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A Take-Home Message: Workplace Food Waste Interventions Influence Household Pro-environmental Behaviors

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ABSTRACT

Previous research on food waste interventions has mostly focused on micro-level factors related to the individuals, and largely neglected macro-level contextual factors such as work-to-home spillovers. Inspired by the multi-level framework, we present a case study of how macro-level workplace campaigns could decrease food waste in staff cafeterias, compete with micro-level factors like environmental identity, and further stimulate some employees' food saving efforts at home. The workplace interventions combined smart bins with fortnightly informational feedback trialed in three staff cafeterias of a large hotel chain in Macau, China. Actual food waste data and self-reported behavior consistently show that the staff cafeteria receiving environmental framing with anthropomorphic cues had more reductions in food waste behaviors. A key determinant of self-reported food saving efforts at home was efforts to reduce food waste at work, which predicted beyond and above environmental identity and provided evidence for positive contextual spillover effects.

1. Introduction

Reducing food waste is key to improving the environmental sustainability of food systems and enhancing food security across the world. For example, in the wake of how Covid-19 disrupted food systems, President Xi Jinping launched the "Clean Plate Campaign" to tackle consumer food waste in China. Apart from signifying the importance of food waste as a national issue, it reflected the growing recognition that a significant amount of food waste comes from consumers' leftovers (Makov et al., 2020). The UNEP food index estimates around 931 million tonnes of food waste was generated in 2019, 61% of which came from households, 26% from food service, and 13% from retail (United Nations Environment Programme, 2021). There is much interest, therefore, in raising consumer awareness of saving food, and reduce wasteful consumer behavior.

There is an emerging literature on how behavioral interventions including informational and physical nudges can change consumer food choices (Garnett, Marteau, Sandbrook, Pilling, & Balmford, 2020; Mehrabi, 2020; Reisch et al., 2020; West et al., 2014). While similar efforts have been made to reduce consumer food waste, many scholars have called for more evidence on intervention effectiveness (Kallbekken & Sælen, 2013; Liu, Gomez-Minambres & Qi, 2022; Richardson, Prescott & Ellison, 2021; Stöckli, Niklaus & Dorn, 2018). There is, in particular, little evidence on whether food waste interventions could lead to behavioral changes in and beyond the immediate context (Clot, Giusta & Jewell, 2021).

The purpose of this article is to explore whether macro-level interventions implemented in staff cafeterias can help reduce food waste in the workplace and further facilitate pro-environmental behaviors in the household. To carry out the study, we collaborated with Winnow, a business specializing in measuring food waste through smart technologies, and Melco, a large hotel-casino chain in the hospitality sector in Macau, China.

Three staff cafeterias in different Melco hotels received smart bins and fortnightly informational feedback on the amount of food they wasted. We varied the type of feedback each site received to investigate if it can be communicated more effectively in some ways: feedback in site A solely illustrated how much food was wasted, whereas we framed feedback with environmental information without and with anthropomorphic cues (e.g., where the food icons had faces) in sites B and C respectively. In addition to actual food waste data, we collected an online survey of staff after the interventions were trialed. This combination of metrics enabled us to examine if actual food waste data corresponded with self-reported levels of effort to save food at work, and if there were

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any unintended impacts on efforts to reduce waste at home. The survey, importantly, also allowed us to identify micro-level psychological determinants (e.g., environmental identity, motivations, and beliefs) for saving food at work and home to analyze how they might interact with the macro-level contextual spillover effects.

The remaining parts of section 1 will present brief literature reviews about informational feedback interventions with environmental framing and anthropomorphic cues, as well as behavioral spillover effects in the context of food waste, to explain the rationale of our interventions and our study design. The data collection and the statistical methodology will then be outlined in section 2, followed by the results in section 3. We will conclude with a discussion of the results, the limitations, and the implications for future research in section 4.

1.1. Informational feedback, environmental framing and anthropomorphic cues

Informational feedback is a widely-used intervention proven to be useful in many other waste reduction contexts (Abrahamse, Steg, Vlek, & Rothengatter, 2005; Schultz, Oskamp, & Mainieri, 1995). The large hotel-casino chain, Melco, required us to provide food waste feedback to all sites involved as the basis of our collaboration. Since we did not have a control site that received no feedback at all, we were unable to examine if feedback itself could effectively reduce waste behaviors. Alternatively, we decided to investigate if other techniques from psychological and behavioral research may enhance the effectiveness of informational feedback.

The first technique we selected is environmental framing. Framing is a nudging technique which draws attention to a specific attribute, motivation or consequence from a given course of action. The impact of "goal framing" where the goal of an action or behavior is made salient (Levin, Schneider & Gaeth, 1998), has been used to motivate pro-environmental actions and spillover effects across related domains like energy conservation and food choice. Past research typically compares the effectiveness of environmental framing versus monetary framing by drawing attention to the environmental or monetary goals of conservation actions (e.g., reducing emissions or increasing financial savings) (Shreedhar & Galizzi, 2021; Steinhorst & Klöckner, 2018; Wolstenholme, Poortinga, & Whitmarsh, 2020). In the food waste domain, Chen and Jai (2018) found that environmental messages (e.g., "Reduce Waste for a Sustainable Future") led to more positive consumer attitudes towards preventing food waste in the restaurant than threat-focused monetary messages (e.g., "We Charge $5 per pound for Food Waste"), even though the effect on behavioral intentions was no significant. On the other hand, van der Werf and colleagues' (2021) curb-side collection-cum-information intervention emphasized that saving waste can save money (although they did not compare the impact of this framing with other framings): they found a significant (29%) reduction in avoidable food waste compared to a no-intervention control group, suggesting that monetary framing may sometimes be beneficial in food waste interventions.

Nonetheless, research also shows that people can judge a pro-environmental and profit-making organization more negatively than a company that pursed profit only (Makov & Newman, 2016), a consideration particularly relevant in our setting. Recall that we were trialing interventions in the workplace cafeterias of a large hotel-casino chain, where guests often wasted food at all-you-can-eat buffets. Furthermore, workers do not pay for their meals in staff cafeterias, so any savings from food waste reduction would not directly financially benefit them, but the company. At least in this specific scenario, monetary framing is likely to do more harm than good, so we chose to focus on the environmental impact of food waste only.

The second technique we chose is anthropomorphism. Anthropomorphism is defined as attributing human-like characteristics to non-human objects (Epley, Waytz, & Cacioppo, 2007). Past studies have found that anthropomorphic cues, such as facial expressions, can induce affective responses and make humans cherish the objects more (Chandler & Schwarz, 2010). Anthropomorphic cues have been unconsciously used alongside environmental framing by both pro-environmental activists and scientists (e.g., Dolnicar, Juvan, & Grün, 2020), indicating good compatibility between the two techniques. Indeed, previous research shows that anthropomorphic cues boost pro-environmental behaviors like waste-sorting (Ahn, Kim, & Aggarwal, 2014) and that anthropomorphism increases consumers' intentions to buy misshapen food products (Cooremans & Geuens, 2019; Shao, Jeong, Jang, & Xu, 2020).

Despite the wide range of studies on environmental framing and anthropomorphism in other domains like energy and food choices, there is no empirical research on whether they could jointly improve the effectiveness of informational feedback in reducing workplace food waste. To fill in this gap, we set out to test the following hypotheses in the current paper:

Hypothesis 1a. Environmental framing of food waste feedback leads to a greater reduction in food waste at work (compared to feedback framed with food waste only).

Hypothesis 1b. Environmental framing of food waste feedback with anthropomorphic cues leads to a greater reduction in food waste at work (compared to feedback framed with food waste only).

1.2. Contextual spillovers and food waste behaviors

There has been a growing interest in "behavioral spillovers" in both policy and academic research in recent years (e.g., Truelove et al., 2014; Dolan and Galizzi, 2015). "Spillovers" refer to the idea that the adoption of one behavior causes the adoption of additional, seemingly unrelated behaviors (Galizzi & Whitmarsh, 2019; Sintov, Geislar & White, 2019). In many cases, the initial behavior change arises from a behavioral intervention (although this may not be the case, e.g., in Maki et al., 2019). From a practical perspective, the possibility of behavioral spillovers is attractive because it enables us to change behaviors in a cost-effective manner by picking interventions that usher in the greatest effects on all desirable behaviors. From an academic perspective, spillover effects are intriguing because they shed new light on the dynamic process of behavior change, by drawing attention to the relationships between behaviors within and between contexts like the workplace and the home, with implications about how we can scale shifts to more sustainable lifestyles (Nilsson, Bergquist, & Schultz, 2017).

Contextual behavioral spillovers occur when interventions aiming to change behavior in one context (e.g., workplace) influence behavior in another context (e.g., home). The evidence of contextual spillovers is very limited for consumer food behaviors (Verfuerth, Jones, Gregory-Smith, & Oates, 2019). Previous studies predominantly investigate food waste behaviors within one context, either in residential households (e.g., Roe et al., 2022; van der Werf, Seabrook, & Gilliland, 2021; Graham-Rowe et al., 2014; Visschers et al., 2016), workplaces, university halls, or cafeterias (Kallbekken & Sælen, 2013; Lim et al., 2021; Liu et al., 2022; Richardson et al., 2021; Sebbane & Costa, 2018).

Recently, Boulet, Hoek, and Raven (2021) proposed a multi-level theoretical framework after having comprehensively reviewed past papers on household food waste behaviors over the past two decades. The framework organizes the factors that are likely to influence consumer food waste behaviors into three levels: the micro-level focusing on the individuals, the meso-level considering the household environment and interactions between family members, and the macro-level concerning physical contexts (e.g., workplaces, schools, and supermarkets) and social networks (e.g., colleagues, friends, and neighbors) external to the household. They found that the research field was heavily skewed towards micro-level factors targeting individual attitudes and awareness, and paid barely any attention to the macro-level factors such as contextual spillovers (Boulet et al., 2021). Only a very small number of

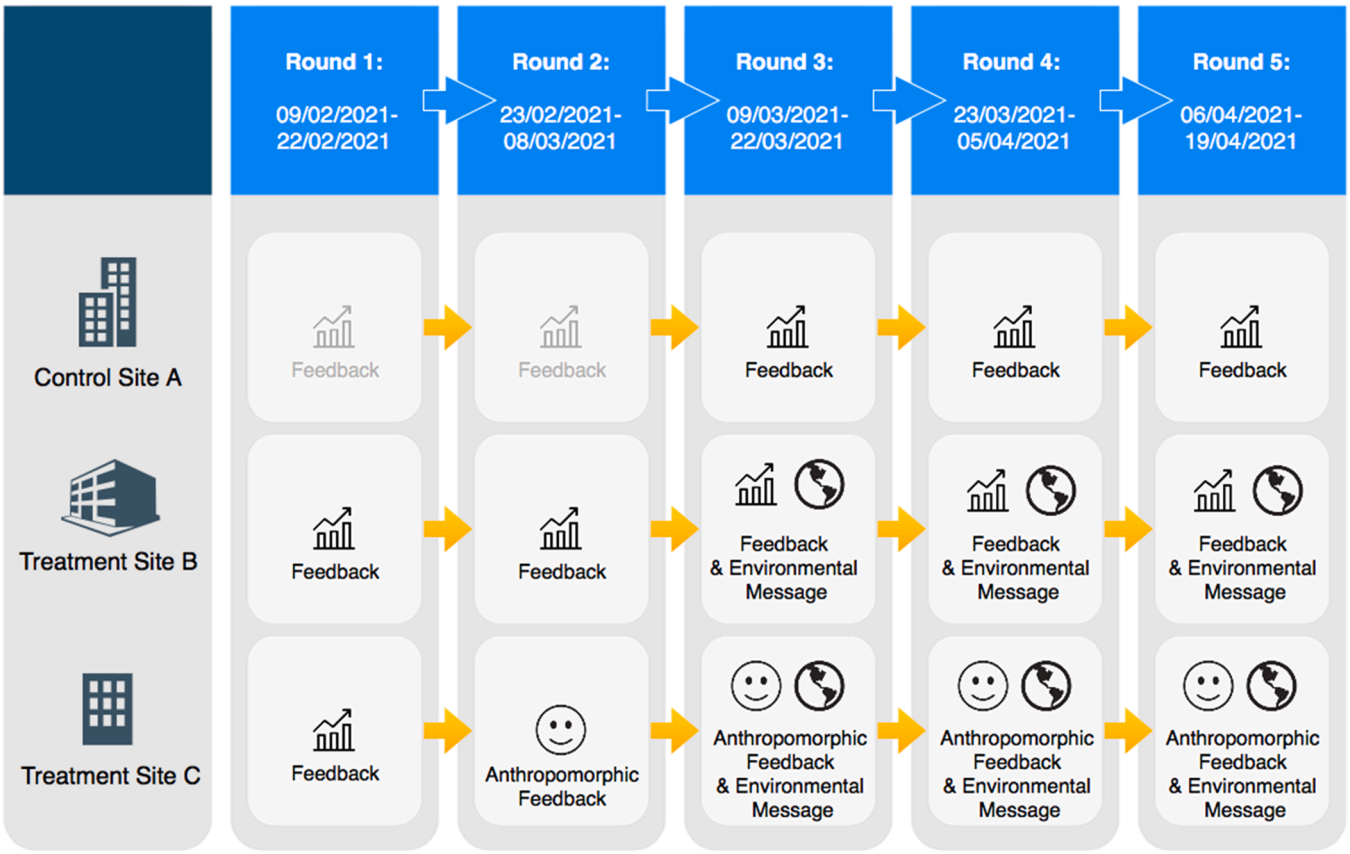


Fig. 1. The detailed design of the field study

researchers pioneeringly studied the spillover effects from school to home. Namely, Boulet, Grant, Hoek, and Raven (2022) showed that school-based educational events on food saving led to a reduction in avoidable food waste in the participating Australian schools, motivated students to change their food-related behaviors at home, and further inspired their parents to reflect on household food waste. Nevertheless, no studies so far, to the best of our knowledge, have empirically explored the possible effects of workplace food waste interventions on household food waste behaviors. Formal education at school means to have an impact "beyond the school gate" (Duvall, & Zint, 2007). Informal learning in the workplace, though often underestimated, is a no less effective route for knowledge acquisition and habit formation, especially in collectivist cultures where workers are more willing to engage in collaborative group activities (Kim, S., & McLean, 2014). Therefore, it is worthwhile to examine if workplace campaigns may influence household food waste behaviors as well. Our hypothesis for this work-to-home spillover is formally stated below:

Hypothesis 2. Efforts to reduce food waste at work are positively associated with efforts to reduce food waste at home (i.e., there are positive contextual spillover effects).

Inspired by Boulet, Hoek, and Raven's (2021) multi-level framework, we will also analyze, on an exploratory basis, how macro-level contextual spillover effects may interact with the micro-level factors such as environmental identity This is the first study to investigate if environmental framing and anthropomorphism facilitate contextual spillovers in food waste behaviors, relying on both real-time automatically recorded data of food waste, and self-reported survey data on food saving actions.

Besides, we will explore if the spillovers extend to other waste reduction behaviors at home (e.g., sorting waste and using less plastic packaging). There is very little research on whether interventions targeting food waste would influence other pro-environmental behaviors. Ek & Miliute-Plepiene (2018) exploited the staggered implementation of a curb-side food waste collection system (either using different containers, multi-compartment bins or different-colored bags) from 2006 to 2015 in 290 Swedish municipalities. They used a difference-in-differences design and found a short-lived positive spillover onto sorting of packaging waste. Miliute-Plepiene & Plepys (2015) also find a spillover from food waste collection onto packaging using survey data in one Swedish municipality. Our exploratory analyses would add on to this literature and provide a new contextual angle to it.

2. Materials and methods

2.1. Research design

Our research consisted of two stages. Firstly, we installed smart bins (i.e., the Winnow Sense (WS) system) to automatically measure food waste in three staff cafeterias of a hotel chain based in Macau, China, and implemented fortnightly feedback interventions. The WS system had the advantage of minimizing the measurement errors associated with manual weighing, and therefore enabled us to estimate food waste reduction more accurately. Secondly, we surveyed the workers who had been exposed to our interventions to examine if the workplace campaign also stimulated efforts to reduce food waste, as well as other pro-environmental behaviors, at home.

2.2. Procedure

2.2.1. Step 1: Framed informational feedback interventions on food waste at work and automatically recorded food waste weight data

To investigate if environmental framing and anthropomorphic cues could improve the effectiveness of food waste feedback (Hypotheses 1a

Fig. 2. Exemplar posters: Round 1 on-site implementations

and 1b), we conducted a quasi-experimental field study in three staff cafeterias in Macau between the end of 2020 and the 2021 summer. The outcome variable was grams of food waste per meal per day, automatically captured by the WS system. We collected the food waste data from 21/12/2020 to 23/05/2021, and the informational feedback campaign ran between 09/02/2021 and 19/04/2021 in sites B & C, and between 09/03/2021 and 19/04/2021 in site A. The study covered 1,536,610 meals in total over the four-month trial period.

We had seven weeks of data before any feedback posters were introduced, and we also tracked changes in food waste data for five further weeks after the posters were removed. To measure the effects of environmental framing and anthropomorphism in the workplace, we employed a difference-in-differences (DID) design where, in all the cafeterias, we gave fortnightly feedback on the reduction of food waste, and introduced environmental framing and anthropomorphic cues into the feedback in some of the sites. The study design is summarized in Fig. 1. Basically, in control site A, we planned to provide food waste feedback in rounds 1-5, but only managed to do so in rounds 3-5, as there was a one-month delay in installing the WS system in site A due to logistical difficulties. In treatment site B, food waste feedback was given for all 5 rounds, while additional posters about the environmental benefits of reducing food waste were added in rounds 3-5. The same food waste feedback and environmental messages were given to treatment site C with the only difference that images (e.g., food, trees, and the globe) were anthropomorphized (see Fig. 3 for exemplar posters).

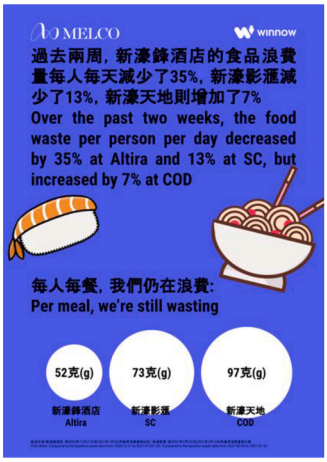
2.2.2. *Step 2: Survey of workers on food waste behaviors at work and home*

To investigate if there were spillovers from work to home (Hypothesis 2), we relied on an online survey with employees from all sites after the food waste campaign ended. The survey was built on Qualtrics and distributed via QR codes from 26/04/2021 to 10/05/2021. In each survey, the questions and responses were available in both Traditional Chinese and English, which were developed by native Chinese and English speakers. We piloted the survey with a small group of on-site teams to ensure comprehension amongst the workers.

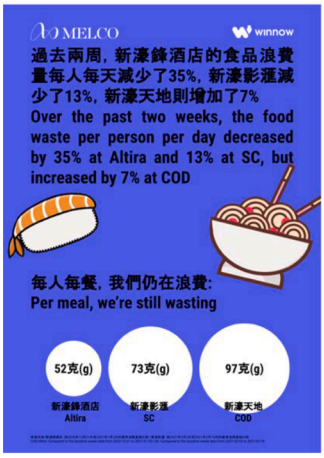
After collecting the consent and information on which site the respondent worked at, the survey began with a question on their memory of the workplace food waste campaign (recall_waste_work: "Have you seen a campaign in your workplace about reducing food waste?" 1="Never" to 5="Always"). We included this to check if the workers noticed our interventions and if their memory of the interventions would influence food saving behaviors. Thereafter, the workers' efforts to reduce food waste at work and home were measured with multiple questions, which would be the main independent and dependent variables in our analyses. The workers' efforts to reduce food waste at work were measured on two 5-point Likert scales: "Have you done any of the following in the past 4 months?" *action_waste_work*: "Tried to reduce food waste at work" (1="Never" to 5="Always") and *talk_waste_work*: "Had a conversation with work colleagues about food waste" (1="Never" to 5="Always"). Likewise, we measured efforts to reduce food waste at home by asking if the respondent had talked about or acted upon saving food at home during the study period (*action_waste_home*: "Tried to reduce food waste at home"; *talk_waste_home*: "Had a conversation with friends/family about food waste"), and if they conducted two specific household food waste saving actions (*specific_action1_home*: "Threw away less food"; *specific_action2_home*: "Used leftover food for meals or cooking"; 1="Never" to 5="Always"). Given that past studies have noted spillover effects on other household waste-reducing behaviors unrelated to food (e.g. in van der Werf et al., 2021), we also added two measurements for plastic usage and waste sorting at home (*other_action1_home*: "Used less plastic packaging"; *other_action2_home*: "Sortied your waste before disposing it"; 1="Never" to 5="Always").

In addition to these variables, we measured a set of micro-level psychological factors. Specifically, we measured self-reported environmental identity, compensatory beliefs, and catalyzing beliefs[1] using previously validated psychological scales because they have the potential to influence food waste behaviors and contextual spillovers (Capstick, Whitmarsh, Nash, Haggar, & Lord, 2019; Hope et al., 2018; Verfuerth et al., 2019; Whitmarsh & O'Neill, 2010). We also measured different motivations to reduce food waste to better understand "why"

[1] We included the measurements for compensatory beliefs (e.g., "The environmental impact of wasting food at home can be made up for by saving food at work.") and catalyzing beliefs (e.g., "Doing something positive for the environment in my everyday life makes me want to do other similar things.") to explore if they could moderate the contextual spillover effects. For example, among the workers who are high in compensatory beliefs and low in catalyzing beliefs, efforts to reduce food waste at work may be negatively associated with efforts at home. Unfortunately, we did not detect any significant moderation effects, so they were just kept in the regression models as covariates.



Control site A



Treatment site B

Treatment site C

Fig. 3. Exemplar posters: Round 3

people save food based on the past literature and the pre-survey pilot (Hebrok & Boks, 2017; Thyberg & Tonjes, 2016; Visschers, Wickli, & Siegrist, 2016).[2] Finally, we recorded socio-demographic characteristics like age, gender, and income at the end of the survey (see Appendix Table A1 for details of those psychological measurements).

In total, we collected 1,253 survey responses, of which 1,198 were valid. Responses were invalidated if the respondent filled in the survey more than one time (27 responses), or if the time spent on the experimental stimuli page or the whole survey was 3 SDs higher than the average (28 responses). We kept responses from workers in all sites (rather than just the treatment sites) since all sites received food waste feedback, and employees across sites could have taken different efforts to reduce their waste. We allowed people to skip questions in the survey if they wished so.

2.3. Data analysis

For the field study, we used DID regression to compare changes in food waste (rather than levels) to eliminate the influence of unobserved fixed factors specific to the three cafeterias which can impact food waste (e.g., canteen size and layout). The DID model is specified below:

$$\begin{aligned} grams\_per\_cover_{it} = \ & \alpha_i + \beta_1 treatmentB_i \times during\_campaign_t \\ & + \beta_2 treatmentC_i \times during\_campaign_t + \beta_3 treatmentB_i \\ & \times after\_campaign_t + \beta_4 treatmentC_i \times after\_campaign_t \\ & + \gamma_t + \varepsilon_{it} \end{aligned} \quad (1)$$

In the equation, β_1 and β_2 are the DID estimators of the treatment effects of the two types of environmental messages in sites B and C, respectively, during the food waste campaign; and β_3 and β_4 estimate if the treatment effects carried over after the campaign ended in sites B and C, respectively. α_i denotes the site fixed effects. γ_t denotes the time-varying variables, including 2 dummies for during_campaign and after_campaign (before_campaign omitted), 6 dummies for the days of the week (Sunday omitted), and 5 monthly dummies (Jan to May 2021, Dec 2020 omitted). Research shows that people's dietary practices differ across weekends and weekdays (Thompson, Larkin, & Brown, 1986). Moreover, the company initiated a Green Monday campaign on 11/01/2021 and provided more vegetarian options every Monday since then. There were also several festival seasons in our study period (e.g., Christmas 25/12/2020, New Year 01/01/2021, Spring Festival 11/02/2021-26/02/2021, Ching Ming Festival 04/04/2021, Labor Day 01/05/2021), and the cafeterias had special menus on some festival dates. Those menu changes could influence the weight of food waste. Therefore, we introduced the dummy variables for days of the week and months into the model to control for those issues.

For the survey study, we checked the consistency between actual and self-reported data by investigating the cross-site differences in self-reported efforts to reduce food waste at work. More importantly, we conducted multiple linear regressions to examine work-to-home spillovers. Our main outcome variable – efforts to reduce food waste at home – was the composite score of its four items since the reliability of the scale was satisfactory (Cronbach's α=0.68). Our main independent variables were workers' memory of the workplace food waste campaign (*recall_waste_work*) and efforts to reduce food waste at work. However, the two items of efforts to reduce food waste at work were not highly correlated (r=0.33), and thus treated as separate variables: *talk_waste_work* and *action_waste_work*. We also replicated the analysis on the four items of the outcome variable separately as robustness tests. Other covariates included in the regression model are detailed in Appendix Table A1. In addition, we used two other pro-environmental actions at home as the outcome variables to test if work-to-home contextual spillovers could also happen between different environmental behaviors.[3]

3. Results and Discussions

3.1. Direct effects on food waste at work: automatically recorded waste weight from Step 1

We started with simply plotting the outcome by site to see the trends. Fig. 4 shows that food waste in control site A gradually increased throughout the study period and increased more rapidly after we removed the last round of feedback. In treatment site B, food waste remained at the same level before and during the campaign period and increased slightly after the posters were removed. In contrast, food waste in treatment site C exhibited a reduction during the campaign period and kept decreasing after the posters were removed.

The DID regression revealed a marginally significant reduction in food waste in site B ($\beta_1 = -8.92$, $SE = 4.65$, z=−1.92, p=0.055, *95% CI*=[−18.05, 0.20]), and a significant reduction in site C (β_2=−17.49, SE=4.65, z=−3.76, $p < 0.001$, *95%CI*=[−26.61, −8.37]) during the food waste campaign as compared to control site A. These results suggest that exposure to environmental messages, especially those with anthropomorphic cues, was associated with a significant decrease in food waste behaviors in the workplace. Moreover, those differences in food waste reduction continued even after the campaign (β_3=−42.80, SE=5.10, z=−8.39, p<0.001, *95%CI*=[−52.83,−32.77]; β_4=−66.33, SE=5.10, z=−13.00, p<0.001, *95%CI*=[−75.36, −56.30]), implying a long-term effect of those interventions. Therefore, changes in actual food waste data, provide relatively weak evidence for Hypothesis 1a regarding the positive effect of environmental framing. Hypothesis 1b on the positive effect of environmental framing with anthropomorphic cues is strongly supported. Apart from running the DID regression using the fixed effects model to control for any time-invariant site-specific characteristics, we conducted robustness tests using the OLS model and the random-effects model (see Table 1 and Fig. 5). The results did not differ substantially across models.

3.2. Discussion of methodological limitations in Step 1

While the results offer strong evidence that exposure to environmental framing with anthropomorphic cues is positively associated with food waste reduction, there are some caveats to interpreting our results as "causal".

First, causal inference from difference-in-differences estimates rests on the assumption that all three cafeterias would have similar trends in

[2] Apart from the variables reported, the survey also contained an experimental manipulation towards the end, where the participants were asked to read a poster similar to the environmental message that we gave them in the last round of the food waste campaign. We randomly assigned participants to one of three posters – the control poster which focused on the total amount of food saved, the environmental poster which highlighted the total CO_2 emissions saved out of food waste reduction, or the anthropomorphic poster which showed information about the CO_2 emissions saved along with smiling trees and earth. However, the variables analyzed in the current paper (except for the socio-demographic data) were collected before the experimental stimuli and they were thus not influenced by it.

[3] Except for our main outcome variable efforts to reduce food waste at home, the outcome variables in our analyses were all measured by a single question on a 5-point Likert scale. Although it is a common practice to treat Likert scales as continuous, those variables could alternatively be treated as ordinal. Therefore, besides the multiple linear regression models reported in the main text, we ran ordered logistic regression models for each of those variables as a further robustness check. The results of the logistic regression models did not differ from the linear regression results in any substantial ways and are presented in Appendix Table A2-A4.

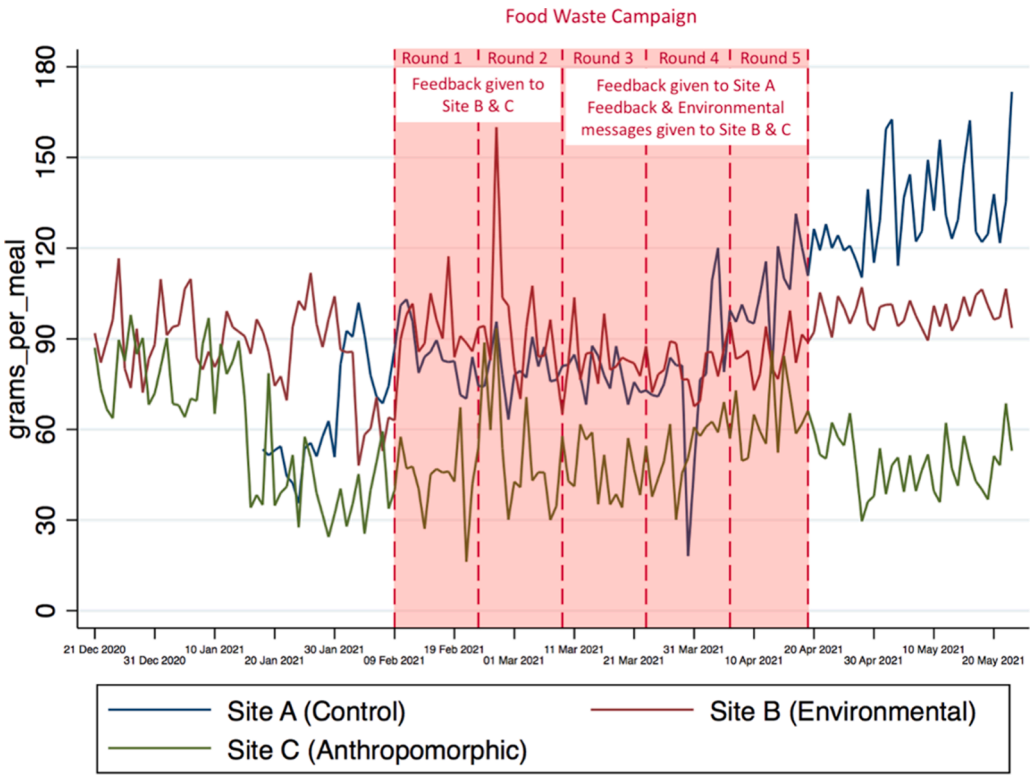


Fig. 4. Average food waste per meal across sites (in grams)

food waste in the pre-treatment period i.e., there would have had to be parallel trends. Unfortunately, we were unable to empirically verify this for a comparable timeframe because we only had three weeks of data from all the sites before the treatment.

Second, there were unavoidable differences in the menus and preparation procedures across sites and in different seasons, which were outside the control of consumers but could influence food waste weight reduction (e.g., the proportion of inedible waste such as bones and fruit peels). The potential seasonal differences in reducible food waste made it hard to make causal inferences even if we observed parallel trends in food waste across sites during the pre-treatment period - the pre-trends might be parallel because the menus did not allow for too much variation in food waste per meal from December to February, which may or may not be the case during the post-treatment period from March to May.

Finally, the cafeterias were located at three hotels run by the same hotel chain, and the company informed us at the beginning of the study that a small number of maintenance workers might sometimes go to different sites to fix emergency issues. Although the company later assured us that all workers including the maintenance team were entitled to eat only at one worksite cafeteria, which prevented them from seeing more than one version of the posters, we cannot rule out the possibility that some maintenance workers entered the cafeteria of a different worksite by chance (not for eating) and saw the posters there, or that they ran into a friend at work and became aware of different versions of posters in conversations. These instances should have been rare, if they occurred at all, so their potential influence on our results should be minor.

3.3. Direct effects on food waste behaviors at work: self-reported behaviors from Step 2 (survey)

Consistent with the actual food waste data, the self-reported survey data confirmed that workers from treatment site C had taken significantly more food-saving actions at work than those from control site A (β=0.41, *SE*=0.08, *t*=5.32, *p*<0.001, *95%CI*=[0.26, 0.55]), and this held even controlling for age, gender, education, income, motivations to save food, and environmental identity (see Table 2). Workers from treatment site B also reported more actions at work than those at site A, but the difference was not statistically significant (β=0.05, *SE*=0.06, *t*=0.93, *p*=0.351, *95%CI* =[−0.06, 0.17]). Therefore, results from analyzing self-reported food waste data, do not support Hypothesis 1a on environmental framing but support Hypothesis 1b on environmental framing with anthropomorphic cues. It is worth mentioning that the dummy variable for site C, which represents the intervention combining environmental framing and anthropomorphism, predicted food waste reducing actions at work beyond and above most micro-level factors including environmental identity.

We also tested the cross-site differences in talk_waste_work and recall_waste_work, as they could validate our manipulations as active treatments and were indirect indicators of intervention effectiveness. Workers from treatment site C also talked with their colleagues about food waste more often than those from control site A, even though the difference failed to reach statistical significance (β=0.14, *SE* = 0.14, *t*=1.03, *p*=0.304, *95%CI*=[−0.13, 0.41]). To our surprise, workers from treatment site B reported a lower frequency of having conversations about food waste than those from control site A. The effect was marginally significant (β=−0.13, *SE*=0.07, *t*=−1.93, *p*=0.054, *95%CI*=[−0.260, 0.002]), but disappeared when controlling for age, gender, education, income, motivations to save food, and environmental identity (see Table 2).

Moreover, workers from treatment site C also recalled seeing the workplace campaign more often than those from control site A (β=0.26, *SE*=0.14, *t*=1.93, *p*=0.054, *95%CI*=[−0.004, 0.532]), whereas workers from treatment site B remembered it less well (β=−0.13, *SE*=0.07, *t*=−1.77, *p*=0.076., *95% CI*=[−0.27, 0.01]). The results did not change when controlling for age, gender, education, income, motivations to save food, and environmental identity (see Table 2). It should be noted that only 4.6% of the participants answered “Never” to this question, suggesting that the majority of participants saw our interventions.

Table 1
Difference-in-differences models testing the direct effects on food waste at work (using automatically recorded data)

	(1) Ordinary Least Squares	(2) Random effects	(3) Fixed effects
Site B (Environmental)	8.887*	8.887**	
	(4.899)	(3.544)	
Site C (Anthropomorphic)	-17.68***	-17.68***	
	(5.139)	(3.544)	
During campaign	12.21***	12.21***	12.21***
	(4.097)	(3.949)	(3.949)
After campaign	46.63***	46.63***	46.63***
	(4.540)	(4.999)	(4.999)
Treatment B (Site B) × During campaign	-8.925	-8.925*	-8.925*
	(5.759)	(4.653)	(4.653)
Treatment B (Site B) × After campaign	-42.80***	-42.80***	-42.80***
	(5.615)	(5.102)	(5.102)
Treatment C (Site C) × During campaign	-17.49***	-17.49***	-17.49***
	(5.921)	(4.653)	(4.653)
Treatment C (Site C) × After campaign	-66.33***	-66.33***	-66.33***
	(5.995)	(5.102)	(5.102)
Monday	0.156	0.156	0.156
	(2.644)	(2.726)	(2.726)
Tuesday	-0.364	-0.364	-0.364
	(2.903)	(2.728)	(2.728)
Wednesday	-0.0509	-0.0509	-0.0509
	(2.835)	(2.738)	(2.738)
Thursday	0.440	0.440	0.440
	(2.764)	(2.725)	(2.725)
Friday	1.477	1.477	1.477
	(3.015)	(2.722)	(2.722)
Saturday	2.071	2.071	2.071
	(2.759)	(2.718)	(2.718)
January	-13.40***	-13.40***	-13.40***
	(3.923)	(3.722)	(3.722)
February	-12.49**	-12.49***	-12.49***
	(5.538)	(4.449)	(4.449)
March	-19.00***	-19.00***	-19.00***
	(6.118)	(5.085)	(5.085)
April	-5.541	-5.541	-5.541
	(6.378)	(5.365)	(5.365)
May	-1.147	-1.147	-1.147
	(6.782)	(6.270)	(6.270)
Constant	87.84***	87.84***	84.71***
	(6.168)	(4.930)	(3.859)
Observations	433	433	433
R-squared	0.711		0.481

Notes: Robust standard errors in parentheses
*** $p<0.01$
** $p<0.05$
* $p<0.1$.

3.4. Spillover effects on food waste behaviors at home: self-reported food saving efforts

A multiple linear regression showed that memory of the campaign and efforts to reduce food waste at work were all positively and significantly associated with efforts to reduce food waste at home (*recall_waste_work*: β=0.06, *SE*=0.02, *t*=3.38, *p*=0.001, *95%CI*=[0.03, 0.10]; *talk_waste_work*: β=0.26, *SE*=0.02, *t*=14.42, *p*<0.001, *95%CI*=[0.23, 0.30]; *action_waste_work*: β=0.40, *SE*=0.02, *t*=17.57, *p*< 0.001, *95%CI* =[0.36, 0.45]). The effects of efforts to reduce food waste at work remained significant even controlling for site fixed effects, age, gender, education, income, motivations to save food, environmental identity, catalyzing beliefs, and compensatory beliefs, while the effect of memory became marginally significant (see Table 3). Additional analyses on the four items for efforts at home yielded similar results (see Table 3). We thus found robust evidence that there were positive spillovers from workplace campaigns onto efforts to reduce food waste at home, lending support to Hypothesis 2. Environmental identity (e.g., "I think of myself as an environmentally-friendly person") was also positively associated with efforts to reduce food waste at home (β=0.15, *SE*=0.03, *t*=5.03, *p*<0.001, *95%CI*=[0.09, 0.21]). Nevertheless, actions to reduce food waste at work, and talking about food waste with work colleagues, i.e., the contextual spillover factors, predicted household food saving efforts beyond and above all the micro-level factors including environmental identity.

To further investigate the interplay between the most salient macro- and micro-level factors, we conducted a path analysis using the PROCESS Model 4 macro for SPSS (Hayes, 2013). We entered the site dummies as the independent variables, action_waste_work, talk_waste_work, and environmental identity as the mediators, and efforts_waste_home as the dependent variable. A bias-corrected bootstrap analysis with 5000 samples indicated no significant direct pathways (site C –> efforts_waste_home: β=−0.05, *SE*=0.06, *95%CI*=[−0.17, 0.08]; site B –> efforts_waste_home: β=−0.04, *SE*=0.03, *95%CI*= [−0.10, 0.03]), so we just present all the indirect pathways in Fig. 6. For treatment site C, the only significant indirect pathway was through action_waste_work (β=0.17, *SE*=0.03, *95%CI*=[0.10, 0.23]), which confirmed a positive spillover from workplace interventions to household food saving efforts. The insignificant pathway through talk_waste_work was positive (β=0.03, *SE*=0.03, *95%CI*=[−0.03, 0.10]), while the insignificant pathway through environmental identity was negative (β=−0.01, *SE*=0.02, *95%CI*=[−0.04, 0.02]). For treatment site

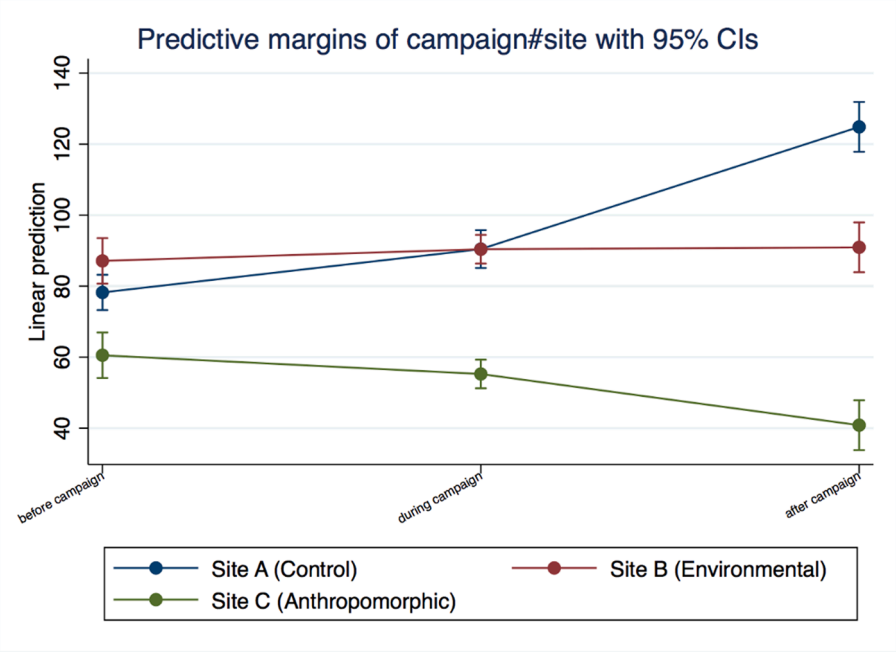


Fig. 5. The marginal effects of the food waste campaign across sites (estimated by the random-effects model)

Table 2
Linear regression models testing the direct effects on behaviors at work (survey data)

	(1) Action_waste_work	(2) Action_waste_work	(3) Talk_waste_work	(4) Talk_waste_work	(5) Recall_waste_work	(6) Recall_waste_work
Site B	0.0539	0.0356	-0.129*	-0.0620	-0.129*	-0.135*
	(0.0577)	(0.0536)	(0.0668)	(0.0629)	(0.0727)	(0.0694)
Site C	0.405***	0.394***	0.141	0.166	0.264*	0.226*
	(0.0762)	(0.0746)	(0.138)	(0.124)	(0.137)	(0.133)
Environmental_identity		0.0818*		0.328***		0.118**
		(0.0449)		(0.0509)		(0.0582)
Motivation_Saving money		0.0270		0.0388		0.0235
		(0.0487)		(0.0664)		(0.0836)
Motivation_Saving resources		0.141**		0.107		0.0670
		(0.0565)		(0.0740)		(0.0769)
Motivation_National security		0.0995*		0.0534		-0.0270
		(0.0581)		(0.0588)		(0.0647)
Motivation_Fairness		0.0361		0.101*		0.102*
		(0.0474)		(0.0537)		(0.0606)
Motivation_Global warming		-0.124***		0.00325		-0.0647
		(0.0446)		(0.0530)		(0.0682)
Motivation_Traditional virtue		-3.81e-05		0.0731		-0.0373
		(0.0442)		(0.0551)		(0.0663)
Motivation_Organizational culture		0.0640		0.153**		0.144*
		(0.0516)		(0.0701)		(0.0762)
Motivation_Personal principles		0.168***		-0.112		0.298***
		(0.0623)		(0.0838)		(0.0885)
Age		0.000357		0.0121***		0.00976***
		(0.00279)		(0.00343)		(0.00374)
Female		-0.0126		0.0120		0.0178
		(0.0485)		(0.0594)		(0.0655)
Education		0.0890***		-0.0381		0.0938***
		(0.0211)		(0.0281)		(0.0302)
Income		-0.0124		-0.0429*		-0.0246
		(0.0180)		(0.0222)		(0.0239)
Constant	4.316***	1.931***	3.207***	-0.131	3.829***	0.562
	(0.0487)	(0.316)	(0.0547)	(0.368)	(0.0597)	(0.359)
Observations	1,191	1,145	1,192	1,146	1,191	1,145
R-squared	0.013	0.136	0.006	0.191	0.009	0.121

Notes: Robust standard errors in parentheses
*** $p<0.01$
** $p<0.05$
* $p<0.1$.

Table 3
Linear regression models testing spillover effects on food waste behaviors at home

	(1) Efforts_waste_home	(2) Talk_waste_home	(3) Action_waste_home	(4) Specific_action1_home	(5) Specific_action2_home
Recall_waste_work	0.0291*	0.00304	-0.0176	0.0903***	0.0408
	(0.0164)	(0.0243)	(0.0188)	(0.0313)	(0.0351)
Talk_waste_work	0.221***	0.555***	0.0422**	0.119***	0.168***
	(0.0191)	(0.0309)	(0.0202)	(0.0357)	(0.0397)
Action_waste_work	0.375***	0.178***	0.662***	0.369***	0.291***
	(0.0229)	(0.0299)	(0.0405)	(0.0420)	(0.0432)
Site B	-0.0429	-0.103**	-0.0166	0.0322	-0.0843
	(0.0337)	(0.0443)	(0.0400)	(0.0652)	(0.0690)
Site C	-0.0579	0.0492	-0.0948	-0.0739	-0.112
	(0.0653)	(0.0950)	(0.0708)	(0.120)	(0.140)
Environmental_identity	0.148***	0.191***	0.0824**	0.137**	0.183***
	(0.0295)	(0.0441)	(0.0372)	(0.0544)	(0.0632)
Motivation_Saving money	0.0840**	0.0329	0.159***	0.0642	0.0802
	(0.0351)	(0.0447)	(0.0447)	(0.0600)	(0.0762)
Motivation_Saving resources	-0.0182	-0.0154	-0.0222	0.0370	-0.0720
	(0.0399)	(0.0585)	(0.0559)	(0.0709)	(0.0817)
Motivation_National security	-0.00399	-0.0349	-0.0207	-0.0208	0.0605
	(0.0392)	(0.0531)	(0.0413)	(0.0682)	(0.0839)
Motivation_Fairness	-0.0487	-0.0176	-0.0296	-0.0667	-0.0807
	(0.0327)	(0.0453)	(0.0433)	(0.0567)	(0.0662)
Motivation_Global warming	0.0552*	0.0471	0.0500	-0.0446	0.168***
	(0.0304)	(0.0413)	(0.0400)	(0.0557)	(0.0621)
Motivation_Traditional virtue	0.0165	-0.00711	-0.00135	0.107*	-0.0324
	(0.0308)	(0.0448)	(0.0363)	(0.0592)	(0.0670)
Motivation_Organizational culture	-0.0342	-0.0595	-0.0302	-0.0278	-0.0195
	(0.0421)	(0.0546)	(0.0523)	(0.0755)	(0.0838)
Motivation_Personal principles	0.0713	0.0783	0.0444	0.00328	0.159*
	(0.0465)	(0.0635)	(0.0563)	(0.0837)	(0.0922)
Catalyzing_beliefs	0.0695*	0.0911*	0.0183	0.134*	0.0344
	(0.0363)	(0.0483)	(0.0389)	(0.0716)	(0.0682)
Compensatory_beliefs	-0.0316**	0.0107	-0.0255*	-0.114***	0.00258
	(0.0129)	(0.0178)	(0.0138)	(0.0243)	(0.0281)
Age	-0.00190	0.00117	-0.00115	-0.0124***	0.00483
	(0.00180)	(0.00241)	(0.00196)	(0.00349)	(0.00364)
Female	-0.00288	0.117***	-0.0254	-0.0361	-0.0674
	(0.0308)	(0.0425)	(0.0357)	(0.0594)	(0.0656)
Education	-0.0141	-0.0311	0.0198	-0.0356	-0.00943
	(0.0152)	(0.0201)	(0.0164)	(0.0290)	(0.0325)
Income	0.0112	0.0156	-0.0114	0.0306	0.00984
	(0.0119)	(0.0166)	(0.0131)	(0.0236)	(0.0258)
Constant	0.0587	-0.429	0.407**	0.950***	-0.693**
	(0.181)	(0.264)	(0.205)	(0.355)	(0.333)
Observations	1,144	1,144	1,144	1,144	1,144
R-squared	0.559	0.545	0.542	0.241	0.206

Notes: Robust standard errors in parentheses
*** $p<0.01$,
** $p<0.05$
* $p<0.1$.

B, the only positive pathway through action_waste_work was not significant (β=0.02, *SE*=0.02, *95%CI*=[−0.02, 0.07]). On the other hand, the pathways through talk_waste_work (β=−0.03, *SE*=0.02, *95%CI*=[−0.065, −0.001]) and environmental identity (β=−0.02, *SE*=0.01, *95%CI*=[−0.038, −0.001]) were both negative and significant. It was theoretically unlikely that our interventions could undermine environmental identity in sites B and C, so we suspect that the observed differences in environmental identity preexisted among those workers. When the workplace intervention was strong enough to significantly increase workplace food saving actions (as in site C), the macro-level contextual spillover effect overrode the effect of environmental identity. However, when the intervention had a relatively weak effect on actions at work (as in site B), the micro-level factor, environmental identity, determined how much effort people put into food saving at home. This interpretation is speculative because we cannot be entirely sure if (observed) environmental identity is exogenous, given that we distributed the survey after the campaign and that people opted to undertake this survey.

3.5. Spillover effects on other behaviors at home: self-reported pro-environmental actions

Exploratory analyses showed that efforts to reduce food waste at work were positively and significantly associated with both using less plastic packaging at home (talk_waste_work: β=0.24, *SE*=0.03, *t*=8.91, $p< 0.001$, *95% CI* = [0.19, 0.29]; action_waste_work: β=0.30, *SE*=0.04, *t*=8.22, $p< .001$, *95%CI*=[0.23, 0.37]), and sorting waste at home before disposing (talk_waste_work: β=0.40, *SE*=0.03, *t*=11.95, $p<0.001$, *95%CI*=[0.34, 0.47]; action_waste_work: β=0.24, *SE*=0.04, *t*=6.19, $p<0.001$, *95%CI*=[0.17, 0.32]). Those associations were statistically significant even controlling for site fixed effects, age, gender, education, income, motivations to save food, environmental identity, catalyzing beliefs, and compensatory beliefs, supporting that the effects of workplace food waste campaigns could spill over onto other pro-environmental behaviors at home (see Table 4). The contextual spillover factors (talk_waste_work, action_waste_work) and the micro-level factor environmental identity were approximately equally strong this time.

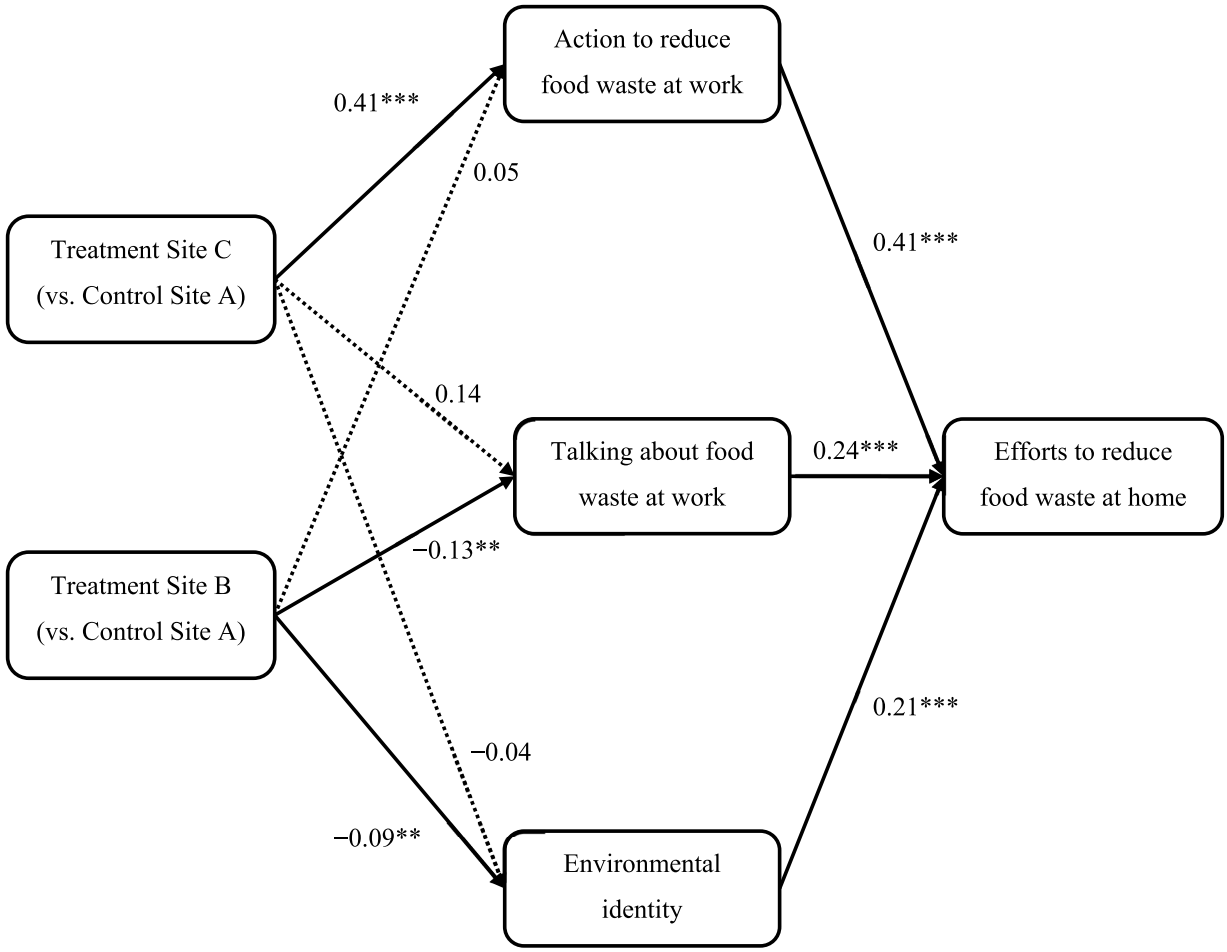


Fig. 6. Pathway analysis showing the interplay between the macro-level work-to-home spillover effects and the micro-level factor environmental identity

Nevertheless, memory of the campaign had no significant effect on plastic usage (β=0.04, *SE*=0.03, *t*=1.54, *p*=0.123, *95%CI*=[−0.01, 0.09]) and even a significant and negative effect on waste sorting (β=−0.06, *SE* = 0.03, *t*=−2.02, *p*=0.044, *95%CI*=[−0.125, −0.002]). These findings, together with the weak effects of memory on household food saving efforts reported in the last section, showed that the mere memory of campaigns could not effectively foster household pro-environmental behaviors. It was the efforts induced by workplace campaigns that could promote further actions at home.

3.6. Discussion of methodological limitations in Step 2

Since we measured all the dependent and independent variables in a single survey, all the results we presented above were correlational in nature. Moreover, measuring attitudes and behaviors with cross-sectional surveys could lead to the issue of common method variance, i.e., some variations in responses might have been caused by the measurement method itself (e.g., item ambiguity, common scale anchors and formats, demand characteristics and social desirability) rather than to the hypothesized associations between constructs (Bagozzi & Yi, 1990; Podsakoff, MacKenzie, Lee, & Podsakoff, 2003).

To control for common method variance, we adopted several preventive remedies when designing the survey. Following Tourangeau, Rips, and Rasinski's (2000) suggestions, we selected measurements carefully, tried to make every question simple and concise, and provided verbal labels for each point of the response scales instead of using numerical scale values. We then piloted the survey with members from the on-site teams and held a focus-group discussion with them afterwards to make sure that no survey items were ambiguous or difficult to understand. In addition, we added a lot of page breaks to psychologically separate the measurement of different variables, and did not allow participants to go back to previous pages in case they tried to synchronize their answers to different questions.

To further check the effectiveness of those ex-ante remedies, we conducted a confirmatory factor analysis (CFA) by loading all the survey items for our independent and dependent variables on the same factor (please see Appendix Table A5 for the model details). This is an improved version of Harman's single-factor test, one of the most commonly used ex-post techniques for detecting common method variance (Fuller, Simmering, Atinc, Atinc, & Babin, 2016; Podsakoff et al., 2003). The CFA model demonstrated poor goodness of fit ($\chi^2(2)$= 915.29, p<0.001; RMSEA=0.17, p<0.001; CFI=0.75, TLI=0.67; SRMR=0.08), suggesting that a single (common method) factor cannot account for all the variance in our independent and dependent variables, and that common method variance was not a concerning issue in the current study.

Nevertheless, this test result could not dismiss the possibility that low to moderate levels of common method variance existed in our data, which might have inflated some observed relationships between constructs, or deflated some theoretical relationships that should have been observed (Fuller et al., 2016; Podsakoff et al., 2003). For instance, the association between action_waste_work and action_waste_home might have been inflated due to the high similarity between the two questions. However, this inflation should have been alleviated when we used the composite score of four items as our dependent variable (i.e., the questions for specific_action1_home and specific_action2_home were asked in a very different way than that for action_waste_work). On the other hand, compensatory and catalyzing beliefs, in theory, should

Table 4
Linear regression models testing spillover effects on other waste-reducing behaviors at home

	(1) Other_action1_home	(2) Other_action1_home	(3) Other_action2_home	(4) Other_action2_home
Recall_waste_work	0.0405	0.0388	-0.0635**	-0.0596*
	(0.0263)	(0.0263)	(0.0314)	(0.0311)
Talk_waste_work	0.240***	0.194***	0.403***	0.268***
	(0.0269)	(0.0298)	(0.0337)	(0.0357)
Action_waste_work	0.301***	0.284***	0.245***	0.245***
	(0.0365)	(0.0382)	(0.0395)	(0.0397)
Site B		0.0507		-0.00747
		(0.0518)		(0.0612)
Site C		0.141		0.0463
		(0.0962)		(0.121)
Environmental_identity		0.304***		0.510***
		(0.0479)		(0.0594)
Motivation_Saving money		0.0405		0.000986
		(0.0543)		(0.0608)
Motivation_Saving resources		0.0131		-0.116
		(0.0668)		(0.0745)
Motivation_National security		-0.102*		-0.0528
		(0.0598)		(0.0699)
Motivation_Fairness		-0.113**		0.0401
		(0.0519)		(0.0551)
Motivation_Global warming		0.152***		0.0288
		(0.0481)		(0.0549)
Motivation_Traditional virtue		0.0777		0.0358
		(0.0490)		(0.0621)
Motivation_Organizational culture		-0.0436		0.0782
		(0.0585)		(0.0699)
Motivation_Personal principles		-0.116		-0.126
		(0.0733)		(0.0853)
Catalyzing_beliefs		-0.0327		0.00459
		(0.0523)		(0.0687)
Compensatory_beliefs		-0.0249		0.00980
		(0.0204)		(0.0252)
Age		0.00266		-0.00138
		(0.00261)		(0.00341)
Female		0.0247		-0.171***
		(0.0474)		(0.0576)
Education		0.00590		-0.0659**
		(0.0220)		(0.0270)
Income		-0.0173		-0.123***
		(0.0182)		(0.0220)
Constant	1.508***	1.048***	1.438***	1.040***
	(0.154)	(0.298)	(0.161)	(0.323)
Observations	1,195	1,144	1,195	1,144
R-squared	0.224	0.277	0.192	0.333

Notes: Robust standard errors in parentheses
*** $p<0.01$
** $p<0.05$
* $p<0.1$.

moderate the spillover effects from work to home (Capstick et al., 2019), but we did not find any evidence for that. The potential moderation effects might have been deflated because participants became aware that compensatory beliefs were socially undesirable and that catalyzing beliefs were desirable after answering so many questions about food waste behaviors at work and at home.

4. General discussion and conclusion

Combining a quasi-experimental field study and an online survey of workers, the current research investigated if workplace food waste campaigns providing informational feedback with environmental framing and anthropomorphic cues could decrease food waste behaviors in staff cafeterias. In line with our expectations, there were significantly greater reductions in food waste in the treatment sites than in the control site. In accordance with earlier observations in energy conservation (e.g., Abrahamse et al., 2005), we found that a combination of multiple interventions achieved the best results in food waste reduction, such that the treatment site C which received the environmental feedback with anthropomorphism saw the most salient reduction in food waste during and after the campaign. Theoretically, this work takes forward past research on anthropomorphism and food consumption (Cooremans & Geuens, 2019; Shao, et al., 2020), and shows that anthropomorphism can reinforce the effects of environmental feedback in eliciting waste-reducing behaviors. Practically, our findings have implications for policymakers and organizations – they should consider promoting the combined use of anthropomorphism and environmental framing in public communication about food waste, and in large-scale food-saving interventions.

More importantly, we also explored if there were spillovers from workplace interventions onto household food saving efforts as well as other waste-reducing behaviors. Workers who put more effort into reducing food waste at work reported significantly more efforts to save food at home and a higher frequency of engaging in other pro-environmental practices, supporting a positive contextual spillover. These results extend the scarce literature on macro-level factors influencing consumer food waste, and offer the first piece of empirical evidence of a positive work-to-home spillover. Nevertheless, this is by no

means denying the importance of micro-level factors such as individuals' environmental identity. In fact, workers in our treatment sites happened to be lower in environmental identity, which diluted parts of the positive spillovers from workplace campaigns to household food savings. This interesting interplay emphasizes the necessity of taking a multi-level perspective when addressing the issue of consumer food waste, and holds valuable practical implications. It urges behavioral scientists and policymakers to factor in macro-level contextual spillover effects when designing and evaluating interventions, and to think carefully if some seemingly effective interventions could unintentionally discourage pro-environmental behaviors in a different context. Multi-level interventions that are likely to not only provoke immediate actions but also enhance environmental identity in the long run should be considered for their potential to facilitate resource-saving behaviors in multiple contexts. Other contextual spillovers, such as from the consumption realm to the production process, can also be studied to manage the complex issue of food waste.

Our study contributes to the evolving literature on behavioral spillover effects in various ways. Although interventions highlighting the environmental impact of food behaviors are widely advocated to achieve positive spillovers, there is limited evidence for this from real-world settings (Asensio & Delmas, 2015; Capstick et al., 2019; Lim et al., 2021; Maki et al., 2019; Nomura, John, & Cotterill, 2011; Wolstenholme et al., 2020). Several studies also note that environmental impacts are frequently ignored or underestimated by consumers (Camilleri, Larrick, Hossain, & Patino-Echeverri, 2019; Gil, 2020; Wolstenholme et al., 2020), which further calls into question if environmental framing can effectively reduce food waste behaviors or promote positive spillovers. Beyond the domain of food waste, a meta-analysis of 77 studies on pro-environmental behavioral spillovers found evidence for positive spillovers only on behavioral intentions, but negative or no effects on actual behaviors (Maki et al., 2019). Our study merely observed weak or no evidence for the effectiveness of environmental framing alone, which echoes those concerns in the literature. However, we innovatively integrated anthropomorphic cues into environmental framing, and found that this combined intervention effectively promoted waste-reduction behaviors across contexts, pointing to positive spillover effects. Unlike many previous studies, our survey asked about concrete waste-reduction behaviors conducted in the recent past. Therefore, our study offers rare and valuable evidence for positive contextual spillovers on self-reported behaviors, rather than just behavioral intentions. These promising findings also suggest that organizations aiming to stimulate pro-environmental spillover can continue to use environmental framing in practice and expect to benefit from this technique as long as they pair it with other compatible techniques like anthropomorphic cues.

Moreover, contextual spillover is a relatively neglected aspect of behavioral spillover research. Most researchers only look at spillovers between different types of behaviors within one context, and the very few studies on spillovers between contexts typically focus on one type of behavior (Andersson, Eriksson, & Von Borgstede, 2012; Littleford, Ryley, & Firth, 2014; Rashid, & Mohammad, 2011; Tudor, Barr, & Gilg, 2007). Our research investigates both spillovers across contexts (work-to-home) and across behavioral types (food saving, waste sorting, and reducing plastic use), and thus provides a comprehensive perspective for future researchers studying behavioral spillover effects. Understanding whether the impact of interventions spillover across contexts and behavioral types allows us to map the net effect of interventions and to pick those which provoke multiple sustainable behavioral changes across a variety of contexts (Maki et al., 2019; Galizzi & Whitmarsh, 2019). This is particularly informative for policymakers because it will allow them to cost-effectively induce positive social changes.

As a case study, our research has some unique strengths. Firstly, we combined actual and self-reported data to explore changes in food waste behaviors whereas many past studies on food waste interventions solely relied on self-reports or pictorial analyses of food waste (Reisch et al., 2020). The combination of metrics in the current study addresses a concern raised by several scholars – i.e., self-reported and observed food waste data do not necessarily match (Sebbane & Costa, 2018; Liu et al., 2022). In Step 1, we quantified actual food waste over 1,536,610 meals in three hotel staff cafeterias in Macau over four months using waste weight data measured via smart bins. In total, the three sites reduced approximately 9819.73 kilograms of food waste during the information campaign as compared to the baselines[4], equivalent to 24,549 meals saved or 42.22 metric tons of reduction in CO_2 emissions. In step 2, we examined self-reported food saving behaviors at work and at home amongst the same employees and found positive correlations between workplace food waste reduction efforts and food savings at home. The cross-site differences in food waste reduction were consistent in two phases, i.e., there were significantly less actual food waste and more self-reported food-saving actions in treatment site C, supporting the validity of both measures. In other words, we did not detect strong discrepancies between observational and self-reported data, which were typically observed in other food waste studies (Sebbane & Costa, 2018). This could be due to that the employees in our study could read their own waste amount on the smart bins, and were given feedback on their collective performance fortnightly at work, so they were less likely to underestimate how much food they wasted.

Secondly, this study was conducted in an under-explored field setting in Macau, China. Most previous research on food waste interventions was carried out in American or European countries (Reisch et al., 2020), and smart bins and feedback were typically installed in residential households (Lim et al., 2021; Roe et al., 2022), rather than the workplace. Therefore, our Chinese sample and workplace setting provide valuable insights into food waste management on a global scale. The typical collectivist culture in China implies that Chinese workers are more likely to be influenced by the collective norms and organizational culture built up in workplace campaigns. The same campaign may not be as effective were it initiated in well-studied individualist societies, but would hopefully have similar impacts in the wide range of countries with collectivist cultures. Companies in collectivist countries also show greater interest in disclosing their environmental policy and disseminating environmental information (Cubilla-Montilla, Galindo-Villardón, Nieto-Librero, Vicente Galindo, & García-Sánchez, 2020), which makes extensive use of the workplace pro-environmental campaign possible. Besides, as a popular tourist destination famous for gambling, Macau is filled with luxury hotels, including the ones we collaborated with. It is interesting and encouraging to see that workers who witness indulgent consumption every day can still be stimulated to reduce their waste behaviors.

Nevertheless, the current study also has limitations. We have previously noted several potential problems specific to Step 1 or Step 2 that make us cautious about interpreting our results as "causal", including the inability to empirically verify if there were parallel trends in the pre-treatment periods, the differences between sites arising from factors like menu changes and food preparation techniques, and the issue of common method variance in cross-sectional surveys. More broadly across the two steps, our study was unable to check if an individual's self-report behavior matched his actual food waste behaviors because individual-level directly observed data on food waste at work and home was unavailable. In addition, we did not have a control group that received no feedback at all, so we were unable to shed light on whether the sites would have had a steeper increasing trend in food waste in the absence

[4] Following the WS system provider's recommendation, we took two weeks of reliable data right after the system was installed in each site and calculated their average food waste per meal as the baseline amounts, which were 86.39 grams, 90.14 grams, and 79.72 grams for Site A, B, and C, respectively.

of any feedback, or indeed if there were any contextual spillovers caused by informational feedback only. Lastly, this study was conducted during a period when the Chinese government was lifting pandemic restrictions, leading to some uncertainty about how representative and generalizable these results would be at other times. Future studies can address these issues and examine the impact of such campaigns in conjunction with other nudges like reducing plate size.

To conclude, the present research demonstrates for the first time that food waste feedback provided together with environmental footprint information and anthropomorphic cues jointly contribute to reducing food waste at work and can have positive spillover effects on food saving behaviors as well as other waste-reduction actions at home. The findings help advance the emerging field of multi-level interventions in managing consumer food waste behaviors.

Statement of author contributions

GS, FW, MMG, SM conceptualized the study and designed the methodology. FW and GS analyzed the data and interpreted the results, FW curated and managed the data, GS and FW wrote the original draft and MMG contributed to subsequent versions. GS supervised the project. All the feedback interventions were co-designed with Winnow and the project was jointly implemented by Winnow, Melco, and LSE.

Declaration of Competing Interest

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

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Supplementary materials

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