

Pictorial Warning Nudges Can Reduce Plastic Packaging Use

Schockbilder als Nudges können die Nutzung von Plastikverpackungen reduzieren

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Abstract

Pictorial warnings are effective tools for nudging individuals' health-related behavior, but much less is known of whether they can also shape pro-environmental decisions. Two online-experiments investigated the effect of simple pictorial warnings to reduce the use of plastic packaging. Experiment 1 ($N = 289$ participants) explored the effect of an environmental pictorial warning (i.e., a seal suffocating in a plastic bag) on the choice of plastic bags within a fictitious shopping scenario. Experiment 2 ($N = 551$ participants) investigated whether an environment-unrelated pictorial warning (i.e., a dead fish infested by maggots) would lead to the same effects on plastic bottle choice as an environment-related pictorial (i.e., a dead fish with a plastic bottle in its mouth). Further, environmental attitude and shame were assessed as mediator variables. As expected, the probability of choosing the sustainable product was significantly enhanced in both experiments when participants were presented with a pictorial warning nudge. Experiment 2 revealed that the effect could be assigned to the general aversiveness of the pictures, and not to their plastic-relatedness. The results demonstrate that pictorial warnings work also for pro-environmental decisions, and should be considered in environmental protection campaigns.

Keywords

Pictorial warning, Nudge, Sustainable decision-making, Pro-environmental intervention, Plastic waste

Impact statement

In two online experiments, we investigated whether pictorial warning nudges—commonly used in the health context—can also be applied in the context of environmental protection, specifically to reduce plastic pollution. In two fictitious scenarios, participants were more likely to choose a sustainable behavioral option after being shown a pictorial warning on a plastic packaging. These results highlight the potential of pictorial warning nudges as an additional intervention tool for environmental campaigns. Notably, the observed nudging effect was primarily driven by the aversive nature of the images rather than their environmental content. Since the decisions in our experiments were made in fictitious scenarios, further research is needed to assess the effectiveness of pictorial warning nudges in real-world consumer choices and across a broader range of products.

1 Introduction

Within the health domain, pictorial warnings have been shown to successfully discourage behaviors that are harmful to individuals themselves, such as smoking and alcohol consumption (Noar et al., 2016; Thrasher et al., 2007; Wigg & Stafford, 2016). This raises the question of whether pictorial warnings can also discourage behaviors that are harmful to the environment. In contrast to health-related applications, environmental pictorial warnings have received considerably less empirical attention (e.g., Hughes et al., 2023; Luo et al., 2022; Wee et al., 2021). Yet, such warnings may represent a promising and easily implementable policy instrument for promoting pro-environmental behavior. Similar to pictorial warnings on cigarette packages, environmental warning images could be placed directly on products or packaging, thereby influencing decisions at the point of choice. Accordingly, the present research focuses on the use of pictorial warnings to reduce preferences for plastic packaging. Plastic packaging represents a particularly relevant domain given its substantial environmental consequences, including waste accumulation, pollution, and resource consumption (Heidbreder et al., 2019; Kibria et al., 2023; Otto et al., 2021). Consequently, identifying effective interventions to reduce plastic packaging use is of considerable societal and policy relevance. Across two online-experiments, we examine the effectiveness of environment-related pictorial warnings placed directly on the plastic packaging. In doing so, the present research provides initial evidence regarding the potential of pictorial warnings as a behavioral intervention tool within the environmental domain and offers a basis for future research in real sales contexts.

1.1 Pictorial Warning Effects in the Environmental Domain

Findings from health-related warning contexts cannot simply be assumed to generalize to pro-environmental behaviors. Although both domains involve behavior change aimed at preventing negative consequences, important differences exist between health-related and pro-environmental behaviors. Health behaviors often provide direct and personally relevant benefits to the individual performing them, such as reducing disease risk or improving well-being. In contrast, the benefits of pro-environmental behaviors are frequently less immediate, more indirect, and distributed across society, potentially affecting geographically distant populations and future generations. Moreover, environmental problems are typically collective in nature, meaning that the actions of a single individual may appear insufficient to meaningfully address the problem unless others also change their behavior. Consequently, environmentally harmful behaviors may be perceived as less personally threatening and less directly connected to individual outcomes than health-related behaviors such as smoking (Nisbet & Gick, 2008). It is therefore important to investigate whether pictorial warnings can exert comparable effects in environmental decision contexts and, thus, whether they represent a useful intervention strategy for promoting pro-environmental behavior.

While a small number of studies have examined pictorial warnings in environmental contexts and provide some evidence for their potential effectiveness, the existing literature remains sparse and mixed, highlighting the need for further research

in this area. For example, Luo et al. (2022) conducted a field experiment in an office building aimed at reducing plastic waste. Participants were exposed to different forms of recycling signage, including simplified recycling instructions, a pledge to be “plastic wise,” and a pictorial warning depicting a marine animal trapped in plastic debris. The pictorial warning produced the largest effect, reducing plastic waste by 17%. In contrast, Vasiljevic et al. (2024) did not observe a reduction in meat meal consumption in a field intervention comparing text-only and text-and-image labels on environmental consequences of meat consumption, conducted across two university dining halls. Importantly, in both studies, the warnings were not presented directly on the products or packaging themselves. Consequently, these studies did not address whether warnings placed directly on products or packaging can influence consumer choice at the point of purchase or selection.

Research examining warnings directly attached to products remains particularly scarce, and are limited to meat consumption. Hughes et al. (2023), for example, investigated pictorial warning labels designed to reduce meat meal selection in a hypothetical online setting. Participants were randomly assigned to labels communicating health, climate, or pandemic risks, each combining an image with accompanying text, or to a control condition without warnings. All warning conditions reduced meat meal selection compared to the control group. Similarly, Kranzbühler and Schifferstein (2023) found that pictorial warnings combined with text-based messages focusing on animal welfare and environmental consequences reduced consumers’ purchase intentions for meat products. However, in both studies the warning labels combined visual and textual elements. Consequently, it remains unclear whether the observed effects were driven primarily by the pictorial component, the textual information, or the combination of both.

Additional evidence comes from studies examining text-based environmental warning labels rather than image-based warnings. For example, Hughes et al. (2024) tested environmental traffic-light labels in an online experiment on meal selection. Labels placed on meat meals that highlighted a high climate impact reduced meat meal selection, whereas labels highlighting a low climate impact on vegetarian and vegan meals did not increase vegetarian or vegan meal selection compared to a no-label control condition. These findings suggest that negatively framed environmental warnings presented on the product to be avoided may be more effective than positively framed labels presented on alternative products, which aligns with the use of aversive pictorial warnings. Similarly, Taillie et al. (2023) found that warning labels (environment- and health related in combination) reduced purchase intentions for red meat in a naturalistic online grocery store. Related research further suggests that such warning labels may even produce spillover effects on other animal-based products (Willits-Smith et al., 2024).

Taken together, prior research provides initial evidence that environmental pictorial warning labels can influence environmentally relevant decisions. However, the existing literature remains fragmented and limited in several important respects. First, relatively little research has examined pictorial warnings in environmental contexts compared to health domains. Second, many studies investigated signage or labels presented separately from the product itself rather than warnings attached directly to products or packaging. Third, several studies combined textual and pictorial elements, making it difficult to isolate the specific influence of images. These

limitations highlight the need for further research examining whether purely pictorial warnings placed directly on environmentally harmful products can influence consumer decision-making.

1.2 Conceptualizing Pictorial Warnings within Behavioral Intervention Frameworks

Pictorial warnings typically consist of strongly aversive images that aim to discourage individuals from choosing specific products (Fumagalli & Shrum, 2024; Hammond, 2011; Peters et al., 2013). Several scholars situate pictorial warnings within the broader framework of nudging (e.g., Hall, Marteau et al., 2018, Luo et al., 2022; Thaler & Sunstein, 2021). Nudges are subtle modifications of the choice environment that influence behavior without restricting available options (Benartzi et al., 2017; Lehner et al., 2016; Thaler & Sunstein, 2008). The effectiveness of nudges is commonly explained through dual-process theories of decision-making (Evans, 2008; Kahneman, 2003). These theories distinguish between a fast, automatic, affective, and intuitive processing system (System 1) and a slower, more reflective, analytical, and deliberate system (System 2). Nudge interventions are generally assumed to primarily target System 1 processes by activating heuristics and affective reactions (Ben Lakhdar et al., 2020; Marchiori et al., 2017). However, there is considerable variation in how nudges are defined (Congiu & Moscati, 2021). Narrow definitions restrict nudges to interventions that influence behavior without individuals' conscious awareness (Gemmecke et al., 2025), whereas broader definitions include any modification of the decision context that systematically influences behavior, even when individuals are aware of the intervention (Thaler & Sunstein, 2021). This definitional breadth implies that nudging encompasses a heterogeneous set of methods that operate through different psychological mechanisms (Ben Lakhdar et al., 2020). Accordingly, Wee et al. (2021) identify seven key nudging techniques in the context of pro-environmental behavior: prompting, sizing, proximity, presentation, labelling, priming, and functional design. Within this classification, pictorial warnings as used in the present study (i.e., warnings displayed directly on product packaging) can be understood primarily as a form of labelling, while simultaneously operating through mechanisms of priming and prompting.

Labelling refers to the provision of information attached directly to a product at the point of choice (Hollands et al., 2013; Wee et al., 2021). From this perspective, pictorial warnings clearly constitute a labelling intervention because they are displayed directly on the product or packaging and communicate product-relevant consequences at the moment of consumption (Van Asselt et al., 2022). In contrast to conventional labelling approaches such as nutrition or energy labels, pictorial warnings typically do not provide comparative or structured information across alternatives. Instead, they emphasize negative consequences associated with a specific product. Thus, pictorial warnings can be understood as a particular form of warning label that combines affective and informational elements (Koch et al., 2022). Accordingly, the effectiveness of pictorial warnings appears to rely primarily on the psychological mechanisms of priming and prompting.

Priming refers to the use of cues that subtly activate associated thoughts, emotions, or behavioral tendencies, thereby shaping responses in a largely non-conscious

manner (Hollands et al., 2013; Wee et al., 2021). From this perspective, pictorial warnings can be understood as primes that discourage harmful choices through emotionally salient imagery. Indeed, pictorial warnings have repeatedly been shown to elicit strong negative emotions such as fear, disgust, guilt, or shame (e.g., Fumagalli & Shrur, 2024; Hammond, 2011; Kees et al., 2010; Koch et al., 2022). These emotional responses may, in turn, trigger coping processes aimed at restoring emotional equilibrium (Lazarus, 1991), thereby motivating individuals to avoid the harmful product in order to reduce emotional discomfort. Consistent with fear appeal theories (e.g., Protection Motivation Theory, Rogers, 1983; Extended Parallel Process Model, Witte et al., 2001), behavioral change is more likely when individuals perceive a threat and believe that an alternative behavior can effectively mitigate it.

Additionally, pictorial warnings may serve as prompts, which direct attention to relevant information at the moment of decision-making (Sharps et al., 2020; Thrasher et al., 2007). Prompts facilitate the retrieval and application of existing knowledge and attitudes that might otherwise remain inactive in the decision situation and can help bridge the gap between intentions and behavior (Gemmecke et al., 2025). In this sense, pictorial warnings can make otherwise overlooked consequences for the environment cognitively accessible and support more reflective decision-making by reminding individuals of prior knowledge about plastic pollution. Accordingly, findings from the health domain suggests that pictorial warnings not only evoke emotions but also increase awareness and knowledge about risks, thereby contributing to more informed decision-making (Hammond, 2011; Noar et al., 2016; Vasiljevic et al., 2024). More generally, visual stimuli can efficiently communicate complex information and activate associations, values, and concepts (Boomsma et al., 2016; Lurie & Mason, 2007; McQuarrie & Mick, 1999; Underwood & Klein, 2002). Environment-related pictorial warnings, as a form of visual prompt, may make the environmental consequences of behaviors more concrete and cognitively accessible, thereby strengthening the salience of long-term environmental goals (Boomsma et al., 2016).

Taken together, pictorial warnings may operate through both an affective (prime-like) pathway, triggering immediate emotional responses, and a cognitive (prompt-like) pathway, reactivating existing environmental knowledge, attitudes, and considerations at the point of choice. This dual function of pictorial warnings may be especially relevant in the context of pro-environmental behavior, where behavioral consequences are often less salient and less directly experienced (Lorenzoni et al., 2007). Accordingly, pictorial warnings may not only discourage environmentally harmful behavior but also reinforce and reactivate knowledge about its consequences at the point of choice.

1.3 Plastic Packaging Use as the Behavioral Context of the Present Research

The present research examines whether pictorial warnings can be adapted from the health domain to the environmental domain, with a particular focus on reducing the use of plastic packaging as one form of waste-related pro-environmental behavior (Heidbreder et al., 2020). The use of plastic packaging is a highly relevant target

behavior because it is associated with substantial environmental impact while simultaneously representing a routine and low-involvement consumption behavior (Espineda et al., 2025). Research suggests that the choice of plastic packaging is frequently guided by affective impressions rather than deliberative evaluation. Accordingly, although consumers generally express environmental concern and report preferences for more sustainable packaging options, these preferences are constrained by factors such as price sensitivity and convenience. In addition, consumers often have limited knowledge about the environmental implications of packaging materials and the practical consequences of recyclability and alternative options (Orzan et al., 2018; Otto et al., 2021). Against this background, interventions that provide salient information directly at the point of decision may be particularly relevant for bridging this gap. Plastic packaging is therefore a suitable context for pictorial warnings, as such interventions can be directly integrated into product-related decision environments in a manner similar to warning labels on cigarette or alcohol packaging, thereby influencing choices at the moment they are made. Examining the transfer of this intervention strategy from the health domain to environmental behavior may thus provide valuable insights into the broader applicability and scalability of pictorial warnings as behavioral interventions (Costa-Font et al., 2014; Lehner et al., 2016).

In the present study, we focus on the concrete decision situation in which consumers choose between a product with plastic packaging and a potential alternative. From an environmental psychology perspective, plastic reduction behavior is shaped by numerous interacting factors. Extended versions of the Theory of Planned Behavior (Ajzen, 1991) and related approaches suggest that plastic consumption is influenced by variables such as attitudes, perceived behavioral control, social and descriptive norms, habits, convenience, and contextual factors (e.g., Heidbreder et al., 2020; Steg & Vlek, 2009; Truelove et al., 2023; Wang et al., 2024). Accordingly, consumers often face barriers that favor plastic consumption, including lower prices, greater availability, habitual purchasing routines, and situational constraints within shopping environments. Consequently, choosing alternatives to plastic packaging may require consumers to overcome the more convenient or habitual option. Against this background, pictorial warnings may serve as an intervention that increases the motivational salience of environmental consequences at the moment of decision-making. By placing aversive environmental imagery directly on plastic packaging, such warnings may interrupt habitual decision processes and encourage consumers to reconsider their choices despite contextual barriers favoring plastic consumption. To investigate this assumption, Experiment 1 examined the effect of a pictorial warning depicting a suffocating seal on the choice of plastic bags in a fictitious supermarket shopping scenario. Experiment 2 extended the investigation to choices involving plastic bottles. In contrast to prior work by Hughes et al. (2023), who examined combined text-and-image warnings on meat meal selection, the present research focused exclusively on pictorial warnings without accompanying written prompts. This design allows for a more direct assessment of the effectiveness of the image itself, independent of potential confounding effects of textual information (Gemmecke et al., 2025).

In addition to examining behavioral effects, the present research also aimed to investigate the psychological mechanisms underlying pictorial warnings. In line with informational approaches to pro-environmental behavior (Gemmecke et al., 2025;

Steg & Vlek, 2009), pictorial warnings may activate previously existing environmental knowledge and attitudes about environmental consequences. Across both experiments, we tested whether pictorial warnings operate by increasing the accessibility of environmental consequences and thereby activating awareness at the point of decision. This mechanism is consistent with the proposed prompt-like function of pictorial warnings, in which behavioral effects are driven by the activation and retrieval of relevant knowledge at the time of choice (Moussaoui et al., 2020).

Moreover, Experiment 2 examined the role of the aversive nature of pictorial warnings, reflecting their potential prime-like characteristics associated with affect-driven responses. Specifically, we compared an environmentally related aversive warning image (i.e., a dead fish with a plastic bottle in its mouth) with an environmentally unrelated but equally aversive image (i.e., a dead fish infested with maggots). This comparison allowed us to disentangle whether the effectiveness of pictorial warnings depends primarily on the environmental relevance of the image content or on its general aversive quality.

2 Experiment 1

Experiment 1 examined the potential of an environment-related pictorial warning to reduce the use of plastic bags. Several established policy measures already aim to reduce plastic bag consumption, including bans and small fees on plastic bags (e.g., Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit, 2019; European Parliament, 2019). These measures have been shown to reduce usage, although their effects are not uniform across all consumer groups (Rivers et al., 2017). Accordingly, additional interventions are needed, and pictorial warnings may represent a useful complementary strategy, as they could be easily implemented by printing warning images directly onto plastic bags.

To date, no study has systematically examined the use of pictorial warnings on plastic packaging. Beyond initial evidence from related pro-environmental contexts (Hughes et al., 2023; Luo et al., 2022), some support for the effectiveness of warning labels in this domain comes from Van Asselt et al. (2022), who found that text-based warning labels on plastic egg packaging reduced consumers' willingness to pay compared to non-plastic alternatives. Taken together with evidence from health psychology showing that pictorial warnings effectively reduce smoking prevalence (Noar et al., 2016), these findings suggest that pictorial warnings may also influence decisions related to plastic packaging. Based on this reasoning, we hypothesized that individuals choose a reusable textile bag more often when a single-use plastic carrier bag was labeled with a pictorial warning compared to an identical plastic bag without such a warning (Hypothesis A.1).

To better understand the mechanisms underlying pictorial warning effects, we examined whether exposure to the warning increases consumers' awareness of the importance of avoiding plastic packaging for environmental welfare. This mechanism would be consistent with a prompt-like function of pictorial warnings, in which effects arise through the activation and retrieval of environmental attitudes at the point of decision (Gemmecke et al., 2025; Moussaoui et al., 2020). While previous research has shown that pictorial warnings can elicit strong negative emo-

tions that individuals are motivated to avoid (Fumagalli & Shrum, 2024; Hammond, 2011; Kranzbühler & Schifferstein, 2023), they can also serve as sources of information that improve knowledge and understanding (Noar et al., 2016). To capture the latter potential prompt-like pathway, we focus on environmental attitudes as an exploratory outcome variable. Environmental attitudes reflect individuals' general evaluation of and commitment to environmental protection goals (Kaiser, 2021; Kaiser et al., 2011) and are partly grounded in environmental knowledge and awareness of environmental consequences (Bamberg & Möser, 2007; Kaiser & Fuhrer, 2003; Stern, 2000). Accordingly, increased awareness of environmental consequences may influence behavior indirectly via changes in environmental attitudes. From this perspective, pictorial warnings may enhance the cognitive accessibility of environmental consequences at the point of decision, thereby activating existing environmental considerations that might otherwise remain inactive during consumption choices. Thus, this exploratory analysis provides initial evidence for a potential prompt-like function of pictorial warnings, in which they not only evoke affective responses (prime-like mechanism) but may also activate environmentally relevant knowledge and considerations during decision-making.

2.1 Methods

Participants were $N = 289$ adults (122 men, 167 women; age range: 18 to 70 years, $M = 27.3$, $SD = 10.1$), recruited via social networks or the online recruiting platform SurveyCircle (SurveyCircle, n.d.). SurveyCircle participants were compensated in the form of credits. According to G*Power (Faul et al., 2007), an optimal sample size of 276 was suggested.¹

The online experiment was based on a single-factor between-subjects design with the independent variable nudge: In the experimental condition, the plastic bag was presented with a pictorial warning depicting a seal suffocating in a plastic bag (see Figure 1), and in the control condition, a blank plastic bag was presented. The dependent variable was participants' choice of a single-use plastic carrier bag or a sustainable textile bag in a simulated purchase situation. For the exploratory analysis, we assessed the environmental attitude operationalized by the attitude scale of the System for Capturing Environmental Consciousness (Schahn et al., 1999, see Table SC1). The scale showed very good internal consistency, with Cronbach's $\alpha = .91$.

The experiment was implemented online with SoSci Survey (Leiner, 2019) and took 7.08 min on average ($SD = 2.91$). After providing online written consent, eligibility criteria of a minimum age of 18 years and sufficient German language proficiency (B1 level) were assessed. Participants who did not meet these criteria were automatically directed to the end of the survey and were therefore not included in the final dataset. Participants then reported their age and gender before

¹ The optimal sample size was calculated a priori using G*Power, Version 3.1.9.2 (Faul et al., 2007). For a two-tailed logistic regression (z test), we assumed an effect size of $OR = 2.47$ based on previous studies (e.g., Noar et al., 2016) and a baseline of 0.50. Type 1 error probability was set to 0.05, power was set to 0.95. We assumed no covariates and a binomial distribution in a balanced design ($\pi = 0.5$).

being randomly assigned (using the built-in randomization function in SoSci Survey) to either the experimental or control condition. All participants subsequently read the same scenario in which they were asked to imagine that they went food shopping for their 80-year-old neighbor and had a fixed budget of 20 €. To transport the purchases, they could decide between a single-use plastic carrier bag for 15 cents or a textile bag for 1 €. To buy the textile bag, they would be required to put back a package of pralines as part of the purchases because of their limited budget (see Appendix SA in the supplemental material for the exact scenario description). The price difference and the return of the pralines were implemented to make the sustainable option costlier and thereby more ecologically valid, given that the more sustainable option is often more expensive.

The only difference between conditions was the visual presentation of the choice options: In the experimental condition, participants could choose between a blank textile bag and a plastic bag with the pictorial warning, and in the control condition, they could decide between a blank textile and a blank plastic bag. The position of the bags (i.e., left or right) was counterbalanced. In the end, participants' environmental attitude was assessed. None of the survey questions or selection procedures included a "no answer" option. No attention checks were included in the survey.

Figure 1

Image Used in Experiment 1 as Pictorial Warning on the Plastic Bag



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2.2 Results

Data analysis was conducted in R (Version 4.1.3; R Core Team, 2021). An alpha level of .05 was employed for all statistical analyses.

The plastic bag was chosen by 60.9% of the participants in the control condition ($n = 151$) and 42.1% in the experimental condition ($n = 138$). To analyze the effect of the nudge intervention on the bag choice, a binomial logistic regression was conducted with the predictor condition (0 = control, 1 = experimental) and the

criterion bag choice (0 = plastic bag, 1 = textile bag). The regression model revealed a significant model fit, $\chi^2(1) = 10.21, p = .001$, Nagelkerke's $R^2 = .05$. Corroborating Hypothesis A.1, the nudge in the experimental condition significantly enhanced the probability of choosing the textile bag compared to the control condition, $B = 0.76$ ($SE = 0.24$), $z = -3.17, p = .002$, $OR = 2.14$, 95% CI [1.34, 3.44]. Based on the guidelines by Chen et al. (2010), the magnitude of the observed effect can be classified as small-to-medium.

For the exploratory analysis, a robust one-way ANOVA was conducted because the assumption of normality of residuals was not met. Environmental attitude was significantly higher in the experimental condition ($M = 5.33, SD = 0.77$) compared to the control condition ($M = 5.18, SD = 0.80$), $F_1(1, 169.34) = 4.01, p = .047$, $\xi = 0.18$, 95% CI [0.03, 0.34].

2.3 Discussion of Experiment 1

Participants chose the textile bag more often when the alternative plastic bag showed a picture of a suffocating seal compared to a conventional plastic bag without the picture. This finding suggests that pictorial warnings can effectively reduce preferences for plastic bags. Thus, the present results extend previous findings on text-based warning labels reducing consumers' preferences for plastic packaging (Van Asselt et al., 2022). In this regard, the findings are consistent with the well-established effectiveness of pictorial warnings in health-related contexts (e.g., Hammond, 2011; Noar et al., 2016) and provide initial evidence that such interventions may also influence environmentally relevant consumer decisions.

Furthermore, our explorative analysis revealed higher environmental attitudes in the pictorial warning condition compared to the control condition. This finding suggests that pictorial warnings may not only operate through automatic affective mechanisms typically associated with System 1 processing, but may additionally activate more reflective and deliberative processes associated with System 2 (i.e., Dual Processing Theories, Evans, 2008; Kahneman, 2003). In this regard, pictorial warnings may function not only as nudges that elicit immediate emotional reactions, but also as prompts that increase the salience of environmental consequences and activate environmental considerations at the point of decision-making. Experiment 2 was designed to investigate these underlying mechanisms in greater detail.

At the same time, Experiment 1 had several limitations that were taken into account in Experiment 2. First, the shopping scenario was very unique (i.e., the return of pralines to be able to afford the textile bag and the fact that the participants went shopping for someone else) and therefore not generalizable to other situations. In Experiment 2, participants shopped for themselves. Second, given that prices affect people's willingness to buy a product (Dodds et al., 1991), the price of the target products was equal in Experiment 2. Third, the effect of the pictorial warning in Experiment 1 might have been due to the negative valence and social undesirability of the motif rather than by its environmental relevance (i.e., plastic pollution). Therefore, Experiment 2 examined whether a pictorial warning related to plastic pollution would lead to the same effects as a plastic-unrelated pictorial warning.

3 Experiment 2

In Experiment 2, the effects of two different aversive pictorial nudges were compared with a ‘no nudge’ condition on participants’ choice of a bottle (i.e., plastic versus glass). The aversive nudges referred to plastic pollution (plastic-related aversive nudge, i.e., a dead fish with a plastic bottle in its mouth—similar pictures are often shown to illustrate plastic pollution of the oceans) or were unrelated to plastic pollution (plastic-unrelated aversive nudge, i.e., a dead fish infested by maggots), depicted on disposable plastic bottles. First, we were interested in the replicability of the pictorial warning effect of Experiment 1. Second, we examined whether the content of the pictorial nudge or the aversive character of the picture discouraged consumers from choosing the product.

In accordance with Experiment 1 and previous findings from investigating pictorial warnings on cigarette packs (e.g., Noar et al., 2016; Peters et al., 2013), we hypothesized that participants would choose a reusable glass bottle more often than a disposable plastic bottle when the disposable plastic bottle was presented with a pictorial warning nudge (plastic-related and plastic-unrelated aversive nudge) compared to a blank disposable plastic bottle (no nudge; Hypothesis B.1).

To explore how pictorial warnings influence pro-environmental decision-making, we examined environmental attitude as a potential mediator reflecting the cognitive accessibility of environmental consequences at the point of decision. Experiment 1 provided initial exploratory evidence for the proposed prompt-like mechanism, showing stronger environmental attitudes in the pictorial warning condition compared to the no-nudge condition. In this experiment, environmental attitude was assessed using a broad measure of general environmental concern (Schahn et al., 1999). In Experiment 2, we employed a more content-specific measure of environmental attitude related to plastic pollution (Weigel & Weigel, 1978; Mathur & Singh, 2019), which better captures plastic-relevant considerations assumed to be activated by plastic-related pictorial warnings. We hypothesized in Experiment 2 that a plastic-related aversive pictorial warning activates environmental attitudes, which in turn increases the probability of choosing the glass instead of the plastic bottle (Hypothesis B.2). This mediation effect was not expected in the conditions containing no nudge or the plastic-unrelated aversive pictorial warning.

The second potential mediator variable assessed in Experiment 2 was shame as a negative emotion. When a person imagines using or buying an aversively designed plastic bottle in public, shame could emerge because the aversive bottle is incongruent with the person’s self-concept or because other people could evaluate the aversive bottle negatively (Lewis, 1971; Tangney & Dearing, 2002). Therefore, choosing an unprinted glass bottle instead of a plastic bottle could be a way to restore positive emotions (Lazarus, 1991). We hypothesized that a plastic-related aversive nudge and a plastic-unrelated aversive nudge evoke state-based shame, which in turn increase the probability of choosing the glass bottle (Hypothesis B.3). This mediation effect should not occur in the ‘no nudge’ condition.

3.1 Method

Experiment 2 was preregistered at <https://doi.org/10.17605/OSF.IO/7ZC3Q>.

3.1.1 Design and sample

The online-experiment followed a one-factorial between-subjects design with the independent variable pictorial warning nudge (no nudge vs. plastic-related aversive nudge vs. plastic-unrelated aversive nudge) and the dependent variable bottle choice (glass vs. plastic bottle). Environmental attitude and shame were assessed as mediator variables. Social desirability was examined as control variable, potentially explaining bottle choice at least to some extent (Heidbreder et al., 2019), since Experiment 2 was also an online-study not involving real decision-making.

A total of 553 participants were mainly recruited via social networks, SurveyCircle (SurveyCircle, n.d.), and the university's internal recruiting platform. As an incentive, participants had the choice to receive credit points for SurveyCircle or their study or participate in a lottery. Two participants were excluded because they were younger than 16 years, although the study was restricted to eligible participants. The final sample ($N=551$) consisted of 185 males, 363 females, and three diverse participants (age range: 16 to 93 years, $M = 27.9$, $SD = 11.0$; $n = 185$ in the 'no nudge' condition, $n = 182$ in the 'plastic-related aversive nudge' condition, $n = 184$ in the 'plastic-unrelated nudge' condition). According to G*Power (Faul et al., 2007), we aimed for a sample size of 552.²

3.1.2 Measurements

Environmental attitude was measured by 12 items, adapted from the Environmental Concern Scale (Weigel & Weigel, 1978) and the Plastic Awareness Scale (Mathur & Singh, 2019; see Table SC2). The scale showed strong internal consistency, with Cronbach's $\alpha = .89$.

Feelings of shame when using plastic and glass bottles was assessed by eight items, adapted from the Experiential Shame Scale (Turner, 1998) and the Adapted Shame and Guilt Scale (Hoblitzelle, 1982; see Table SC3). The plastic-related shame ratings were used for testing a mediation effect of shame because shame was expected to be caused by the pictorial warnings on the plastic bottles. The glass-related shame values were surveyed for a descriptive purpose only and were expected to be lower than the plastic-related shame values because buying glass bottles is environmentally more responsible and should thus be associated with less shame. Internal consistency was good to excellent for both scales, with Cronbach's $\alpha = .87$ for glass-related shame and Cronbach's $\alpha = .93$ for plastic-related shame.

² The optimal sample size was calculated a priori with reference to H1 using G*Power, Version 3.1.9.2 (Faul et al., 2007). The analysis was conducted with reference to a two-tailed logistic regression with the pictorial warning about plastic pollution as dummy predictor and the bottle choice as dependent variable. Based on Experiment 1, we expected an effect size of $OR = 2.41$. The baseline was set to .40, Type 1 error probability to .05 and power to .95. An R^2 of .25 was expected for the second dummy-predictor pictorial warning unrelated to plastic pollution. We set a binomial distribution in a balanced design with three conditions ($\pi = 0.33$).

Figure 2

Images Used in Experiment 2 as Pictorial Warnings on Plastic Bottles

A



B



Note. Image A was used in the ‘plastic-related aversive nudge’ condition; Copyright by Julie Dermansky. Image B was used in the ‘plastic-unrelated aversive nudge’ condition; Copyright by Ian Thraves/Alamy. The images are reproduced with permission and not covered by the Creative Commons Attribution 4.0 license applicable to this article. For reuse, permission must be obtained directly from the copyright holder.

Social desirability was examined using the 7-item scale for measuring social desired responsiveness (Satow, 2012). Internal consistency was relatively low, with Cronbach’s $\alpha = .66$.

3.1.3 Procedure

The study was implemented online with SoSci Survey (Leiner, 2019) and took 8.16 min on average ($SD = 3.47$). After providing online written consent, eligibility criteria of a minimum age of 16 years and sufficient German language proficiency (B1 level) were assessed. Participants who did not meet these criteria were automatically directed to the end of the survey and were therefore not included in the final dataset. Participants then reported their age, gender, and current primary occupation before being randomly assigned (using the built-in randomization function in SoSci Survey) to one of three experimental conditions. Participants subsequently read a scenario in which they were asked to imagine shopping for a dinner with friends, including water in either a glass or a plastic bottle (see Appendix SB for the full scenario description).

Across all conditions, the scenario and decision context were identical. The only difference between conditions was the type of pictorial warning applied to the presented plastic bottle. In the ‘plastic-related aversive nudge’ condition, the plastic bottle was presented with a pictorial warning nudge, depicting a dead fish with a plastic bottle in its mouth (see Figure 2A). In the ‘plastic-unrelated aversive nudge’ condition, the plastic bottle was presented with a pictorial warning nudge depicting a dead fish infested by maggots (see Figure 2B). In the ‘no nudge’ condition, a blank plastic bottle was presented. In all conditions, a blank glass bottle was depicted as an alternative to the respective plastic bottle. Participants were randomly assigned to one of the three conditions, with the position of the glass and plastic

bottles counterbalanced. Based on actual water bottles from German supermarkets, information about the deposit amount (plastic = 0.25 €, glass = 0.15 €), weight (plastic = 1.4 kg, glass = 1.7 kg) and price per liter (plastic = 0.94 €, glass = 0.94 €) were provided to approximate a realistic decision context. This information ensured that choosing glass bottles was not perceived as equally convenient as choosing plastic bottles, but instead involved practical disadvantages (e.g., greater weight) that consumers encounter outside the experimental setting.³ After making their choice, participants answered the environmental attitude scale and the shame scale. The order of scales and the items within each scale was randomized. Social desirability was assessed last. None of the survey questions or selection procedures included a “no answer” option. No attention checks were included in the survey.

3.2 Results

Data analysis was conducted in R (Version 4.1.3; R Core Team, 2021). All analyses employed an alpha level of .05.

3.2.1 Testing the effect of aversive pictures on bottle choice

A binomial logistic regression was conducted for testing the effect of the dummy-coded independent variable pictorial warning nudge (i.e., the plastic-related and plastic-unrelated aversive nudge compared to no nudge) on bottle choice as criterion. The ‘plastic-related aversive’ nudge and the ‘plastic-unrelated aversive’ nudge both had significant effects on bottle choice (see Table 1), with higher probabilities of choosing the glass bottle in both experimental conditions compared to the control condition (see Figure 3). The corresponding odds ratios indicated effects of medium magnitude according to the benchmarks proposed by Chen et al. (2010), with the converted effect sizes corresponding to $d = 0.72$ and $d = 0.54$, respectively. A pairwise comparison of the estimated marginal means (*EMMs*) showed no significant difference between both conditions, *EMM Difference* = 0.31 (*SE* = .33), $z = 0.94$, $p = .345$, suggesting that the aversiveness of the picture stimulated the effect, not its plastic-relatedness.

³ It was not assessed whether or how participants attended to or made use of this information in their decision-making; however, the information was held constant across conditions.

Table 1

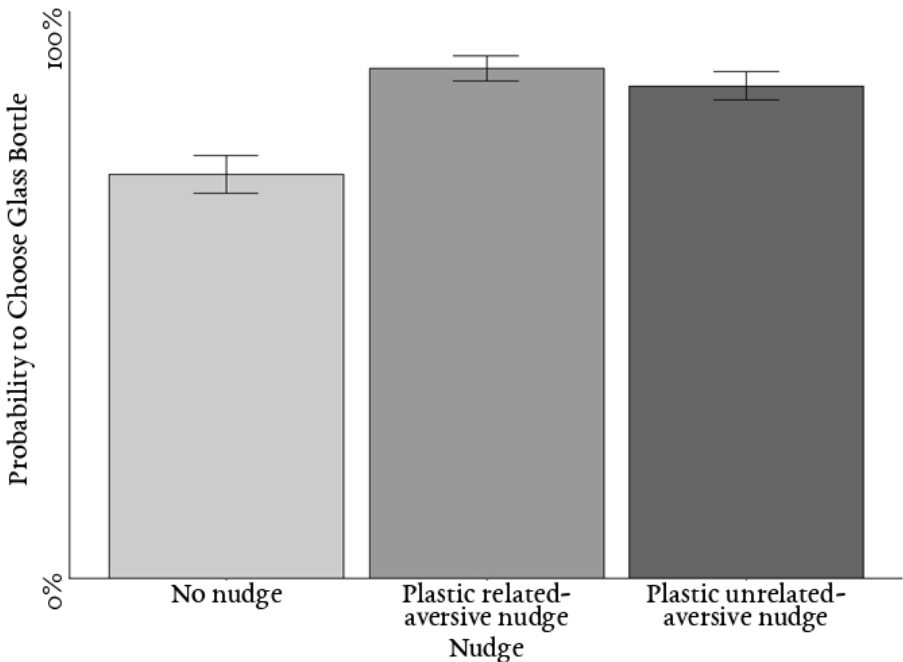
Binomial Logistic Regression Analysis for the Effect of the Pictorial Warning Nudges on Bottle Choice in Experiment 2

Predictor Variables	<i>B (SE)</i>	<i>z</i>	<i>p</i>	<i>95% CI for Odds Ratio</i>		
				<i>LL</i>	<i>Odds Ratio</i>	<i>UL</i>
Constant	0.91 (.16)	5.61	< .001	1.82	2.49	3.45
Plastic-related aversive nudge	1.30 (.29)	4.37	< .001	2.10	3.66	6.70
Plastic-unrelated aversive nudge	0.98 (.27)	3.61	< .001	1.58	2.68	4.68

Note. *N* = 551. The dependent variable bottle choice was coded with 0 = plastic bottle and 1= glass bottle. ‘Plastic-related aversive nudge’ and ‘plastic-unrelated aversive nudge’ as dummy variables of pictorial warning nudge with the ‘no nudge’ condition as the base group. See Table SD1 for dummy coding scheme.
*R*² = .05 (Hosmer-Lemeshow), .07 (Nagelkerke), .04 (Cox-Snell). Model $\chi^2(2) = 25.01, p < .001$.

Figure 3

Estimated Probabilities of Choosing the Glass Bottle over the Plastic Bottle for Each Pictorial Warning Nudge Condition



Note. *N* = 551. Error bars represent $\pm 1 SE$ of the estimated marginal means (*EMMs*).

3.2.2 Testing mediation effects

To test for possible mediating effects of environmental attitude and shame, two causal mediation analyses were conducted for each mediation variable, with bottle

choice as the dependent variable and the respective pictorial warning (i.e., plastic-related vs. plastic-unrelated) compared to the no nudge condition as the independent variable. The mediation analysis was calculated according to the four-step method by Baron and Kenny (1986): Three regression models were tested in which the mediator functioned 1) as single predictor of the bottle choice, 2) as a second predictor together with the dummy-coded predictor pictorial warning nudge, or 3) as criterion. Thereafter, the mediate-function of the *mediation*-package was used to test the significance of the respective mediation effect (Imai et al., 2010). Within the mediate-function, a number of 1000 bootstrap samples was used. For testing the regression models, the dummy coding of the pictorial warning nudge and the bottle choice was maintained. For calculating the mediation effect between the control and the respective experimental condition, the following coding was used in the mediate function: 1 = no nudge, 2 = plastic-related aversive nudge, 3 = plastic-unrelated aversive nudge.

First, potential mediation effects of environmental attitude were analysed. The values of the environmental attitude were descriptively similar in the three conditions (no nudge: $M = 4.18$, $SD = 0.69$; plastic-related aversive nudge: $M = 4.29$, $SD = 0.53$; plastic-unrelated aversive nudge: $M = 4.16$, $SD = 0.74$). In the first mediation analysis, the ‘no nudge’ condition served as control value and the ‘plastic-related aversive nudge’ condition as treatment value, which, however, had no significant effect on environmental attitude, $b = 0.11$, $SE = 0.07$, $t(548) = 1.63$, $p = .103$. In addition, the analysis revealed no mediation effect of environmental attitude in the ‘plastic-related aversive nudge’ condition, $\delta = 0.02$, 95% $CI [-0.00, 0.04]$, $p = .084$. The results do not support Hypothesis B.2: The ‘plastic-related aversive nudge’ did not enhance participants’ environmental attitude, which did not increase the probability of choosing the glass bottle instead of the plastic bottle.

In a second causal mediation analysis, the ‘plastic-unrelated aversive nudge’ condition was used as treatment value with the ‘no nudge’ condition as control value. In line with Hypothesis B.2, the ‘plastic-unrelated aversive nudge’ had no significant effect on environmental attitude, $b = -0.02$, $SE = 0.07$, $t(548) = -0.28$, $p = .782$, and environmental attitude had no mediating effect on the bottle choice in the ‘plastic-unrelated aversive nudge’ condition, $\delta = -0.00$, 95% $CI [-0.02, 0.02]$, $p = .770$.

We also tested the relationship between environmental attitude and bottle choice across all conditions. Higher values in environmental attitude in general increased the probability of choosing a glass bottle, $b = 1.07$, $SE = 0.16$, $z = 6.76$, $p < .001$, with $OR = 2.91$, 95% $CI [2.14, 3.98]$. The general effect of environmental attitude on bottle choice remained significant after including pictorial warning nudge as an additional predictor in the logistic model, $b = 1.09$, $SE = 0.16$, $z = 6.63$, $p < .001$, with $OR = 2.97$, 95% $CI [2.16, 4.11]$. A model comparison showed that including environmental attitude as additional predictor to the pictorial warning nudge explained an incremental proportion of variance in bottle choice, $\chi^2(1) = 45.50$, $p < .001$. Thus, even though environmental attitude had no mediating effect on the ‘plastic-related aversive nudge’, it had a significant effect on bottle choice.

Second, potential mediation effects of shame were analyzed. A preliminary analysis showed that glass-related shame was lower than plastic-related shame, $t(550) = -23.01$, $p < .001$, $d = .98$, 95% $CI [-1.08, -0.88]$, making a potential mediation effect

of shame plausible. To test Hypothesis B.3 that (plastic-related) shame mediates the effects of the plastic-related aversive nudge and the plastic-unrelated aversive nudge on the bottle choice, we ran two causal mediation analyses.

In the first mediation analysis, the ‘no nudge’ condition served as control value and the ‘plastic-related aversive nudge’ as treatment value. The ‘plastic-related aversive nudge’ significantly increased shame, $b = 0.43$, $SE = 0.10$, $t(548) = 4.51$, $p < .001$, with $\beta = .22$. Furthermore, higher values of shame significantly increased the probability of choosing the glass bottle, $b = 1.08$, $SE = 0.14$, $z = 7.67$, $p < .001$ with $OR = 2.95$, 95% $CI [2.25, 3.92]$. The effect of the ‘plastic-related aversive nudge’ on the bottle choice was mediated by shame, $\delta = 0.06$, 95% $CI [0.03, 0.09]$, $p < .001$. The total effect of the ‘plastic-related aversive nudge’ on bottle choice ($b = 1.30$, $SE = 0.30$, $z = 4.37$, $p < .001$) decreased from $OR = 3.66$ to $OR = 2.61$ after shame was included as a further predictor in the logistic model, but it remained significant ($b = 0.96$, $SE = 0.31$, $z = 3.05$, $p = .002$).

In the second mediation analysis, the ‘plastic-unrelated aversive nudge’ served as treatment value with the ‘no nudge’ condition as control value. The ‘plastic-unrelated aversive nudge’ significantly increased shame, $b = 0.39$, $SE = 0.09$, $t(548) = 4.10$, $p < .001$, with $\beta = .20$. The effect of the ‘plastic-unrelated aversive nudge’ on the bottle choice was mediated by shame, $\delta = 0.05$, 95% $CI [0.02, 0.18]$, $p = .004$. The total effect of the ‘plastic-unrelated aversive nudge’ on bottle choice ($b = 0.98$, $SE = 0.27$, $z = 3.61$, $p < .001$) decreased from $OR = 2.68$ to $OR = 2.01$ after shame was included as a further predictor in the logistic model but remained significant ($b = 0.70$, $SE = 0.29$, $z = 2.39$, $p = .017$).

The results indicate that the nudge intervention affected not only the bottle choice but also the feelings of shame. It can be assumed that plastic-related shame partially mediated the effect of the nudge intervention on the bottle choice, confirming Hypothesis B.3.

3.2.3 Testing the potential effect of social desirability on bottle choice

To explore the potential effect of social desirability on bottle choice, a binomial logistic regression was conducted with social desirability as a predictor in addition to the predictors pictorial warning nudge, shame, and environmental attitude. Social desirability had no significant effect on bottle choice, $b = 0.06$, $SE = 0.05$, $z = 1.12$, $p = .240$. A model comparison with a regression model without social desirability as predictor revealed that social desirability explained no incremental proportion of variance, $\chi^2(1) = 1.38$, $p = .239$.

3.3 Discussion of Experiment 2

In line with Hypothesis B.1 and results of Experiment 1, participants were more likely to choose the glass bottle when the alternative plastic bottle was presented with a pictorial warning than without such a nudge. Results further suggest that the effect of the pictorial warning on bottle choice can be explained by the aversive character of the pictorial nudge in general, and not only by the plastic-related pictorial warning.

Hypothesis B.2 was not confirmed because environmental attitude did not mediate the effect of the aversive pictorial nudge on bottle choice. While the nudge intervention had no differential effect on environmental attitude, environmental attitude predicted bottle choice. Thus, people with higher values in environmental attitude were more likely to choose glass bottles instead of plastic bottles. This finding corresponds to previous research findings on the positive association of environmental attitude with pro-environmental behavior (e.g., Bamberg & Möser, 2007; Kautish & Sharma, 2020).

Hypothesis B.3 was confirmed with shame partially mediating the effect of both pictorial warning nudges on bottle choice. Shame was increased by the pictorial warning nudges, which in turn enhanced the probability of choosing the glass bottle. Results are in line with other findings showing that shame mediated effects of negative framing on pro-environmental behavior (Amatulli et al., 2017; Rees et al., 2015).

4 General Discussion

With two online experiments, we investigated whether pictorial warnings, proven to be effective in the health context (e.g., Hammond, 2011; Noar et al., 2016), are also effective in the environmental context by reducing the use of plastic packaging. Overall, the findings suggest that pictorial warnings may represent a promising intervention strategy for promoting pro-environmental consumer decisions.

4.1 Summary of results and theoretical contribution

Across both experiments, participants were less likely to choose products with plastic packaging when the packaging displayed an environment-related pictorial warning. Experiment 1 demonstrated that a pictorial warning reduced the choice of single-use plastic carrier bags, while Experiment 2 replicated this effect in the context of plastic bottle choices. These findings extend the still limited literature on pictorial warnings in environmental contexts and align with previous research demonstrating effects of pictorial warnings on meat consumption decisions, although these studies combined images with written warning messages (Hughes et al., 2023; Kranzbühler & Schifferstein, 2023). The present findings therefore provide initial evidence that pictorial warnings themselves, even without accompanying text-messages, may influence environmentally relevant consumer choices.

The findings are also broadly consistent with the field experiment by Luo et al. (2022), who found that recycling signage combined with a pictorial warning depicting a turtle affected by plastic waste reduced plastic waste in an office setting. Importantly, Luo et al. presented the warnings near disposal bins rather than directly on products or packaging. The present studies extended this line of research by demonstrating that pictorial warnings may also influence decisions when placed directly on the product itself at the point of choice, thus making use of the labelling technique (Hollands et al., 2013; Wee et al., 2021).

Additionally, our findings contribute to the theoretical understanding of how pictorial warnings may influence pro-environmental behavior. Research on pictorial

warnings in the health domain has primarily emphasized their affective and aversive qualities, suggesting that they operate through the elicitation of strong negative emotions that individuals are motivated to avoid (Hammond, 2011; Koch et al., 2022; Rogers, 1983; Witte et al., 2001). In line with this perspective, Experiment 2 revealed that shame partially mediated the relationship between pictorial warnings and plastic bottle choices. This finding is consistent with Kranzbühler and Schifferstein (2023), who showed that warning labels combining images and text in the context of animal and environmental welfare evoke feelings of guilt and shame in meat consumption contexts. Together, these results support a prime-like interpretation of pictorial warnings, in which behavior is influenced through affective reactions triggered by salient imagery (Wee et al., 2021).

Turning to prompt-like mechanisms, the present findings provide only limited and inconsistent evidence for more deliberative mechanisms. In Experiment 1, exposure to pictorial warnings was associated with more positive environmental attitudes compared to the control condition, suggesting a potential increase in the accessibility of environmental knowledge and awareness. However, this effect was not replicated in Experiment 2. Importantly, environmental attitudes were operationalized differently across the two experiments. Whereas Experiment 1 employed a broad measure of general environmental concern as an exploratory assessment (Schahn et al., 1999), Experiment 2 used a more content-specific measure of plastic-related environmental attitudes (Weigel & Weigel, 1978; Mathur & Singh, 2019) to better align with the hypothesized mediation mechanism. Although this refinement improved the conceptual correspondence between the measure and the hypothesized process, it also limits the direct comparability of the findings across studies. Consequently, conclusions regarding the role of environmental attitudes as a prompt-like mechanism should be interpreted with caution. Overall, these results suggest that pictorial warnings primarily exert their influence through affective, prime-like processes that operate at the point of decision, whereas prompt-like effects (e.g., an activation of environmental attitudes) appear less robust. Nevertheless, the possibility that pictorial warnings engage both affective and cognitive pathways remains theoretically compelling, particularly in environmental contexts. In contrast to many health-related behaviors, environmentally relevant behaviors often provide less direct and less immediate personal benefits (Lorenzoni et al., 2007). While quitting smoking primarily protects one's own health, reducing plastic consumption contributes to collective and long-term environmental outcomes that may appear psychologically distant from the individual. In this regard, pictorial warnings may help make otherwise abstract environmental consequences more concrete and emotionally salient. Accordingly, Boomsma et al. (2016) argues that visual imagery can increase the salience of long-term environmental goals and motivate environmentally relevant action by making environmental consequences more imaginable and concrete. Taken together, this perspective highlights pictorial warnings as informative intervention that may integrate affective engagement with cognitive processing in the promotion of pro-environmental behavior.

4.2 Limitations and Future Directions

The present research employed randomized controlled designs in both experiments, allowing for a causal examination of the impact of pictorial warnings on

hypothetical consumer choices. Experiment 2 replicated the findings of Experiment 1 conceptually, in a different consumption context and with a different product category. The convergence of results across the two experiments supports the robustness of the observed effects of pictorial warnings. However, several limitations should be considered when interpreting the present findings.

First, both experiments were conducted online and relied on fictitious decision scenarios rather than real purchasing behavior. Consequently, the extent to which the observed effects generalize to real-world consumer decisions remains unclear. This limitation is particularly relevant given mixed evidence from prior field studies. While Luo et al. (2022) found positive effects of pictorial warnings on plastic waste reduction in a real-world setting, Vasiljevic et al. (2024) did not observe effects on meat consumption in a dining hall intervention. Future studies should therefore investigate whether pictorial warnings on plastic packaging continue to affect consumer behavior in naturalistic purchasing environments. This includes examining potential habituation effects and the question of whether pictorial warnings remain effective over longer periods of repeated exposure or primarily exert effects during the initial implementation phase. The field experiment by Luo et al. (2022), which reported reductions in plastic waste over a six-week intervention period when combining a recycling sign with a pictorial warning, provides promising initial evidence that such effects may persist beyond short-term exposure.

Second, the present studies relied on relatively simple behavioral operationalizations involving binary choices between products. This approach was chosen to approximate realistic purchasing decisions involving plastic versus non-plastic alternatives. However, real consumer environments typically involve multiple competing products and repeated decisions. Future research could therefore employ more complex and repeated choice paradigms similar to previous studies on meat consumption (e.g., Hughes et al., 2023, 2024) or naturalistic online shopping paradigms (e.g., Taillie et al., 2023).

Third, the scenarios used in the present experiments involved relatively specific social contexts. In Experiment 1, participants made purchasing decisions for another person, whereas Experiment 2 involved decisions in a dinner context involving friends. Consequently, social norms and anticipated social evaluation may have influenced the observed effects (Gutiérrez Taño et al., 2022). Shame, in particular, is strongly shaped by social contexts and perceived social expectations (McDonald & Crandall, 2015). Future research should therefore examine whether pictorial warnings differ in effectiveness between private and public consumption situations.

Forth, although pictorial warnings are intended to be salient by design, their implementation in the present study may have been relatively unconventional, as they were not embedded within a broader contextual framing or cover story. This may have introduced additional variance beyond the intended psychological mechanisms of the intervention that was not fully captured by our measures of social desirability. While the unrelated nudge condition (i.e., a dead fish infested by maggots) was suitable from an internal validity perspective, as it provided a clearly distinct comparison condition, it was (as intended) not directly linked to the consumption context (i.e., plastic pollution). However, as a result, it may have

been perceived as incongruent within the fictional decision environment, potentially influencing choice behavior beyond the intended manipulation. Future research using different cover stories and alternative control conditions in online settings, as well as field studies and longitudinal designs in real purchasing contexts, would be valuable to further assess the ecological validity of such interventions and to clarify their underlying mechanisms.

Another important limitation concerns the specific content and normative framing of the pictorial warnings used in the present studies. All warning images depicted animals harmed by pollution or decay, which may have activated not only concerns about plastic pollution in the context of environmental welfare but also empathy toward animals and animal welfare concerns. Although these domains substantially overlap in the context of plastic pollution, they remain conceptually distinct. Environmental protection primarily relates to ecosystems, resource use, pollution, and climate-related consequences, whereas animal welfare focuses more directly on the suffering and moral status of individual animals (Ammann et al., 2024; Broom, 2019; Klink-Lehmann et al., 2023). Prior research suggests that animal welfare concerns can exert particularly strong effects on consumer decision-making (Ammann et al., 2024; Kranzbühler & Schifferstein, 2023). Consequently, the behavioral effects observed in the present studies may not be attributable exclusively to environmental concerns, but may also partly reflect reactions related to animal welfare. This distinction is relevant because prior research suggests that different warning contents may evoke distinct psychological processes despite similar behavioral outcomes. For example, Kranzbühler and Schifferstein (2023) found that environmental, health, and animal welfare warnings did not differ in behavioral effects, but did elicit differences in emotional responses, with health warnings inducing weaker negative affect. Similarly, Hughes et al. (2023) found that health-, climate-, and pandemic-related pictorial warning labels all reduced meat meal selection compared to a control condition, with no differences between warning types. At the same time, it is important to note that these studies combined pictorial warnings with textual warning messages, leaving unclear the extent to which effects are driven specifically by pictorial information or whether similar effects would emerge with text alone. Koch et al. (2022) suggest that in combined text-and-image warning labels, the graphical component mainly elicits affective avoidance motivation, whereas the textual component primarily provides information and educates consumers. This is noteworthy, as evidence from text-only warning studies indicates a potential advantage of health-related warning messages compared to environmentally framed messages (Taillie et al., 2022; Van Asselt et al., 2022), whereas the previously mentioned studies combining pictorial and text warnings did not reveal consistent differences between health- and environment-related framings (Hughes et al., 2023; Kranzbühler & Schifferstein, 2023). These findings raise the question of whether pictorial information in the context of pro-environmental behavior may contribute additional or distinct effects beyond text warning alone. Future research should therefore directly compare pictorial, textual, and combined warning formats, as well as different pictorial contents, to better isolate their relative effectiveness and underlying psychological mechanisms.

Relatedly, future research should more systematically examine the underlying mechanisms of pictorial warnings in the context of pro-environmental behavior,

including the potential dual-process nature of their effects, in particular the relative contribution of affective (prime-like) and cognitive (prompt-like) pathways. With regard to affective mechanisms, not only shame but also additional emotional constructs should be considered, such as guilt (Kranzbühler & Schifferstein, 2023). In this context, further aspects such as perceived behavioral effectiveness may also be relevant. Research on fear appeals in health psychology indicates that threat-based messages are most effective when individuals also believe that the recommended behaviors are effective in mitigating the threat (Peters et al., 2013). This may be particularly relevant in environmental contexts, where problems are often perceived as collective in nature and difficult to address through individual action (Ostrom, 2010).

Besides, future studies should investigate the conditions under which pictorial warnings extend beyond immediate emotional reactions and additionally enhance the cognitive accessibility and salience of environmental consequences at the point of choice, and whether this translates into meaningful behavioral effects. Addressing this question requires more differentiated and psychometrically refined measures of underlying mechanisms. In the present studies, environmental attitudes were included as a key construct but operationalized differently across experiments, limiting comparability and constraining conclusions regarding prompt-like effects. Moreover, this approach may not fully capture the nature of prompting mechanisms, which are assumed to operate by temporarily activating existing attitudes at the moment of decision, even when competing considerations such as cost or convenience are salient (Gemmicke et al., 2025). Future research may therefore benefit from directly assessing cognitive accessibility using association-based or reaction-time paradigms, as well as from examining heterogeneous treatment effects as a function of baseline attitudes.

Finally, future research should examine for whom pictorial warnings are most effective. The present studies served as an initial test of pictorial warnings in the context of plastic packaging and therefore included only limited socio-demographic information. More detailed assessments of factors such as education, income, pro-environmental attitudes, and political orientation may help identify subgroups that respond particularly strongly or weakly to such interventions (e.g., Bamberg & Möser, 2007; Klein et al., 2019; Wyss et al., 2022). In this context, future research should consider whether pictorial warnings elicit defensive or reactant responses in subgroups differing in these characteristics. As with many visible and negatively framed interventions, some degree of resistance or reactance is to be expected (Bergquist & Nilsson, 2016; Koch et al., 2022). Evidence from the tobacco domain suggests that pictorial warning labels can elicit defensive responses in some individuals and thereby attenuate intervention effectiveness (Hall, Sheeran et al., 2018), while nevertheless being perceived by many consumers as legitimate and useful tools for communicating risks (Hall, Marteau et al., 2018; Sychareun et al., 2015). Finally, comparing the effects of pictorial warnings with positive valenced pictorial nudges would clarify when and to what extent pictorial warnings are more suitable and practically viable than positive interventions.

4.3 Practical implications

Despite these limitations, the present findings have important practical implications. Together with previous research (e.g., Luo et al., 2022), the results suggest that pictorial warnings may represent a feasible and comparatively low-cost intervention strategy for reducing plastic consumption and promoting more pro-environmental consumer behavior. In contrast to many structural policy measures, pictorial warnings can be implemented directly at the point of decision and may therefore complement existing interventions such as taxes, bans, or informational campaigns. One practical advantage of pictorial warnings is their simplicity and accessibility. Images can evoke stronger affective reactions than written text alone (De Houwer & Hermans, 1994; Noar et al., 2016) and may reach broader audiences independent of literacy levels or language barriers (Jae & Viswanathan, 2012; Viswanathan et al., 2005). Moreover, prior research suggests that warning effectiveness may depend more strongly on perceived credibility than on the specific source of the message itself (Kranzbühler & Schifferstein, 2023), indicating that pictorial warnings could potentially be implemented by a range of governmental or commercial actors. At the same time, the use of pictorial warnings raises ethical and practical considerations, particularly regarding their exposure to vulnerable populations such as children and adolescents in everyday retail environments, which may require careful consideration of their appropriate placement.

The present findings suggest that pictorial warnings should not be considered a standalone solution to environmental problems. Rather, they may function most effectively as one component within broader environmental policy strategies that also address structural barriers to sustainable behavior (Otto et al., 2021; Van Valkengoed et al., 2022). Pro-environmental consumer behavior is shaped by multiple constraints, including habits, convenience, and infrastructural conditions (e.g., Bamberg & Möser, 2007; Heidbreder et al., 2020). While pictorial warnings may interrupt habitual consumption processes, they are likely to be less effective for behaviors involving substantial financial investments, infrastructural constraints, or established ownership patterns (Wyss et al., 2022). For example, interventions at the point of decision may have limited impact on private car use once a vehicle has already been purchased and integrated into everyday routines, as such behaviors are often constrained by mobility needs, infrastructure, and prior financial commitments. Consistent with this view, research on text-based warning labels suggests that intervention effectiveness may depend on habit strength; for example, Ding et al. (2024) observed effects primarily among individuals with moderate habit strength.

Overall, the present findings and prior evidence indicate that pictorial warnings may be particularly suitable for “moment-of-choice” behaviors in which consumers can easily switch between directly available alternatives. Beyond plastic packaging, pictorial warnings may therefore be applicable to other waste- and consumption-related domains, including recycling behavior, plastic waste reduction (Luo et al., 2022), and single product-level consumption decisions, such as choosing meat products at the point of purchase (Hughes et al., 2023). Such interventions may also prove relevant in consumer domains characterized by frequent, low-threshold purchasing decisions, such as fast fashion or certain electronic products.

5 Conclusion

Our study demonstrated that pictorial warnings may represent a promising intervention strategy for promoting sustainable decision making in the context of the use of plastic packaging. Across two experiments, pictorial warnings reduced preferences for plastic bags and plastic bottles, thereby extending findings from health-related warning research to the environmental domain. The findings further suggest that pictorial warnings may operate through affective mechanisms such as shame and may additionally influence how salient environmental consequences become during decision making. At the same time, the present research should be understood as an initial step toward a broader research agenda on pictorial warnings in environmental contexts. Further research is needed to investigate their effectiveness across different environmental behaviors, their interaction with individual and contextual factors, and their applicability in real sales contexts. Nevertheless, the current findings provide initial evidence that pictorial warnings may constitute a useful addition to existing strategies aimed at reducing plastic pollution and promoting pro-environmental behavior.

6 Open science statement

All data and analysis scripts can be downloaded at <https://doi.org/10.17605/OSF.IO/CHM68>. Questionnaire items can be found in the supplementary materials of this article. Study 1 was not preregistered. Study 2 was preregistered at <https://doi.org/10.17605/OSF.IO/7ZC3Q> and was conducted in accordance with this preregistration. We confirm that our paper includes all studies that we have conducted on this research question and that, for all studies reported, we have reported all measures, conditions and data exclusions, as well as the rationale behind our sample size.



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