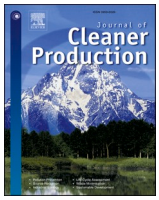
Journal of Cleaner Production 475 (2024) 143677

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro



To sort or not to sort? – Consumers' waste behavior in public☆

Barbara Hartl [a,b,d,*], Eva Hofmann [b,c]

[a] Vienna University of Economics and Business, Austria
[b] Danube University Krems, Austria
[c] University of Applied Sciences Fern FH Wiener Neustadt, Austria
[d] Institute for Advanced Studies, Austria

ARTICLE INFO

Handling Editor: Janine Fleith de Medeiros

Keywords:
Waste sorting
Waste segregation
Public waste
Recycling
Consumers waste behavior

ABSTRACT

While waste sorting in private households is considered a social norm, we still lack knowledge about individuals' waste sorting behavior in public, such as on the street, in parks or on public transport. Research on public spaces has primarily focused on littering, drawing the spotlight away from the valuable materials lost due to a lack of public waste sorting. Employing social practice theory, we conducted interviews with consumers and cleaners, observed practices, documented waste bins, and engaged with stakeholders to describe the role of materials, competencies, and ideas for performing waste sorting in public. Key findings include individuals' use of cognitive maps to locate residual waste bins, revealing paradoxes of public waste bin designs, and a lack of responsibility for waste sorting (e.g., individuals arguing that machines can perform this task more efficiently). Bridging this knowledge gap is vital to develop targeted strategies that encourage responsible waste practices.

1. Introduction

Waste and its processing are a worldwide ecological, financial and social problem. Yet, many components of waste can be reused, which may help to combat problems, such as using organic waste to produce necessary fertilizer (Lin et al., 2016). Improving the collection of different waste components as well as the quality of materials collected for recycling is at the top of the waste agenda for (inter-)national authorities (Timlett and Williams, 2008). As such, the European Union (EU) has set a goal that its member states need to recycle at least 60% of their waste by the year 2025 and 65% by 2030 (Árnadóttir et al., 2019), the United Nations has put the issue of unmanaged waste as a hidden cause of climate change on the agenda (United Nations Office on Drugs and Crime, 2022), and the United States Environmental Protection Agency EPA (2022) promotes a circular economy "[…] that keeps materials, products, and services in circulation for as long as possible" (p.1). An important key to success is the participation of private individuals sorting waste at the source, i.e., directly after consuming a product. This practice is now well established in many countries for household waste (Lin et al., 2016), but not in the public sphere. Public places serve as vital arenas for consumption and waste generated in these areas, such as streets, parks, and public transportation, can substantially contribute to overall waste volumes in urbanized cities (Kladnik et al., 2024). Research on waste in public places has mainly addressed the issue of littering (Bateson et al., 2015; Chaudhary et al., 2021; Cialdini et al., 1990), leaving a gap regarding waste sorting practices: How do private individuals handle waste in public?

Studying the social practice of waste sorting in public spaces is of paramount importance, preserving the cleanliness and aesthetic appeal of public places while also safeguarding the environment. The significance of managing the waste stream in public becomes even more pronounced with the growing trend of out-of-home consumption and the increased reliance on convenience-driven, single-use, and to-go packaging, including plastic trays and beverage cups (Benoit et al., 2016). Understanding how consumers perceive waste sorting and identifying the associated challenges is crucial, as it enables concrete assistance to improve waste collection. While extensive research has been dedicated to waste sorting within private households (Timlett and Williams, 2008), the dynamics of public waste sorting are likely to significantly differ. For instance, past research indicates that people's willingness to act in accordance with ecological standards vary depending on where they are: at home, at work or on holiday (Barr et al., 2011; Miao and Wei, 2013).

The aim of the current research is thus to describe consumers' waste

☆ This research has been funded by the Vienna Science and Technology (WWTF) and by the State of Lower Austria [10.47379/ESR20019].
* Corresponding author. Vienna University of Economics and Business, Austria.
E-mail address: barbara.hartl@wu.ac.at (B. Hartl).

https://doi.org/10.1016/j.jclepro.2024.143677
Received 27 December 2023; Received in revised form 18 April 2024; Accepted 15 September 2024
Available online 16 September 2024

sorting practices in public by examining the central elements of these practices, which can serve as a basis for further research and support policy makers aiming to increase recycling rates in public. First, the issue of waste and recycling is explored and the social practice theory (Reckwitz, 2002; Shove et al., 2012) is introduced as an analytical viewpoint for the empirical study. The social practices theory has often been used as the basis for studying pro-environmental behavior in various settings (e.g., sufficiency lifestyles, Kropfeld, 2022;, practices in eco-villages, Roysen and Mertens, 2019), and to study waste sorting in the private household (Katan and Gram-Hanssen, 2021), although not in public. The subsequent method section elaborates on the triangular approach of our study and the dataset, consisting of (a) interviews with consumers (b) and with cleaners, (c) photographical documentation of waste bins in eight countries, (d) observations of interactions with waste bins in public, and (e) notes from workshops with stakeholders (e.g., representatives from waste agencies and public transportation operators). Finally, we present the findings of the study and discuss their implications for theory and practice.

2. Theoretical and conceptual background

Successful recycling of waste must start with successful sorting at source and, thus, people need to sort their waste after consuming a product. While waste sorting through different procedures in waste facilities does recycle valuable materials, such procedures still represent a labor-intensive and costly process that requires a significant amount of energy. In general, waste systems and waste sorting vary widely across the globe, with no one-size-fits-all solution. Even within the European Union, where many regulations are relatively standardized, each country adopts a unique approach. For instance, Austria, situated in the heart of Europe with a population of 9 million, showcases significant diversity in waste management systems and regulations at the municipal level. The Austrian federal ministry advises citizens to collect non-avoidable waste separately and, as far as possible, prepare it for reuse or recycling (Bundesministerium für Finanzen, 2023). Although some materials, like metal, can be separated in specific sorting centers, the quality, however, is significantly lower due to the incineration process compared to material that has already been separated beforehand. Thus, sorting after treatment cannot replace separate collection at the source, like in households or in public.

2.1. The relevance of waste sorting in public

The current empirical study was conducted in Austria, which provides an ideal setting to study waste sorting. Around 1.4 million tons of residual waste are generated in Austria every year (Die Umweltberatung, 2023). Austria follows the European specification stating that the recycling rate should increase sharply over the next few years. Waste sorting must be intensified to achieve the target of a 90 percent collection rate for plastic beverage bottles and a 65 percent recycling rate for municipal waste (Schubert, 2020). In Austria, expenses for out-of-home consumption increased by 67 % during the period from 2008 to 2018 and the yearly amount of disposable tableware and to-go packaging is expected to be 20,000 tons (BMK, 2019; RegioData Research, 2019). A recent study in Austria indicates a high share of 52% recyclable materials in mixed public waste, most of which is packaging (Kladnik et al., 2024). Specific locations such as gastronomic establishments (e.g., coffee shops, take-away restaurant) and high-traffic pedestrian areas like pedestrian zones and shopping areas hold the potential for even higher rates of recyclable materials, such as plastic and metal (Gangl et al., 2022). Proper disposal and separate collection of these materials could facilitate their reintroduction into recycling schemes, thereby fostering a circular economy.

2.2. Social practice theory

Theories of practice are currently widely employed across different disciplines and have become increasingly prominent in discussions on sustainable consumption (Welch and Warde, 2015). Social practice theory provides a suitable base for research on waste sorting, as it emphasizes the broader social context in which practices take place and recognizes the role of material arrangements (e.g., waste bins) that shape practices. Most importantly, practice theories transcend the narrow focus on individual attitudes, behaviors, and choices often emphasized in approaches like the Theory of Planned Behavior (TPB) (Ajzen, 1991). The TPB's emphasis on individual decision making may overlook the multifaceted role of external factors in shaping practices (Borch et al., 2015; Shove, 2010; Soma et al., 2021). Waste sorting is not just about individual behaviors, it also involves material artifacts and infrastructure (such as bin signage, collection systems). Social practice theory encourages the study of how these materials shape and are shaped by social practice. For example, one can analyze how the design of waste bins, or the accessibility of recycling facilities influence people's waste separation behavior.

Social practice theory recognizes that individuals' practices exist as a combination of different elements (Reckwitz, 2002; Shove, 2012; Shove and Pantzar, 2005; Soma et al., 2021): (i) material, encompassing objects, infrastructure, tools, or hardware, (ii) meaning, in terms of culture, values or emotions, and (iii) competences incorporating know-how and skills (Fig. 1).

For example, farming practices that reduce food loss emerge if farmers positively value food (element: meaning), have the skills to manage food accordingly (element: competence) and have access to properly functioning infrastructure, such as machinery (element: infrastructure) (Soma et al., 2021). Likewise, a positive idea of waste sorting (element meaning), knowledge of how to sort waste (element: competence) and accessible waste bins (element: infrastructure) may be essential to establish a practice of waste sorting in public. Social practice theory helps us to understand the transformation of social practices and examine how social practices become 'normal'. For example, Shove and Southerton (2000) explored the 'normalization' of the use of the freezer

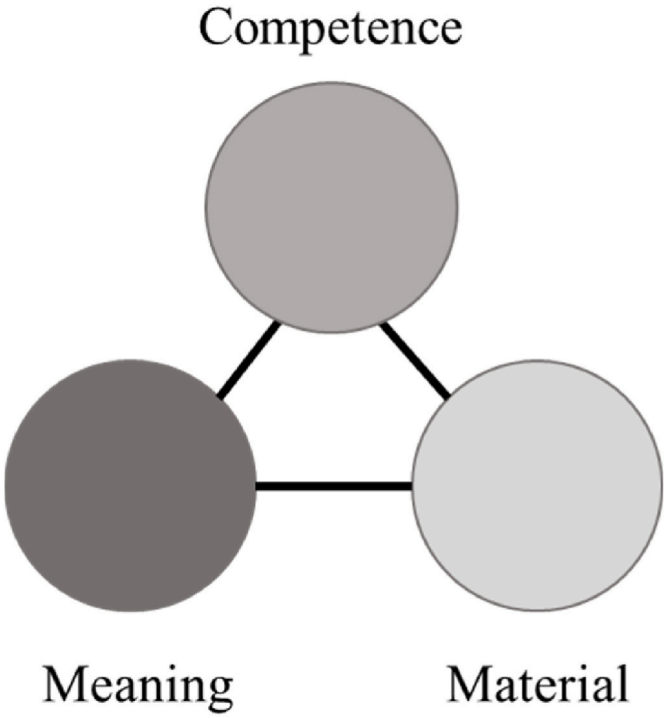


Fig. 1. Elements of a social practice (Shove et al., 2012).

and Shove (2003) the use of air-conditioning.

In this paper we explore the social practice of waste sorting in public by analyzing the different elements associated with it. Also, we discuss the difference of waste sorting in public and in households.

3. Study overview

The main part of the dataset comprises interviews with private individuals ('consumers') and cleaners. To gain a holistic view, these data were triangulated conducting photographical documentation of waste bins, observations, and communication with stakeholders, such as waste agencies and public transportation services (see Fig. 2 and Table 1 for an overview of the data collection).

3.1. Methodology

Recognizing the pivotal role of material and infrastructure in social practices, we first took photos of 83 different waste bins across eight nations (Austria, France, Germany, Italy, Iceland, Slovenia, Switzerland, and the UK) to document the design of the wastebins.[1] These visuals not only provided a comprehensive overview of waste bin designs but also formed the basis for generating stimulus material for the interviews. We recruited the interview partners through purposive sampling and chose them based on their experience with the waste management system in two Austrian cities, in which we also conducted observations of public waste sorting behavior. Following the principle of theoretical saturation and the call for data triangulation, the sample for this research consisted of 21 consumers, whose insights were triangulated with two interviews with cleaners as well as the observations of consumers' and cleaners' interactions with waste bins. The term data saturation can be defined as "the point in data collection when no new additional data are found that develop aspects of a conceptual category" (Francis et al., 2010, p. 1230). Francis et al. (2010) suggest starting with an initial analysis sample of ten people. After these interviews, more interviews will be held to reveal if new topics emerge. For Guest et al. (2006), saturation occurred after 12 interviews. We reflected on the theoretical saturation throughout the research process and decided to conduct a further seven interviews with consumers from Krems to contrast and enrich our findings from Vienna, a significantly larger urban center (c.f. Gangl et al., 2022; Kladnik et al., 2024), after 14 interviews.

To address the research objectives, we conducted semi-structured episodic interviews (Flick, 2011; Mueller, 2019). This approach combines short narratives in a dialogic interview format in order to elicit interview partners' memories of certain situations (Mueller, 2019). The interview guidelines consisted of the following: (1) definition of waste and handling, (2) experience with waste disposal in public, and (3) knowledge about sorting waste (e.g., ideas to facilitate or hinder waste separation). Further, the participants provided (4) answers to three visual stimuli (see Appendix): (4.1.) associations with colors and waste fractions, (e.g., the color red was associated with paper), (4.2.) hypothetical disposal of waste (e.g., glass bottle, plastic packaging) and (4.3.) assessment of the appeal of waste bins. This interview guideline was used for all interviews with consumers and was partly adapted for the interviews with cleaners (e.g., experience with emptying waste bins). Consumers were recruited via a market research agency and the cleaners were recruited via stakeholder organizations. All interviewees gave informed consent, the interviews were recorded and then transcribed for further analysis.

In addition, six observations of consumers' waste behavior and waste bin emptying by cleaners were conducted in public places next to public train stations. The researcher wrote an observation protocol, including photographs and sketches of the surroundings. Individuals were observed in a public place and were not individually identified in pictures or written notes. During the research process, we conducted two stakeholder workshops with representatives from waste agencies and public transportation operators to reflect on the interview guidelines and recruitment criteria.

[1] An expanded database of this documentation and additional categorization is publicly accessible (Kladnik, 2024).

4. Results

Our empirical data demonstrate that if people must deal with waste in public, they use bins for residual waste most of the time instead of looking for a separation system. This is different compared to the social practice of waste sorting in the household, which has become normative in many communities (c.f. Thomas and Sharp, 2013). Although in Austria only products that cannot be recycled further are allowed to be disposed of in residual waste bins (Stadt Wien, 2023), consumers use these bins for recyclables even close to separation systems. This is often due to individuals being unsure about how to dispose of the product correctly. Based on our interviews and observations, using the bin for residual waste is perceived by consumers as the "safe" option without the risk of doing something wrong. Our data reveal that it is considered normal that people do not make the effort to separate waste in public.

If consumers actually want to sort their waste in public, they face several challenges: First, they have to find the appropriate infrastructure. Most public waste bins in Austria are bins for residual waste and no guiding system is in place that show the location of separation systems. Second, public sorting bins differ in color, size, and the types of material they collect (see Tables 2a and 2b). During our data collection, we documented waste bins made out of metal, plastic, wood or stone in ten different colors, and some of the bins were moveable. This makes it difficult for consumers to spot a waste bin from a distance and to identify the correct bin for their waste. Third, it is often challenging for consumers to identify the material of modern products, as plastics or papers have different characteristics due to new technologies. For instance, nowadays disposable coffee cups are made from plastic or coated paper, which look very similar. Consumers cannot identify the material with certainty and have problems disposing of the cup correctly. Finally, products made of different materials need to be disassembled, e.g., the paper label on a metal can or yoghurt pot needs to be removed before throwing it in the waste bin. In public, the tools required for separating the materials, such as scissors, are not available, or consumers refrain from removing materials to avoid staining themselves. This is another important distinction compared to the private household setting, in which consumers can use the required tools.

In the following chapters, we elaborate on these issues by describing the three elements of waste sorting in public in more detail, starting with materials and infrastructure (e.g., waste bin location and design), followed by required competencies (e.g., knowledge about product materials) and closing with the meaning of waste sorting, discussing attitudes towards waste sorting and the question of who is responsible for sorting waste (Table 2).

4.1. Material

The practice of waste sorting is defined by the materials and infrastructure involved. The number of waste bins, their location, and their design were identified as critical factors for waste sorting in public (see Table 2a). Unlike in a private household, where individuals can choose their own containers for storing waste, they have no control over the design of a public waste bin (e.g., at home they can decide to use a bin with or without lid) or its accessibility. The design of waste bins is a paradox in itself, as consumers' desire for convenient usage conflicts with other factors, such as aesthetics, prevention of misuse or security issues. While eye-catching designs are often avoided by authorities to blend with the surrounding landscape (e.g., grey waste bins), a colorful design makes it easier for consumers to find a waste bin if needed. In general, waste bins used in public need to be very robust and vandalism-

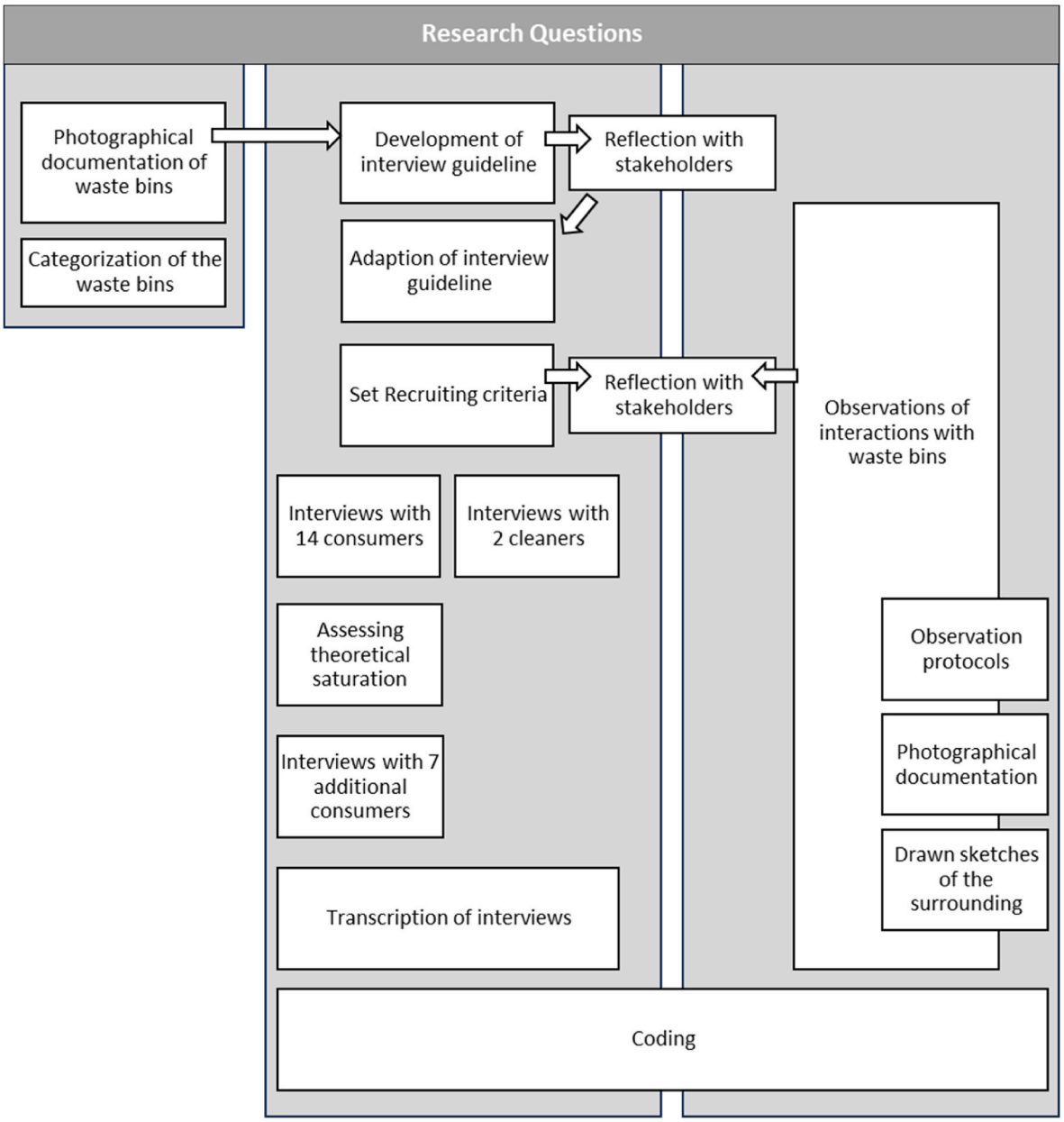


Fig. 2. Overview of the research process.

Table 1
Data overview.

	Interviews with consumers	Interviews with cleaners	Photographical documentation of waste bins	Observation of interactions with waste bins	Communication with stakeholders
Dataset	21 interviews with consumers • 13 female/8 male • Age range [19, 65] • Income range [below 1000 EUR, 3000–4000 EUR]	2 interviews with male cleaning persons	Photos of 83 waste bins	Six observations in public places next to public train stations in two cities	Notes from two workshops with stakeholders and informal communication.
	770 pages of transcript	109 pages of transcript			
	Interviews lasting between 38 and 61 min	Interviews lasting 48 and 53 min	Categorization of design elements (e.g., size, material)		
Timeframe	2022	2022	2021–2022	2021–2022	2021–2022

Table 2a
Separating waste as a social practice.

Theme	Finding
Material	
Infrastructure to segregate waste	Satisfactory amount of residual waste bins is available Consumers are not really looking for sorting bins
Location of the waste bins	Sorting bins are located only at specific locations, like train stations
Design paradoxes:	
Labeling:	Too little is not informative enough
Informative vs. overwhelming	Too much might be overwhelming or confusing
Form:	The area around square bins is easier to clean
Practicality vs. security	Square bins are easier to put next to each other Round bins have no edges where passers-by can hurt themselves
Opening:	If the opening of the bin is big (or does not have a lid), it is easier to dispose of waste (1) to throw waste into it while passing by (2) to avoid touching the bins or others' waste when throwing away the waste
Convenience vs. Prevention of misuse	If the opening of the bin is small (or has a lid), (1) waste will be less visible when passing by and smell less (2) misuse by individuals is prevented, as they cannot pull garbage out of the bin and are not able to throw away big items not intended for public waste bins (e.g., home appliances) (3) waste is protected against weather (e.g., rain)
Transparent vs. non-transparent	If bins are transparent (1) they allow consumers to see what others have disposed of, which can serve as a guidance for correct waste sorting (2) incorrect sorting might lead to even more incorrect waste sorting (3) the waste inside the bin is visible to others, resulting in feelings of disgust

Table 2b
Separating waste as a social practice.

Competence	
Knowledge about product material	Consumers and experts have difficulties identifying materials and sorting them correctly
Cognitive map of bin locations	(1) For residual waste bins, consumers seem to use a cognitive map that provides them with information of where to expect residual waste bins (2) Consumers seem to have no cognitive map for sorting bins in the public space
Understanding symbols and colors of waste bins	Allocation of color and recycling materials varies between Austrian states, but also between different municipalities
Meaning	
Attitude towards segregating waste	(1) Refraining from sorting waste in public is viewed as less reprehensible than littering (2) Associations with waste evoke disgust
Responsibility	(1) Waste sorting is often not perceived as consumers' responsibility (2) Waste sorting should be undertaken by machines, because they are better at sorting waste than consumers

proof. For example, a bin's sloped surface is designed to avoid waste being placed on top of the bin. As a side-effect, consumers are not able to put handbags or other products on top of the bin in order to free their hands to dispose of waste, which makes the disposal of waste less convenient.

Convenience is an important factor worth considering. Consumers especially want to avoid any physical contact with waste, as they associate waste with disgust and hygiene issues. Therefore, the opening of the bin is a critical design feature that affects the ease of waste disposal. Openings located on top of the bin as well as big openings are more convenient for consumers to use (see Table 2a), as they reduce contact with others' waste as well as the bin, prevent waste from falling out, and are easier to use when walking by. However, openings at the side of a bin protect against weather, such as the contents becoming wet from rain.

4.2. Competence

For consumers to successfully carry out the practice of sorting waste, they need to possess certain competences or skills (Table 2b). First, they need to be able to identify the different product materials of their waste, as different fractions may require different methods of disposal and should be disposed of via different waste bins. Consumers suggested in interviews that color codes or written information on the product packaging might help to identify the correct waste bin. In contrast, the idea of recycling apps that display information about the correct separation of waste after scanning a product was disliked by our interview partners, as it was perceived as too effortful, and consumers would refrain from installing such an app. Second, consumers need to have the competence to allocate their waste to the correct waste bin or disposal method. This requires an understanding of the local waste management system, including the handling of waste after it is collected, whether it is incinerated or processed. This helps consumers to decide which materials to dispose of jointly or separately in bins. Our study demonstrates that consumers are expected to inform themselves, e.g. via websites or service centers, as information on the waste and waste bins are kept to a minimum. Labels on bins are used for information, but usually only include the name of the material that should be disposed of (e.g., "paper"). Sometimes color coding and pictures of example products provide additional orientation for correct disposal. Notably, color coding is used inconsistently throughout Austria. Our interviews reveal that individuals are confused by different color coding, with only the color "red" being strongly associated with "paper" throughout the interviews.

An unexpected finding of the current study is that consumers have a good gut feeling of where to expect residual waste bins in public. They might form and use a cognitive map to locate the bins, orientating themselves by virtue of the knowledge stored in their long-term memory (c.f. research on cognitive mapping, Gärling and Golledge, 2018). A cognitive map of the environment provides consumers with a feeling of where to expect the next residual waste bin, with a lack of or an incorrect cognitive map potentially increasing littering behavior. Although our interview partners knew where to expect residual waste bins in public, they had not developed a similar cognitive map of separation systems.

Without the competences described above, consumers may make mistakes when sorting waste in public. Notably, our study revealed that when performing these competences and skills in public, a key challenge is limited cognitive processing, as people more often engaged in simultaneous tasks in public compared to waste sorting at home, such as disposing of waste while walking around, using a phone or talking with others.

4.3. Ideas/meaning

Separating waste in public is perceived as a diligence task, an extra task that consumers *can* do. Whereas littering is perceived as inappropriate, using a residual waste bin instead of separating the waste is widely accepted. Individuals are convinced that they are already doing their share when they dispose of waste using a residual waste bin (Table 2b). Sorting waste is a nice bonus goal and consumers openly admit that they do not pursue it to an "extreme". For instance, they may not take the extra step of shredding products or separating them into distinct components. The separation of waste is not universally regarded as essential, with some people not perceiving it necessary to segregate waste consistently in every situation. Individuals do not consider waste separation as their responsibility; instead, in interviews they refer to

advanced technologies in sorting centers that can perform the task in less time and with fewer resources. It is often believed that current sorting procedures in such centers can sort waste much better and more efficiently than individuals, which is grounded in a lack of knowledge about the waste management system. Our interview partners did not know how the waste is treated after collection and they were not aware of the functioning and logistics of sorting centers. A lack of knowledge might further result in myths and misconceptions. For example, some people believe that cleaners emptying sorting bins in public mix all the waste together anyway. Without an adequate understanding of the waste management system, individuals lack the motivation to engage in sustainable waste management practices, as they do not perceive it as necessary.

4.4. Alternative waste practices

During our research, we identified several distinct forms of consumers' public waste disposal: using residual waste bins and sorting waste, littering, or taking waste with them. Although the main focus of our research is the social practice of sorting waste (see Table 2), we give a short overview of alternative behaviors: Rather unexpectedly, individuals sometimes reported keeping and taking their waste home with them to dispose of it correctly or reuse the product (e.g. an empty water bottle). This was especially mentioned with products made of glass, as individuals are unsure in which bin they should dispose of it. In their households, people usually collect glass and bring it to special recycling containers throughout the city (e.g., next to supermarkets).

During our observations, some individuals engaged in littering. Incorrect sorting is less visible than littering, so throwing waste on the street is perceived as the much bigger issue for our interview partners and stakeholders. The most common type of littering was improper disposal of waste near full waste bins. Often, people would place their cigarette butt or paper bag on top of the trash bin or nearby. Some of these people even took the effort of a detour to pass by the waste bin, but they did not take the effort to look for the next waste bin in case the first one was full. This might indicate a complex concept of responsibility for one's own waste: Individuals might feel responsible for disposing of their waste as it is not socially accepted to throw the waste on the floor, but they hold authorities responsible for providing an infrastructure that makes disposal as convenient as possible. When a waste bin is already overflowing, many people find it acceptable to place the garbage on top of the bin or beside it, or to stack it on the existing trash, even though the logical consequence is that this waste is not being disposed of properly. With the next gust of wind, the garbage may no longer be near the waste bin. This situation can best be described with the phrase "I tried, but the circumstances were against me".

5. Discussion

The incorrect sorting of waste in public is problematic because of its environmental, economic and social impact. Although technical progress, like new sorting technologies, and regulatory initiatives, like the ban on throwaway plastics in the European Union (Chatain, 2019), are essential steps towards efficient resource use, an established practice of individuals sorting waste can help increase recycling rates (c.f. Nemat et al., 2022).

The aim of this study was to gain new insights into the practice of sorting waste in public, building on social practice theory (Shove et al., 2012). The findings underline the relevance of social practice theory when studying waste management practices (c.f. Nguyen, Nguyen, Phung and Yến-Khanh, 2023), as the technical infrastructure and social context play an important role for waste sorting in public. Our findings challenge knowledge derived from studies on household waste sorting, highlighting the nuanced differences between private and public waste management practices. Thus, interventions tailored to private settings may not seamlessly translate to public places.

From a theoretical perspective it is important to note that in contrast to waste sorting practices in private households (Thomas and Sharp, 2013), waste sorting in public is not yet ingrained as a normalized behavior. This relates to the theoretical discussion on how individuals learn social norms (e.g. Zhang et al., 2023) and how norms develop (Van Kleef, Gelfand and Jetten, 2019). The high amount of public residual waste bins in Austria appears to signal to consumers that disposing of waste without separation is the normative behavior. This is related to the idea that the provision or removal of ashtrays informs individuals that smoking is (not) acceptable in the corresponding venue (Suarjana et al., 2020). In contrast to the vast amount of residual waste bins in public, household waste in residential complexes is disposed of in garbage rooms with separate containers for various types of waste, which might indicate that waste sorting is expected. Further, we did not observe any indication of negative social feedback when people use residual waste bins instead of separating waste, like judgmental gazes or negative comments, which also indicates the absence of a social norm for separating waste. Social feedback might be a relevant concept to promote waste sorting, as research indicates that negative social feedback is effective in promoting sustainable behavior, such as energy conservation behavior (Santika and Sudiartha, 2016).

The disparity in public waste separation practices carries significant practical implications as well: First, the location and accessibility of bins matter. In household or work settings the location is usually known to private individuals, with bins being easily accessible and placed in the immediate vicinity of where items are consumed and packaging disposed of (c.f. O'Connor, Lerman, Fritz, & Hodde, 2010). In public, the distance to the waste bin and its accessibility affect waste disposal behavior, as suggested in laboratory experiments (Zhang et al., 2016) and field experiments in academic buildings (Brothers et al., 1994; Ludwig et al., 1998). The more easily accessible waste bins are, the lower the personal costs for private individuals to dispose of their waste correctly. Our research indicates that individuals use some sort of cognitive map to locate waste bins in public. They seem to navigate in public space based on prior experiences. For particular environments, they might already have a specific cognitive map or mental representation (Gärling and Golledge, 2018). Our research indicates that even if consumers are not familiar with the surroundings, they develop a gut feeling of where to expect certain inanimate objects. This needs to be further investigated in interviews investigating the cognitive map as it makes it easier for waste management agencies to place waste bins in public. Similarly, an important aspect is to conveniently locate separation systems to foster waste sorting (Eklund et al., 2010), such as in an area where many people pass through (Leeabai et al., 2019).

Second, waste bin design is an important issue. The color of the bin (Montazeri et al., 2012), different materials (Keramitsoglou and Tsagarakis, 2018), as well as the use of emoticons or sound to reward users (Berengueres et al., 2013) affect individuals' disposal behavior. Our study reveals that one of the challenges with public waste sorting is making bins identifiable in public while still fitting into the cityscape. At the same time, a waste bin should be convenient to use for both consumers and cleaners, who often have contradictory preferences (e.g., the size of the opening, the form of the waste bin). Our interview partners not only suggested using the design of the waste bin to provide information on correct disposal, but also mentioned that the packaging of the products should be used to simplify the sorting of materials. This could be done by putting stickers on products that correspond with the colors of the bins, as suggested in a study by Árnadóttir et al. (2019). Moreover, the form, size, durability, and haptic aspects may influence how valuable the packaging is perceived to be, and as a result whether the packaging is considered to be worth recycling (Nemat et al., 2022). Last, a key issue for waste sorting in public might be limited cognitive processing during the act of waste disposal as people often engage in another simultaneous task, like talking to others, using a phone or walking (Duffy and Verges, 2009): "In such dual-task situations, people may exhibit higher thresholds for distinguishing waste containers […]"

(p. 746).

One important issue with waste sorting in public is that consumers do not see the harm in using the provided residual waste bins instead of sorting their waste. This corresponds with results of intervention studies that failed to increase recycling (Árnadóttir et al., 2019) and underlines the assumption that littering, as a more visible problem, has posed far more aesthetic, social, economic, and environmental concerns (Finnie, 1973; Schultz et al., 2013). Litter is an unpleasant and ugly sight (Adam, 2021; La Hart and Bailey, 1975), so the main goal has been to prevent littering. However, our results indicate that if individuals dispose of their waste in residual waste bins in public, they have a feeling of "having done their share". If many residual waste bins are provided, individuals seem not to be motivated to look for sorting bins or carry their waste with them so they can sort it later. A critical area for future research lies in investigating whether the proliferation of residual waste bins indeed fosters a social norm where waste sorting is disregarded as an individual responsibility. This could be rigorously examined through field experiments that manipulate the density of residual waste bins alongside the availability of sorting systems. Moreover, our findings underscore the pressing need to address the lack of information surrounding waste management systems among the general public. Individuals' lack of awareness regarding how waste is treated after its disposal leads to a perception that waste sorting is not their personal obligation. Winterich et al. (2019) propose that consumers are more inclined to engage in waste sorting when they are inspired by the potential transformation of recyclables into new products. Thus, future studies should examine more closely the impact of disseminating information about product afterlife.

Although the current research has its merits, a limitation of this research is that we did not test the effect of different bin designs or waste infrastructure experimentally. Additionally, a social desirability effect must be taken into account for the interviews, especially as pro-environmental behavior is a much-discussed topic. By triangulating our results derived from the interviews with other sources of data (e.g., observations), we tried to address this issue. Nevertheless, future research might use field experiments in combination with observations to gain more insights into the practice of waste sorting and the effect of different waste bin designs.

6. Conclusion and implications

In conclusion, the study contributes new insights to the practice of sorting waste in public and identifies various factors that influence waste disposal behavior. In contrast to sorting waste at home (c.f. Thomas and Sharp, 2013), sorting waste in public is not yet an established practice. To improve waste sorting practices in public, it is important to provide comprehensive campaigns that explain the purpose and meaning behind the sorting system, increase the visibility and relevance of waste sorting, and provide more information about what happens to waste after collection. Notably, changing the material, particularly product packaging or waste infrastructure, and highlighting the transformation of recyclables into new products in recycling communication could be effective ways to change waste sorting practices.

Based on the current results, three main recommendations can be given to municipalities as well as public organizations regarding waste sorting in the public space. First, the design of the waste sorting bin is important. Especially from the perspective of consumers, the opening should be rather big and have no lid so that passersby can easily dispose of their sorted waste and do not need to touch the bin, which they definitely try to avoid. For certain kinds of waste, it might be helpful to have transparent waste sorting bins, because consumers more easily realize the kind of waste that is collected in the respected bin. The usage of transparent bins depends on the collected kind of waste (e.g., already decomposing biodegradable waste might result in feelings of disgust). Second, consumers' cognitive maps for bins in the public space (at crossings of streets, next to an exit, at bus stations, etc.) should be used to place waste sorting bins. Third, it should be made clear that waste sorting is the responsibility of all consumers (e.g. with flyers sent to each household, special lessons at school or if citizens moved to the city), because there are only special kinds of waste that can be sorted automatically by machines and therefore consumer action is necessary.

CRediT authorship contribution statement

Barbara Hartl: Writing – review & editing, Writing – original draft, Project administration, Methodology, Funding acquisition, Conceptualization. **Eva Hofmann:** Writing – review & editing, Project administration, Methodology, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Appendix

Fig. A1. Pictures used in the interview guidelines.

References

Adam, I., 2021. Tourists' perception of beach litter and willingness to participate in beach clean-up. Mar. Pollut. Bull. 170, 112591.

Ajzen, I., 1991. The theory of planned behavior. Organ. Behav. Hum. Decis. Process. 50, 179–211.

Árnadóttir, Á.D., Kok, G., Van Gils, S., Ten Hoor, G.A., 2019. Waste separation in cafeterias: a study among university students in The Netherlands. Int. J. Environ. Res. Publ. Health 16 (1), 93.

Barr, S., Shaw, G., Coles, T., 2011. Sustainable lifestyles: sites, practices, and policy. Environ. Plann. 43 (12), 3011–3029.

Bateson, M., Robinson, R., Abayomi-Cole, T., Greenlees, J., O'Connor, A., Nettle, D., 2015. Watching eyes on potential litter can reduce littering: evidence from two field experiments. PeerJ 3, e1443.

Benoit, S., Schaefers, T., Heider, R., 2016. Understanding on-the-go consumption: identifying and quantifying its determinants. J. Retailing Consum. Serv. 31, 32–42. https://doi.org/10.1016/j.jretconser.2016.03.003.

Berengueres, J., Alsuwairi, F., Zaki, N., Ng, T., 2013. Gamification of a recycle bin with emoticons. In: Paper Presented at the 2013 8th ACM/IEEE International Conference on Human-Robot Interaction (HRI).

BMK, 2019. Bericht gem. In: Art. 4 der EU-Richtlinie über die Verringerung der Auswirkungen bestimmter Kunststoffprodukte auf die Umwelt (Report according to

Art. 4 of the EU Directive on the Reduction of the Impact of Certain Plastic Products on the Environment). Retrieved from Vienna).
Borch, A., Vittersø, G., Stø, E., 2015. Studying sustainable change: from ABC to practice. GAIA-Ecological Perspectives for Science and Society 24 (2), 102–107.
Brothers, K.J., Krantz, P.J., McClannahan, L.E., 1994. Office paper recycling: a function of container proximity. J. Appl. Behav. Anal. 27 (1), 153–160.
Bundesministerium für Finanzen [Federal Ministry of Finance], 2023. Abfall. Retrieved from. https://www.oesterreich.gv.at/themen/bauen_wohnen_und_umwelt/abfall.html.
Chatain, B., 2019. Parliament seals ban on throwaway plastics by 2021. Retrieved from. https://www.europarl.europa.eu/news/en/press-room/20190321IPR32111/parliament-seals-ban-on-throwaway-plastics-by-2021.
Chaudhary, A.H., Polonsky, M.J., McClaren, N., 2021. Littering behaviour: a systematic review. Int. J. Consum. Stud. 45 (4), 478–510.
Cialdini, R.B., Reno, R.R., Kallgren, C.A., 1990. A focus theory of normative conduct: recycling the concept of norms to reduce littering in public places. Journal of Personality and Social Psychology 58 (6), 1015.
Die Umweltberatung, 2023. Restmüll und Abfalltrennung. Retrieved from. https://www.umweltberatung.at/restmuell-und-abfalltrennung.
Duffy, S., Verges, M., 2009. It matters a hole lot: perceptual affordances of waste containers influence recycling compliance. Environ. Behav. 41 (5), 741–749.
Eklund, J., Kihlstedt, A., Engkvist, I.-L., 2010. Sorting and disposing of waste at recycling centres–A users perspective. Appl. Ergon. 41 (3), 355–361.
Finnie, W.C., 1973. Field experiments in litter control. Environ. Behav. 5 (2), 123–144.
Flick, U., 2011. Das episodische interview. In: Empirische Forschung und Soziale Arbeit. Springer, pp. 273–280.
Francis, J.J., Johnston, M., Robertson, C., Glidewell, L., Entwistle, V., Eccles, M.P., Grimshaw, J.M., 2010. What is an adequate sample size? Operationalising data saturation for theory-based interview studies. Psychol. Health 25 (10), 1229–1245.
Gangl, K., Spitzer, F., Walter, A., 2022. Abfalltrennung und Littering im öffentlichen Raum. Ein verhaltensökonomisches Feldexperiment. Available at https://irihs.ihs.ac.at/id/eprint/6097/7/ihs-report-2022-gangl-spitzer-walter-abfalltrennung-littering-im-oeffentlichen-raum.pdf.
Gärling, T., Golledge, R.G., 2018. Cognitive mapping and spatial decision-making. In: Cognitive Mapping. Routledge, pp. 44–65.
Guest, G., Bunce, A., Johnson, L., 2006. How many interviews are enough? An experiment with data saturation and variability. Field Methods 18 (1), 59–82.
Katan, L., Gram-Hanssen, K., 2021. 'Surely I would have preferred to clear it away in the right manner': when social norms interfere with the practice of waste sorting: a case study. Cleaner and Responsible Consumption 3, 100036.
Keramitsoglou, K.M., Tsagarakis, K.P., 2018. Public participation in designing the recycling bins to encourage recycling. Sustainability 10 (4), 1240.
Kladnik, V., 2024. Waste Containers in Public and Semi-public Spaces, 1.0.0.
Kladnik, V., Dworak, S., Schwarzböck, T., 2024. Composition of public waste - a case study from Austria. Waste Manag. 178, 210–220. https://doi.org/10.1016/j.wasman.2024.02.031.
Kropfeld, M.I., 2022. Lifestyles of enough exploring sufficiency-oriented consumption behavior from a social practice theory perspective. J. Consum. Cult., 14695405221095008
La Hart, D.E., Bailey, J.S., 1975. Reducing children's littering on a nature trail. J. Environ. Educ. 7 (1), 37–45.
Leeabai, N., Suzuki, S., Jiang, Q., Dilixiati, D., Takahashi, F., 2019. The effects of setting conditions of trash bins on waste collection performance and waste separation behaviors; distance from walking path, separated setting, and arrangements. Waste Manag. 94, 58–67.
Lin, Z.Y., Wang, X., Li, C.J., Gordon, M.P., Harder, M.K., 2016. Visual prompts or volunteer models: an experiment in recycling. Sustainability 8 (5), 458.
Ludwig, T.D., Gray, T.W., Rowell, A., 1998. Increasing recycling in academic buildings: a systematic replication. J. Appl. Behav. Anal. 31 (4), 683–686.
Miao, L., Wei, W., 2013. Consumers' pro-environmental behavior and the underlying motivations: a comparison between household and hotel settings. Int. J. Hospit. Manag. 32, 102–112.
Montazeri, S., Gonzalez, R., Yoon, C., Papalambros, P., 2012. Color, cognition, and recycling: how the design of everyday objects prompt behavior change. In: Paper Presented at the DS 70: Proceedings of DESIGN 2012, the 12th International Design Conference. Dubrovnik, Croatia.
Mueller, R.A., 2019. Episodic narrative interview: capturing stories of experience with a methods fusion. Int. J. Qual. Methods 18, 1609406919866044.
Nemat, B., Razzaghi, M., Bolton, K., Rousta, K., 2022. Design affordance of plastic food packaging for consumer sorting behavior. Resour. Conserv. Recycl. 177, 105949. https://doi.org/10.1016/j.resconrec.2021.105949.
Nguyen, A.T., Nguyen, N., Phung, P., Yến-Khanh, N., 2023. Residents' waste management practices in a developing country: a social practice theory analysis. Environmental Challenges 13, 100770.
O'Connor, R.T., Lerman, D.C., Fritz, J.N., Hodde, H.B., 2010. Effects of number and location of bins on plastic recycling at a university. J. Appl. Behav. Anal. 43 (4), 711–715.
Reckwitz, A., 2002. Toward a theory of social practices: a development in culturalist theorizing. Eur. J. Soc. Theor 5 (2), 243–263.
RegioData Research, 2019. Anteil von Außer-Haus-Essen an den gesamten Konsumausgaben für Ernährung in Österreich in den Jahren 2008 und 2018 (Austria - Expenditures on out-of-home consumption as percentage of total food expenditures in 2018). Retrieved from. https://de.statista.com/statistik/daten/studie/48095/umfrage/ausgaben-fuer-ausser-haus-essen-an-konsumausgaben-fuer-ernaehrung-in-oesterreich.
Roysen, R., Mertens, F., 2019. New normalities in grassroots innovations: the reconfiguration and normalization of social practices in an ecovillage. J. Clean. Prod. 236, 117647. https://doi.org/10.1016/j.jclepro.2019.117647.
Santika, W.G., Sudiartha, I.K.G., 2016. Persuasive technology with normative feedback to reduce energy consumption. In: Paper Presented at the 2016 International Conference on Progress in Informatics and Computing (PIC).
Schubert, E., 2020. Sammelquote erhöhen: Mehr Bewusstsein für Mülltrennung. Retrieved from. https://gemeindebund.at/sammelquote-erhoehen-mehr-bewusstsein-fuer-muelltrennung.
Schultz, P.W., Bator, R.J., Large, L.B., Bruni, C.M., Tabanico, J.J., 2013. Littering in context: personal and environmental predictors of littering behavior. Environ. Behav. 45 (1), 35–59.
Shove, E., 2003. Converging conventions of comfort, cleanliness and convenience. Journal of Consumer policy 26, 395–418.
Shove, E., 2010. Beyond the ABC: climate change policy and theories of social change. Environ. Plann. 42 (6), 1273–1285.
Shove, E., 2012. Habits and Their Creatures.
Shove, E., Pantzar, M., 2005. Consumers, producers and practices: understanding the invention and reinvention of Nordic walking. J. Consum. Cult. 5 (1), 43–64.
Shove, E., Pantzar, M., Watson, M., 2012. The Dynamics of Social Practice: Everyday Life and How it Changes. Sage.
Shove, E., Southerton, D., 2000. Defrosting the freezer: from novelty to convenience:A narrative of normalization. J. Mater. Cult. 5 (3), 301–319. https://doi.org/10.1177/135918350000500303.
Soma, T., Kozhikode, R., Krishnan, R., 2021. Tilling food under: barriers and opportunities to address the loss of edible food at the farm-level in British Columbia, Canada. Resour. Conserv. Recycl. 170, 105571. https://doi.org/10.1016/j.resconrec.2021.105571.
Stadt Wien, 2023. Restmüll - mülltrennung. Retrieved from. https://www.wien.gv.at/umwelt/ma48/beratung/muelltrennung/restmuell.html.
Suarjana, K., Astuti, P.A.S., Artawan Eka Putra, I.W.G., Duana, M.K., Mulyawan, K.H., Chalidyanto, D., Wahyuni, C.U., 2020. Implementation of smoke-free law in denpasar bali: between compliance and social norms of smoking. Journal of Public Health Research 9 (3). https://doi.org/10.4081/jphr.2020.1747 jphr.2020.1747.
Thomas, C., Sharp, V., 2013. Understanding the normalisation of recycling behaviour and its implications for other pro-environmental behaviours: a review of social norms and recycling. Resour. Conserv. Recycl. 79, 11–20. https://doi.org/10.1016/j.resconrec.2013.04.010.
Timlett, R.E., Williams, I.D., 2008. Public participation and recycling performance in England: a comparison of tools for behaviour change. Resour. Conserv. Recycl. 52 (4), 622–634.
United Nations Office on Drugs and Crime (UNODC), 2022. COP27 Side Event: unmanaged Waste - a hidden cause of climate change. Retrieved from. https://www.unodc.org/unodc/en/environment-climate/cop27-unmanaged-waste.html.
United States Environmental Protection Agency EPA, 2022. Reduce, reuse, recycle. Retrieved from. https://www.epa.gov/recycle.
Van Kleef, G.A., Gelfand, M.J., Jetten, J., 2019. In: The Dynamic Nature of Social Norms: New Perspectives on Norm Development, Impact, Violation, and Enforcement, 84. Elsevier, 103814.
Welch, D., Warde, A., 2015. Theories of practice and sustainable consumption. In: Handbook of Research on Sustainable Consumption, pp. 84–100.
Winterich, K.P., Nenkov, G.Y., Gonzales, G.E., 2019. Knowing what it makes: how product transformation salience increases recycling. J. Market. 83 (4), 21–37.
Zhang, S., Zhang, M., Yu, X., Ren, H., 2016. What keeps Chinese from recycling: accessibility of recycling facilities and the behavior. Resour. Conserv. Recycl. 109, 176–186.
Zhang, W., Liu, Y., Dong, Y., He, W., Yao, S., Mu, Y., 2023. How we learn social norms: a three-stage model for social norm learning. Front. Psychol. 14, 1153809.