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Effects of bin proximity and informational prompts on recycling and contamination

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ABSTRACT

This between-subjects experiment manipulated the proximity of a waste bin relative to a recycling bin and the presence of information about why and how to rinse recyclables. After completing a yogurt taste test, 272 undergraduate students disposed of their plastic tasting cups in either a waste bin or a recycling bin. Binary logistic regression showed use of the recycling bin roughly tripled when the waste bin was made less convenient by moving it away from the tasting area ($p < .001$, Nagelkerke $R^2 = 0.54$). Univariate ANOVA showed the contamination level of recycled items was lower when an informational prompt indicated how clean recyclables need to be ($p < .001$, $\eta^2_p = 0.08$), but not when it indicated why rinsing is important. These findings showcase how manipulating the physical environment can be a powerful tool to steer behavior and how tailored information can complement physical changes to promote proenvironmental actions.

1. Introduction

Most current environmental problems are related to human behavior, and environmental sustainability requires behavioral changes (Steffen et al., 2015; Steg and Vlek, 2009). Environmental policy efforts often target raising awareness and changing how people think about the environment, but even when individuals have proenvironmental attitudes or intentions, they do not always engage in proenvironmental behaviors (Kollmuss and Agyeman, 2002). Recent research has emphasized how the careful design or manipulation of the physical environment can be an effective, albeit underutilized, intervention to steering behavior and reducing that gap (Kaaronen, 2017; Sörqvist, 2016).

In the context of recycling, an effective intervention is to make recycling easier. Research has shown the use of recycling bins increases when the bins are made more immediately accessible at the point of behavioral decision (DiGiacomo et al., 2018; Miller et al., 2016), often by placing them adjacent to waste bins (Zhang et al., 2016). But what happens if the waste bin is made less immediately accessible relative to the recycling bin? Such a scenario would deviate from typical bin arrangements and might encourage recycling by disrupting environmental factors that automatically cue habitual non-recycling (Verplanken and Wood, 2006). That question does not appear in the recycling literature and is a central question of the current research.

Moving the waste bin away from the point of behavioral decision may encourage people to recycle, but it may backfire if the recycling contamination rate increases (De Young et al., 1995; DiGiacomo et al., 2018). This is a known issue in Singapore, where we conducted this research. Despite the government's ongoing efforts to make recycling easier, as much as half of the items people recycle are contaminated and end up being incinerated (Boh, 2016). The public waste collectors will send even lightly contaminated items for incineration rather than recycling (R. Cheah, personal communication, 2 March 2019), so if people in Singapore wish to recycle effectively, they must first clean their recyclables.

Providing people with relevant information at the decision point may help them recycle correctly (Miller et al., 2016). Interventions often use informational prompts to achieve this (Osbaldiston and Schott, 2012; Rhodes et al., 2014), and information may be more effective when environmental factors disrupt habits (Verplanken and Wood, 2006). The current study is interested in two kinds of information that can appear in prompts. The first is *declarative* information about why a behavior is important for resolving a problem. The second is *procedural* information related to how individuals can perform the behavior. We are interested in how such information can supplement the placement of bins, so people not only use the recycling bin more but do so correctly. The

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following sections review prior research on bin proximity, declarative information, and procedural information.

2. Literature review

2.1. Proximity and affordances

While studying as an undergraduate, the lead author experienced a memorable learning moment. During a lecture, his professor said, "If you want people to sign your petition, you need to give them a pen." The idea was simple but powerful: people are much more likely to do what you want if you make it easy for them.

Simplifying a behavior is an effective way to promote it, and if a target behavior is made to be easier than an alternative behavior, the desired change is likely to follow (McKenzie-Mohr and Schultz, 2014). In a meta-analysis of environmental behavior experiments, Osbaldiston and Schott (2012) found "making it easy" was an especially promising tool for getting people to recycle. That kind of intervention often involves changing the environmental parameters of a choice context. Scholars have described those parameters as affordances, or the "possibilities for action provided to an animal by the environment—by the substances, surfaces, objects, and other living creatures that surround the animal" (Rietveld and Kiverstein, 2014, p. 327). The concept of affordances is useful for understanding human behavior in relation to the physical environment (Gibson, 1979). Different environments and objects within environments can afford several actionable features and possibilities for individuals using those environments.

Accounting for affordances helps in identifying leverage points to create more powerful behavioral interventions (Duffy and Verges, 2008; Kaaronen, 2017). In the context of recycling, the relative positioning of recycling and waste bins alters what the environment affords individuals and influences their decisions of whether to recycle or not. Examples of this include households recycling more when they have access to curbside recycling (Domina and Koch, 2002), office workers recycling more paper when recycling bins are located inside their offices (McKenzie--Mohr, 2011), and individuals recycling more when recycling bins in public areas are placed more accessibly (DiGiacomo et al., 2018; Zhang et al., 2016). Those studies involved the positioning of recycling bins, finding there was more recycling when bins were closer to the point of behavioral decision. In terms of affordances, a distant recycling bin preferentially afforded using the waste bin. Moving the recycling bin closer created more balanced affordances for using either bin. We extend that intervention by considering what happens when, rather than moving the recycling bin closer, we move the waste bin further away. That would make using the waste bin less convenient and create a preferential affordance for recycling. Thus, we expect that when the waste bin is moved away from the point of behavioral decision, individuals will use the recycling bin more than when the waste bin is co-located with the recycling bin (Hypothesis 1).

2.2. Informational prompts

Affordances can help people perform more of a behavior, but do not ensure they are motivated to perform it or able to perform it correctly. There may be a need for informational prompts to support behavior change (Austin et al., 1993; Osbaldiston and Schott, 2012). Prompts are a communication tool commonly used in social marketing to encourage proenvironmental behaviors. They are simple, conspicuous reminders to perform a behavior placed at the point of behavioral decision (Cole and Fieselman, 2013; McKenzie-Mohr and Schultz, 2014).

There are studies of prompts in the contexts of many environmental behaviors, including litter prevention (Durdan et al., 1985), composting (Sussman et al., 2013), water conservation (Aronson and O'Leary, 1982), energy conservation (Tetlow et al., 2014), and recycling (Miller et al., 2016; Werner et al., 2009). Although simple reminders can be effective (e.g., Werner et al., 2009), prompts may be especially effective when they provide certain kinds of information. For example, Durdan et al. (1985) found cafeteria patrons were more likely to clear their tables when prompts emphasized being helpful than when they emphasized not littering.

2.3. Declarative and procedural information

The current study is interested in informational prompts emphasizing the why and how of recycling. When prompts or other kinds of messages extoll the benefits of engaging in a behavior, they convey declarative information about why the behavior is effective or essential toward achieving desired ends. That kind of information is important because people do not always know why a behavior is desirable and have a limited basis for comparing it to alternative options, including inaction (Kaiser and Fuhrer, 2003). As a result, people who receive declarative information about a behavior may become more motivated to adopt it or feel more justified in their existing behavior (Trumbo and O'Keefe, 2005).

When people are motivated to act, their ability is a good predictor of their behavior (Ajzen, 1991). Messages describing or clarifying how to perform a behavior can help people improve their ability. These kinds of messages convey procedural information, which may be especially effective when individuals have uncertainty about what it takes to perform the behavior correctly. There is evidence seeking procedural information helps close the intention-behavior gap in the context of recycling because it is positively related to behavioral control (Rosenthal, 2018).

2.3.1. Effects on recycling. It may seem intuitive declarative and procedural information would motivate people to engage in a behavior. However, information about why and how to rinse recyclables will not necessarily lead to more recycling when people can easily choose not to recycle. By emphasizing the importance of behaving in a certain way, declarative information may create concern over doing the wrong behavior or anticipated effort to do the behavior correctly. Procedural information can help guide the behavior of individuals who are concerned about doing the wrong behavior, but it can also inhibit action by emphasizing the amount of effort required. Given those potentially competing effects of information, we ask a first research question: When recycling and general waste bins are co-located, how does declarative and procedural information about rinsing affect the recycling rate?

2.3.2. Effects on rinsing. The main interest of this study is what happens when the physical environment preferentially affords using a recycling bin over a waste bin. If there is no information about the contamination issue, not only should the recycling rate increase, but also the contamination of recyclables. How can the design of an informational prompt reduce that effect? We expect declarative information will result in more rinsing but are unsure if it will lower the overall contamination level. This is because the declarative information may give individuals the motivation to rinse, but it does not explain how to rinse sufficiently. Thus, we ask a second research question: When the waste bin is moved away from the point of behavioral decision, what effect does declarative information have on the contamination level of items in the recycling bin? On the other hand, we expect procedural information will reduce contamination because it shows how much rinsing is enough. Thus, when the waste bin is moved away from the point of behavioral decision, the contamination level of items in the recycling bin will be lower when the prompt includes procedural information about rinsing (Hypothesis 2). Yet, individuals who learn how to properly rinse recyclables will be especially more likely to rinse when they also learn why rinsing is important. Thus, the effect of procedural information will be stronger when the prompt also contains declarative information about rinsing (Hypothesis 3).

3. Method

After obtaining approval (IRB-2019–02–009) from the Institutional Review Board at Nanyang Technological University, Singapore, we conducted a 2 (co-located bins vs. distant waste bin) × 2 (absence vs. presence of declarative information) × 2 (absence vs. presence of procedural information) between-subjects factorial experiment. To guide the development of the experimental intervention, we followed recommendations from the community-based social marketing framework and conducted a qualitative pilot study to gain insights on barriers to recycling (McKenzie-Mohr, 2011). This part of the study involved two focus group discussions with a total of 10 undergraduate students. Barriers to recycling included inaccessibility of bins, habits, subjective norms, and unclear benefits of recycling. Barriers to rinsing recyclables included inaccessibility of rinsing facilities and low awareness of the need to rinse. These results justified the experimental focus on bin proximity and declarative information. They also guided the design of informational prompts to include a general statement about a recycling norm. Appendix 1 contains additional details about the procedure and results of the pilot study.

3.1. Sample

We recruited participants for the experiment by sending email invitations to a random sample of 4000 undergraduate student email addresses. The invitation stated individuals would receive 10 Singapore dollars for participating in a "yogurt drink taste test" study, with no mention of recycling or rinsing. This resulted in 409 participants. We removed three participants who did not consent to us using their recycling data after being debriefed and five participants who learned of the recycling focus of the study prior to completing it. In addition, two participants did not put their cups in either bin—one left it on the counter, and one took it from the laboratory—which we had to treat as missing data and delete list-wise. List-wise deletion is appropriate when the number of missing values is below five percent (Rosenthal, 2017). This resulted in 399 participants. At the end of the experimental sessions, participants responded to the statement, "At the taste test area, there was a poster encouraging recycling." We excluded 127 participants who indicated "neither agree nor disagree," "disagree," or "strongly disagree" because those responses suggested they were inattentive during the study. The final sample ($N = 272$) ranged in age from 19 to 28 ($Mdn = 22$) and was 62% female. Most participants were ethnic Chinese (88%), with smaller proportions of ethnic Malay (4%), Indian (4%), Eurasian (1%), and "other" (3%). We did not collect any other demographic information.

3.2. Procedure

Sixty-three experimental sessions took place two consecutive weeks in March and April 2019. Each session took up to 30 min and had up to nine participants. We rotated the sessions so each of the eight conditions had an equal number of morning and afternoon sessions.

Each experimental session had three stages. First, participants arrived at the laboratory's foyer, where they reviewed and signed the information and consent form (Appendix 2) and completed a brief pre-survey (Appendix 3) related to the taste test study. Participants under the age of 21 ($n = 23$)—which is the age of majority in Singapore—were also required to obtain consent from a parent or guardian.

Next, participants moved to the taste test room. There, a researcher gave a scripted explanation of the taste test procedure. This was a variation of the scissor testing task, which prior researchers have used to create paper waste and induce recycling behavior (Catlin and Wang, 2013; Zhang et al., 2016). It allowed us to observe actual recycling behavior, which scholars have long called for (Osbaldiston and Schott, 2012; Steg and Vlek, 2009). We used a taste test rather than a scissor test because the yogurt drink left a visible residue on the cups to induce rinsing behavior. We are unaware of prior research using this approach to study contamination. One at a time, participants received a 2.5-ounce plastic cup half-filled with a yogurt drink. They were directed into a private tasting booth containing a counter with sink, the waste bin, and the recycling bin. There was also a recycling prompt affixed to the wall above the recycling bin, a stack of taste test questionnaires on the counter, and an empty yogurt drink bottle for participants to examine. Participants were instructed to drink the sample, fill out the questionnaire, and dispose of the tasting cup. The research assistant explained the private booth was to prevent participants from influencing each other in the taste test. In truth the main reason was to minimize social desirability bias and social norming of recycling in front of other people.

Finally, after exiting the tasting booth, participants received a link to an online survey, which included demographics items, intervention checks, and a debriefing statement revealing the true purpose of the study. They completed the survey using their own smartphones and received their incentive payment.

3.3. Interventions

3.3.1. Waste bin location

This intervention varied the proximity of the waste bin at the point of behavioral decision (see Fig. 1). In the "co-located bins" condition, the recycling and waste bins were located next to the sink and adjacent to each other. In the "distant waste bin" condition, the waste bin was moved roughly three meters away and placed behind a small partition wall immediately inside the tasting booth, but clearly visible to participants entering the booth. As we noted, this is in contrast with prior interventions that varied the location of recycling bins (e.g., Domina and Koch, 2002; Miller et al., 2016; Zhang et al., 2016). It is perhaps most similar to what Austin et al. (1993) used in a field intervention comparing two academic departments at a university. One department had co-located bins plus an additional waste bin located in the corner of the room. The other department had bins separated by roughly four meters, which the researchers co-located after several sessions. The current intervention creates the more extreme but still plausible case where the waste bin is the less proximal option at the point of behavioral decision.

3.3.2. Declarative and procedural information

This intervention created different recycling prompts with declarative and procedural information about rinsing (see Fig. 2). The basic version of the prompt included a descriptive normative statement about "more and more" students recycling and a simple call to "please recycle responsibly." We included the normative statement to help overcome the barrier of a non-recycling descriptive norm. We chose the phrasing of the call to action so it would be compatible with the information related to rinsing but still make sense in the context of general recycling.

There were three additional versions of the prompt containing only declarative information, only procedural information, and both kinds of information. The declarative information stated dirty recyclable items can contaminate other items in the recycling bin and contaminated items cannot be recycled. The procedural information used a three-item photo series as a visual guide about how clean recyclables need to be. We based the visual guide on feedback we received after consulting with Singapore public waste collectors and the National Environment Agency. We designed the declarative and procedural information to make equal sense separately and in combination. Although prior research has not used this combination of declarative and procedural information in recycling prompts, the general design and placement of the prompts was similar to prior interventions (e.g., Austin et al., 1993; Miller et al., 2016).

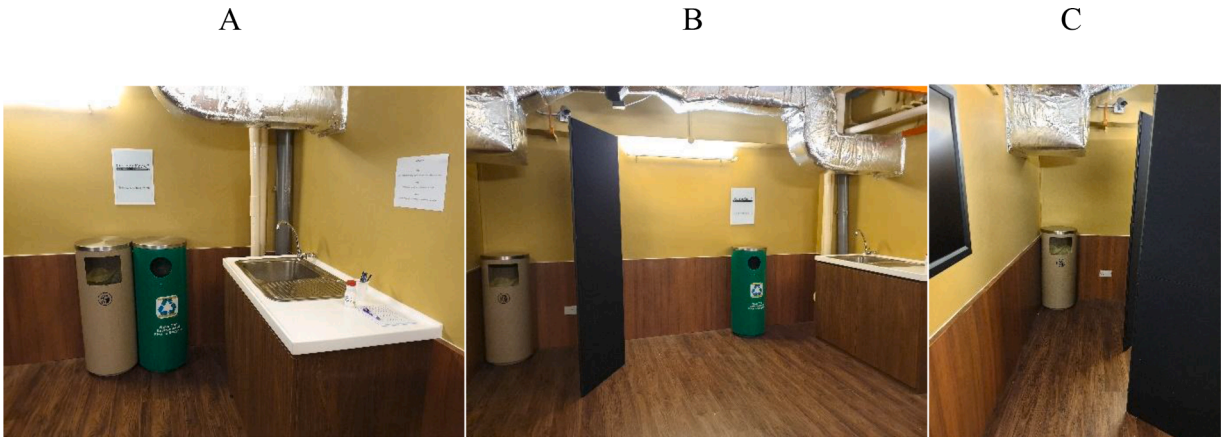

Fig. 1. The tasting booth with co-located bins (panel A) and a less immediately accessible waste bin (panel B). In the latter condition, the rubbish bin is clearly visible upon entering the tasting booth (panel C).

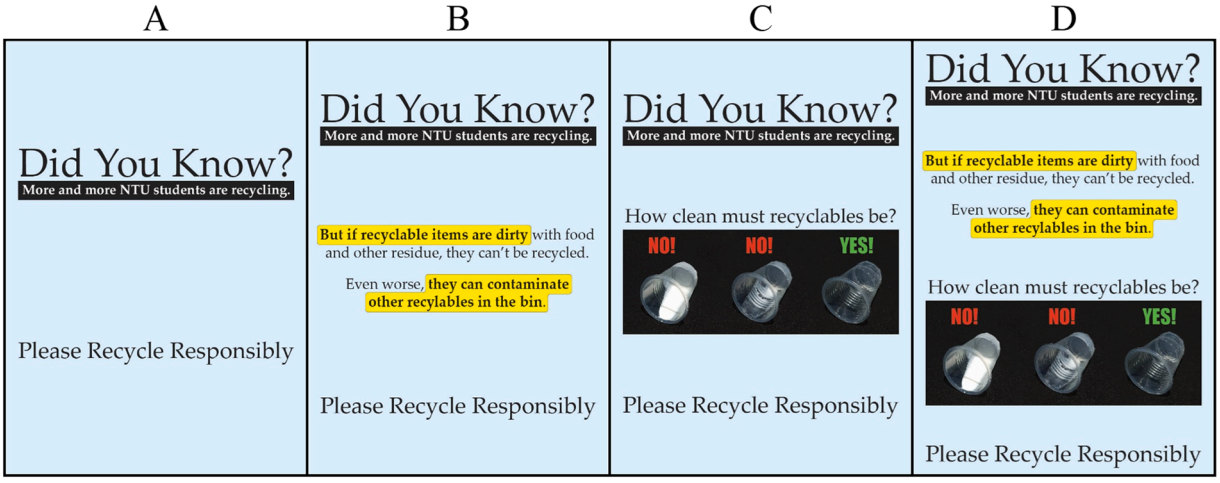

Fig. 2. Four versions of the recycling prompt included the basic prompt (panel A) and the prompt with declarative information (panel B), procedural information (panel C), and both kinds of information (panel D).

3.4. Measurement

3.4.1. Recycling and rinsing behavior

At the end of each session, one of the researchers collected the used tasting cups from the bins and coded them based on which bin they were in and to what extent they were contaminated. The coding of bins was straightforward, with values of 0 (*waste bin*) and 1 (*recycling bin*). The coding of contamination had five levels. Fig. 3 shows the visual guide we used to score the contamination level. Because scoring was subjective, the two authors and a graduate research assistant separately evaluated the contamination level of 50 cups from the first day of experimental sessions. We assessed interrater reliability using Krippendorff's alpha (Hayes and Krippendorff, 2007), which showed good reliability (α = 0.92, 95% CI [.88, 0.96]).

3.4.2. Intervention checks

Since the effects of the declarative and procedural information involve cognitive processing, it was important to know if the participants perceived the information as intended. Therefore, participants indicated their level of agreement with two statements: "The poster described why contamination is a problem," and "The poster explained how to properly rinse recyclables." Response options ranged from 1 (*strongly disagree*) to 5 (*strongly agree*).

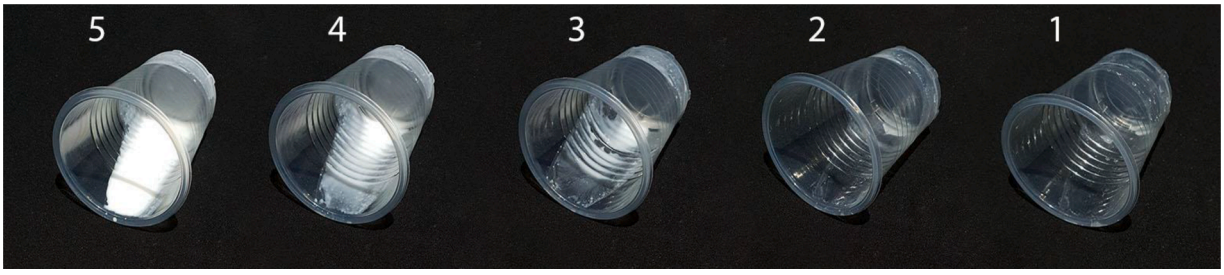

Fig. 3. Visual guide for scoring the contamination level.

4. Results

4.1. Intervention checks

We conducted all analyses in IBM SPSS Statistics version 27. We used independent samples *t*-tests to analyze the intervention checks. As expected, participants agreed more with the first statement when the prompt had declarative information ($M = 3.61$ $SD = 0.96$) than when it did not ($M = 2.81$, $SD = 1.11$), $t(270) = -6.40$, $p < .001$. Similarly, participants agreed more with the second statement when the prompt had procedural information ($M = 3.56$ $SD = 1.12$) than when it did not ($M = 2.95$, $SD = 1.12$), $t(270) = -4.54$, $p < .001$. These results suggest participants experienced the informational interventions as intended.

4.2. Descriptive summary

Overall, 69% of the sampling cups were in the recycling bin and those cups had moderate contamination ($M = 3.24$, $SD = 1.26$). Table 1 contains a descriptive summary of the recycling rates and contamination levels among the eight experimental conditions.

4.3. Hypothesis testing

Use of the recycling bin or waste bin was a binary variable. Therefore, we addressed Hypothesis 1 using binary logistic regression. In support of Hypothesis 1, there were higher odds of using the recycling bin over the waste bin when the waste bin was moved away from the point of behavioral decision, OR = 45.46 [95% CI: 18.51, 111.61], Wald $\chi^2 = 69.36$, $p < .001$, Nagelkerke $R^2 = 0.54$. When the two bins were co-located, 35% of participants recycled. When the waste bin was moved behind the partition, 96% recycled.

To answer the first research question, we analyzed only data from when the two bins were next to each other ($n = 121$). Results showed the odds of using the recycling bin over the general waste bin were unrelated to the presence of declarative information, OR = 0.98 [95% CI: 0.46, 2.08], Wald $\chi^2 = 0.002$, $p = .964$. Similarly, the odds of using the recycling bin over the general waste bin were unrelated to the presence of procedural information, OR = 1.31 [95% CI: 0.61, 2.77], Wald $\chi^2 = 0.49$, $p = .486$. The main effects model explained less than 1% of the variance, Nagelkerke $R^2 = 0.006$. We also modeled the interaction of declarative and procedural information. Results showed there were higher odds of using the recycling bin over the general waste bin when the prompt included only procedural information than when it included neither type of information, OR = 0.18 [95% CI: 0.04, 0.84], Wald $\chi^2 = 4.76$, $p = .029$, Nagelkerke $R^2 = 0.06$ (Fig. 4).

We addressed the second research question and Hypotheses 2 and 3 by analyzing the contamination level of cups in the recycling bin when the waste bin was moved behind the partition ($n = 145$). Looking only at the items in the recycling bin makes practical sense: whatever the contamination level of items in the waste bin, they will not be recycled. Given the ordinal measurement of the contamination level, we used ANOVA and report cell means.

In answering the second research question, we found the main effect of declarative information on the contamination level was not significant, $F(1, 142) = 0.44$, $p = .507$. In support of Hypothesis 2, the main effect of procedural information on the contamination level was significant, $F(1, 142) = 11.65$, $p < .001$, $\eta^2_p = 0.08$. Contamination was lower when the prompt included procedural information ($M = 2.96$, $SD = 1.40$) than when it did not ($M = 3.66$, $SD = 0.91$). Failing to support Hypothesis 3, the interaction of declarative and procedural information was non-significant, $F(1, 141) = 0.003$, $p = .957$.

Although there was support for Hypothesis 2, the analysis did not show if the effect of procedural information on the contamination level was stronger when the waste bin was moved away than when the bins were co-located. We conducted an additional analysis of items in the recycling bin for both waste bin locations ($n = 187$) to see if this was the case. The interaction between the presence of procedural information and the location of the waste bin was not significant, $F(1, 183) = 0.11$, $p = .743$. The pattern of cell means (Fig. 5) suggest the presence of procedural information resulted in a lower contamination level when the waste bin was moved away but was unrelated to the contamination level when the bins were co-located. Furthermore, the effect of procedural information on the contamination level was not different between the two bin location conditions, which the non-significant interaction indicates.

5. Discussion

We studied how features of the physical environment can support behavior and how, for some behaviors, information helps people perform the behavior correctly. As expected, we found that making a waste bin less immediately accessible than a recycling bin increased the recycling rate. In that condition, contamination of recycled items was lower when the recycling prompt included procedural information about how clean the items need to be. This is an important finding because getting people to use recycling bins more may backfire if the items they recycle are contaminated. Below we discuss the significant findings and briefly address some null findings.

5.1. Affording recycling

Our study showed a subtle manipulation of the physical environment can generate a big change in behavior. By moving the waste bin away from the point of behavioral decision, we changed what the environment afforded the study participants for disposing of their tasting cups. We see a parallel between this intervention and the ways behavioral scientists use inconvenience to shift the default option. In the behavioral economics literature, the default option is the one individuals take if they do not actively opt-out of it and pursue an alternative option (Johnson and Goldstein, 2003). Whereas the waste bin was always accessible, using it when it was moved away involved a minor inconvenience of carrying the tasting cup a few extra steps. We suggest this minor inconvenience made using the recycling bin the default option in that situation. Similar effects have appeared in other contexts, for

Table 1
Descriptive summary of experimental results.

Waste Bin Location	Declarative Information	Procedural Information	Cell Size (*n*)	Cups in Recycling Bin (%)	Contamination Level *M* (*SD*)
Co-Located	No	No	31	23	3.00 (1.41)
Co-Located	No	Yes	32	47	2.73 (1.34)
Co-Located	Yes	No	29	41	3.67 (1.07)
Co-Located	Yes	Yes	29	28	3.13 (1.36)
Moved Away	No	No	34	97	3.73 (0.84)
Moved Away	No	Yes	43	95	3.02 (1.35)
Moved Away	Yes	No	34	91	3.58 (0.99)
Moved Away	Yes	Yes	40	100	2.90 (1.46)

Note. The first three columns indicate the experimental conditions. The last column indicates the contamination level of the tasting cups from only the recycling bin.

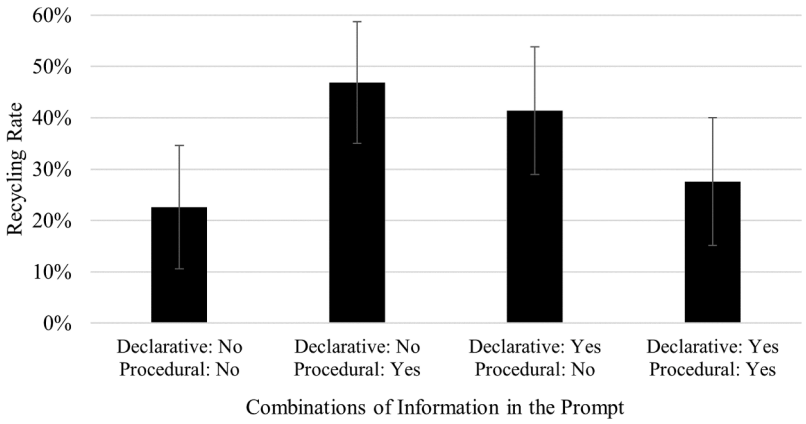

Fig. 4. The effects of declarative and procedural information on the recycling rate when the bins were co-located. The error bars show the 84% confidence intervals of the point estimates. We used 84% confidence intervals to allow for a direct comparison of differences at approximately $p = .05$ (see Payton et al., 2003).

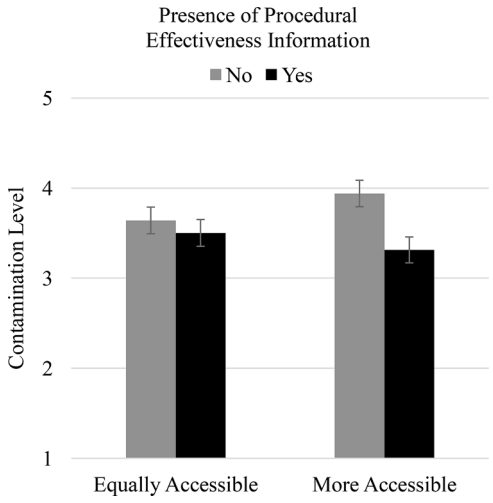

Fig. 5. The interaction of bin location and the presence of procedural information on contamination level among items in the recycling bin. The error bars show the 84% confidence intervals of the estimated marginal means. See the Fig. 4 caption for why we used 84% confidence intervals.

example getting office workers to stand at their desks by increasing the desk height (Venema et al., 2018) and reducing paper usage by changing office printers to print double-sided by default (Egebark and Ekström, 2016).

Furthermore, at the point of decision, the waste bin was out of direct line of sight, while the recycling bin was within an arm's reach. Because the waste bin was out of view, participants might have momentarily perceived the recycling bin to be the only option. Alternatively, the environment may have created the impression that recycling was the recommended option. When there is uncertainty about a behavior or if a decision is hard to make, a default option can often be perceived as the recommended action and act as a heuristic for choosing (McKenzie et al., 2006). This may be especially the case in the context of recycling, where uncertainty about practices is a common barrier to action (Nixon and Saphores, 2009; Prestin and Pearce, 2010). Our aim is not to resolve the mechanism of this effect, but simply to highlight that affordances of the decision situation matter.

The effect of bin location is important to point out because efforts to encourage recycling often try making it equally as convenient as not recycling. Certainly, co-located bins will result in more recycling relative to when the recycling bin is less conveniently placed than a waste bin (e.g., DiGiacomo et al., 2018; Zhang et al., 2016), but this is not necessarily the way to maximize the recycling rate. As the current findings showed, the recycling rate was only 23% when the two bins were co-located and there was a basic recycling prompt (see Table 1). This is similar to Miller et al. (2016), who found co-located bins led to more recycling, but not a large amount of recycling. Why was that the case? One explanation is many individuals habitually throw away recyclables. If there is nothing to disrupt their habit, they will often do it without conscious thought (Mazar and Wood, 2018; Verplanken and Wood, 2006). Furthermore, if an environment equally affords two behaviors, but the first one is tied to habit, adoption of the second one is unlikely.

It might also be some individuals are unsure if an item can be recycled, either because of questions about the material or an awareness of the contamination issue. In that case, some individuals might want to recycle but still choose the waste bin. One solution to either case is to make the waste bin less immediately accessible at the point of behavioral decision. For habitual non-recyclers, the change may be a disruption, forcing a more conscious appraisal of the situation. Some of those individuals may reflect on the situation and choose to recycle, while others may still opt for the waste bin despite it being less convenient. Of course, some of these individuals might use the recycling bin for general waste disposal, not realizing the bin is for recycling. For individuals with uncertainty about recycling, the change in the environment might simply nudge them toward recycling despite their reservations. Whatever the mechanism, the current results support the argument that explanations of proenvironmental behavior should account for the physical environment, which can be a powerful tool to steer behavior (see Sörqvist, 2016).

5.2. *Informational prompts*

Next, we examined the effects of declarative and procedural information separately on recycling and rinsing. Although the information focused on why and how to rinse, it is useful to understand how it may have affected decisions to use the recycling bin in the first place. The answer to our first research question showed participants used the recycling bin more when the prompt included only procedural information than when it included neither type of information. This is generally compatible with Miller et al. (2016), who found the use of informational prompts increased the use of recycling bins. However, that prior study did not differentiate between types of information, so we look to other scholarship for an explanation of the current finding. Research in cognitive psychology has described a procedural reinstatement principle (Healy and Bourne, 1995). Originally, it characterized procedural information as durable but lacking generalizability. When people gain procedural knowledge, they remember it for a long time, but its application is limited to specific tasks. Later, scholars extended the principle to also characterize declarative information as less durable and

more generalizable (Healy, 2007). That means people forget declarative information more quickly but more easily transfer that knowledge to other tasks (Lohse and Healy, 2012). This principle may explain the current finding. To the extent that participants sought to recycle responsibly, as the prompt encouraged, then the procedural information may have been specifically useful for the task of recycling. But the principle might also favor declarative information in this instance. Although the declarative information in the prompt encouraged rinsing of recyclables, it emphasized the problem of not recycling correctly. It is possible that participants used that information to draw inferences about the problem of not recycling at all. Our results do not support that latter view, but they do not directly contradict it, either. The procedural reinstatement principle would be a useful framework to guide future research in this area.

The answer to our second research question showed the presence of declarative information did not affect the contamination level. We asked a research question because we thought the presence of declarative information might have resulted in more, but incomplete, rinsing. For brevity, we offer one explanation of this null finding: participants may have already known why rinsing is important. If that were the case, then participants would have learned nothing new from the declarative information to guide their behavior. We are unable to test this idea because we did not measure prior knowledge of the contamination issue.

In support of Hypothesis 2, the contamination level was lower when the prompt included procedural information on how to rinse, but only when the waste bin was moved away. We think this was partly a learning effect: participants were more likely to rinse when they learned from the prompt at what level rinsing was satisfactory. This explanation is consistent with Rosenthal (2018) and Rosenthal and Leung (2020), who argued that individuals can better act on their intentions to recycle when they seek procedural recycling information. But also, moving the waste bin away may have disrupted participants' waste disposal routines, forcing more attention to the situation. Verplanken and Wood (2006) explained such interventions are effective in the contexts of routine behaviors because they "disrupt the environmental cues that trigger habit performance automatically" (p. 90). They also argued that informational campaigns are most effective when environmental disruptions make habits vulnerable to change. This argument is consistent with Betsch et al. (2001), who found when individuals with strong routines perform a behavior in a novel situation, they acquire more information disconfirming their routine. We used a post hoc analysis to test this argument. Including participants who failed the attention check, participants reported greater awareness of the prompt when the waste bin was moved away ($M = 3.98$, $SD = 1.18$) than when the waste bins were co-located ($M = 3.67$, $SD = 1.15$), $t(396) = -2.63$, $p = .009$. Although the intervention was subtle, moving the waste bin away may have been sufficient to disrupt routine use of the waste bin and increase the salience of the informational prompt.

Despite finding that contamination was lower when the waste bin was moved away and the prompt included procedural information, the post hoc analysis failed to show if that effect of procedural information was different from when the bins were co-located. When the recycling bins were co-located, only 42 out of 121 participants used the recycling bin. Given the small number of tasting cups that intervention group recycled, we believe the null finding is a type II error. Additional research using a larger sample, perhaps in a field experiment, could clarify if there is a differential effect of procedural information.

5.3. Ecological validity and caveats

As is common to laboratory experiments, our study's external validity was limited. First, the design provided an optimal situation for rinsing and recycling and there was a behavioral prompt. This scenario is unlikely in real-world settings: Prompts often appear in public spaces where rinsing facilities may be uncommon. People can rinse at home, but it can be a challenge getting residents to put up prompts and move their waste bins to inconvenient locations. Second, it is possible the relative effects of declarative and procedural information reflect idiosyncrasies of our sample. The current findings need to be replicated. Third, there were several instructions for completing the taste test study. These instructions may have made participants more cognizant of their behavioral decisions, especially since the final step of the taste test was to dispose of the cup, which may have disrupted any recycling-related habits. Fourth, although we moved the waste bin so participants would walk past it in the tasting booth, some might not have noticed it. Such inattention would artificially inflate the effect of moving the waste bin. Then again, that might be a true effect that would arise outside the laboratory when a disposal option is made less immediately accessible. Finally, removing participants who failed the attention check limits ecological validity because outside the laboratory not everyone notices informational prompts.

6. Conclusions

We conclude with a couple broad implications for design processes. First, physical environments should, as much as possible, afford desired behaviors over alternative behaviors. "Making it easy" can be an effective tool for behavior change (Osbaldiston and Schott, 2012), but if an alternative behavior is equally easy, the strategy might not result in the desired level of change. Reducing affordances for unsustainable behaviors, especially those tied to habits, might at times be a needed compliment and should be considered in design processes. For example, it is often the case recycling bins are not preferentially afforded but are merely co-located with waste bins. Designing physical environments to make waste bins less convenient may be necessary to see significant gains in recycling rates. This implication might be the most relevant to the planning of new construction, where accessible recycling and rinsing facilities are built-in. In such instances, the environment can support the desired behavior without environmental cues activating old behavioral responses (Verplanken and Roy, 2016; Verplanken and Wood, 2006). In other words, new construction is a window of opportunity for behavior change interventions. That assertion is beyond the scope of this study but is a logical extension of the current findings.

Second, when an environment preferentially affords a desired behavior, informational prompts at the point of decision may be a necessary supplement to ensure people perform the behavior correctly. As much as the environment needs careful design, so do the messages (Linder et al., 2018). For example, we found declarative information has limited usefulness for getting people to rinse recyclables. But this is probably a context-specific effect. When the desired behavior involves one or two simple steps, behavioral barriers might be more attitudinal and more likely to be resolved by providing information about why it is a good behavior to perform. There may also be a normative element tailored messaging could address. Considering the complexity of human behavior, message designers should be aware of why people fail to perform desired behaviors and choose the smallest set of information they think can directly attack those barriers. Future research testing different combinations of information in different behavioral contexts would support that message design process.

CRediT authorship contribution statement

Sonny Rosenthal: Conceptualization, Methodology, Funding acquisition, Project administration, Formal analysis, Data curation, Writing - original draft, Visualization. **Noah Linder:** Conceptualization, Methodology, Supervision, Investigation, Writing - original draft.

Declaration of Competing Interest

The authors have no conflicts of interest to disclose.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.resconrec.2021.105430.

Appendix 1: Pilot Study

Method

We recruited participants by placing flyers in halls of residence. Participants signed up using an online survey and received 20 Singapore dollars for participating in the focus groups. Each session lasted roughly 45 min. We conducted two focus group interviews with 10 participants who were evenly split between male and female and ranged in age from 21 to 30 years. The key discussion questions centered on barriers and motivations for recycling and rinsing recyclables on campus. Thematic analysis revealed several insights about barriers for recycling and rinsing on campus.

Results

We identified four main barriers to recycling. First, participants identified inaccessibility as a barrier, with one saying, "Living in the dorms… they do have segregation, but it's all the way down at the lobby, and people are too lazy to go down, myself included" (Participant 7). Another said, "I recycle when I see a recycling bin. I wouldn't walk 10 min in the sun to recycle" (Participant 1). This barrier justified our experimental focus on affordances and relative accessibility. Second, there was a common theme of needing to be reminded. One participant said, "I'm not aware of where the recycling bins are, and I don't want to walk around holding trash" (Participant 5). Another had more to say on that subject, remarking, "There is an unconscious line of thought that after an item is consumed… you don't need it anymore. I just want to throw it away, and when you don't see a visual it's hard to remind yourself to recycle" (Participant 3). This finding provided general support to our use of prompts. Third, participants noted a strong descriptive norm of non-recycling. Participants said things like, "Maybe half of one percent of items at campus gets recycled" (Participant 6) and "I can't even guess how much gets recycled because I so rarely see people recycle" (Participant 8). Based on this insight, we included a normative statement in our prompt design. Finally, some participants thought there was no pressing need for recycling, for example, "I have the impression that Singapore is now managing its waste quite well without recycling. They are burning to produce energy, for example. I like to know if you can make something better if I recycle" (Participant 1). This finding was indirectly related to our focus on contamination, which reduces the effectiveness of waste management.

We identified two barriers to rinsing recyclables. The first theme had to do with accessibility. Several participants commented about this, for example, "There is no way [to rinse], unless you find a toilet or bring it home to clean" (Participant 3). Another participant said, "If it's next to a recycling bin, a water stream, or a sink I might rinse. Otherwise, I would just use the regular trash" (Participant 1). Likewise, a third participant said, "If I consume something in a mall, why would I go to a restroom and wash it?" (Participant 7). This finding necessitated a sink or other means of rinsing recyclables in the experimental laboratory. The second theme had to do with a lack of awareness, which appeared in statements like, "I have never really thought about rinsing" (Participant 6) and "This is considered trash now, so why would you clean it before you recycle it?" (Participant 3). This was insightful, as it supported the use of informational prompts about rinsing, particularly the use of declarative information.

Appendix 2: Study Information sheet

Name of PI: Assistant Professor Sonny Rosenthal

Institution: Wee Kim Wee School of Communication and Information

Contact details: sonnyrosenthal@ntu.edu.sg; 6790 4070

IRB reference number: IRB-2019–02–009

Title of Study: Effects of package design elements on beverage preference

Objective: This is a taste-test study. We are interested in how label design elements influence product beliefs.

Procedures: In this study, you will sample a yogurt drink and provide your feedback about it. Before and after the taste-test, you will complete brief surveys that ask for demographic information and questions about your attitudes, values, beliefs, and behaviors. After completing the final survey, you will receive your incentive.

Right to Refuse or Withdraw: Your participation in this study is voluntary. You may choose to not answer any questions you do not wish to answer. In addition, you may withdraw from the study at any time without penalty.

Risks and Discomforts: There are no anticipated risks or discomforts associated with this study beyond those encountered in daily life.

Benefits: There are no direct benefits from participating in this study.

Compensation: You will receive $10 incentive for participating in this study.

Anonymous and Confidential Data Collection: Your participation in this study is anonymous. It is anonymous because we do not collect information that would allow someone easily identify you. In other words, your identity cannot be determined, not even by the researchers, from the information we collect in this study. The personal information you provided when you signed up for this study will not be linked with your study data.

Confidentiality of records: The anonymous data will be retained indefinitely on the password-protected cloud storage of the PI and co-investigators. In addition, the anonymous data may be uploaded to an online data repository, such as DR.-NTU. By uploading to a data repository, other researchers may access the data to perform secondary analyses. Data collected are the property of Nanyang Technological University.

Personal Data: The current data collection and handling complies with the Personal Data Protection Act. Because this study collects anonymous data, there are no personal data involved.

Whom to Contact with Questions: If you have any questions about this study, you may contact the principal investigator listed at the top of this information sheet. If you have questions or concerns about your rights as a participant, please contact the NTU Institutional Review Board as listed below. If you are contacting the IRB, please mention the IRB reference number listed at the top of this information sheet.

NTU Institutional Review Board
Research Integrity and Ethics Office
62 Nanyang Drive, N1.2-B1–02A, (S)637,459
Tel: +65 6592 2495; Email: irb@ntu.edu.sg

Consent Form

I have read, discussed and understand the information and procedures in the study information sheet attached to this consent form. My questions concerning the study have been answered to my satisfaction, and I acknowledge that I am participating in this study of my own free will. I understand that I may refuse to participate or stop participating at any time.

Appendix 3: Pre-Survey

How much do you agree or disagree with the following statements? (1 = *strongly disagree*, 5 = *strongly agree*)

1 Health means a lot to me.

2 I care a lot about health.
3 I do whatever I can to stay healthy.
4 Healthy food is important to me.
5 I am very involved in health issues.
6 It is important to me to have variations in my diet.
7 When I have questions on healthy nutrition, I know where I can find information on this issue.
8 It is easy for me to compose a balanced meal at home.
9 It is easy for me to order a balanced meal when eating out.
10 I am able to advise others about nutritional issues.
11 I am able to get advice from others about nutritional issues.
12 I am able to choose nutrition information relevant to me.
13 It is easy for me to judge the trustworthiness of nutrition information.
14 It is easy for me to evaluate health claims in food advertisements.
15 It is easy for me to judge the long-term health impacts of my dietary habits.
16 It is easy for me to advocate a healthy diet to others.

Below are some different sources of nutrition information. Please think about how much you trust each source and rank them from 1 (most trustworthy) to 10 (least trustworthy).

1 Family and friends
2 Food industry
3 Consumer organizations
4 Government
5 Scientists
6 Supermarkets
7 Doctors
8 Dieticians
9 Advertisements
10 News media

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