can motivate compliance, if designed playfully.

Facilitators for Performing the Target Behavior

Facilities and Abilities to Perform the Behavior

In addition to having the intention to perform a certain behavior, a person needs to have the ability to do so [cf.,2,20]. As shown with BinCam, this includes having adequate waste management facilities as well as the appropriate 'know how' and confidence to perform the behavior. BinCam successfully invited individuals to reflect on their perceived behavioral control. Being situated in their homes, it made them more aware of 'how' they manage or mismanage their waste and revealed a certain complexity behind waste-related actions.

Trigger and Reminder

The sound of the BinCam bin camera was found to act as a 'signal trigger', reminding participants of the presence of the BinCam system and prompting thoughts about their waste management. According to Fogg's Behavioral Model [10], triggers are, along with a person's motivation and ability to perform the target behavior, the most powerful element to change behavior. Despite the low usage of the BinCam App, its very existence – reflecting the potential of one's behavior being visible to others – added significance to the 'signal trigger'. However, to persuade users to re-visit the BinCam App more regularly, the App should adapt to the ecology of Facebook and more closely integrate its existing interaction and persuasion styles. Future versions will also incorporate reminders and notifications about interesting ongoing activities and users' progress.

Flexibility towards Individual Preferences and Needs

The heterogeneous findings of how BinCam was appropriated by its users show that persuasive technologies should be adaptable to inter-individual expectations and needs. Users differ in their attitudes, motives and habits related to social platforms, like Facebook, and they have different preferences for the frequency and presentation of feedback. That individuals are at "*different stages of readiness, willingness and ableness to change*" [1, p.927] also effects their receptiveness of persuasive influences. In order to appeal to a wide range of users and to successfully fulfill their constantly changing informational and motivational needs [24], persuasive designs should employ a combination of persuasive strategies to promote change.

Ethical Issues

In BinCam, participants were more aware of their behavior or misbehavior, while the interaction with the system evoked feelings of guilt or shame. Although potentially effective [cf.,13], it raises ethical concerns as to whether persuasive designs should employ strategies that originate aversive emotions to induce behavioral change. In Fogg's [12] understanding, persuasion does not include the use of force and is neither coercive, nor manipulative or deceitful. Feelings of guilt or shame in BinCam, however were not directly evoked through the system or external pressures of others observing, but primarily based on an internal evaluation resulting from users' increased awareness of the discrepancy between their own perceived and ideal behavior. Furthermore, and considering the privacy concerns raised, BinCam should be regarded as playful reflection stimulating intervention that finds temporarily acceptance in peoples' lives, if users remain in control of their data and know to whom it is visible. It is neither an obscure monitoring device nor to be used by third parties.

Limitations of the Evaluation

The sample of our study was small and participants, from the outset, reported being motivated to recycle and prevent food waste. Since participation was voluntary, this may confirm a tendency identified by Strengers [27], where eco-feedback systems are generally more appealing to people who are environmentally motivated. In addition to recycling constraints, this may further explain why our quantitative results did not show significant effects. Above all, our results are solely based on individuals' self-reports in focus groups. We found however that participants responded equally and were notably uninhibited to share personal feelings of guilt or of being observed by others. Despite these limitations, we believe that the exploratory character of the study, the authentic deployment of the BinCam system into an everyday setting as well as reported user experiences provide a valuable lens onto the potential use of social media and social group dynamics to engage people in reflections on their behavior and to persuade change.

CONCLUSION

BinCam is a social persuasive system designed to playfully engage young adults collectively in reflections on their waste management lifestyle. While deployments of BinCam in shared households did not impact on participants' already well-established attitudes or intentions to improve their behavior, it increased their perceived behavioral control. Invited reflections helped identify barriers in their personal abilities, motivated self-education about recycling properties and improved their planning and sharing of food. Behavioral feedback was presented through BinPictures and the BinLeague, which provide a source for informational and normative social influences. At times, aversive feelings of guilt for non-recycling or the disposal of food were evoked, that did not disengage but motivate individuals in using the system and improving their behavior. A neat integration of BinCam into the existing structures of individuals' lives facilitated the logging, access and exploration of collected data. We envisage our work will motivate future HCI research bridging social media and strategies of social persuasion to promote change.

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