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Waste Bin Design Matters: Evidence From a Controlled Experiment With a Waste Separation Task

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ABSTRACT

Waste separation prevents material contamination, which is key to sustainable recycling. Evidence suggests that waste bin design can influence the way people separate waste when recycling. However, this evidence comes from field studies with relatively low internal validity. We report results from a controlled experiment ($N = 100$) using a novel waste sorting task to isolate the effect of bin design on recycling behavior. We focused on whether participants accurately placed refundable bottles/cans in special waste bins (called "deposit collection tubes"). Results showed that a blue/experimental deposit collection tube improved sorting of refundable bottles/cans compared to a gray/conventional version. This effect was quite large (odds ratio = 2.25), remained consistent after statistical control of individual differences (e.g., recycling norms, habits), and was explained by the blue tube's superior noticeability. These results show that waste bin design really matters to recycling behavior and that an appropriate design can guide people to a desirable outcome. Design and policy implications are discussed.

1 | Introduction

For plastic PET bottles and aluminum cans (henceforth called refundable bottles/cans) to be recycled, they must be separated from other waste streams and, for example, not be mixed up with general waste in public trash bins. Some countries such as Sweden have a well-established deposit refund system for refundable bottles/cans that serves this separation purpose and that is widely recognized among the public. A key component of the system is that consumers pay a deposit when they buy refundable bottles/cans (usually with beverages) and then receive this money back when they return the refundable bottles/cans to a collection station (e.g., a vending machine). Still, nearly 400 million refundable bottles/cans annually are lost from the recycling chain in Sweden alone (Pantamera, n.d.). One way to increase the collection rate of refundable bottles/cans and prevent them from being mixed up with general waste, is to install bins specifically intended only for the disposal of refundable bottles/cans. For example, a special type of bin (Figure 1), called a "deposit collection tube" ("pantrör" in Swedish), is presently being introduced in public spaces (e.g., recreational parks, bus stops, etc.) in Sweden. These deposit collection tubes are often placed next to general waste bins with the intention of achieving the desirable separation of general waste and refundable bottles/cans. However, they are also often given a design, shape and color that makes them blend in with the environment. In such circumstances, people can easily misunderstand the purpose and intention with the deposit collection tube (Figure 2). Can such design decisions stop them from reaching their full potential?

Human attention is naturally drawn to salient features in the environment, particularly elements that distinguish themselves through color, contrast, or size. This is consistent with the Salience, Effort, Expectancy, and Value (SEEV) model of visual attention, which proposes that visual scanning is influenced by the salience of information, the effort required to attend to it, the expectancy of relevant information, and

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Highlights

- A blue deposit collection tube improves sorting of refundable bottles/cans compared to a gray/conventional version.
- The blue tube's advantage is attributable to a superior noticeability.
- An appropriate waste bin design can guide people to a desirable recycling behavior.

FIGURE 1 | The figure also shows two deposit collection tubes next to each other, a blue (new/experimental) deposit collection tube to the left and a gray (conventional/control) deposit collection tube to the right.

its value to the observer (Wickens 2021). In line with this model, previous studies have shown that design features of waste bins, such as color and size, can have a marked effect on how people use and attend to the bins (Högberg and Sörqvist 2026). For instance, the shape of lids and bin openings (Duffy and Verges 2009), visual prompts (e.g., text messages; Cao et al. 2023) and the match between packages and bins (Buckland et al. 2025) can improve waste separation, indicating that the design of a waste collection system influences waste sorting behavior (Leeabai et al. 2022).

A design component of particular interest here is the color of the waste bin. Color can have marked effects on behavior because it can attract attention, especially if the color of an object makes it stand out from the surrounding (Itti and Koch 2001). There is a clear link between color and the level of visibility (Berger et al. 2005; Corbetta and Shulman 2002). Some colors

FIGURE 2 | The figure shows a photograph of a black waste bin with a same-color deposit collection tube attached to its side. The photograph is taken from a central street in a midsized municipality in Sweden. As can be seen in the area circled red, regular trash has been pushed down the deposit collection tube, suggesting that its purpose is unclear to users.

can make waste bins more noticeable and, consequently, used more. For example, Linder et al. (2023) conducted a field experiment and found that orange waste bins were used more than gray (regular) bins. This field experiment was complemented by a lab experiment examining participants' response times when identifying waste bins of different colors. Participants were significantly faster at identifying the orange waste bin when viewing photographs of street environments, suggesting that the orange waste bin's superior noticeability is what makes it attract more use in the field. Similarly, Abdel Sater et al. (2023) investigated the perceptual effects of waste bin color using photographs with and without waste bins. The waste bins were either gray or red, and the results showed that the red waste bins had 23% higher discriminability than gray waste bins, indicating that they were easier to distinguish from their surroundings. In a related field experiment, Leeabai et al. (2021) explored interactions between trash bin colors, color preferences and the perceived ease to notice trash bins. They found that color preferences depend on the perceived ease to distinguish waste bins, in particular when those waste bins have different purposes. When it is easy to see the difference between trash bins, decision making becomes easier. Collectively, these studies suggest that waste bin color plays an important role, especially in outdoor public environments where waste disposal often happens quickly and automatically without reflective thought.

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However, even though attention-attracting colors can be advantageous, in the sense that they increase waste bin use, it should also be noted that such colors might increase overinclusive recycling (i.e., a failure to sort waste appropriately). Factors that make bins more noticeable may also encourage people to throw items in the bins that are not supposed to go there (Catlin et al. 2021; Rosenthal and Linder 2021). An optimal waste bin design should increase use while also preventing overinclusive recycling. From a human behavior and technology acceptance perspective, several factors need to be fulfilled for a product to be used as intended. Models such as the Technology Acceptance Model (TAM; Davis 1993) and the Unified Theory of Acceptance and Use of Technology (UTAUT; Venkatesh et al. 2003) highlight the importance of attitudes, social influence, and perceived ease of use. For example, a positive attitude toward correct waste sorting may increase the intention to recycle appropriately, and social influence may shape behavior depending on how others are perceived to act. However, such attitudinal and normative factors are difficult to influence solely through product design.

A more design-sensitive determinant is effort expectancy, defined as "the degree of ease associated with the use of the system" (Venkatesh et al. 2003, 450). Effort expectancy can be affected both by the physical design of the bin (e.g., openings, labeling, accessibility) and by the clarity and interpretability of the information provided. Ambiguous instructions or visually cluttered interfaces may increase cognitive load and thereby reduce correct usage. If correct sorting is perceived as too effortful or cognitively demanding, users may refrain from engaging with the waste bin as intended. The experience of the product as too complex and hard to learn may outweigh the anticipated benefits, leading users to avoid the system altogether (Keil et al. 1995). Thus, even individuals who hold strong pro-environmental attitudes and intend to sort correctly may disengage if the bin's design makes correct sorting difficult to infer.

Designing products for public and unsupervised environments presents particular challenges. According to Shackel (2009), usability depends on the design of the product in relation to its intended users, the task and environment. It is important to consider the context of use for the product (Maguire 2001). Unlike specialized or professional systems, public waste bins must be immediately understandable to a heterogeneous user group, including first-time users and individuals with different linguistic and cultural backgrounds, such as tourists. In the context of waste sorting, high usability implies that users should be able to quickly interpret the bin's function and deposit waste correctly with minimal errors, even at first encounter. The interaction should preferably be intuitive, require minimal interpretation, and support rapid and accurate decision-making. Reducing effort and ambiguity is therefore central not only to increasing usage rates but also to preventing overinclusive recycling.

There has been extensive research on recycling behavior, but relatively few studies have experimentally examined how different bin designs influence recycling and waste sorting behavior. Moreover, much of the existing research on the effects of waste bin designs has been conducted in field settings, not in a controlled laboratory environment (see Högberg and Sörqvist 2026, for a review). While field studies have a range of advantages from the point of ecological validity, this comes with a cost to internal validity (i.e., control over extraneous variables). Without high internal validity, it is difficult to pinpoint the precise reason why some waste bins improve sorting behavior more than others. In field studies, potential extraneous variables such as the type of garbage people carry with them and need to sort, people's spontaneous movement, weather, and daily shifts in temperature, are difficult to control for. To be able to isolate the effect of visual appearance of waste bins on waste sorting behavior, there is a need for laboratory experiments with control over such external factors. These more controlled laboratory experiments can contribute with a theoretical understanding of the mechanisms underpinning waste sorting behavior.

Another advantage with laboratory experiments is that they offer control over internal factors (i.e., individual differences in psychological factors, such as attitudes, habits and values). Individual differences in attitudes (Huffman et al. 2014), habits (Aboelmaged 2021), values (McCarty and Shrum 1994) and environmental identity (Nigbur et al. 2010) influence recycling behavior. Individuals with higher environmental concerns are more likely to recycle in their everyday life, especially when it is easy to act in accordance with these attitudes (Diekmann and Preisendörfer 1998). As more experience with recycling and higher environmental values afford practice and motivation, individuals with strong recycling habits and strong environmental values are also more likely to perform better than their counterparts in a waste sorting task. Some studies indicate that external factors (e.g., waste bin location) have a stronger influence on behavior than internal factors have (Geiger et al. 2022; Linder et al. 2021), but internal factors are still a potential source of confounding variables that need to be controlled in order to isolate waste bin design effects.

In the present study, we developed an experimental paradigm that allowed us to study waste sorting performance under controlled conditions. Our focus was sorting refundable bottles/cans versus garbage of other types and the design of waste bins (deposit collection tube) created with the specific purpose of collecting refundable bottles/cans. With our novel paradigm, we tested how design features of deposit collection tubes influence accuracy in the separation of refundable bottles/cans from non-recyclable items in a waste sorting task. Our experimental approach also allowed us to control a range of individual difference variables (recycling norms, recycling habits, recycling intentions, and environmental identity), including perceived (waste bin) system usability and previous experience with deposit collection tubes.

We gave participants a waste sorting task in two experimental conditions. In one condition, participants sorted waste into five different fractions, including a blue/experimental deposit collection tube with visual details that were designed to improve usability (Figure 3). In the other, control condition, participants also sorted waste into five fractions, but here the deposit collection tube was of the conventional gray, smaller type (Figure 1). An important aspect of the experimental setup was that participants were not told of the presence or purpose of the deposit

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FIGURE 3 | The figure shows the task setup with the to-be-sorted material on a desk in front of waste bins, including a deposit collection tube. The figure depicts the experimental condition with the blue deposit collection tube. The control condition was identical, except that the blue tube was replaced with the gray/conventional tube seen in Figure 1.

collection tubes in either condition. Instead, the purpose of the experiment was to test whether the blue collection tube's design features improved waste-separation performance spontaneously without explicit instructions beyond what was conveyed by the bin's design. This simulates a real-world scenario where people might encounter special waste bins such as deposit collection tubes in public spaces. The hypothesis of the experiment was as follows: fewer participants will make waste sorting errors (of items that should go into the deposit collection tube) in the condition with the blue collection tube in comparison with the condition with the gray collection tube.

2 | Method

2.1 | Participants

A total of 100 Swedish persons (50% women, 50% men) were recruited to participate in the study. The age distribution was as follows: 29 were 18–24 years old, 29 were 25–34 years, 16 were 35–44 years, 15 were 45–54 years, and 11 were older than 55 years. The sample size was determined based on a power analysis using G*Power (Faul et al. 2007) with an arbitrary assumption of an effect size of Cohen's $d = 0.50$ for the difference between two independent samples with power set to $1 - \beta$ error probability of 0.80 (one-tailed). This yielded a required sample size of approximately 50 in each condition. All participants gave their informed consent prior to participation, and everyone received a small honorarium for their participation.

2.2 | Materials

2.2.1 | Deposit Collection Tubes

Two deposit collection tubes were used (Figure 1). One of standard shape and color (right hand side of Figure 1), and one larger in blue color (left hand side of Figure 1).

2.2.2 | Waste Sorting Task

In this task, participants sorted waste in five fractions, including refundable bottles/cans. Twenty-eight different items were placed on a table in front of five containers (waste bins) representing different waste fractions (Figure 3). The fractions included glass packaging, residual waste, metal packaging, plastic packaging, and refundable bottles/cans. All waste containers were white and had a lid that could be opened halfway. A sign was placed on each lid. The signs used for the different fractions were taken from the standardization system developed by the Swedish organization "Avfall Sverige" in collaboration with other organizations in the Nordic countries.

The participants were instructed to place each item in the correct waste bin (i.e., the waste bin where it belonged, based on the match between waste type and bin purpose). Participants were also told that once an item was placed in a waste bin, it could not be replaced to another waste bin. Participants were given 2 min to complete the task. This introduced time pressure, to simulate a situation that resembles how people dispose of their waste when they are "on-the-go". Participants were instructed to immediately exit the room as soon as the final item had been placed in its container. The experimenter took note of the time that elapsed from participants entering the room to the point when they exited the room. When a participant was done with the sorting task, the experimenter took note of whether the refundable bottles/cans were accurately sorted or not. The experimenter also took note of other sorting errors, as a measure of participants' general waste sorting knowledge/ability. Whether an item was considered correctly or incorrectly sorted was determined according to the sorting guide provided by the municipal waste management company "Gästrike återvinnare".

2.2.3 | Measures of Individual Differences

A questionnaire was created with seven parts. Each part had a set of questions/statements. Participants were asked to respond to each question/statement using a five-point Likert scale, ranging from "Strongly disagree" to "Strongly agree" (except if noted otherwise). In the first part, participants responded to three questions/statements (e.g., "to act environmentally friendly is an important part of who I am") designed to measure environmental self-identity based on Van der Werff et al. (2013). The responses were used to create an index of environmental self-identity with good internal consistency (Cronbach's $\alpha = 0.78$).

In the second part, participants responded to three questions/statements (e.g., "I feel a strong personal responsibility to recycle") on recycling personal norms based on Harland et al. (1999). This index had an acceptable internal consistency (Cronbach's $\alpha = 0.69$). The same questions/statements were used but modified to assess personal norms in relation to recycling refundable bottles/cans (e.g., "I feel a strong personal responsibility to return refundable bottles/cans"). This index had a similar internal consistency (Cronbach's $\alpha = 0.67$).

In the third part, there were three questions/statements (e.g., "I will recycle during the coming month") on recycling intentions

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based on Malek et al. (2017). The index's internal consistency was high (Cronbach's $\alpha = 0.80$). The three questions/statements were modified to assess deposit intentions (e.g., "I will return refundable bottles/cans during the coming month"), again with an index of high internal consistency (Cronbach's $\alpha = 0.90$).

In the fourth part, four questions/statements (e.g., "It would feel weird if I didn't recycle") on habit strength for recycling was used, based on Verplanken and Orbell (2003). This index's internal consistency was good (Cronbach's $\alpha = 0.78$). The four questions/statements were modified (e.g., It would feel weird if I didn't return refundable bottles/cans) to measure habit strength for returning refundable bottles/cans. This index also had a good internal consistency (Cronbach's $\alpha = 0.83$).

In the fifth part, participants were asked three questions (i.e., "I think I did well on the waste sorting task". "I think the waste sorting task I just did was easy to do". "I think the waste sorting task I just did was hard to understand") about how they experienced the difficulty of the task. The answers to the last question were inversed prior to analysis. The answers across questions formed an index with low internal consistency (Cronbach's $\alpha = 0.58$). Because of this, the three questions were analyzed separately.

In the sixth part, the participants were asked about their previous experience of deposit collection tubes ("I have seen deposit collection tubes before") and responded on a five-point scale ranging from "Never" to "Many times". They were also asked whether they noticed the deposit collection tube in the room ("I noticed the deposit collection tube in the room") and responded on a five-point scale ranging from "Do not agree at all" to "Agree to a large degree".

Finally, in part number seven of the questionnaire, the System Usability Scale (SUS) questionnaire with its standard 10 questions based on Bangor et al. (2008) was used as a measure of the deposit collection tubes' perceived usability. The index showed good internal consistency (Cronbach's $\alpha = 0.83$). The specified SUS equation (Lewis 2018) was used in order to calculate a SUS score. According to Bangor et al. (2008), products should have a SUS score above 70 to be considered passable, and the highest possible score is 100.

2.3 | Design

A laboratory experiment with one independent variable was conducted. The independent variable comprised color/design of deposit collection tube with two conditions: a condition with a blue/larger deposit collection tube (experimental condition) and a condition with a gray/smaller deposit collection tube (control condition). A between-subjects design was used. In total, half (24 men, 26 women) of the participants were allocated to the control condition, and half (26 men, 24 women) to the experimental condition.

The number of misplaced refundable bottles/cans was recorded during the waste sorting task, with a maximum score of 6. The scores took a bimodal distribution (i.e., most participants either had no errors at all or errors across the board) and were unsuitable for parametric testing. Because of this, scores were coded as nominal data (no error vs. at least one error). The experiment's dependent variable was, hence, dichotomized error (yes/no) in waste sorting of refundable bottles/cans.

2.4 | Procedure

The participants were recruited by convenience sampling at a university campus. The data collection took place in three regular, adjacent office rooms at the campus. Each room had the same task setup (Figure 3) but the deposit collection tubes were counterbalanced across the rooms. That is, two rooms had a blue deposit collection tube, and one room had a gray collection tube 1 day, and every other day, two rooms had a gray collection tube, and one room had a blue collection tube. Since three separate rooms were used, up to three participants could take part in the experiment at the same time, one participant per room. They could not communicate or interact with each other during the experiment.

Upon entry, participants were pseudo-randomly assigned to one of the three rooms, according to a predetermined sequence. When the first participant was recruited, they were assigned to room number 1, the next to room number 2, and the third to room number 3. This sequence was then repeated from the fourth participant onwards. The condition (experimental vs. control) to which each participant was allocated was determined by the room to which they were assigned.

The procedure began with participants reading instructions and providing informed consent to take part in the study. The test leader asked if they understood the instructions and gave the participants the opportunity to ask questions about the upcoming task. They were then instructed to position themselves in front of the door leading to the assigned room, where the waste sorting task was conducted. When the participants were ready, they entered the room, and the experimenter started the stopwatch as they performed the waste sorting task. When they had finished the task, they exited the room, and the experimenter stopped the stopwatch. When done with the waste sorting task, they were given the questionnaire with the individual difference measures described above. After completing the questionnaire, they were debriefed and thanked.

2.5 | Openness and Transparency

We declare our hypotheses, methods, analyses (statistical tests conducted in Jamovi, version 2.6.26.0, and SPSS, version 30.0.0.0, and the PROCESS macro by Andrew F. Hayes), and results. The data for this article are publicly available in the Open Science Framework (OSF) database and can be accessed at https://doi.org/10.17605/OSF.IO/6VDEX.

3 | Results

We begin our analysis by focusing on the effect of deposit collection tube on the tendency to sort the refundable bottles/cans accurately or not. As can be seen in Table 1, a majority of the

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TABLE 1 | The table shows the number of participants in the two conditions who placed refundable bottles/cans accurately or inaccurately, respectively.

	Deposit collection tube condition		
Error made	**Blue (experiment)**	**Gray (control)**	**Total**
No	31	21	52
Yes	19	29	48
Total	50	50	100

Note: $\chi^2 = 4.01$, $p = 0.045$.

participants (62%) in the experimental condition with the blue deposit collection tube (henceforth called "blue condition") sorted the refundable bottles/cans accurately, whereas a minority (42%) did so in the control condition with the gray deposit collection tube (henceforth called "gray condition"). Conversely, a minority (38%) made at least some error with the refundable bottles/cans in the blue condition, and a majority (58%) did so in the gray condition. Thus, the blue collection tube improved performance, with an effect size (odds ratio) of 2.25. A 2(condition: blue vs. gray tube)×2(error: yes vs. no) χ^2 analysis confirmed that the effect of condition was statistically significant, $\chi^2 = 4.01$, $p = 0.045$.

Next, we focus on how this effect can be explained. As a first step, we analyze results from participants' responses to the question concerning the degree to which they noticed the collection tube in the experimental setting. The blue collection tube was noticed to a higher extent ($M = 3.88$, SD = 1.59, Mdn = 5.00) compared to the gray collection tube ($M = 3.00$, SD = 1.68, Mdn = 3.00), $t = 2.69$, $p = 0.008$, Cohen's $d = 0.54$. To examine whether noticeability explains why fewer participants made errors in the blue condition, we conducted a binomial logistic multiple regression mediation analysis (with a bootstrapped sample of 5000). Experimental condition (blue vs. gray) was selected as the independent variable, collection tube noticeability was selected as a mediator variable, and error in the sorting of refundable bottles/cans (yes/no) was selected as the dependent variable. The analysis revealed a significant effect of condition on noticeability, $t = 2.69$, $p = 0.008$, with greater noticeability in the blue condition. In turn, noticeability had a direct effect on sorting error, coefficient = −0.91, $Z = -5.06$, $p < 0.001$, but so did not condition, coefficient = −0.22, $Z = -0.42$, $p = 0.671$. The indirect effect of condition on error via noticeability was −0.80, bootstrapped 95% CI [−1.60 to −0.20]. Therefore, one reason why the blue deposit collection tube constraints sorting errors of refundable bottles/cans is because it has greater noticeability.

As a second step, we explore the difference between conditions concerning perceived task difficulty and time taken on task. Although more participants made errors in the control (gray) condition, participants perceived the task as relatively easy in both conditions. The two conditions did not differ statistically on any of the three questions concerning task difficulty: "I think I did well on the task" (blue: $M = 4.00$, SD = 1.03, Mdn = 4.00; gray: $M = 4.04$, SD = 1.07, Mdn = 4.00), $t = 0.19$, $p = 0.849$, Cohen's $d = 0.04$, "I think the task was easy to do" (blue: $M = 3.96$, SD = 0.97, Mdn = 4.00; gray: $M = 3.98$, SD = 0.85, Mdn = 4.00), $t = 0.11$, $p = 0.913$, Cohen's $d = 0.02$, and "I think the task was difficult to understand" (inversed) (blue: $M = 4.60$, SD = 0.78, Mdn = 5.00; gray: $M = 4.32$, SD = 0.94, Mdn = 5.00), $t = 1.63$, $p = 0.108$, Cohen's $d = 0.32$. Moreover, there was no significant difference between the two conditions regarding time taken on the task (blue: $M = 78.02$ s, SD = 17.12, Mdn = 76.50 s; gray: $M = 83.42$ s, SD = 23.16, Mdn = 82.00 s), $t = 1.33$, $p = 0.188$, Cohen's $d = 0.27$. If anything, participants were slightly quicker in the experimental (blue) condition. Hence, the higher performance in the blue condition cannot be attributed to slower and more careful task execution (i.e., there was no evidence of a speed-accuracy trade-off).

Next, we explore if the difference in performance between the conditions can be explained by systematic sampling bias. A comparison between the two groups suggests that the randomization of participants across conditions was successful (Table 2) as participants in the two groups did not statistically differ regarding any of the measures of individual differences (e.g., in habits, values, or general waste sorting knowledge/ability). Also, participants in the two groups reported comparable experience with deposit collection tubes from before. If anything, previous experience was slightly higher in the gray condition. Therefore, sampling bias seems not to be responsible for the better performance in the blue condition.

In addition, we conducted a binomial logistic multiple regression analysis with experimental condition (blue vs. gray) as independent variable, all individual differences measures in Table 2 as co-variates, and error in sorting of refundable bottles/cans (yes/no) as dependent variable. The results of this analysis are reported in Table 3. Previous experience of deposit collection tubes had an effect in the expected direction (participants with more experience were less likely to make errors) and personal norms in relation to deposit recycling were also a statistically significant predictor (stronger personal norms were associated with a lower chance of errors). However, most importantly, the effect of condition (blue vs. gray) remained statistically significant even when all these variables were statistically controlled.

Finally, we explore how participants rated the two deposit collection tubes on the System Usability Scale (SUS). The two collection tubes were rated similarly (blue: $M = 70.80$, SD = 14.20, Mdn = 70.00; gray: $M = 74.30$, SD = 16.9, Mdn = 72.50), $t = 1.09$, $p = 0.277$, Cohen's $d = 0.22$. In absolute terms, both collection tubes were given an average rating above 70, meeting the threshold for being considered passable (Bangor et al. 2008). To better understand what contributed to the relatively low SUS scores for both deposit collection tubes, we conducted a more detailed analysis of responses to the individual questionnaire items. We focus here on the item themes that fell below a mean value of 3 (on a 5-point scale) for positively worded items, and above 3 for negatively worded items. Using this threshold, both collection tubes were perceived as exhibiting a degree of inconsistency and as somewhat awkward to use. In addition, the blue collection tube was rated as unnecessarily complex, while participants indicated that they would need to learn more before using the gray collection tube effectively. Although only one participant made an error of misplacing a non-recyclable item in a deposit

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TABLE 2 | The table shows the means, standard deviation (SD) for individual difference measures of participants in the two conditions, and *t*-test statistics, *p* values, and effect sizes (Cohen's *d*) for tests of the difference between the two conditions.

	Deposit collection tube condition				
	Blue (experiment)	Gray (control)			
	Mean (SD)	Mean (SD)	*t*	*p*	Cohen's *d*
Environmental identity	4.03 (0.66)	4.23 (0.50)	1.78	0.079	0.36
Recycling norms	4.14 (0.75)	4.29 (0.61)	1.10	0.275	0.22
Deposit norms	4.30 (0.64)	4.29 (0.79)	0.09	0.931	0.02
Recycling intentions	4.57 (0.64)	4.67 (0.62)	0.74	0.459	0.15
Deposit intentions	4.61 (0.63)	4.39 (0.96)	1.36	0.177	0.27
Recycling habits	4.20 (0.72)	4.42 (0.71)	1.47	0.145	0.30
Deposit habits	4.23 (0.68)	4.32 (1.00)	0.47	0.643	0.09
Previous experience of deposit collection tubes	2.90 (1.47)	3.18 (1.52)	0.93	0.352	0.19
General waste sorting errors	3.40 (2.23)	3.52 (2.10)	0.28	0.783	0.06

TABLE 3 | The table shows the results of a binomial logistic multiple regression analysis with error made to the refundable bottles/cans in the waste sorting task (yes/no) as dependent variable.

Predictor	*Z*	*p*
Intercept	2.50	0.013
Experimental condition	−2.29	0.022
Environmental identity	−0.47	0.642
Recycling norms	1.15	0.250
Deposit norms	−2.28	0.023
Recycling intentions	0.67	0.505
Deposit intentions	−0.31	0.756
Recycling habits	−1.38	0.168
Deposit habits	0.85	0.393
Previous experience of deposit collection tubes	−2.66	0.008
General waste sorting errors	−0.70	0.483

collection tube. A reusable sports water bottle in plastic was placed in the blue collection tube.

4 | Discussion

The blue/experimental deposit collection tube improved waste sorting behavior as fewer participants sorted the refundable bottles/cans incorrectly with this collection tube present, compared to when the gray/conventional deposit collection tube was present in the room. Our experimental approach provides strong evidence for a causal effect of waste bin design on waste sorting behavior, with greater internal validity and control over extraneous factors than previous studies on this topic (Leeabai et al. 2021; Linder et al. 2023; for a review, see Högberg and Sörqvist 2026). Field studies conducted in public settings often have less control over extraneous factors, such as the type of waste people carry with them, people's attitudes and experience, social influence, and distractions that can affect the way people use waste bins. By standardizing the conditions, instructions, decision context, and measuring and statistically controlling individual differences, potential confounds were largely eliminated in the present study.

A number of previous studies have demonstrated the importance of waste bin design on recycling behavior (Abdel Sater et al. 2023; Duffy and Verges 2009; Högberg and Sörqvist 2026; Leeabai et al. 2021, 2022; Linder et al. 2023). Some of these studies have shown that the physical shape of the waste bin can influence how the bin is used (Leeabai et al. 2022) and whether it is used as intended (Duffy and Verges 2009).

Our study focused primarily on color as the aspect of waste bin design. Linder et al. (2023) also studied the effects of waste bin color. Consistent with our results, they found that eye-catching orange waste bins were used more frequently than gray waste bins. Abdel Sater et al. (2023), in turn, found that a blue waste bin has superior visibility to gray waste bins. In our study reported here, participants showed higher noticeability of the blue deposit collection tube than of the conventional gray deposit collection tube. Taken together, this allows us to reliably conclude that waste bin design influences waste bin behavior and that waste bin's noticeability is a primary factor underpinning this effect. However, Leeabai et al. (2021) found that lower color preference can increase waste separation accuracy, contrary to our findings. The authors argued that low noticeability can help waste separation because waste bins with low noticeability require more effort. Future research should disentangle these possibilities and explore if the positive effects of noticeability on waste separation found in the present study are mediated by the effort that is required to sort the waste appropriately.

Moreover, our findings do not align with results reported by Catlin et al. (2021) and Rosenthal and Linder (2021) regarding

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overinclusive recycling. In our study, only one error was made in the deposit collection tube. A reason for this discrepancy could be that the design and shape of the deposit collection tube are very specific and do not have the appearance of a regular waste bin. Thus, its appearance alone signals that it is intended for a specific purpose and therefore counteracts overinclusive recycling. A very specific design, together with the yellow signs, can provide participants with enough information to make the right decision quickly.

4.1 | Implications for Policy and Waste Bin Design

Participants were not told specifically about the purpose or meaning of the deposit collection tube prior to conducting the waste sorting task. This is an important feature of our experimental design, as it allowed us to test how well the collection tubes' design informs people about their function and purpose through perceptual affordance (cf. Gibson 1979). A good collection tube design should arguably be self-explanatory with regard to its use and make the collection tube noticeable, especially in public outdoor environments where pedestrians and visitors should preferably not have to rely on written instructions or be taught how to use the devices. Our results show that the blue/larger deposit collection tube gains its advantage through its superior design features and improves waste sorting behavior without explicit instructions or external guidance.

This conclusion is further reinforced by an analysis of participants' previous experience with deposit collection tubes. Such experience could affect how easily they noticed the collection tube in the room, how to make use of it and, consequently, improve waste sorting behavior. The blue/larger collection tube was superior despite the fact that participants' prior experience of deposit collection tubes was similar in the two conditions. If anything, participants in the gray condition reported slightly higher previous experience than those in the blue condition.

The higher noticeability of the blue deposit collection tube compared to the gray one can be interpreted in light of Wickens' SEEV model of attention (Wickens 2021). According to this framework, salience is a key determinant of attentional capture. The gray collection tube, designed to blend into the urban environment, is visually less prominent and therefore more difficult to detect. In contrast, the more vibrant color of the blue (and yellow) collection tube increases its visual salience, allowing it to stand out from the surroundings and more readily attract attention. In addition, object size is another factor influencing attention (Wickens 2021). In the present study, the blue collection tube was also substantially larger, which likely further enhanced its visibility. Taken together, these findings suggest that if the goal is to promote deposit return behavior, a more visually salient design is preferable to a discreet one.

The System Usability Scale (SUS) results suggest that the deposit collection tubes can be considered passable rather than highly usable, according to the acceptability descriptions in Bangor et al. (2008). Given the nature of this type of product, it is important that it is designed to be intuitive and easy to understand. However, the findings indicate that the collection tubes were perceived as somewhat inconsistent and awkward to use.

One possible explanation is that the collection tubes differ conceptually from more conventional deposit or waste collection systems. Traditional deposit containers are typically designed for one-way input (i.e., depositing items), whereas the collection tubes in this study are intended to support both depositing and retrieving bottles and cans. This dual-function design may not be immediately apparent to users. In standard waste management systems, items are collected by municipal waste services, whereas in this case the system relies on other citizens retrieving the deposited items for recycling. If users are not familiar with or do not fully understand this concept, the collection tubes may be perceived as inconsistent with prior experiences and, consequently, awkward to use. From this perspective, the observed usability issues may not solely reflect shortcomings in the physical design, but rather a lack of user familiarity with the underlying concept.

The present paper also has some further policy implications. It is important to take color and design of waste bins into account in urban planning. For deposit collection tubes (and for other waste bins in public spaces) to reach their full potential, they should be designed with high noticeability, despite noticeability's tradeoff with having waste bins blend in with the surrounding. However, with high noticeability comes a larger risk for overinclusive recycling, especially if the waste bin's purpose is misunderstood. In our experiment, only one participant put one wrong item in the blue collection tube. There was no case of overinclusive recycling with the gray collection tube. It was perhaps the higher noticeability of the blue collection tube that led to this instance of overinclusive recycling. In any case, the effect was very small. Furthermore, whether the instance of overinclusive recycling was due to unclear design of the deposit collection tube, misunderstood instructions, or mistaking a regular plastic bottle for a refundable PET bottle is unclear. However, when noticeability is increased, it is also important to make sure the bin is properly understood without prior experience or excessive instructions, even to first-time users and tourists who might not be familiar with localized cues. This can be achieved with clear signs or symbols on the deposit collection tube, which make its purpose explicit and guide people to the appropriate waste sorting behavior (Catlin et al. 2021; Rosenthal and Linder 2021).

4.2 | Limitations and Future Studies

We decided to conduct a strong experimental manipulation of waste bin (deposit collection tube) design and compare two quite different collection tubes. This was done in order to increase the likelihood of obtaining an effect on performance in our novel waste separation task. However, this was done at the cost of not isolating the variable responsible for the blue deposit collection tube's advantage. Multiple attributes (e.g., color, size, and symbols) were manipulated simultaneously, which makes it impossible to identify precisely which factor explains the effect. Our choice represents a first step toward isolating a causal effect of waste bin design on people's waste sorting behavior. As a next step, it would be interesting to examine each attribute individually and systematically, in order to determine which factor has the greatest effect. Future studies could also study how these factors interact. For example, color alone might increase noticeability and frequency of waste bin use, but it's only with proper symbols that overinclusive recycling is also avoided. The importance of

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noticeability might also vary with the location of the waste bin. Location (e.g., the distance between the user and the waste bin) is one of the main factors that influence waste bin use (Högberg and Sörqvist 2026; Zhang et al. 2016). Future studies could explore how distance and strategic placement interact with waste bin noticeability. Noticeability probably becomes increasingly important as distance increases or waste bins are placed outside natural walking paths. One way of exploring this could be with an experiment with a design inspired by Hadjichristidis et al. (2025) where recycling behavior was measured inconspicuously.

We introduced a time limit as a methodological choice. It is possible that the effect of waste bin design on sorting error would be different if the time limit changed. For example, more (or even unlimited) time would allow for more careful and thoughtful sorting behavior. Under such circumstances, it is possible that waste bin design, especially noticeability, matters less. One possibility is that noticeability only plays an important role when people want to (or are instructed to) get rid of their waste swiftly. Such time demands are often present in public spaces. The presence of time pressure in the experimental design of the present study therefore arguably increases the experiment's ecological validity. However, future research could explore whether time pressure and waste bin noticeability interact on waste sorting behavior, such that the beneficial effect of noticeability is only found when time pressure is low.

The geographic and cultural localization of the present study might be another source of constraint on generalizability. In Sweden, the refund system is well-established and widely known, and the general population demonstrates relatively high levels of recycling knowledge. The results might look different in other countries where people are less knowledgeable of waste sorting in general, and bottle/can refund in particular. Our results show that waste bin design matters in a context where knowledge is high. Design factors that can help people sort their waste accurately, such as noticeability, are expected to be even more important when people are less knowledgeable. Also, in outdoor public environments, where individuals are often on the go and under time pressure, cultural differences such as knowledge might matter less. Instead, time might be the crucial factor. Under hasty circumstances, even with good knowledge about recycling, people might act sloppily and misplace refundable bottles/cans, and our results suggest that an appropriately designed waste bin can then be helpful.

5 | Conclusions

The results in this study provide strong evidence for the claim that waste bin design really matters and can influence waste sorting behavior even when people are not given instructions about how to use the waste bin beyond what is conveyed by its design. The study also highlights that noticeability is one of those design factors that appears to be particularly important. This is highly relevant for key stakeholders to take into account when working with waste management in urban areas. While the effects of design factors may vary across contexts, our findings show that design matters even in populations where knowledge is high concerning how specific waste items should be separated. Design factors likely matter even more when knowledge is low, a question that can be addressed in future studies, for example by using the waste separation task introduced here.

Author Contributions

Anna Högberg: conceptualization, methodology, software, formal analysis, investigation, resources, data curation, visualization, writing – original draft, writing – review and editing. **Camilla Grane:** methodology, writing – original draft, writing – review and editing. **Patrik Sörqvist:** conceptualization, methodology, formal analysis, writing – original draft, writing – review and editing, supervision, funding acquisition, project administration.

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Ethics Statement

The study was reviewed by the Swedish Ethical Review Authority (Dnr 2025-01961-01).

Consent

All participants gave their informed consent prior to participation.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data for this article are publicly available in the Open Science Framework (OSF) database and can be accessed at https://doi.org/10.17605/OSF.IO/6VDEX.

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