Not (B)interested? Using Persuasive Technology to Promote Sustainable Household Recycling Behaviour

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Abstract. In many recycling systems around the world, waste is separated at the source. Their success therefore depends on an active participation of households. However, especially young people have been found to not consistently follow their local recycling schemes. A promising approach to tackle such suboptimal household recycling behaviour (HRB) is the use of persuasive technology. While existing studies have highlighted its potential, they also commonly relied on waste container augmentation. To better understand the requirements of augmentation-independent HRB-related persuasive technology, a two-phase study was carried out with young adults in Sweden. First, an online survey (N=50) was used to establish the target users' recycling-related problems, attitudes, and interests. Then, based on the survey results, a mobile phone application was designed and evaluated in an iterative manner. This led to the following design recommendations: (1) easy access to information about optimal household recycling behaviour, (2) employment of several motivational strategies, (3) recognition of recycling scheme differences, (4) regard of users as equals, and (5) use of a readily accessible technology channel. The technological format of persuasive technology interventions was found to spark the users' curiosity. Within a well-functioning recycling system, and along with engaging content, it could encourage repeated use and elicit reflection to help break unsustainable household recycling habits.

Keywords: Household recycling behaviour · Persuasive technology · User-centred design · Sustainable human-computer interaction.

1 Introduction

With a growing population, increasing consumerism, urbanisation, and the intensive use of packaged products, the amount of waste that we as humans produce is steadily increasing. Particularly the waste that is not collected and recycled has a large negative impact on public health and contributes to environmental pollution and climate change [1]. Of the estimated 7-10 billion tonnes of urban waste that are produced annually, 2 billion tonnes stem from households. By 2025, this number is predicted to rise to 2.2 billion [2]. A key approach to reducing the negative impact of waste is recycling which describes the general process of collecting previously used materials and reprocessing them into

products, materials or substances [3]. However, for recycling to be effective, a well-functioning recycling system and the cooperation of citizens is required [4]. Due to the environmental and economic benefits of recycling household waste, a policy goal in many countries, including Sweden, is to improve the household recycling behaviour (HRB) of their citizens [5].

In sustainable human-computer interaction, a widespread approach for behaviour change is the use of persuasive technology, which is sometimes called 'persuasive sustainability'. By 2012, persuasive sustainability had mainly been applied to consumption behaviour (related to energy, water, gas, and solid materials), transportation, air quality, and CO_2 emissions [6, 7]. Recycling-related persuasive technology has received a moderate amount of attention. Several studies have introduced innovative eco-feedback systems to highlight its potential [8–10]. However, gathering eco-feedback data commonly requires augmented waste containers or additional equipment which can be costly and difficult to deploy on a larger scale. This paper aims to complement the existing literature by exploring the role and requirements of HRB-related persuasive technology that does not rely on augmentation of recycling bins or the home environment. It first reviews the relevant literature, before going on to describe the survey and intervention methods used with the Sweden-based young adult participants. It then describes the iterative design of the prototype, and concludes with the key recommendations for HRB systems. These answer directly to the existing challenges of engaging users with digital interventions in recycling.

1.1 Household Recycling Behaviour (HRB)

HRB comprises the collection, preparation, and separation of waste at home. The extent to which citizens are asked to engage in these behaviours depends on the implemented recycling system. The higher the citizens' degree of involvement, the better quality waste materials can be extracted [11]. HRB is commonly considered a habit as it occurs frequently, in a stable context, and as an automatic response to a specific context [12]. This entails the need for awareness raising [8]. There is a consensus in the literature that young people tend to exhibit worse recycling habits than older people [13].

In 2013, Miafodzyeva and Brandt [14] conducted a meta-analysis of prior research that had investigated the determinants of HRB. The results revealed that the convenience of the recycling facility is the strongest predictor of HRB. It is closely followed by both moral norms, which are defined as personal concerns about recycling, and information. Miafodzyeva and Brandt [14] concluded that citizens need to be educated about recycling and encouraged to follow good recycling practices sufficiently and regularly. These findings are complemented by those of a 2017 meta-analysis by Varotto and Spagnolli [15] who focused on the most common persuasive strategies to improve HRB and their effectiveness. Varotto and Spagnolli [15] found that social modelling and environmental alterations were the most effective strategies, followed by combined interventions, prompts and information, incentives, commitment, and feedback.

1.2 Sweden as the Study Context

Sweden provides a relevant study context as the responsibility for handling waste is divided between municipalities, producers, businesses, and households [17]. This division in responsibility means that the initial sorting and disposal process is of particular importance. It also means that the recycling schemes for Swedish households differ depending on their geographic location. Across the country, the schemes rely on a basic separation of paper, plastic, metal, and glass. Some municipalities have included economic incentives into their waste management policies to encourage a higher participation in their recycling schemes [16]. Between 2006 and 2018, Sweden recycled and composted around 50% of its household waste [17]. This stagnating percentage is a cause for concern, not only with regard to the European Commission's recycling target of 65% by 2030 [18].

1.3 Recycling-related Persuasive Technology

Both within and outside of academia, technology has been used as a tool to address unsustainable recycling behaviour. The most relevant found consist of four systems: (1) Weigh Your Waste, (2) BinCam/BinLeague, (3) the Trash Game, and (4) the Sorteringsguide. These are described below.

Weigh Your Waste is a platform for users to monitor their waste charges and learn about related topics, including recycling, reuse, and composting [9]. It consists of a digital weighing scale at the bottom of a wheelie bin and a touch screen monitor. The weight measurements of the waste are sent to the screen via WiFi technology. Weigh Your Waste can be integrated along with 'pay by weight' waste schemes or alternatively used solely as an educational platform.

BinCam/BinLeague is a social persuasive system that aims to encourage reflection and promote sustainable HRB [8]. Instead of a normal kitchen refuse bin, users install a BinCam 'bin', which captures the bin's content via a camera and uploads the pictures onto a social media platform, where they are visible to all users of the BinCam system. The pictures are then sent to a crowd-sourcing service which identifies and counts the number of waste items. The numeric values that are generated this way can be used for the BinLeague application which visualises and compares the recycling achievements and food waste savings of the participating households. In an evaluation study, 22 participants used the system for five weeks. The participants stated that this made them more aware of their recycling behaviour. Their responses towards the system were mixed. Most of the participants enjoyed using the system while some reported that they found it intrusive and that it made them feel guilty or ashamed.

The Trash Game is a gamified system which aims to encourage better recycling behaviour [10]. It consists of (1) several bins which are augmented with a camera to capture the waste and a screen to present feedback and (2) a mobile application designed as a game. In the game, the users manage a recycling company and one of their main activities is to sort waste in order to improve their revenue. The sorting choices of each user are evaluated against the choices made by all other users. The crowd feedback is also presented on the screens of the

bins. In a preliminary evaluation study, the participants (N=35) indicated that they liked the augmented bins and the application, but showed a tendency to focus more on the classification task rather than the game as a whole.

Finally, the Sorteringsguide is a web-based application that aids the categorisation and disposal of waste [19]. Users can specify waste items and are given information about their category (e.g. garden waste) and where they should be disposed of (e.g. recycling centre). The Sorteringsguide is only available in Swedish and can be found on the website of Uppsala Vatten.

Weigh Your Waste, the Trash Game, and BinCam/BinLeague follow the popular eco-feedback approach, in which feedback is given on individual or group behaviour to encourage more sustainable choices [20]. Hence, they rely on technologically augmented waste containers and even additional equipment like the stand-alone touch screen for Weigh Your Waste. In comparison, this study focuses on interventions without such augmentation. This makes it easier to apply the findings in different settings and reach a large audience. Similar to the Weigh Your Waste and Trash Game studies, this study adopts a user-centred approach in which the persuasive design is largely based on user input. It also places importance on the technology's role as an educational platform. The goal was to design an application on household recycling that users would be motivated to try out and ideally consult again if they had any questions on the topic. In order to achieve this, the gathered user input extensively covered the target users' recycling-related attitudes, interests, problems, and design requests. An example of a purely educational approach from outside of academia is the Sorteringsguide.

2 Methodology

The study consisted of: (1) the design, implementation, and analysis of an online survey and (2) iterative design work, including user evaluations. The results of the online survey were thereby intended to inform the design work. The chosen design methodology was Fogg's eight-step design process as it specifically targets persuasive technology [21]. Based on the consensus in the literature that young people tend to exhibit worse HRB than older people, the study targeted young adults aged 18 to 30. As it was conducted in the context of the Swedish recycling system, participants were required to live in Sweden.

2.1 Online Survey

In the first phase of the study, an online survey was carried out among Sweden-based young adults aged 18 to 30. It was intended to provide insight into the their recycling-related interests, problems, and attitudes. In addition, participants were asked to assess their own HRB, and state their requests and ideas for an HRB-related application. The survey contained multiple choice and ranking items, as well as open-ended questions. It was distributed via social media and accessible for a total of four weeks. Fifty participants (35 female and 15 male) filled in the survey. The average age of the participants was 24 years. The

survey responses were analysed using descriptive statistics. For the open-ended questions, a thematic content analysis was used, similar to the one described by Braun and Clarke [22].

2.2 Iterative Design Work

In the second phase of the study, a mobile phone application was designed and evaluated in an iterative manner. The aim was to complement the results from the online survey with findings from the design and evaluation process, and to compare the survey responses with feedback from the evaluation sessions. The initial paper prototype was informed by the literature, findings from the online survey, existing technology, and a set of design principles adapted from Preece, Rogers, and Sharp [23]. It was improved in three design iterations, each involving a task analysis and a short semi-structured interview with one or two participants. The evaluation sessions were audio recorded and lasted approximately one hour each. Based on the final version of the paper prototype, a digital prototype was built. It was intended to reflect the obtained results and function as groundwork for future research.

3 Results

The results are divided into five subsections. Subsections 3.1 - 3.4 outline the survey outcomes, while subsection 3.5 describes the findings from the iterative design and evaluation of the mobile phone prototype.

3.1 HRB Self-Evaluation and Difficulties

Sixty-eight percent of the survey participants agreed that they could improve how they prepare their household waste and 56% how they dispose of it. Linked to these results, 32% agreed that they are often unsure into which container they should put their waste items. Eighteen percent disagreed that they know how many waste containers there exist for their household waste. Of the five predefined response options, overflowing waste containers were reported as a problem by the largest number of participants (58%), followed by difficulties in dismantling waste (54%), difficulties in cleaning waste (32%), difficulties with inconvenient locations of waste containers (20%) and difficulties with unclear/no labelling of waste containers (18%). Fifty-four percent of the participants disagreed that it requires a lot of effort to prepare and dispose of their household waste correctly; 32% agreed. In the open-ended survey responses, one participant outlined their current work-around as: “when I don’t know what to do with the item at hand I just put it in the brännbart [burnable waste] container, which I think is not good”. Two participants expressed uncertainty about the precise location of “recycling centres” and waste containers (“finding where these damned containers are”).

3.2 Recycling-related Interests

Seventy-six percent of the participants disagreed that it does not make a difference whether they recycle and 84% disagreed that they do not really care about recycling. The participants wanted learn about the impact of recycling onto the environment (72%), how to integrate good recycling practices into their daily life (64%), how different waste items get recycled (64%), the recycling efforts of other people in the community (60%), and the recycling system in the area (50%). A key theme in the open-ended responses was feedback. The participants wanted to know about the "impact that [their] personal contribution to recycling has on the environment" and if their HRB "made a difference", particularly in "reducing different environmental problems". It would be motivational for them to know that their HRB matters (e.g. "it would help motivate me to keep up if I knew I made a difference"). Related to the idea of feedback is the request to "monitor" or "track" recycling performances, usually on a "weekly" or "monthly" rhythm. The participants would like to see the development of their own HRB (e.g. "graphs of recycling habits over time") and compare it to the HRB of others (e.g. "everyone in the corridor I live in"). Other suggestions were to "make groups and monitor a consolidated performance" and to use an application as "something to talk about with other people and compare habits". As an additional step, goal-setting (e.g. "make people more aware about their optimum possible recycling performance against their current performance") and an achievement system with "points" or "rewards" were suggested. This opinion, however, was not shared by everyone as one participant preferred to have "no leader boards creating social pressure". After having disposed of their waste items, the participants were interested to know "what happens to [their] disposed items", and how they be would transformed into new materials (e.g. "showing what your recycled items become").

3.3 Use Context

Another key theme in the open-ended survey responses was the participants' wish for guidance when deciding which waste item they should put into which container, and how they should prepare and dismantle the waste. Their wordings suggest that they require decision support "at the time" or "in situations" when they do not know what to do with a waste item. A particular focus was on uncommon waste items (e.g. "ceramics") and waste items that "need to go to a special station". The participants were also interested in learning about household waste recycling more generally (e.g. "showing basics how to recycle/what is recycling"; "apps that show how to do the recycling in steps"). One participant asked for guidance when "making a choice on which product to buy (what has a better chance of being recycled or what is easier to recycle, for example)". Two groups that were specifically believed to benefit from a HRB-related application were people who have changed their place of residence ("when you arrive at the new place, or the people come from the place without recycling training") and students ("especially in student housing it is often unclear how the recycling

system works and there is no real explanation except for from other students who have lived there before").

3.4 Desired Platform, Content, and Features

The survey participants were asked how interested they were in using an application that would help them improve their HRB. On a scale from 1 to 10 where 1 meant 'not interested at all' and 10 meant 'very interested', the average response was 5.8 and the median response 7.0 (26% of participants). The participants were asked to rank five types of applications according to how interested they were in using them. The weighted average scores were: (1) an application that gives feedback (3.44), (2) an application that visualises the recycling system (3.20), (3) an application that sends reminders (2.94), (4) an application that lets the users communicate with recycling providers (2.82), and (5) a game (2.60).

A common request in the participants' open survey responses were reminders (e.g. "it would be nice to have something to teach me and remind me"). One participant referred to the habitual nature of HRB, saying that they would like "reminders for everyday habits to stabilise regarding recycling". Not everyone, however, shared this view. One participant in particular wanted "no stressful alerts and notifications". Another request was a platform to communicate with the recycling provider(s). Specifically, the participants wanted to use the platform to let the recycling providers know about problems ("when there are parts of the recycling system that don't work well", communicate "improvement ideas", and ask questions ("then I could ask the people in charge right away"). To avoid everyone asking the same questions, a "Frequently Asked Questions" section was proposed.

Design-wise, a "well detailed and simple" design and "clarity" were seen as important. Specific requests included "lots of pictures", "small movies", or something similar to "tutorial videos on YouTube". One participant asked for movies with "interesting facts about recycling". At the same time, the application should "not be patronising" or give the users the impression of being judged (e.g. "anything that doesn't make me feel bad and blamed"). Two participants suggested the use of games/game elements but to shift the focus from the competitive aspects to the explorational and cooperational ones ("in the case of a game, I would rather it either challenged me to do it or that it invited me to explore the area, instead of any kind of social competition."; "maybe add some gamification and play not as an individual but as a community?"). Another two participants liked the idea of presenting information on a map (e.g. "I would also want to see some recycling place for electronics/paint etc on a map").

3.5 Design and Evaluation of the Prototype

The design of the application was intended to incorporate the requests by the survey participants but still give its users the autonomy to use it in the way that would suit them best. It was also intended to encourage a dialogue between the

users and the recycling providers. Table 1 summarizes the structure and features of the application, and the changes made in response to the user feedback.

Table 1. Prototype structure and development.

Function	**Content**	**Development**
Sign-up	Opportunity to create a user profile; selection of location and local recycling scheme(s)	Several icons were revised; a 'login' button was added
Home screen	A digital representation of the local recycling scheme, including relevant waste containers; a search function for waste items, similar to the Sorteringsguide [19]	The design of the container representations was altered; a link to the map was added
Map	A map with waste container locations and optional directions; the collection times for each waste container and a possibility to set reminders for them; the option to indicate when a specific container is full and statistics on such indications by other users	Most substantial design change: two screens and an additional map pop-up were merged into a map screen with various features
Communication platform	Frequently Asked Questions (FAQ); a chat function to ask questions or make suggestions to the recycling provider(s); a noticeboard for the recycling provider(s) to make announcements	The 'questions' and 'suggestions' tabs were merged; a search bar and private messaging feature were added
Background information	Links to additional recycling-related material and statistics	A 'how to reduce waste' link was added
Settings	A menu to adjust the language, reminders, and account settings	A 'logout' menu item was added

Overall, the participants of the evaluation sessions seemed pleased with the design of the application. One participant positively mentioned the bottom menu bar as he could see all menu items at the same time. The participant also described the design as "simple" and "to the point". Three of the four participants suggested independently of each other that the application could be beneficial for people who recently changed their place of residency. In the interviews, the participants reflected critically on their own HRB and how the application could help them overcome their current problems. These problems included a lack of knowledge on how to recycle milk cartons and waste containers that were only labelled in Swedish. The four participants differed as to which function of the application they found most useful: two participants liked the search function

for waste items, one the visualisation of the recycling scheme, and one the waste container collection times. Screenshots of the final design (excluding the sign-up process and settings) can be seen in Fig. 1.

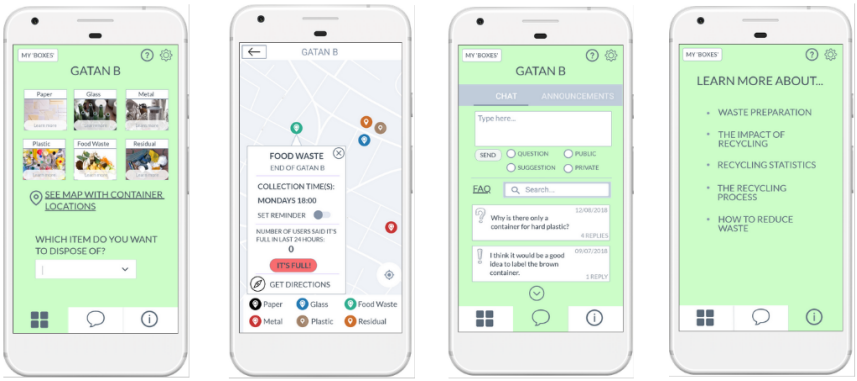

Fig. 1. Sample screenshots of the digital prototype.

4 Discussion

The research confirms the relevance of targeting HRB among young adults, with Sweden as a case study. The results show that a large majority of the participants believe that they can improve one or several aspects of their HRB, despite them being potentially more interested in recycling than the average member of the target population. The participants, however, also pointed out several issues that limit their ability to correctly dispose of their waste, the most common one being overflowing waste containers. These issues can be addressed by persuasive technology but must eventually be solved by the recycling providers. Overall, the survey participants showed a substantial interest in using persuasive technology to improve their HRB. This opens up the possibility to use the technological format of the interventions to attract interest.

The participants of the evaluation sessions highlighted the potential benefits of the designed application for people who recently changed their place of residence. After relocating, people might be especially receptive to the provided information as they are trying to settle in and look for guidance.

Together, the findings from the online survey and iterative design work led to five recommendations for the design for persuasive technology that is intended to improve their users' HRB. They are outlined in the following section.

4.1 Recommendations for HRB Intervention Design

Recommendation 1: Easy Access to Information about Optimal HRB. This recommendation was supported by the results of the online survey and

design evaluations, and confirms previous findings in the literature, notably those in [14] and [15]. The participants of the online survey indicated that they care about recycling but lack the knowledge to always dispose of their household waste in the correct way. Later on, the participants of the evaluation sessions emphasised the usefulness of the application's educational elements. The easy access to the information was highlighted as most of the information that the target users require is already available but not sought out.

Recommendation 2: Employment of Several Motivational Strategies. The study results show that different target users are motivated by different features. There does not exist a 'one-size-fits-all'. In the survey responses, the ranked average of the proposed types of applications were close together. The answers to the open questions were also diverse and sometimes even contradicting each other. Similarly, the participants in the evaluation sessions considered different parts of the application helpful. This is in line with the result by Varotto and Spagnolli [15] that combined interventions are among the three most successful strategies to improve people's HRB. Comparing the findings in [15] and the survey outcomes more closely, a large overlap regarding the role of information, prompts/reminders, moral norms, and environmental concern can be seen. What stands out is the role of feedback. Varotto and Spagnolli found feedback to be the least successful strategy while the survey participants considered it as one of the most motivating features. Another interesting finding was the survey participants' lack of enthusiasm for the use of games as a persuasive strategy. It got the lowest ranked average of the proposed applications and was mainly supported by the participants in a non-competitive form. This is in line with the findings in [10] that the users of the Trash Game focused more on the classification tasks than the game scenario.

Recommendation 3: Recognition of Recycling Scheme Differences. Due to a division in responsibility, the recycling schemes for Swedish households differ depending on their geographic location. As HRB can only be sustainable if it is in accordance with the local recycling schemes, persuasive technology needs to acknowledge these differences.

Recommendation 4: Regard of Users as Equals. The use of persuasive technology comes with a variety of ethical challenges, so much care is required of those who design and develop it. While they might consider sustainability a good cause, it is crucial that the developed systems are unobtrusive and transparent. Users should be made aware of the aims behind the persuasion and shown the researchers' underlying reasoning. In the survey, several participants stated that they did not want to use persuasive technology that was patronising or would made them feel judged. As can be seen from the BinCam/BinLeague application [8], pressure can be an enticing tool to improve HRB. It should, however, be seen critically, not only because users who associated negative emotions with a persuasive system are unlikely to continue its use.

Recommendation 5: Use of a Readily Accessible Technology Channel. A readily accessible technology channel means that the technology channel should be accessible in the situations in which it is needed. By definition, HRB comprises several activities which do not necessarily take place in the same location. So if people wanted to consult an application as decision support, it should ideally be accessible in all of the different locations. One simple way to achieve this is by focusing on portable devices like mobile phones. The need for a readily accessible technology channel was supported by the survey outcomes: the participants asked for situational decision support, particularly when they had to decide what to do with a specific waste item.

5 Conclusion

For both economic and environmental reasons, countries around the globe aim to increase the recycling rates for household waste. This research has established five recommendations for the design of persuasive technology which aims to promote sustainable HRB behaviour without the need for waste container augmentation. It also emphasises the importance of HRB as an area for future research. Most polled members of the target audience (young people living in Sweden) were to some extent motivated to use an application to improve their HRB. This opens up the possibility to use the digital format of the interventions as a 'carrot' to spark people's curiosity. The design of the mobile phone application illustrates a way of implementing the established key elements in an artifact, and its design can be used as a starting point for future HRB interventions.

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