Understanding householders' perspectives on sorting plastic waste

Polyportis, A.; Mugge, R.; Magnier, L.B.M.

Publication date
2022

Document Version
Final published version

Interreg North-West Europe TRANSFORM-CE

Understanding householders' perspectives on sorting plastic waste.

Authors: Dr. Athanasios Polyportis, Dr. Ruth Mugge, Dr. Lise Magnier
Faculty of Industrial Design Engineering, TU Delft

Understanding householders' perspectives on sorting plastic waste.

This report provides an overview of the individual and contextual factors that have been found to influence households' recycling and sorting of their waste, including recycling of plastic waste. It also unveils a comprehensive overview on how specific intervention strategies could encourage households to recycle more frequently and effectively. Finally, the academic report includes guidelines that can help foster households' recycling and sorting behaviour.

Date 2022

Authors Dr. Athanasios Polyportis, Dr. Ruth Mugge, Dr. Lise Magnier (TU Delft)

Deliverable WPT1 D2.3
Date: 29/07/2022

This research has been conducted as part of the TRANSFORM-CE project. More information about the project can be found on: **www.nweurope.eu/transform-ce**. TRANSFORM-CE is supported by the Interreg North West Europe programme as part of the European Regional Development Fund (ERDF).

Table of contents

1. Introduction

Recycling is defined as "individuals' waste collection intentions and behaviour to allow materials to be re-used" (Geiger et al., 2019, p.1). Processing facilities, collecting infrastructure, suitable legislative and enforcement actions are all required for the recycling loop to become successful. Individuals are responsible for performing primary waste separation at home, including identifying and distinguishing plastic recyclables from the rest of the waste, properly preparing them for recycled plastic collection, sorting them in the appropriate bin, and/or transporting them to the nearby collection centre. Hence, household participation is important for achieving successful recovery of good-quality recyclables with an easier post-collection separation, therefore contributing to the efficiency and cost minimisation of the overall recycling process (Miranda Carreño & Blanco Suarez, 2010).

In the present report, we start with a brief description of the method applied to acquire and develop the theoretical grounds of our research (Chapter 2). We then analyse the individual (Chapter 3) and contextual (Chapter 4) factors that have been found in scientific research to influence households' recycling of their waste, including recycling of plastic waste. We then present the state-of-the-art knowledge on possible interventions that can enhance households' recycling behaviour (Chapter 5), partially building on the insights from Chapters 3 and 4. In other words, we provide a comprehensive overview on how specific intervention strategies could encourage households to recycle more frequently

and effectively. Throughout the report, when applicable, we propose distinct guidelines that can help foster households' recycling/sorting behaviour. For each guideline, it is explained why this could increase householders' recycling.

2. Method

To provide a holistic picture of the householders' perspective on recycling plastic waste, we performed a literature review on potential factors influencing recycling behaviour and, on the interventions, that have been highlighted in prior research to promote household recycling. To select articles for this review, we conducted a search for relevant articles based on the academic database Web of Science. The following search terms were applied to screen title, abstracts and keywords, with the use of the Boolean operators AND and OR: household AND (recycling OR sorting) AND (plastic OR intervention). The search results yielded 732 records from Web of Science until July 10th, 2022. Then, based on the title, as well as on the abstract when the title was not clear, we applied specific inclusion and exclusion criteria. The articles included were expected to be mainly focused on householder's recycling and/or sorting intentions and behaviour. We excluded engineering, chemistry, biological science, physics, and other journals that did not fit with the perspective of the present research. From this process, we concluded in the selection of 38 unique records. Finally, a cited search was conducted, including a snowball technique in which citations within the 38 articles as well as relevant papers that cited these 38

articles were searched and retained if they appeared relevant to the present research (Hepplestone et al., 2011). This final step led to a pool of 55 selected articles. The main findings are presented below.

3. Individual factors

Prior research on recycling unveiled that various individual factors, such as knowledge about environmental problems and recycling, norms, attitudes towards recycling, perceived behavioural control, biospheric values and anticipated affect, were strongly related to recycling behaviour (Geiger et al., 2019; Hornik et al., 1995).

3.1 Norms

Norms are expectations regarding others' behaviours and internal motivations to conform to what one expects others to do (Bicchieri, 2006). Cialdini et al. (1991) extended Deutsch and Gerard's (1955) seminal work on informational and normative social influence, and established three distinct types of norms: social norms of *descriptive* nature, which guide subsequent behaviour through establishing the perception of how others would behave; social norms of *injunctive* nature, which guide subsequent behaviour through the perception of how others would approve or disapprove of a person's actions; and *personal* norms, which guide subsequent behaviour through the perception of how a person would approve or disapprove of his or her own actions.

Norms motivate and direct action mainly when they are activated (i.e. made salient, Norm-Activation-Model; Schwartz & Howard, 1981); therefore, individuals who are even temporarily focused on normative considerations are more likely to act in norm-consistent ways (Berkowitz, 1972; Cialdini et al., 1991).

The above-mentioned theories can be applied in a pro-environmental context, such as a recycling context. From this perspective, a descriptive norm to commit to recycling behaviour reflects the extent to which individuals believe that other people recycle their waste. Householders are expected to act in consistency with their descriptive norms. Hence, householders are more likely to recycle their waste when they are characterized by higher descriptive norms, or in other words when they believe that many other people recycle their waste (Geiger et al., 2019).

In a similar fashion, injunctive norms are conceptualised as individuals' perceptions of the extent to which others would approve or disapprove certain behaviours (Cialdini & Trost, 1998), such as recycling, or pro-environmental behaviour in general. Complying with an injunctive norm is expected to yield social approval and rewards, while not following injunctive norms is likely to lead to social disapproval and punishments. Consequently, it is expected that the more a householder experiences a favourable injunctive norm towards recycling, the more likely one is to recycle Geiger at al. (2019).

Personal norms towards a recycling behaviour reflect states of moral obligation to commit to this behaviour and serve as internal moral rules for the individual's own behaviour

(Kallgren, Reno, & Cialdini, 2000). Descriptive and injunctive social norms have been found to be significant activators of personal norms (e.g. Han et al., 2018; Bratt, 1999). For instance, Bratt (1999) highlighted the effect of the social norms on personal norms, which in turn affected recycling behaviour. Furthermore, the varying strength of these personal (moral) norms explains a large part of the variation in recycling behaviour across households.

3.2 Perceived behavioural control

Perceived behavioural control (PBC) has been identified as a key predictor of behavioural intentions and actual behaviour (Theory of Planned Behaviour; Ajzen, 1991). Perceived behavioural control is also linked to "self-efficacy" (Ajzen, 2002; Tabernero et al., 2015), reflecting the degree to which an individual perceives him or herself as being able to engage in a certain behaviour, such as recycling. The higher a householder's perceived behavioural control to recycle, and the higher their perceived self-efficacy to do so, the more likely householders would be to engage in recycling (Geiger et al., 2019).

3.3 Biospheric values

Values are relatively stable trans-situational means and goals that reflect what people find important in life (Feather, 1995; Schwartz, 1992). Biospheric values correspond to the trans-situational belief that environmental protection is an important goal in life

(Boomsma and Steg, 2014). People holding a biospheric value orientation tend to view their own and others' actions by taking the advantages and drawbacks for nature into consideration (Bouman et al., 2020). Based on this conceptual background, several studies have investigated the role of biospheric values in sustainability and environmental psychology (e.g. Martin & Czellar, 2017; Steg & de Groot, 2012).

Biospheric values may affect a wide range of pro-environmental behaviours (De Groot & Thøgersen, 2012; Martin & Czellar, 2017; Wang et al., 2021), including recycling (e.g. Dietz et al., 2005). Therefore, householders with stronger biospheric values are more likely to recycle than householders with weaker biospheric values because the former tend to base their choices on the consequences of their behaviour for the environment (De Groot & Steg, 2007).

3.4 Knowledge about environmental problems and environmental attitudes

Knowledge about environmental problems reflects the extent to which people understand the origins and implications of environmental issues, as well as which behaviours contribute to such issues (Schultz, 2002). An individual who is more knowledgeable about the environmental issues is more likely to recycle than someone who is less knowledgeable (Kaiser & Fuhrer, 2003).

The amount to which an individual is worried about the environment is reflected in their environmental attitudes (Steg et al., 2011). The New Environmental Paradigm (NEP; Dunlap

et al., 2000; Dunlap, 2008), reflects people's attitudes of and perceptions about the connection between humans and the environment. In general, the stronger a householder's environmental attitudes are, the more likely he or she will engage in recycling behaviour (Geiger et al., 2019).

3.5 Knowledge and attitudes towards recycling

Knowledge about recycling reflects the extent to which people know how to recycle their household waste, such as plastic waste. An individual who is more knowledgeable about recycling is more likely to recycle than someone who is less knowledgeable (Babaei et al., 2015; Liu et al., 2022; Ng, 2020). Low levels of knowledge on source separation and recycling can hinder recycling behaviour (Babaei et al., 2015). However, once individuals understand how to recycle, they will be more likely to commit to this behaviour in the future (Geiger et al., 2019; Schultz et al., 1995).

Attitudes toward recycling indicate how positively individuals view recycling (Geiger et al., 2019). Such attitudes depend on the awareness of the consequences, and of the expected costs and benefits of recycling (consistent with Ajzen, 1996). Overall, the more positive one's attitudes towards recycling, the more he or she is likely to engage in this behaviour (Oskamp et al., 1991).

3.6 Past recycling behaviour

High levels of attitudes towards recycling are usually accompanied by high levels of past recycling behaviour (e.g. Carrus et al., 2008; Daneshvary et al., 1998; Geiger et al., 2019). Past recycling behaviour may be expressed as a habit to recycle (Verplanken & Aarts, 1999). Ouellette & Wood (1998) unveiled that past behaviour may impact future behaviour through two different paths; for behaviours that are performed in relatively stable contexts, past behaviour works through the process of habit formation. For behaviours that are performed in less stable contexts, past behaviour works through the process of intention formation. In this case, the role of past recycling behaviour is more probably to be mediated by conscious and reasoned decision-making processes (Carrus et al., 2008). If householders have developed a recycling habit, they may engage in recycling automatically, without conscious decision-making. Hence, the more householders recycled in the past, the more likely they have developed a habit to continue recycling in the future (Geiger et al., 2019).

3.7 Anticipated affect

In general, when making decisions, people often anticipate the emotions they might experience because of the outcomes of their choices. In this process, people simulate what emotions could be experienced with one outcome or another (Mellers & McGraw, 2001).

Anticipated affect in the recycling context indicates the extent to which individuals anticipate that recycling will elicit different emotions. These emotions can be both positive (e.g. anticipated pride) and negative (e.g. anticipated guilt; Haj-Salem & Al-Hawari, 2021). People can be motivated to engage in a particular proenvironmental behaviour because they believe it will make them feel good (i.e. experience positive emotions), or because they believe it will help them to avoid feeling bad (i.e. experience negative emotions) (Taufik et al., 2016). Anticipated affect has therefore been established to be a key predictor of pro-environmental behaviour (Gatersleben & Steg, 2012). The more people anticipate positive emotions for engaging in a specific behaviour, such as recycling, the more likely they are to engage in this behaviour (Taufik et al., 2016). Similarly, anticipated negative emotions (e.g., due to smelly trash cans) may inhibit the recycling behaviour (Carrus et al., 2008; Elgaaied, 2012). For instance, anticipated guilt evoked due to inconvenience and awareness of the negative consequences related to non-recycling may lead to lower intentions to recycle (Elgaaied, 2012). Householders are more willing to recycle when they anticipate that their recycling behaviour will elicit more positive feelings than negative feelings (Geiger et al., 2019).

3.8 Individual demographic differences

Individual demographic differences such as gender and age, have been highlighted to influence the perceptions and recycling propensity of packaging (e.g. Guiot et al., 2019;

Martinho et al., 2015). For instance, women are more devoted to recycling than are men (Schultz et al., 1995; Martinho et al., 2015). Regarding the effect of age, although aging is associated with lower levels of enthusiasm for recycling, it is also associated with more skills and available time that allow recycling to be accomplished with increased ease (Guiot et al., 2019).

4. Contextual factors

4.1 Housing condition

The housing condition, conceptualized as the house type in which a person lives has been found to affect the feasibility of recycling, which in turn influences the likelihood of recycling (Geiger et al. 2019; Oskamp et al., 1991). More specifically, two crucial factors, one related with ownership (i.e. owned vs. rental house), and the other regarding type of house (i.e. single-family house, apartment or detached houses) were highlighted in prior research (Geiger et al., 2019). Individuals living in a single-family, owned house were associated with higher recycling rates than individuals living in a rented apartment (Oskamp et al., 1991; Hage et al., 2009).

4.2 Recycling facility conditions

Ownership of a recycling bin at home (Robertson & Walkington, 2009) and availability of recycling facilities in the proximity (D'Amato et al., 2016; Hage et al., 2009; Rosenthal & Linter, 2021; Schulz et al., 1995) have been found to positively influence recycling behaviour. These factors are related with perceived convenience of recycling, which matters in the sense that property-close collection, especially in multi-family houses (i.e., single buildings that are divided to accommodate more than one family living separately; Hage et al., 2009), may lead to higher collection rates. Furthermore, if the recycling services are difficult to use, inappropriate or badly organized, they may not lead to increased recycling behaviour (Pocock et al., 2008).

Another factor that influences recycling is related to the size of each neighborhood. Specifically, residents of smaller neighborhoods tend to recycle more than residents of bigger neighborhoods, as they have an easier access to a structured recycling program (Derksen & Gartrell, 1993).

4.3 Packaging

Design affordances generally refer to product characteristics that provide options to users when using the product (Norman, 1999, 2013). The plastic packaging design affordances, including the packaging form, size, durability, haptic aspects, and visual communicative elements, have been found to influence how consumers perceive the value of packaging and their sorting behaviour (Nemat et al., 2019, 2020, 2022).

Specific design affordances of plastic packages can lead to the perception that packaging is not recyclable or not worth recycling because it is of low value. More specifically, various design characteristics, namely: 1: *form*, 2: *colour and haptics*, 3: *material*, 4: *size* and *cleanability* were revealed to influence the mis-sorting of packages. First, if the consumption process distorts a product or package sufficiently from its original form (i.e., changes its size and/or form), consumers perceive it as less useful and in turn are more likely to throw it in the garbage, instead of recycling it (Trudel & Argo, 2013). It is noteworthy to mention that this product or packaging distortion was found to not alter the actual value of the package, as the amount and quality of material remains the same, yet to lower its perceived value and usefulness and increases its categorization probabilities as garbage. Second, packages made from non-transparent material, with glossy appearance, or coloured in bright and longer-wavelength (i.e. red, yellow, or mixed) colours were more often mis-sorted than packaging with matte colours, because these characteristics lead the packaging to be perceived of lower perceived value (Nemat et al., 2022). In a similar vein, thin, soft plastic, such as plastic foil, is more frequently mis-sorted than packaging with a rough texture, due to its lower perceived value, regardless of if it is used as an exterior or intermediate layer in the packaging. The perceived low value of soft plastics depends on their inexpensive feel and low durability. An additional reason for mis-sorting soft plastic is the inconvenience related to its sorting, as highlighted by Nemat et al (2020, 2022).

Third, packaging made from a combination of plastic and other materials, for example, paper or aluminum, was often accidentally or intentionally mis-sorted, probably due to lack of knowledge or due to uncertainty about how to recycle these packages (Nemat et al., 2022).

Fourth, small packages, with a size of less than 200 grams, are often mis-sorted. This finding is consistent with Trudel & Argo's (2013) findings that demonstrated higher propensity to recycle bigger packages, as they are perceived of higher recycling value. Furthermore, soft and loose packages were perceived as difficult to clean, as they needed to be washed. The smaller (pocket) sizes could augment the mis-sorting issue because these packages cannot be cleaned easily, especially if they contain wet/fatty contents (Nemat et al., 2022).

To tackle the highlighted plastic packaging affordance problems, Nemat et al. (2019) suggested to rule out the use of soft plastics and replace them with other recyclable materials, such as bioplastics, glass, and paper. However, Nemat et al. (2022) underlined that usually individuals are often unaware or are uncertain of the consequences of replacing plastics with these types of materials.

The above synopsis of the research findings on plastic packaging design affordance and mis-sorting leads to the formulation of guidelines for designing packaging that will improve the quality of householders' sorting behaviours. More specifically:

Guideline 1: Householders' recycling behaviour can be improved by highlighting the value of the packaging for recycling (which is currently especially problematic for small packages and packages made of soft plastics). This can be improved:

a) By including signs on the package about the recyclable nature.

b) By presenting relevant environmental information.

c) By using a matt color and a rough texture.

The overview of the individual and contextual factors that influence household recycling behaviour and were analyzed above is presented in Figure 1 below:

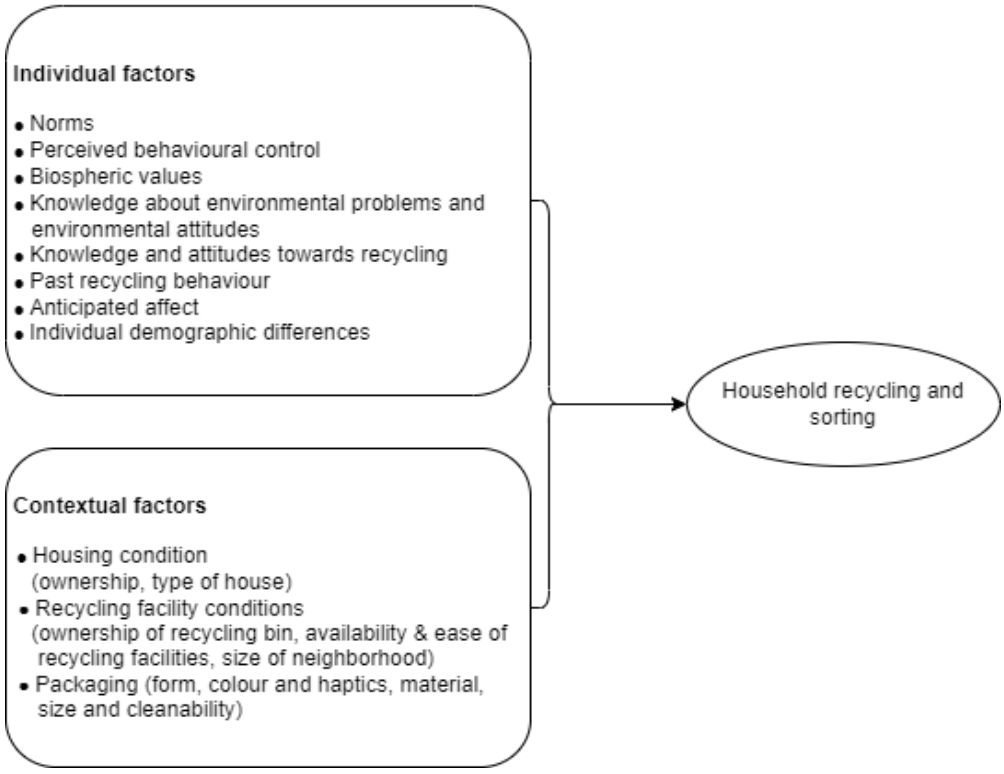

Figure 1 Individual and contextual factors that influence household recycling.

5. Interventions to foster recycling behaviour

A variety of intervention strategies have been highlighted by prior research (e.g. Iyer & Kashyap, 2007; Schulz et al., 1995; Varotto & Spagnolli, 2017) to apply a wide array of behaviour-change techniques to promote household recycling. These intervention strategies are based on different types of persuasive strategies and can be classified in six distinct types, namely prompts and information, feedback, commitment, behaviour modelling, environmental alterations, and incentives (i.e., rewards and penalties) (Varotto & Spagnolli, 2017).

These six intervention strategies that can lead to behaviour change are further analysed below.

5.1 Prompts and information

The intervention strategy of prompts and information focuses on providing (factual or persuasive) information on recycling in order to foster recycling behaviour. This intervention mainly focuses on changes in recycling behaviour by providing more information about recycling to households (also see Chapter 3.5). The lack of information on recycling is recognized as one of the main barriers to participation in recycling programs and quality of recycling (Alexander et al., 2009; McKenzie-Mohr, 2013; Perrin & Barton, 2001; Schultz, 2002). Indeed, people often do not know exactly how to recycle (i.e.,

at the start of a new recycling program or when the existing program changes or is particularly complex; Schultz, 2002).

The information provided through this intervention can be written (Schultz et al., 1995; Varotto & Spagnolli, 2017) or delivered face-to-face, for instance through informative letters, fliers and brochures that promote recycling and explain how and why to commit to recycling actions or a recycling program (e.g. Chong et al., 2015; Mee, 2005; White, Mac-Donnell, & Dahl, 2011). In addition, other informational materials, such as signs or posters, can be placed close to recycling bins in public areas to prompt the correct discarding of recyclable materials and describe the benefits and importance of recycling (Moreland & Melsop, 2014; Schultz, 2011).

For instance, Figure 2 presents the prompt intervention strategy used in municipalities in the Western US, such as that of San Francisco, with posters on the recycling bins. The design of this strategy facilitates the provision of information to householders on how to recycle and what to include in each recycling bin.

Figure 2 Prompt intervention strategy on the recycling bins informs householders on how to recycle.

Another example of a prompt intervention strategy is the letter/poster that Australian authorities in Victoria have implemented, which informs householders on how to reduce their environmental impact via their recycling actions. This intervention is shown in Figure 3 below:

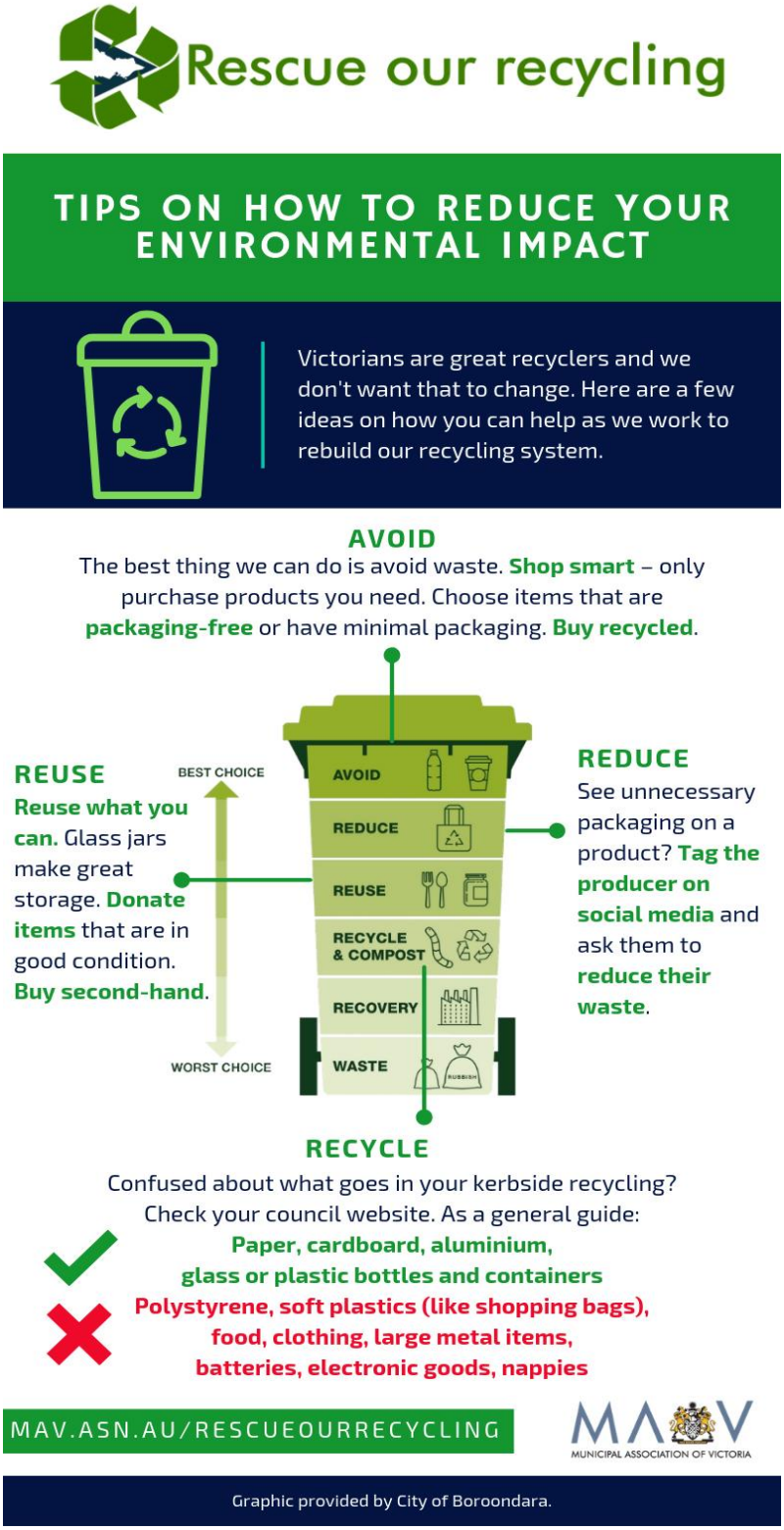

Figure 3 Prompt intervention strategy on the environmental impact of recycling and information about how to achieve this impact in the municipality of Victoria, Australia.

These findings lead to the following guideline:

Guideline 2: Householders' recycling behaviour can be improved by the implementation of prompts and informational campaigns that disseminate factual and/or persuasive information about the environmental consequences of recycling and about how to recycle.

5.2 Feedback

This intervention strategy entails presenting householders or larger social groups with information about their recycling habits, as well as a historical or social comparison to a predetermined standard, to demonstrate the discrepancy with the standard and motivate them to close the gap. This presentation can take place through traditional means (e.g. newspapers, TV) or through official web sites or social media, or even through providing tailored feedback on householders' personal mobile devices or on ambient displays (Froehlich et al., 2010; Paulos & Jenkins, 2006; Reif et al., 2010; Thieme et al., 2012). Feedback on individual/household performance as well as on past recycling behaviour (also see Chapter 3.6) may improve a recycler's perceived self-efficacy, or belief in their ability to engage in or improve their recycling behaviour (Abrahamse & Steg, 2013). For instance, energy companies usually provide feedback through providing a comparison of the present and last year's energy household consumption (Figure 4).

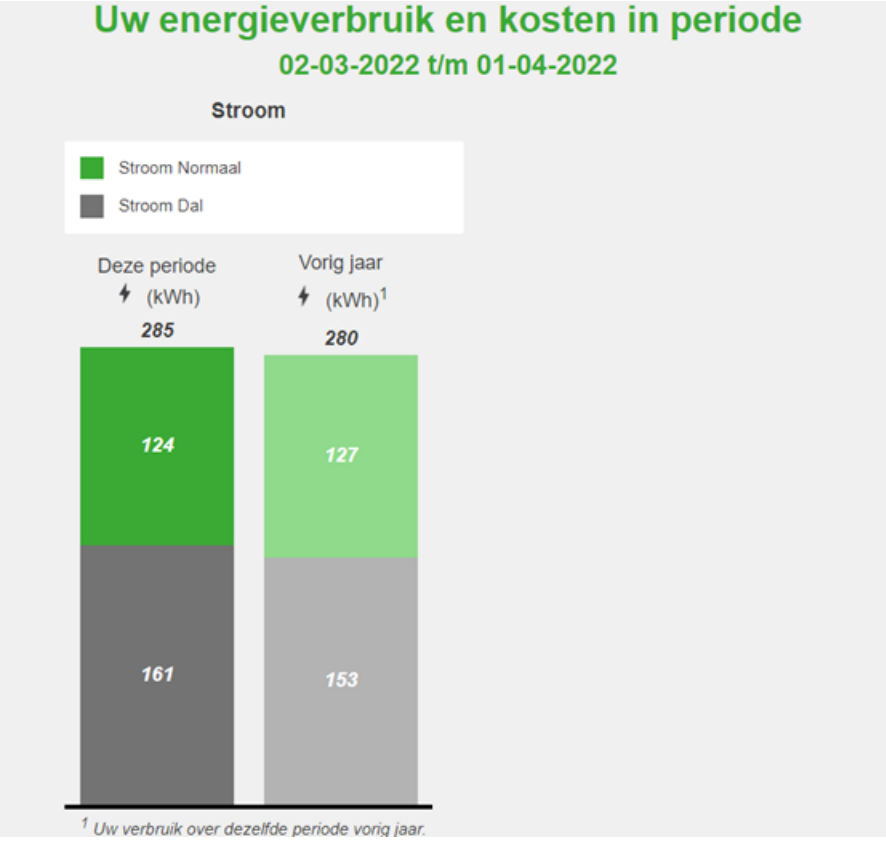

Figure 4 Feedback intervention strategy of energy companies through a comparison of the present and last year's energy household consumption.

Noteworthy, this strategy presents some shortcomings related to its practicality (e.g. Katzev and Mishima, 1992). To be able to provide feedback, it is necessary to constantly monitor recycling behaviour. Furthermore, merely informing people about the consequences of their behaviour by for example a historical or social comparison does not automatically imply a behavioural change (Tabanico, 2013) if the decision-maker lacks, for instance, information to commit to recycling behaviour. For this reason, it is not unusual for different intervention strategies to be implemented simultaneously. For instance,

Moreland and Melsop (2014) provided feedback to the students living in US university housing facilities through the Facebook page of a recycling program. In the same Facebook page, information on how to improve recycling performance was posted, therefore researchers implemented the feedback (5.2) and prompt (5.1) intervention strategy at the same time.

Therefore, the following guideline is formed:

Guideline 3: Householders' recycling behaviour can be improved by the provision of feedback on individual/household performance and/or on past recycling behaviour, either through traditional or new channels.

5.3 Commitment

In interventions resorting to commitment, individuals commit to produce a certain behaviour or reach a certain target. This strategy is effective as the internalization and self-accountability of an act (Dupré et al., 2014) increases the consistency of attitudes and subsequent behaviours (Cialdini & James, 2009; also see Norms, Chapter 3.1). Once a commitment is made, people tend to modify their attitudes to be consistent with the committed behaviours, to reduce cognitive dissonance in consistency with the Cognitive Dissonance Theory (Festinger, 1957). Therefore, commitment involves an automatic tendency to change attitudes (Cialdini & James, 2009; Deng et al., 2022).

In the recycling context, past research has unveiled that commitment was more effective in changing recycling behaviour than for example information provision and prompts via fliers and brochures (see Chapter 5.1; Dupré, 2014; Werner et al., 1995) and incentives (see Chapter 5.6; Wang & Katzev, 1990). Furthermore, compared to commitments with general, nonspecific messaging, specific and written commitments made by individuals in public lead to higher commitment rates and better recycling performance (Baca-Motes et al., 2013; Wright & Kacmar, 1994). For instance, Deng et al. (2022) explored how children at Chinese schools can effectively commit to recycling behaviour, by signing a commitment letter and by additionally circulating their commitment to recycle to their families. Another example is related to the California Waste Management Board, which in the context of their CalRecycle campaign, sends commitment letters to the households of the greater California region, intended to be filled in and returned, as an effort to increase used oil and filter recycling in their communities (see Figure 5 below).

Figure 5 Commitment Letter for the households of California, intended to increase recycling rate of used oils and filters.

The above information leads to the Guideline below:

Guideline 4: Householders' recycling behaviour can be improved by the implementation of commitment interventions and campaigns.

5.4 Social modelling

The use of social modelling techniques is effective as it communicates to the individuals that other people are recycling, generating a social recycling norm (Burn, 1991; also see Norms in Chapter 3). The effectiveness of this type of intervention rests on the fact that people learn through observation of the behaviour of others, by imitating this behaviour

especially when it is relevant, easily understandable and permits to the individual to reach meaningful and positive outcomes (Varotto & Spagnolli, 2017).

For instance, prior studies (e.g. Bernstad, 2014; Boonrod et al., 2015) that analysed the effect of community/block leaders (e.g. honoured citizens having shown exemplary effort, energy, and dedication to their community through their role, such as district sustainability leaders, educators, etc.) on households' recycling. These studies found that using such leaders as a means of social modelling was more effective than for example prompts and information provision. Furthermore, Maddox et al. (2011) implemented an educational school-based campaign, during which they asked children to act as "cost-effective" social models to improve their parents' recycling behaviour. The intervention was efficient, since it led to an increase in the children's and their families' knowledge about recycling (also see Knowledge and attitudes towards recycling, Chapter 3), as well as to an increase on recycling rates. A possible drawback of this intervention derives on its dependence from the extent to which householders see themselves as part of the community (Schultz et al., 1995).

An example of these social modelling techniques that is implemented in practice is shown in Figure 6. The Leader of the Women's Initiative of Gambia teamed up with WasteAidUK, an International NGO, and acted as a social model to teach the community on how to recycle (also see 5.1 – Prompts and Information) and to generate a social recycling norm.

Figure 6 Leader of the Women's Initiative of Gambia teaching the community on how to recycle.

A potential guideline may be:

Guideline 5*:* Householders' recycling behaviour can be improved by the use of social modelling interventions, potentially implemented through recruiting distinguished community members.

5.5 Environmental alterations

The effectiveness of the intervention strategy environmental alterations is based on the fact that households are more likely to recycle if the amount of physical and mental effort required to recycle is minimized (Schultz et al., 1995; Varotto & Spagnolli, 2017). This intervention consists of making recycling more convenient and easier to perform by

modifying the physical environment. For example, by increasing waste bins' proximity (also see Chapter 4 "Contextual factors") or number, optimizing their appearance, or by providing auxiliary home equipment for sorting waste.

The provision of recycling bins to householders actually consists of a nudging mechanism because the presence of recycling bins in homes serves as an external cue that encourages people to recycle by changing the context in which recycling decisions take place (Phillips, 2011). It should be highlighted that householders generally prefer to have the possibility to choose between different sizes depending upon their waste habits and storage space (Willman, 2015). In addition, Lin et al. (2015) highlighted the benefits of using brightly coloured recycling bins in public areas, in order to make them more noticeable to potential recyclers.

An extrapolation of the above findings, together with the findings Recycling facility conditions (Chapter 4.2) leads to the guidelines below**:**

Guideline 6: Householders' recycling behaviour can be improved by a geographically optimized network of adequately designed recycling facilities (e.g. recycled bins close to each house, especially for densely populated urban areas, with desirable characteristics, e.g. bright colour, with additional signage on them, optimal size).

Guideline 7: Householders' recycling behaviour can be improved by providing tailor-made recycling bins to homes (e.g. through a special recycling social program).

5.6 Incentives (rewards and penalties)

Previous researchers acknowledged that householders are usually reluctant to join recycling programs because they need to sacrifice time and effort to prepare, sort, store, and transport their old belongings (Li et al., 2021; Ramayah et al., 2012). For this reason, householders often need to be incentivized in order to commit to recycling behaviour. In general, incentives may refer to any kind of benefit received by consumers because of their participation in a recycling process or program (Varotto & Spagnolli, 2017). For instance, gifts, monetary prizes, refund programs, lottery tickets, and discount coupons are incentives towards recycling behaviour.

Previous studies have examined the effectiveness of the incentives intervention strategy to encourage consumer and household recycling behaviour. Researchers concentrated on different types of financial incentives, such as coupons (Allen et al., 1993), cash (Diamond & Lowey, 1991), discount cards (Li, 2018a, 2018b) and grants/subsidy (Kirakozian, 2016). The main findings refer to the fact that interventions providing incentives on an individual level seem to be more efficient than those providing awards based on the performance of an entire group (Diamond & Loewy, 1991; Harder & Woodard, 2007; Varotto & Spagnolli,

2017). Furthermore, a higher level of participation in recycling programs was recorded for incentives associated with a probabilistic reward, such as an immediate large payoff from the winning of a lottery. Such rewards seem to generate a greater level of participation in recycling than receiving a certain reward, such as a flat cash payment (Diamond & Loewy, 1991).

To optimize the long-term effectiveness of lottery rewards on recycling behaviour, Varotto & Spagnolli (2017) unveiled that there should be many smaller prizes to increase the amount of people who will win, since winners reveal more persistent behavioural and attitudinal change towards recycling in this way. Furthermore, the effectiveness of financial incentives seems to depend on the initial participation rate in the recycling scheme: the lower the initial participation rate, the higher the increased recycling behaviour achieved (Harder & Woodard, 2007).

The above findings lead to a guideline**:**

Guideline 8: Householders' recycling behaviour can be improved by financial rewards, especially for areas that are characterized by a low participation rate to a recycling program. Probabilistic rewards (e.g. lottery rewards) that will offer many prizes, instead of only a big prize, is more efficient in fostering recycling behaviour.

Furthermore, apart from financial incentives, interventions can include tangible non-financial incentives, such as a badge or a thank-you card for joining a recycling program (Baca-Motes et al., 2013; Li, 2018a, Li et al., 2021). Prior research unveiled that, for recyclables that are characterized by higher emotional involvement, non-financial incentives may be more efficient than financial incentives (Li et al., 2021; Viscusi et al., 2012). Non-financial incentives lead householders to focus on the contribution they are making to the environment (also see Chapter 3.4), which in turn positively affects their recycling behaviours. Hence, non-financial incentives work better for households with high levels of environmental concern, when compared to financial incentives (Li et al., 2021).

To summarize, different kinds of incentives seem to match with different groups of households. Practically, it could be difficult for policymakers and municipalities to organize their recycling programs and incentives by distinguishing between households of high and low environmental concern. However, they could attempt such distinction on a larger scale, by comparing e.g. neighbourhoods' or municipalities' participation rates to recycling programs.

Hence, a specific guideline is presented below:

Guideline 9: Householders' recycling behaviour can be improved by non-financial rewards, especially in municipalities or neighbourhoods that are characterized by higher levels of environmental concern.

Interestingly, as underlined by prior research (Li et al., 2021), the effectiveness of nontangible non-financial incentives (Wang et al., 2021), such as a thank-you email, has not yet been unveiled by academic research. In addition, previous research in other domains found that non-financial incentives could complement financial incentives to motivate pro-environmental behaviours, such as energy consumption (Liebe et al., 2018) and waste management (Van den Bergh, 2008). However, such combination of financial and non-financial incentives has yet to be researched in the recycling context.

A drawback of the incentive intervention strategies is that it requires constant observation of household recycling behaviour (Varotto & Spagnolli, 2017). Furthermore, the cost of such interventions often is greater than the economic benefits of recycling (Li et al., 2021; Schultz et al., 1995). Most importantly, after the termination of a reward/incentive program, recycling often tends to return to baseline levels (Schultz et al., 1995), unless it has been established as a habit (also see Chapter 5.2 on past recycling behaviour intervention). The reason for this is the “over justification effect”, a term coined by Burn (1991) as the tendency for external rewards to reduce intrinsic motivation since householders usually believe that the extrinsic reward is the reason for which they are performing the recycling activity. Hence, the termination of the extrinsic reward can sometimes lead to the drop of recycling rates to levels similar with those prior to the intervention.

Unlike rewards, penalties have only received little attention in recent prior research. Only a handful of studies provided evidence that an increase in financial penalties increases the probability that householders will participate in the recycling process/program (e.g. Wang et al., 2020), while others (e.g. Shaw & Maynard, 2008) unveiled mixed views on penalties for refusing to recycle or mixed effects of penalties on recycling behaviour (Keramitsoglou & Tsagarakis, 2013; Seacat & Boileau, 2018). Under circumstances, householders had a positive view on the implementation of penalties, if the revenue of such penalties would be invested in environmental benefit (Keramitsoglou & Tsagarakis, 2013).

In addition, with respect to financial rewards and penalties delivered at households, it is noteworthy to refer to pay-as-you-throw (PAYT) schemes. Prior research has highlighted the effectiveness of variable and direct charging through PAYT, based on the quantity of residual waste collected from each household on recycling behaviours (Price, 2001; Shaw & Maynard, 2008). This scheme delivers financial penalties and rewards through a single mechanism. Householders who reduce residual waste are rewarded by lower charges, whilst those who fail to reduce residual waste face penalties in the form of higher disposal costs. Thøgersen (2003) focused on a pay-by-weight scheme and unveiled that householders who prefer to pay a fee depending on the weight of their garbage, instead of a fixed fee, recycle more. Higher perceived self-efficacy and personal norms (also see Chapters 3.1 and 3.2) were found to explain these effects.

Figure 7 refers to Diftar, a Dutch system for the collection of waste in which the amount and type of waste that is collected per household or legal entity is registered. The higher the amount of non-recyclable waste, the higher the waste levy will be. In this way, the Diftar system influences households to attempt preventing financial pain by recycling more.

Figure 7 Diftar suggests that householders pay for the amount of rest garbage. Hence, householders want to prevent financial pain by recycling more.

Hence, the following guideline is proposed:

Guideline 10: The implementation of a pay-as-you-throw (PAYT) schemes may encourage household recycling behaviour.

Finally, Prospect Theory (Kahneman & Tversky, 1979) can be a helpful theoretical foundation that may drive future reward and penalty intervention strategies on recycling. Prospect Theory describes how people make decisions between alternatives that include risk. According to this theory, the outcomes of the decisions can be framed as either perceived losses (loss frame) or perceived gains (gain frame). Specifically, a loss-framed message would emphasize the disadvantages associated not to adopt the target action while a gain-framed message will emphasize the benefits of the target action (Meyers-Levy & Maheswaran, 2004). Previous research (e.g. Meyerowitz & Chaiken, 1987) suggests that human beings are characterized by loss aversion due to a negativity bias. From this perspective, negatively framed messages are usually more effective than positively framed ones (Kahneman & Tversky, 1979; Meyerowitz & Chaiken, 1987).

An extrapolation of these findings has already been applied in the context of recycling in the tourism sector. For instance, Grazzini et al. (2018) unveiled that hotel guests recycle more when a concrete message is paired with a loss-framed message. In this way, guests were found to be characterized by higher self-efficacy (also see Chapter 3.1) and tended

to commit to higher recycling behaviour due to the risk aversion prospect described in the loss-framed message. A similar mechanism might apply in household recycling. Therefore**,** the guideline below is formed:

Guideline 11: The implementation of campaigns with loss-framed messages (e.g. letters or emails that include penalties deriving from absence of recycling behaviour) to households may foster recycling intentions and behaviour.

The summary of the proposed Guidelines to foster household recycling behaviour can be found in Table 1 below:

	Guidelines - Householders' recycling behaviour can be improved by:
Guideline 1	Highlighting the value of the packaging for recycling (which is currently especially problematic for small packages and packages made of soft plastics). This can be improved: a) By including signs on the package about the recyclable nature b) By presenting relevant environmental information c) By using a matt color and a rough texture.
Guideline 2	The implementation of prompts and informational campaigns that disseminate factual and/or persuasive information about the environmental consequences of recycling and about how to recycle.
Guideline 3	The provision of feedback on individual/household performance and/or on past recycling behaviour, either through traditional or new channels.
Guideline 4	The implementation of commitment interventions and campaigns.
Guideline 5	The use of social modelling interventions, potentially implemented through recruiting distinguished community members.
Guideline 6	A geographically optimized network of adequately designed recycling facilities (e.g., recycled bins close to each house, especially for densely populated urban areas, with desirable characteristics, such as a bright colour, with additional signage and an optimal size).

Guideline 7	Providing tailor-made recycling bins to homes (e.g., through a special recycling social program).
Guideline 8	Financial rewards, especially for areas that are characterized by a low participation rate to a recycling program. Probabilistic rewards (e.g., lottery rewards) that will offer many prizes, instead of only one big prize, are more efficient in fostering recycling behaviour.
Guideline 9	Non-financial rewards, especially in municipalities or neighborhoods that are characterized by higher levels of environmental concern.
Guideline 10	Pay-as-you-throw (PAYT) schemes may encourage household recycling behaviour.
Guideline 11	Loss-framed messages (e.g., letters or emails that include penalties deriving from absence of recycling behaviour) to households may foster recycling intentions and behaviour.

Table 1 Synopsis of guidelines to foster recycling behaviour.

6. Conclusion

Closing the circular loop through adopting sustainable patterns such as household recycling (which is the focus of the present report), or acceptance of recycled products (Polyportis, Magnier, & Mugge, 2022; Polyportis, Mugge, & Magnier, 2022) is of paramount importance towards environmental conservation. In the present report, we analysed the individual and contextual factors that influence household recycling & sorting behaviour, as well as the state-of-the-art interventions that have been highlighted to foster household recycling. The illustrated intervention types have been found successful in increasing recycling behaviour for the duration of the intervention itself (e.g., Varotto & Spagnolli, 2017). However, the long-lasting effects of these treatments remained largely untested, with obvious adverse implications for authorities and policymakers. Methodologically, it is therefore recommended to conduct further research on the long-term effectiveness of the implemented interventions. We also presented distinct guidelines (Table 1) that can help

optimize recycling and sorting propensity, based on the conceptual underpinnings of our research. These guidelines can serve as inspiration for various stakeholders on how to encourage household recycling towards a more sustainable society.

References

Abrahamse, W., & Steg, L. (2013). Social influence approaches to encourage resource conservation: A meta-analysis. *Global Environmental Change, 23*(6), 1773-1785.

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, *50*(2), 179-211.

Ajzen, I. (1996). The directive influence of attitudes on behavior. In P. M. Gollwitzer, J. A. Bargh, P. M. Gollwitzer, & J. A. Bargh (Eds.). *The psychology of action: Linking cognition and motivation to behavior* (pp. 385–403). New York, NY, US: Guilford Press.

Ajzen, I. (2002). Perceived behavioral control, self-efficacy, locus of control, and the theory of planned behavior. *Journal of Applied Social Psychology*, *32*(4), 665-683.

Alexander, C., Smaje, C., Timlett, R., & Williams, I. (2009). Improving social technologies for recycling. *Proceedings of the ICE-Waste and Resource Management, 162*(1), 15-28.

Allen, J., Davis, D., & Soskin, M. (1993). Using coupon incentives in recycling aluminum: A market approach to energy conservation policy. *The Journal of Consumer Affairs, 27*(2), 300–318.

Babaei, A. A., Alavi, N., Goudarzi, G., Teymouri, P., Ahmadi, K., & Rafiee, M. (2015). Household recycling knowledge, attitudes and practices towards solid waste management. *Resources, Conservation and Recycling, 102*, 94-100.

Baca-Motes, K., Brown, A., Gneezy, A., Keenan, E. A., & Nelson, L. D. (2013). Commitment and behavior change: Evidence from the field. *Journal of Consumer Research, 39*(5), 1070–1084.

Bandura, A. (1977). *Social learning theory*. Englewood Cliffs, US: Prentice-Hall.

Berkowitz, L. (1972). Social norms, feelings, and other factors affecting helping and altruism. In *Advances in Experimental Social Psychology* (Vol. 6, pp. 63-108). Academic Press.

Bernstad, A. (2014). Household food waste separation behavior and the importance of convenience. *Waste Management, 34*(7), 1317-1323.

Bicchieri, C. (2006). *The grammar of society: The nature and dynamics of social norms.* Cambridge University Press.

Boomsma, C., & Steg, L. (2014). The effect of information and values on acceptability of reduced street lighting. *Journal of Environmental Psychology*, *39*, 22-31.

Boonrod, K., Towprayoon, S., Bonnet, S., & Tripetchkul, S. (2015). Enhancing organic waste separation at the source behavior: A case study of the application of motivation mechanisms in communities in Thailand. *Resources, Conservation and Recycling, 95*, 77-90.

Bouman, T., Steg, L., & Zawadzki, S. J. (2020). The value of what others value: When perceived biospheric group values influence individuals' pro-environmental engagement. *Journal of Environmental Psychology*, *71*, 101470.

Bratt, C. (1999). The impact of norms and assumed consequences on recycling behavior. *Environment and Behavior*, *31*(5), 630-656.

Burn, S. M. (1991). Social psychology and the stimulation of recycling behaviors: The block leader approach. *Journal of Applied Social Psychology, 21*(8), 611-629.
Carrus, G., Passafaro, P., & Bonnes, M. (2008). Emotions, habits and rational choices in ecological behaviours: The case of recycling and use of public transportation. *Journal of Environmental Psychology*, *28*(1), 51-62.
Chong, A., Karlan, D., Shapiro, J., & Zinman, J. (2015). (Ineffective) messages to encourage recycling: Evidence from a randomized evaluation in Peru. *The World Bank Economic Review, 29*(1), 180-206.
Cialdini, R. B., & James, L. (2009). *Influence: Science and practice* (Vol. 4). Boston: Pearson education.
Cialdini, R. B., Kallgren, C. A., & Reno, R. R. (1991). A focus theory of normative conduct: A theoretical refinement and reevaluation of the role of norms in human behavior. In *Advances in Experimental Social Psychology* (Vol. 24, pp. 201-234). Academic Press.
Cialdini R.B., & Trost M.R. (1998). Social influence: social norms, conformity, and compliance. In *The Handbook of Social Psychology*, ed. D.T. Gilbert, S.T. Fiske, & G. Lindzey, (Vol. 2, pp. 151–192). Boston: McGraw-Hill.
Dai, Y. C., Gordon, M. P. R., Ye, J. Y., Xu, D. Y., Lin, Z. Y., Robinson, N. K. L., ... & Harder, M. K. (2015). Why doorstepping can increase household waste recycling. *Resources, Conservation and Recycling*, *102*, 9-19.
D'Amato, A., Mancinelli, S., & Zoli, M. (2016). Complementarity vs substitutability in waste management behaviors. *Ecological Economics*, *123*, 84-94.
Daneshvary, N., Daneshvary, R., & Schwer, R. K. (1998). Solid-waste recycling behavior and support for curbside textile recycling. *Environment and Behavior, 30*(2), 144–161.
de Groot, J. I., & Thøgersen, J. (2018). Values and pro-environmental behaviour. *Environmental psychology: An introduction*, 167-178.
Deng, J., Tang, J., Lu, C., Han, B., & Liu, P. (2022). Commitment and intergenerational influence: A field study on the role of children in promoting recycling in the family. *Resources, Conservation and Recycling*, *185*, 106403.
Derksen, L., & Gartrell, J. (1993). The social context of recycling. *American Sociological Review*, 434-442.
Deutsch, M., & Gerard, H. B. (1955). A study of normative and informational social influences upon individual judgment. *The Journal of Abnormal and Social Psychology*, *51*(3), 629-636.
Diamond, W. D., & Lowey, B. Z. (1991). Effects of probabilistic rewards on recycling attitudes and behavior. *Journal of Applied Social Psychology, 21*(9), 1590–1607.
Dunlap, R. E. (2008). The new environmental paradigm scale: From marginality to worldwide use. *The Journal of Environmental Education*, *40*(1), 3-18.

Dunlap, R. E., Liere, K. D. Van, Mertig, A. G., & Jones, R. E. (2000). Measuring endorsement of the new ecological Paradigm : A revised NEP scale. *Journal of Social Issues, 56*(3), 425–442.

Dupré, M., Dangeard, I., & Meineri, S. (2014). A review of literature: Influence and communication applied to waste management. *Pratiques Psychologiques, 20*(4), 211-230.

Eberl, J., Flannery, M., Queen, N., McGrath, K., Guyer, R., Dennings, K., et al. (2009). Use of new media to cause recycling behavior change. Discussion paper. Retrieved online: https://docplayer.net/21703219-Use-of-new-media-to-cause-recycling-behavior-change-summary-report.html.

Elgaaied, L. (2012). Exploring the role of anticipated guilt on pro-environmental behavior–a suggested typology of residents in France based on their recycling patterns. *Journal of Consumer Marketing*, *5*, 369-377.

Feather, N. T. (1995). Values, valences, and choice: The influences of values on the perceived attractiveness and choice of alternatives. *Journal of Personality and Social Psychology, 68*(6), 1135–1151.

Froehlich, J., Findlater, L., & Landay, J. (2010, April 10-15). The design of eco-feedback technology. In Paper presented at *CHI'10: International conference on human factors in computing systems* (pp. 1999-2008). Atlanta, USA: ACM.

Gatersleben, B., & Steg, L. (2012). Affective and symbolic aspects of environmental behaviour. In *Environmental psychology: An introduction* (pp. 165-174). Wiley-Blackwell.

Geiger, J. L., Steg, L., van der Werff, E., & Ünal, A. B. (2019). A meta-analysis of factors related to recycling. *Journal of Environmental Psychology*, *64*, 78-97.

Grazzini, L., Rodrigo, P., Aiello, G., & Viglia, G. (2018). Loss or gain? The role of message framing in hotel guests' recycling behaviour. *Journal of Sustainable Tourism*, *26*(11), 1944-1966.

Guiot, D., Malas, Z., & Urien, B. (2019). Re-examining the effects of aging on household recycling behavior: A study in France. *Psychology & Marketing*, *36*(6), 618-629.

Hage, O., Söderholm, P., & Berglund, C. (2009). Norms and economic motivation in household recycling: Empirical evidence from Sweden. *Resources, Conservation and Recycling*, *53*, 155–165.

Han, H., Yu, J., Kim, H. C., & Kim, W. (2018). Impact of social/personal norms and willingness to sacrifice on young vacationers' pro-environmental intentions for waste reduction and recycling. *Journal of sustainable tourism*, *26*(12), 2117-2133.

Haj-Salem, N., & Al-Hawari, M. A. (2021). Predictors of recycling behavior: the role of self-conscious emotions. *Journal of Social Marketing, 11*(3), 204-223.

Harder, M. K., & Woodard, R. (2007). Systematic studies of shop and leisure voucher incentives for household recycling. *Resources, Conservation and Recycling*, *51*(4), 732-753.

Hepplestone, S., Holden, G., Irwin, B., Parkin, H. J., & Thorpe, L. (2011). Using technology to encourage student engagement with feedback: a literature review. *Research in Learning Technology*, *19*(2), 117-127.
Hornik, J., Cherian, J., & Madansky, M. (1995). Determinants of recycling behavior: A synthesis of research results. *The Journal of Socio-Economics*, *24*(1), 105-127.
Iyer, E. S., & Kashyap, R. K. (2007). Consumer recycling: Role of incentives, information, and social class. *Journal of Consumer Behaviour: An International Research Review*, *6*(1), 32-47.
Kaiser, F. G., & Fuhrer, U. (2003). Ecological behavior's dependency on different forms of knowledge. *Applied Psychology*, *52*(4), 598-613.
Katzev, R., & Mishima, H. R. (1992). The use of posted feedback to promote recycling. *Psychological Reports*, *71*(1), 259-264.
Kallgren, C. A., Reno, R. R., & Cialdini, R. B. (2000). A focus theory of normative conduct: When norms do and do not affect behavior. *Personality and Social psychology Bulletin*, *26*(8), 1002-1012.
Kahneman, D., & Tversky, A. (1979). Prospect Theory: An Analysis of Decision under Risk. *Econometrica, 47*(2), 263–291.
Keramitsoglou, K. M., & Tsagarakis, K. P. (2013). Public participation in designing a recycling scheme towards maximum public acceptance. *Resources, Conservation and Recycling*, *70*, 55-67.
Kirakozian, A. (2016). One without the other? Behavioural and incentive policies for household waste management. *Journal of Economic Surveys, 30*(3), 526–551.
Li, Y. (2018a). Research on the effect of intervention strategies on garment recycling behaviors. *Journal of Marketing Science, 13*(3), 114–128 (in Chinese).
Li, Y. (2018b). Effect of marketing information on purchase intention for proenvironmental products in China. *Social Behavior and Personality, 46*(7), 1215–1232.
Li, Y., Yang, D., Sun, Y., & Wang, Y. (2021). Motivating recycling behavior—Which incentives work, and why?. *Psychology & Marketing*, *38*(9), 1525-1537.
Liebe, U., Gewinnerb, J., & Diekmannb, A. (2018). What is missing in research on non-monetary incentives in the household energy sector? *Energy Policy, 123*, 180–183.
Liu, Z., Yang, J. Z., Bloomfield, A., Clark, S. S., & Shelly, M. A. (2022). Predicting recycling intention in New York state: The impact of cognitive and social factors. *Environmental Development*, *43*, 100712.
Maddox, P., Doran, C., Williams, I. D., & Kus, M. (2011). The role of intergenerational influence in waste education programmes: The THAW project. *Waste Management, 31*(12), 2590-2600.
Martin, C., & Czellar, S. (2017). Where do biospheric values come from? A connectedness to nature perspective. *Journal of Environmental Psychology*, *52*, 56-68.

Martinho, G., Pires, A., Portela, G., & Fonseca, M. (2015). Factors affecting consumers' choices concerning sustainable packaging during product purchase and recycling. *Resources, Conservation and Recycling*, *103*, 58-68.
McKenzie-Mohr, D. (2013). *Fostering sustainable behavior: An introduction to community-based social marketing*. Gabriola Island, Canada: New Society Publishers.
Mee, N. (2005). A communications strategy for kerbside recycling. *Journal of Marketing Communications, 11*(4), 297-308.
Mellers, B. A., & McGraw, A. P. (2001). Anticipated emotions as guides to choice. *Current Directions in Psychological Science*, *10*(6), 210-214.
Meyers-Levy, J., & Maheswaran, D. (2004). Exploring message framing outcomes when systematic, heuristic, or both types of processing occur. *Journal of Consumer Psychology*, *14*(1-2), 159-167.
Meyerowitz, B. E., & Chaiken, S. (1987). The effect of message framing on breast self-examination attitudes, intentions, and behavior. *Journal of Personality and Social Psychology*, *52*(3), 500.
Miranda Carreño, R., & Blanco Suarez, A. (2010). Environmental awareness and paper recycling. *Cellulose Chemistry and Technology*, *44*(10), 431-449.
Moreland, J., & Melsop, S. (2014). Design interventions to encourage pro-environmental behavior. An action research study on waste diversion in a university residence hall. *In proceedings of the 30th international plea conference*.
Nemat, B., Razzaghi, M., Bolton, K., & Rousta, K. (2019). The role of food packaging design in consumer recycling behavior—A literature review. *Sustainability*, *11*(16), 4350.
Nemat, B., Razzaghi, M., Bolton, K., & Rousta, K. (2020). The potential of food packaging attributes to influence consumers' decisions to sort waste. *Sustainability*, *12*(6), 2234.
Nemat, B., Razzaghi, M., Bolton, K., & Rousta, K. (2022). Design affordance of plastic food packaging for consumer sorting behavior. *Resources, Conservation and Recycling*, *177*, 105949.
Ng, S. L. (2020). Knowledge–intention–behavior associations and spillovers of domestic and workplace recycling. *The Social Science Journal*, 1-20.
Norman, D.A., 1999. Affordance, conventions, and design. *Interactions 6*(3), 38–43.
Norman, D.A. (2013). The design of everyday things. In Basic Book. https://www.basicbooks.com/titles/don-norman/the-design-of-everyday-things/9780465072996/
Oskamp, S., Harrington, M. J., Edwards, T. C., Sherwood, D. L., Okuda, S. M., & Swanson, D. C. (1991). Factors influencing household recycling behavior. *Environment and behavior*, *23*(4), 494-519.
Ouellette, J. A., & Wood, W. (1998). Habit and intention in everyday life: The multiple processes by which past behavior predicts future behavior. *Psychological bulletin*, *124*(1), 54.

Paulos, E., & Jenkins, T. (2006, September 17e21). Jetsam: Exposing our everyday discarded objects. Demo presented at Ubicomp'06: 8th International Conference on Ubiquitous Computing, Orange County, US.
Perrin, D., & Barton, J. (2001). Issues associated with transforming household attitudes and opinions into materials recovery: A review of two kerbside recycling schemes. *Resources, Conservation and Recycling, 33*(1), 61-74.
Phillips, R. (2011). Bringing it home: Using behavioural insights to make green living policy work. Green alliance. Discussion paper. Retrieved online: http://www. green-alliance.org.uk/resources/Bringing%20it%20home.pdf.
Pocock, R., Stone, I., Clive, H., Smith, R., Jesson, J., & Wilszak, S. (2008). Barriers to recycling at home. Banbury, UK: Waste and resources action programme. Retrieved online: http://www.wrap.org.uk/sites/files/wrap/Barriers_to_Recycling_at_ Home_Technical_Report.pdf.
Polyportis, A., Magnier, L., & Mugge, R. (2022). Guidelines to foster consumer acceptance of products made from recycled plastics. *Circular Economy and Sustainability, 1-14*.
Polyportis, A., Mugge, R., & Magnier, L. (2022). Consumer acceptance of products made from recycled materials: A scoping review. *Resources, Conservation and Recycling, 186*, 106533.
Price, J. L. (2001). The landfill directive and the challenge ahead: demands and pressures on the UK householder. *Resources, Conservation and Recycling*, *32*(3-4), 333-348.
Ramayah, T., Lee, J. W. C., & Lim, S. (2012). Sustaining the environment through recycling: An empirical study. Journal of Environmental Management, *102*(6), 141–147.
Reif, I., Alt, F., Hincapie Ramos, J. D., Poteriaykina, K., &Wagner, J. (2010, April 10-15). Cleanly: Trashducation urban system. In *Extended abstract presented at CHI'10: International conference on human factors in computing systems* (pp. 3511-3516). Atlanta, US: ACM.
Robertson, S., & Walkington, H. (2009). Recycling and waste minimisation behaviours of the transient student population in Oxford: results of an on-line survey. *Local Environment*, *14*(4), 285-296.
Rosenthal, S., & Linder, N. (2021). Effects of bin proximity and informational prompts on recycling and contamination. *Resources, Conservation and Recycling*, *168*, 105430.
Schultz, P.W. (2002). Knowledge, information, and household recycling: Examining the knowledge-deficit model of behavior change. In T. Dietz, & P. C. Stern (Eds.), *New tools for environmental protection: Education, information, and voluntary measures* (pp. 67-82). Washington, US: National Academies Press.
Schultz, G. (2011). *Examining the effects of recycling outreach on recycling behavior in residence halls at the University of California, Berkeley*. Discussion paper. Retrieved online: http://nature.berkeley.edu/classes/es196/projects/2002final/Schultz.pdf
Schultz, P. W., Oskamp, S., & Mainieri, T. (1995). Who recycles and when? A review of personal and situational factors. *Journal of Environmental Psychology*, *15*(2), 105-121.

Schwartz, S. H. (1992). Universals in the content and structure of values: Theoretical advances and empirical tests in 20 countries. *Advances in Experimental Social Psychology, 25*, 1–65.

Schwartz, S. H., & Howard, J. A. (1981). A normative decision-making model of altruism. *Altruism and helping behavior*, 189–211.

Seacat, J. D., & Boileau, N. (2018). Demographic and community-level predictors of recycling behavior: A statewide, assessment. *Journal of Environmental Psychology*, *56*, 12-19.

Shaw, P. J., & Maynard, S. J. (2008). The potential of financial incentives to enhance householders' kerbside recycling behaviour. *Waste Management*, *28*(10), 1732-1741.

Steg, L., & De Groot, J. I. M. (2012). Environmental values. In S. Clayton (Ed.), *The Oxford handbook of environmental and conservation psychology* (pp. 81-92). New York: Oxford University Press.

Steg, L., de Groot, J., Dreijerink, L., Abrahamse, W., & Siero, F. (2011). General antecedents of personal norms, policy acceptability, and intentions: The role of values, worldviews, and environmental concern. *Society & Natural Resources, 24*(4), 349–367.

Tabanico, J. J. (2013). Fostering sustainable behavior change beyond brochures. Retrieved online: http://digitalcommons.calpoly.edu/cgi/viewcontent.cgi?article%3d1031%26context%3dccapc.

Tabernero, C., Hernández, B., Cuadrado, E., Luque, B., & Pereira, C. R. (2015). A multilevel perspective to explain recycling behaviour in communities. *Journal of Environmental Management*, *159*, 192-201.

Taufik, D., Bolderdijk, J. W., & Steg, L. (2016). Going green? The relative importance of feelings over calculation in driving environmental intent in the Netherlands and the United States. *Energy Research & Social Science*, *22*, 52-62.

Thieme, A., Comber, R., Miebach, J., Weeden, J., Kr€amer, N., Lawson, S., et al. (2012, May 5-10). We've Bin Watching You": Designing for reflection and social persuasion to promote sustainable lifestyles. In Paper presented at *CHI'12: International conference on human factors in computing systems* (pp. 2337-2346). Austin, US: ACM.

Thøgersen, J. (2003). Monetary incentives and recycling: Behavioural and psychological reactions to a performance-dependent garbage fee. *Journal of Consumer Policy, 26*(2), 197-228.

Trudel, R., & Argo, J. J. (2013). The effect of product size and form distortion on consumer recycling behavior. *Journal of Consumer Research*, *40*(4), 632-643.

Van den Bergh, J. C. J. M. (2008). Environmental regulation of households: An empirical review of economic and psychological factors. *Ecological Economics, 66*(4), 559–574.

Varotto, A., & Spagnolli, A. (2017). Psychological strategies to promote household recycling. A systematic review with meta-analysis of validated field interventions. *Journal of Environmental Psychology, 51*, 168-188.

Verplanken, B., & Aarts, H. (1999). Habit, attitude, and planned behaviour: is habit an empty construct or an interesting case of goal-directed automaticity?. *European Review of Social Psychology*, *10*(1), 101-134.
Viscusi, W. K., Huber, J., & Bell, J. (2012). Alternative policies to increase recycling of plastic water bottles in the United States. *Review of Environmental Economics and Policy, 6*, 190–211.
Wang, T. H., & Katzev, R. D. (1990). Group Commitment and Resource Conservation: Two Field Experiments on Promoting Recycling. *Journal of Applied Social Psychology, 20*(4), 265-275.
Wang, X., Van der Werff, E., Bouman, T., Harder, M. K., & Steg, L. (2021). I am vs. we are: how biospheric values and environmental identity of individuals and groups can influence pro-environmental behaviour. *Frontiers in Psychology*, *12*: 618956.
Wang, Z., Huo, J., & Duan, Y. (2020). The impact of government incentives and penalties on willingness to recycle plastic waste: An evolutionary game theory perspective. *Frontiers of Environmental Science & Engineering, 14*(2), 1-12.
Werner, C. M., Turner, J., Shipman, K., Shawn Twitchell, F., Dickson, B. R., Bruschke, G. V., et al. (1995). Commitment, behavior, and attitude change: An analysis of voluntary recycling. *Journal of Environmental Psychology, 15*(3), 197-208.
White, K., MacDonnell, R., & Dahl, D. W. (2011). It's the mind-set that matters: The role of construal level and message framing in influencing consumer efficacy and conservation behaviors. *Journal of Marketing Research*, *48*(3), 472-485.
Willman, K. W. (2015). Information sharing and curbside recycling: A pilot study to evaluate the value of door-to-door distribution of informational literature. *Resources, Conservation and Recycling, 104*, 162-171.

About the project

The problems associated with plastic waste and in particular its adverse impacts on the environment are gaining importance and attention in politics, economics, science and the media. Although plastic is widely used and millions of plastic products are manufactured each year, only 30% of total plastic waste is collected for recycling. Since demand for plastic is expected to increase in the coming years, whilst resources are further depleted, it is important to utilise plastic waste in a resourceful way.

TRANSFORM-CE aims to convert single-use plastic waste into valuable new products. The project intends to divert an estimated 2,580 tonnes of plastic between 2020 and 2023. Two innovative technologies – intrusion-extrusion moulding (IEM) and additive manufacturing (AM) – will be used to turn plastic waste into recycled feedstock and new products. To support this, an R&D Centre (UK) and Prototyping Unit (BE) have been set up to develop and scale the production of recycled filaments for AM, whilst an Intrusion-Extrusion Moulding Facility, the Green Plastic Factory, has been established in the NL to expand the range of products manufactured using IEM.

Moreover, the project will help to increase the adoption of technology and uptake of recycled feedstock by businesses. This will be promoted through research into the current and future supply of single-use plastic waste from municipal sources, technical information on the materials and recycling processes, and circular business models. In-depth support will also be provided to a range of businesses across North-West Europe, whilst the insights generated through TRANSFORM-CE will be consolidated into an EU Plastic Circular Economy Roadmap to provide wider businesses with the 'know-how' necessary to replicate and up-scale the developed solutions.

Lead partner organisation
Manchester Metropolitan University

Partner organisations
Materia Nova
Social Environmental and Economic Solutions (SOENECS) Ltd
Gemeente Almere
Save Plastics
Technische Universiteit Delft
Hogeschool Utrecht
Hochschule Trier Umwelt-Campus Birkenfeld Institut für angewandtes Stoffstrommanagement (IfaS)
bCircular GmbH
Viridor Waste Management Limited

Countries
UK | BE | NL | DE

Timeline
2019-2023

www.nweurope.eu/transform-ce