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EMPIRICAL ARTICLE

Recurrent carbon labels induce bipartisan effects in environmental choices under risk

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Abstract
Addressing climate change requires substantial shifts in individual behavior. Providing information about climate externalities through carbon labels is a promising tool to foster sustainable choices when individuals weigh environmental against personal outcomes. We study the impact of carbon labels over time and their underlying mechanisms in a repeated risky choice task. We ran two preregistered experiments (US samples, N = 1,268) with realized carbon and monetary payoffs, examining how choice is influenced by the timing of carbon information (One-off vs. Recurring) and participants' political preference (i.e., Democrat or Republican voters). In Study 1, we find that both Democrats and Republicans reduce carbon emissions when carbon labels were provided. Further, recurring labels significantly reduced carbon choices compared to one-off labels. Study 2 replicated the results in a within-participant design and showed that the impact of recurring carbon labels on sustainable choices cannot be explained by the strength of emission recall. This suggests that recurring labels amplify the importance given to the climate attribute in the decision process, operating via attentional rather than informational mechanisms. Our results emphasize the importance of providing climate externality information at time of use to raise awareness about climate costs and bolster sustainable preferences across population segments.

1. Introduction

Mitigating global climate change and its impacts requires rapid and extensive transformations at all levels, including behavioral changes at the individual level (Creutzig et al., 2018; Niamir et al., 2020; Peters et al., 2020; Schneider et al., 2023). Estimates suggest that reducing consumer demand for high-emission products and services can potentially reduce 40 – 80% of current greenhouse gas emission levels in different sectors (e.g., food and transport, (Creutzig et al., 2022)). Climate policies and interventions, including economic incentives, information campaigns, or modifications of the choice architecture, play a crucial role in fostering sustainable behavior and shifting demand to sustainable consumption alternatives (Dietz et al., 2009; IPCC, 2023).

Despite many studies consistently showing a deep concern about climate change among the general population, results highlight a very slow uptake of high-impact sustainable behaviors (Colombo et al., 2023; Roy et al., 2021; Thøgersen, 2021; Willett et al., 2019). The discrepancy between widespread worry over climate change and the relatively low levels of personal action is commonly referred to as the attitude-behavior gap (Gifford, 2011). One key factor contributing to the attitude-behavior gap is the need to tradeoff sustainability goals against a wide range of personal priorities. Additionally, everyday decisions are frequently made with limited resources, which can lead to prioritizing immediate rewards over long-term sustainability goals (Beattie and Sale, 2011; Korteling et al., 2023; Lindenberg and Steg, 2007; Steg et al., 2016).

Another contributor to the environmental attitude-behavior gap is the fact that while environmentally costly decisions often involve personal benefits, their costs for the climate are borne by society (Klein et al., 2022). Flying, for instance, can be faster and oftentimes cheaper than traveling by train. Yet, the climate externalities of flying are borne by the collective and are intangible for the individual in the short-term. This potential imbalance is intensified by the limited knowledge laypersons have about the climate and environmental impacts of their actions (Camilleri et al., 2019; Frings et al., 2024). This limited knowledge can lead to situations where people's choices do not reflect their true preferences regarding the climate consequences.

Information on carbon emissions may support decision makers in better recognizing and incorporating the climate impact of their actions into the decision-making process. Climate externality[1] information, however, is often absent or less salient than cues related to other goals, such as the price and potential rewards. One previously discussed cost-effective intervention is carbon labeling, aimed at promoting more sustainable behaviors (Hahnel et al., 2020; Schaefer and Blanke, 2014; Vandenbergh et al., 2011). Carbon labels, as defined here, refer to clear and comprehensible climate externality information about a service or product, allowing consumers to compare the climate impact of substitutable choice options. Importantly, a carbon label provides comparative information about the climate impact of a good. While carbon emission metrics are relatively abstract and may be difficult to interpret in itself, a carbon label allows for clear comparisons of a product's climate impact in relation to similar products (similar to electricity consumption labels that provide energy ratings within product categories). That is, unlike a physical sticker or tag, our definition focuses on the label as an informative tool without specifying how the information is conveyed—whether in format or illustration. Our definition of a carbon label is also agnostic with respect to where or when this information is provided.

While carbon labeling is a promising avenue to promote sustainable behavior, empirical evidence suggests that a clear understanding of the effectiveness of these labels is still lacking. For example, Camilleri et al. (2019) found that carbon labels showing carbon emissions in terms of lightbulb hours for different food items increased sustainable choices. Lohmann et al. (2022) report a field experiment in which carbon-labels reduced greenhouse-gas emissions associated with meal choices by 4.2%. In contrast, other studies report no impact of carbon labels on consumer preferences, questioning its effectiveness (Kortelainen et al., 2016; Yudhistira et al., 2023). Yet other studies highlight important moderators for the effect of carbon labels (Majer et al., 2022; Taufique et al., 2022). Specifically, the effect of labels may be contingent to its design (Thøgersen and Nielsen, 2016), the presence of other (competing) labels (Birkenberg et al., 2021; Feucht and Zander, 2018) or the product category (Liu et al., 2016). Another potential moderator of carbon label effects is political preferences by the target group. A study manipulating environmental salience with an energy conservation label found that the effectiveness of the intervention was moderated by political affiliation. While the label increased sustainable choices for liberals, people reporting more conservative views were even less likely to choose a sustainable option with a label than in its absence (Gromet et al., 2013).

In the current paper, we highlight another important attribute of information labels and consumer decisions: The timing in which (carbon) labels appear. Specifically, we ask whether it matters not only *if*

[1]An externality is defined as "a consequence of an industrial or commercial activity that affects other people or things without this being reflected in market prices" (Oxford University Press, n.d.). Greenhouse-Gas emissions are a form of negative externalities, because the costs of climate change are borne by the society and are not reflected in the costs for the individual.

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labels are presented, but also *when* they are presented. We test two boundary conditions for the timing of carbon labels in an incentivized, repeated choice task with real world climate consequences. Specifically, we compare the behavioral impact of carbon labels when presented once, i.e., when a choice is first made (One-off label) and when presented every time the choice is made (Recurring label). We test the effect of carbon label timing for practical and theoretical reasons. From a practical standpoint, testing carbon label timing generates insights as to when a carbon label is most effective. For example, it may inform whether a television advertisement explaining the climate impact of two similar products is more effective than carbon labels on the products' packaging. From a theoretical perspective, it allows to shed light on the underlying mechanisms of carbon labels, specifically to differentiate between informational and attentional components of label effects. If a carbon label is more effective at the point of decision/use than before the decision situation, this may suggest that the effect extends beyond mere information provision.

Previous research suggests that in repeated incentivized choice tasks, the timing of information is crucial in driving decision and preference over time (e.g., Cohen and Teodorescu, 2022; Plonsky et al., 2015). That is, people deviate from value maximization, showing sensitivity to other attributes of the information presented such as its timing, saliency, and reliability (e.g., Nevo and Erev, 2012; Ungemach et al., 2018). Evidence from a field study found that temporally contingent feedback of energy use led to greater savings compared to the weekly provision of information and consumption feedback (Tomic et al., 2024). Building on this line of research, we study repeated choices between abstract options with monetary and carbon outcomes. This allows isolating the impact of carbon information timing on decisions and to disentangle informational and attentional carbon label effects.

Consistently recurring compared to one-off carbon labels might increase sustainable choices through attentional mechanisms. Recurring labels increase the salience of emission outcomes compared to one-off labels where emission information is absent. Preferences are often constructed in bottom-up processes (Johnson et al., 2012; Slovic, 1995), in which salient attributes in the immediate decision environment exert a stronger impact on decisions compared to less salient ones (Bond et al., 2008; Bordalo et al., 2012; Milosavljevic et al., 2012). More salient information attracts more attention during the decision process (Parkhurst et al., 2002), and process tracing experiments have shown a causal link between attention allocation and decisions in multi-attribute choice tasks (Bhatnagar and Orquin, 2022; Fisher, 2021). Therefore, the emission attribute should have a greater impact on choices in the Recurrent carbon label condition, leading to more sustainable choices than in the One-off condition.

In contrast to the predicted attentional impact, an informational account would suggest that decisions are primarily driven by the informational value of the label. From an informational account, a recurrent label should increase sustainable choices only by as much as it increases awareness about climate externalities beyond a one-off label. Given an overall limited knowledge about climate impacts of individual consumer behaviors, increasing awareness has often been discussed as a starting point for pro-environmental interventions (Attari et al., 2010; Howell, 2018; Kretschmer, 2024; Pickering et al., 2020). Distinguishing between attentional and informational mechanisms could generate important insights regarding where and when information interventions such as climate labels would be most effective.

Previous research has also proposed that processing of climate relevant information is modulated by respondents' identity and motivation (e.g., Hahnel and Brosch, 2016). Using a signpost analogy, Ungemach et al. (2018) propose that the effect of carbon labels is contingent on motivation: Saliency of climate-relevant attributes activates existing pro-environmental goals, and provides guidance to which choice option is best aligned with these goals (Ungemach et al., 2018). This goal-activation account suggests that higher climate concern would lead to more choice sensitivity to carbon emissions labels. A similar effect is expected based on people's political affiliation, when these are differently aligned with pro-environmental goals (Egan and Mullin, 2017; Hornsey, 2021; Kahan et al., 2012). While evidence shows clear partisan differences in climate change beliefs and policy support, it is less clear if these differences extend to actual environmental behaviors (e.g., Mayer and Smith, 2023). We thus aim to

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examine if environmental interventions, like recurring vs. one-off labeling, have different impacts across political groups.

In two preregistered experiments, we tested how carbon labels—shown either once or at every decision—impact decisions in a repeated choice task that involved both real-world personal *and* climate consequences. In Study 1, we tested our hypotheses that recurring carbon emission labels increase sustainable choices compared to a One-off label condition and a Control condition without emissions. We hypothesized that for a U.S. based sample, political affiliation would predict carbon-emitting choices. In Study 2, we tested the effects of Recurring (vs. One-off) carbon emission information on sustainable choices in a within-participant design. To clarify whether attentional or information processes better account for label-timing effects, we tested emission information's retrieval under recurring emission information compared to one-off information. Study 2 also examined the tradeoff between sustainable choices and personal preference, and whether the willingness to accept tradeoffs for sustainable choices differed as a function of label-timing and political orientation.

2. Study 1

In this study, we tested the effects of a recurring vs. a one-off carbon label in a repeated choice task with real world financial and climate consequences. We also tested whether political orientation predicted sustainable choices in conditions with climate externalities. We report all experimental conditions and all measures. Figure 1 and Figures S1 to S9 in the Supplementary Material show screenshots from the participant screens for Studies 1 and 2.

2.1. Method

2.1.1. Participants

Having no informed priors about the effect sizes, we preregistered a (total) target sample size of 500 participants mostly based on resource considerations. A post-hoc power analysis using the mixedpower

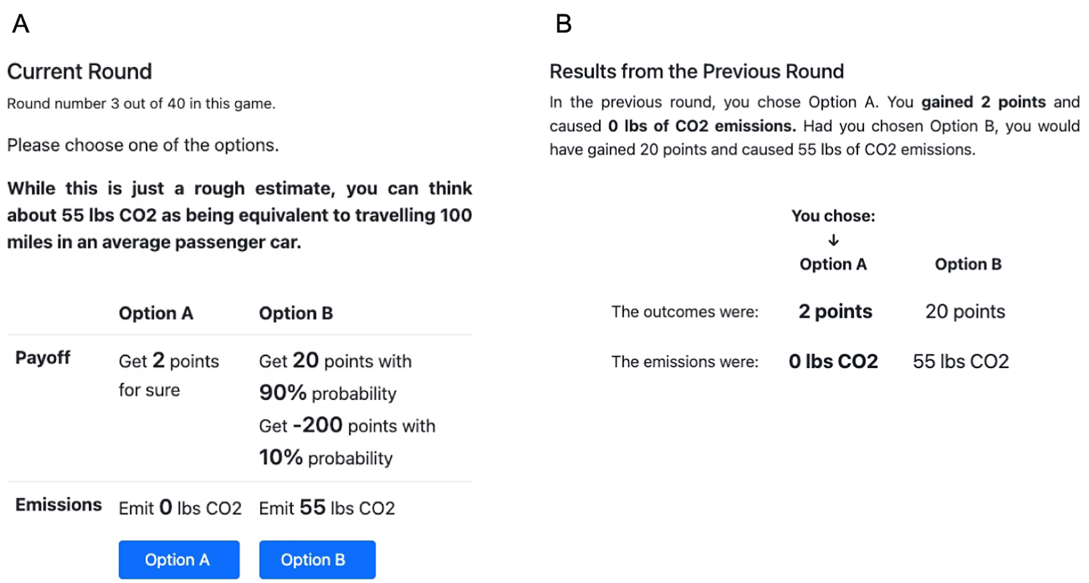

Figure 1. *Screenshots from the decision task for a participant in the Recurring label condition. Panel A shows an example of the Decision screen from Study 1. Panel B shows an example of the Feedback screen, presented after each choice.*

Table 1. *Demographic Information by condition for Study 1.*

	Control (N = 104)	One-off (N = 198)	Recurrent (N = 199)	Overall (N = 501)
Age				
Mean (SD)	43.2 (13.0)	42.7 (13.7)	40.3 (13.7)	41.8 (13.6)
Median [Min, Max]	41.0 [19.0, 72.0]	40.0 [20.0, 79.0]	37.0 [19.0, 73.0]	39.0 [19.0, 79.0]
Gender				
Female	47 (45.2%)	104 (52.5%)	97 (48.7%)	248 (49.5%)
Male	56 (53.8%)	91 (46.0%)	100 (50.3%)	247 (49.3%)
Other/prefer not to say	1 (1.0%)	3 (1.5%)	2 (1.0%)	6 (1.2%)
Political party preference				
Democrat	52 (50.0%)	98 (49.5%)	98 (49.2%)	248 (49.5%)
other	2 (1.9%)	1 (0.5%)	1 (0.5%)	4 (0.8%)
Republican	50 (48.1%)	99 (50.0%)	100 (50.3%)	249 (49.7%)

package (Kumle et al., 2021) indicated our statistical models had high power to detect the observed effect sizes at an alpha level of 5%. Specifically, the post-hoc power was 99% for the main effect of political party, 93% for carbon label timing, and 100% for round number. We report a sensitivity analysis of our research design for different effect sizes in the Supplementary Material. We recruited 501 US participants using Prolific Academic (https://prolific.ac). With preregistered exclusion criteria, we removed 11 inattentive participants. We also excluded 4 participants who indicated a party preference that was neither the Democratic nor Republican party. This exclusion was not pre-registered but necessary to test our preregistered hypotheses regarding political affiliation. In the Supplementary Material, we report analyses for the full sample, which yielded similar results. After exclusions, the final sample size was N = 486. Table 1 shows demographic characteristics of the sample by condition. The study was approved by the ethics committee of the University of Basel (003-23-1) and implemented in oTree (Chen et al., 2016). Preregistration, data, and analysis code are available on the Open Science Framework: https://osf.io/e78da/.

2.1.2. Materials and procedure

The experiment involved a repeated binary choice task between a risky lottery and an option providing a sure gain. Table 2 presents the experimental options used in the current study. The "Risky option" was a lottery that yielded a gain of 20 points with a high probability of 90% and a large loss of −200 points with a small probability of 10% (expected value of the Risky option was −2 points). The "Safe option" granted a certain small gain of 2 points. Whether the Safe option was shown on the left-hand side of the screen ("Option A", see Figure 1A for a screenshot) or on the right-hand side ("Option B") was counterbalanced between participants. Sidedness of option display had no effect on participant choices ($\chi^2(1) = 0.053, p = .818$). Participants played 40 rounds, in each choosing between the two alternatives. Participants were shown the described outcome distribution associated with each option in each round. After each choice was made, feedback was provided including the outcome from the chosen option, and the forgone outcome from the unchosen option (Figure 1B).

After signing informed consent, participants were instructed about the choice task. Participants were informed that they would receive the outcome of one randomly selected round as a bonus payment with an initial endowment of 200 points and a conversion rate of 200 points = 1£ (At the time of data collection, the British Pound Sterling was the only currency available for paying participants on Prolific, regardless of their country of residence; see screenshot of experimental instructions Figures S1–S3 in the Supplementary Material). Participants were also informed that the emissions from their choice in that randomly selected round would be realized through the carbon emission certificate trading system

Table 2. *Task design and aggregate results in Studies 1 and 2.*

	Choice options			% Carbon neutral choice rates [95%CI]	
Condition	Safe	Risky	Carbon emissions	Democrats	Republicans
Study 1					
Control		20, p = .9; −200, p = .1	0 kg	33.3 [25.2, 41.4]	30.2 [22.4, 38.1]
One-off	2		5 kg or 25 kg	58.5 [51.4, 65.6]	40.0 [33.4, 46.6]
Recurring				67.9 [60.9, 74.9]	54.9 [48.3, 61.6]
Study 2					
One-off	7	.030, p = .9; −200, p = .1	15 kg	72.6 [69.3, 75.8]	62.7 [59.8, 65.6]
Recurring				76.1 [72.8, 79.5]	68.3 [65.0, 71.6]

Note: In Study 1, carbon neutral choices corresponded with Safe choices. For the Control condition in Study 1, Safe choice rates are displayed (since there were no emissions, there were no carbon neutral choices). In Study 2, carbon neutral choices corresponded with Safe choices in half of the rounds, and with Risky choices in the other half of rounds.

(as explained below). The median completion time was 10:45 minutes and the base compensation was £1.45. On top of that, participants received a bonus calculated from their initial endowment (£1) and the realized gain or loss from their choice in the payoff-relevant round. This bonus ranged between £0 and £1.10, with an average bonus of £1.02 (95% CI [£1; £1.04]).

Participants were randomly allocated to one of three experimental conditions. In the Control condition, no carbon emissions were presented, and participants only chose between the monetary options (see Table 2). In line with previous findings, we expected most participants to prefer the Risky over the Safe option in the absence of emissions, as this option is better most of the time (see Cohen et al. (2020) for supporting results). In the two experimental conditions (hereafter referred to as *Externality conditions*), the Risky option entailed carbon emissions (see below). Between participants, we varied the amount of carbon dioxide emissions: 5kg (≈ 11lbs, "low emissions group") or 25kg (≈ 55lbs, "high emissions group"). Attribute translations in terms of car miles for the carbon emissions were presented (e.g., 11lbs CO_2 ≈ 20 miles in an average passenger car as shown in Figure 1; for a detailed discussion of attribute translations, see Mertens et al. (2020)). The Safe option was always carbon-neutral. In the Recurring-label condition, carbon emission labels denoting the climate externalities of choosing the Risky option were presented in each of the 40 rounds. In the One-off condition, participants were only presented with information about the carbon emissions in the preview and instructions of the task. In the first round, participants in the One-off condition read that they would not receive further reminders about climate externalities. These participants were also informed that emission outcomes would stay constant over the 40 rounds and would be realized according to their choices.

Carbon emission choices were realized via the European emission trading system (ETS) following the procedure by Berger and Wyss (2021). The ETS is a carbon market where corporations can trade CO_2 emission allowances. The amount of CO_2 emissions certificates is regulated via a cap-and-trade system, limiting the maximum amount of emissions for several industries within the European Union (Zhang and Wei, 2010). For the current study, we first reserved the maximum amount of carbon certificates for our planned sample size. The amount of emissions corresponding to participants' realized choices were returned to the market, making these available for future CO_2 emitters. The remaining reserved certificates were then purchased by us and destroyed, effectively removing the corresponding amount of allowances from the market. Similar procedures to realize carbon emissions from participant choices via carbon certificates have been employed in recent studies (Berger and Wyss, 2021; Farjam et al., 2019; Ockenfels et al., 2020).

We registered (https://aspredicted.org/F4P_1BJ) the following hypotheses: 1) In the Control condition, on average, participants would prefer the Risky option. 2) In the conditions with climate externalities, Risky choice rates would be significantly lower than in the Control condition. 2a) We expected that recurring carbon emission labels would decrease the preference for the Risky

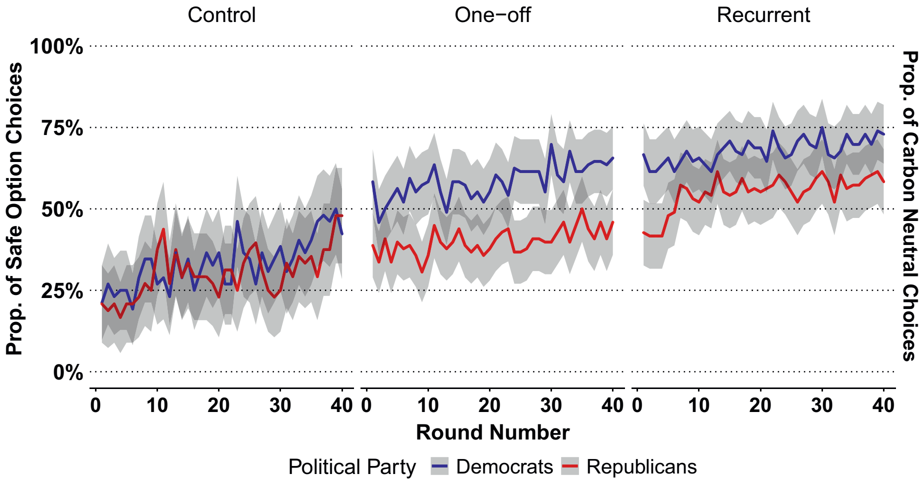

Figure 2. *Mean choice rate by round number, experimental condition, and voter group in Study 1. Shaded areas show 95% CIs of the mean. High- and low-emission groups are collated.*

(carbon-emitting) option compared to a one-off label (main effect of label condition) and 2b) that this effect would become more pronounced over the course of multiple rounds (interaction between label conditions and round number). 3) We expected partisan differences in climate-friendly choice rates with more carbon-neutral choices among Democrat than Republican leaning voters.

Statistical analyses were conducted using R version 4.3.3 (R Core Team, 2024) and several software packages for data handling, visualization and analysis: lme4 (Bates et al., 2015), lmerTest (Kuznetsova et al., 2017), sjPlot (Lüdecke, 2023) and tidyverse (Wickham et al., 2019). When multiple tests were performed on the same data, we used the Holm–Bonferroni method to adjust *p*-values.

2.2. Results

Figure 2 shows the proportions of Safe choices across rounds and conditions. As expected (Hypothesis 1), the Risky option was preferred in the Control condition, the Safe option being chosen 31.8% (95% CI [26.3%, 37.4%]) of the time. Compared to the Control condition, the Safe, carbon-neutral option was chosen significantly more in the One-off condition (49.2%, 95% CI [44.2%, 54.1%], $p < .001$) and in the Recurring label condition (61.4%, 95% CI [56.5%, 66.3%], $p < .001$). In the Externality conditions, Safe and carbon neutral choice rates were higher for Democrats than for Republicans (Table 2). The mean difference in carbon neutral choice rates for Republicans between Recurrent and One-off label conditions was 14.90% and 8.28% for Democrats. There were no significant differences in choice rates between the high and low-emissions scenarios (mean Safe choice rate in groups with 25kg CO_2 = 52.9%, 95% CI [47.7, 58.2]; mean Safe choice rate in groups with 5kg CO_2 = 57.6%, 95% CI [52.9, 62.4], $t(381) = -1.31, p = .191$). When comparing choice rates between the high and low-emission scenarios by party affiliation, none of the pairwise comparisons was significant either (Republicans: $t(192) = -1.69, p = .279$; Democrats: $t(188), p = .830$, *p*-values Holm–Bonferroni adjusted). Therefore, we collapsed both emission groups and report aggregate results.

Following the preregistration, we tested the effects of round number (1–40, continuous variable, *z*-transformed), political party preference (Democrats/Republicans) and carbon label (Control/One-off/Recurring) on Safe choices (Safe and carbon neutral in the Externality conditions = 1 vs. Risky and emitting in the Externality conditions = 0) with logistic mixed effect models with random intercepts per participant. Standardization (e.g., *z*-transformation) of independent variables does usually not influence statistical inference of the model and is sometimes recommended for better interpretability of regression

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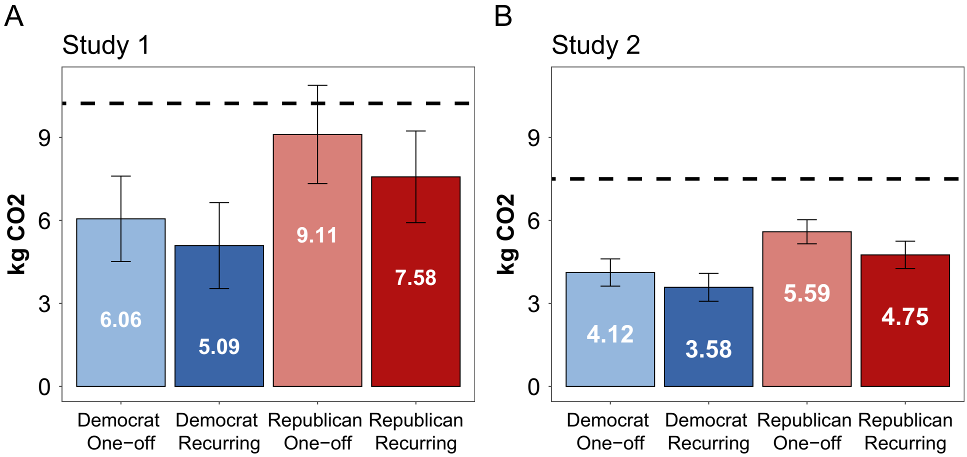

Figure 3. *Average* CO_2 *Emissions in metric kilos per round from participant choices.*
Note: Dashed lines depict baseline emissions. Panel A shows results from Study 1. The baseline is calculated from the Control condition, i.e., dashed line depicts virtual emissions in the Control condition as if Risky choices had caused emissions. Panel B shows results from Study 2. Emissions are compared to a baseline (dashed line) of a decision-maker who is indifferent to emissions.

coefficients (Dawson, 2014; Schielzeth, 2010). We found significant main effects for round number ($\chi^2(1) = 183.44$, OR $= 1.31$, 95% CI $[1.26, 1.37]$, $p < .001$), and political party preference ($\chi^2(1) = 21.61$, $OR_{Republican} = 0.28$, 95% CI $[0.16, 0.47]$, $p < .001$). Moreover, we found a significant effect of carbon label with higher Safe choice rates in the One-off label condition compared to the Control condition and higher Safe choice rates in the Recurrent than in the One-off label condition ($\chi^2(2) = 44.44$, $OR_{Control} = 0.23$, 95% CI $[0.11, 0.48]$, $p < .001$; $OR_{Recurring} = 2.83$, 95% CI $[1.57, 5.24]$, $p < .001$). Other than expected, we found no interaction between round number and carbon label condition ($\chi^2(1) = 0.49$, $p = .486$).

The interaction effects between political party and condition suggested that in conditions with carbon emissions (One-off and Recurring), the difference in Safe choice rates between Democrats and Republicans was significantly greater than in the control condition ($OR_{RepublicanXOne\text{-}off} = 0.20$, 95% CI $[0.05, 0.84]$, $p = .028$; $OR_{RepublicanXRecurring} = 0.22$, 95% CI $[0.05, 0.93]$, $p = .039$). With no significant differences between Republicans and Democrats in the Control Condition ($OR_{RepublicanXControl} = 0.94$, 95% CI $[0.30, 2.99]$, $p = .923$), this suggested that the partisan difference emerged only in the Externality conditions but not in the Control condition.

2.2.1. Emissions from participant choices

To examine the environmental impact from participant choices, we computed average carbon emissions from participant choices per round. In Figure 3, the mean emissions per round are plotted by voter group and condition. For Study 1 (Figure 3A), the emissions were compared to a baseline of 10.23 kg, that we computed from participant choices in the Control condition assuming virtual emissions (i.e., had choices caused emissions in the Control condition, 10.23 kg CO_2 would have been the average emissions per round). We computed a linear regression model with carbon emissions as the dependent variable and Externality condition (Yes vs. No) and political party (Republican vs. Democrat) as binary predictor variables. Actual carbon emissions were lower in the Externality conditions compared to virtual emissions in the Control condition ($\beta_{One\text{-}off} = -2.69$, 95% CI $[-4.49, -0.88]$, $p = 0.004$; and $\beta_{Recurrent} = -3.94$, 95% CI $[-5.75, -2.13]$, $p < .001$). For Republican leaning participants, emissions were higher than for Democrat leaning participants ($\beta_{Republican} = 2.30$, 95% CI $[0.96, 3.63]$, $p < .001$). This analysis suggests that participants' choices were significantly sensitive to climate externalities and the timing of carbon labeling: Providing recurrent labeling reduced carbon emissions by 16% compared to the One-off label condition.

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2.3. Discussion

In Study 1, we found that participants' choices tended to reflect a preference for carbon neutral options, and that the presence and timing of carbon labels significantly affected this preference. Compared to a Control condition without carbon emissions, participants shifted from primarily selecting the Risky option to more frequently choosing the Safe, carbon-neutral option (Hypotheses 1 and 2). While Democrat and Republican choices did not differ in the Control condition, Democrats chose the Safe and carbon-neutral option significantly more often than Republicans in both Externality conditions (Hypothesis 3). Preference for the carbon-neutral option was stronger when carbon emissions were displayed with recurrent compared to one-off labels (Hypothesis 2a). Both voter groups, Democrats and Republicans significantly increased carbon neutral choices with recurrent compared to one-off labels. Other than expected, we found no differential effects for the experimental conditions by round number (Hypothesis 2b). This suggests that increased temporal distance to the emission information in the One-off label condition did not drive the effect of the label timing. We also found that choice did not differ as a function of the amount of carbon emissions associated with choice of the Risky option.

The observed effects of Recurring vs. One-off carbon labels in Study 1 are consistent with both attentional and informational mechanisms. Even when a decision maker is fully aware of the climate impact of their choices, a carbon label might still direct attention toward the environmental attribute. This hypothesis is in line with process-tracing experiments showing that salient features exert bottom-up influence on decisions (Bhatnagar and Orquin, 2022; Motoki et al., 2021). Similarly, an informational account of carbon labels would also suggest differences in sustainable choices between one-off and recurring labels. However, an informational account would predict more sustainable choices only in as much as recall for the environmental costs is improved. Consistent with this view, more accurate emission recall would imply that recurrent labels improve information retention, which may be a potential mediator for label-timing effect on increased sustainable choices. Given that memory decays over time and decision-makers tend to better recall more recent information, an informational account would predict that the effect of recurrent labels should increase over time (Hernandez et al., 2023). As we found no difference in the effects of carbon label timing with increasing round number, this lends support to attentional accounts. To clarify whether better emission recall may explain label effectiveness, Study 2 tests retention of carbon emission information between one-off and recurrent labels.

While we focused on differentiating attentional and informational affects, motivational accounts, e.g., the moral wiggle room theory (Dana et al., 2007) can also explain the effects of recurrent carbon labels. This theory suggests that decision-makers tend to make more selfish choices when they can justify these choices to maintain a positive self-image (Dana et al., 2007). In our experimental paradigm, it was easier to ignore emission outcomes in the One-off than in the Recurring label condition, where participants are continuously reminded about emissions. Recurring labels leave less wiggle room to justify non-sustainable choices, e.g., through deliberate ignorance. As a result, they should lead to more sustainable decisions, especially when these choices require personal sacrifices or involve less-preferred outcomes. Study 2, using a within-participant design, tests whether differences between One-off and Recurring labels vary as a function of whether choices were aligned with participants' initial preferences.

3. Study 2

The objectives of Study 2 were twofold. First, we aimed to replicate the findings from Study 1 in a within-participant design. In the previous study, we found between-participant differences in sustainable choice proportions. Yet, our previous findings do not demonstrate the extent to which recurring labels change initial behaviors and preferences. In Study 2, making consistently sustainable choices required switching from the Risky to the Safe option or vice versa mid experiment. That is, we tested if carbon emission information induces within-participant behavioral change. Second, Study 2 also aimed to clarify whether the effect of recurrent carbon labels was driven by informational or attentional mechanisms. In the second study, we directly tested the prediction from informational accounts that emission information

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should be better recalled with recurrent compared to one-off labels. To this end, Study 2 included an unannounced, incentivized memory test to compare emission information retention between label conditions. The study design and analysis plan were preregistered (https://aspredicted.org/7ZP_MKJ). Other than in Study 1, the decision task was split into two blocks: In one block, the Risky option caused carbon emissions. In the other block, the Safe option caused emissions while the Risky option was carbon neutral. Upon completion of the choice task, there was an incentivized surprise recall task where participants were asked to recall the emissions of the choice options in each block. In line with Study 1, we expected 4) Democrats compared to Republicans, and 5) Recurrent vs. One-off carbon labels, to increase carbon-neutral choices. We also tested whether the effect of labels could be explained by memory effects such that participants in the Recurrent label condition would recall the emissions more accurately than in the One-off label condition. We expected 6) recall to be better in the Recurrent label condition, moderated by party preference: 6a) Democrats were expected to show better retention accuracy compared to Republicans for carbon emission information. We expected partisan differences in memory recall, as previous research found that Democrats tend to pay more attention to climate-related information (Luo and Zhao, 2019; Whitman et al., 2018). Our hypothesis is also in line with research on motivated memory which found that altruistic instances of behavior were better remembered than egoistic instances (Saucet and Villeval, 2019). Finally, we also looked at sustainable choices when aligned or misaligned with participant's initial naïve preference for the Safe vs. Risky options. We expected that 7) even when misaligned with initial preference, participants would 7a) predominantly choose the carbon neutral option, and 7b) this effect would be stronger for Democrats than for Republicans.

3.1. Method

Unless otherwise stated, the procedure of Study 2 was identical to the experimental task used in Study 1. Study 2 did not include a Control condition without emissions. Participants were randomly assigned to one of two between-participant conditions: One-off vs. Recurrent carbon label conditions. All experimental conditions and measures are reported.

3.1.1. Participants

We preregistered our study (https://aspredicted.org/7ZP_MKJ) with a sample size of 800 US-based participants recruited from Prolific Academic (https://prolific.ac). The sample size was informed through simulation-based power estimations for a mixed effect model with random intercepts for participants. We used 75% of the effect sizes from Study 1 (as a smallest effect size of interest for the replication of our previous findings; which were OR = 0.19 for partisanship; OR = 2.2 for Recurrent labels) and assessed power through data generating simulations with mixedpower (Kumle et al., 2021). Aiming for 95% power at an alpha level of 5% for the main effects of political party preference and Recurrent labels, the results suggested a sample size of around 800 participants (estimated power for label: 95.3%; for political preference: 100%) was adequate. We applied quotas to achieve a balanced number of participants who had either voted for the Democratic or Republican party in the last presidential election. The actual sample size consisted of 789 participants (11 Prolific workers falsely claimed completion by copying the study code). Table 3 shows demographic information of the sample. As preregistered, we removed 7 participants who did not indicate a preference for the Republican or the Democrat party, which left 782 participants in the final sample. In the Supplementary Material, we report results for all participants without the exclusions of participants with "Other" party preference. The results did not differ with respect to excluding those participants or not.

3.1.2. Materials and procedure

Table 2 presents the payoffs used in the choice task of Study 2. Both options had the same monetary expected values. The 40 rounds of the task were subdivided into two blocks of 20 rounds each. Emissions and payoffs were reallocated after the first block: In the first (second) block, the Risky (Safe) option would cause carbon emissions while the Safe (Risky) option was carbon neutral. The order of the two

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Table 3. *Demographic information by condition for Study 2.*

	One-off (*N* = 396)	Recurrent (*N* = 393)	Overall (*N* = 789)
Age			
Mean (SD)	44.8 (13.5)	44.7 (13.6)	44.8 (13.6)
Median [Min, Max]	45.0 [19.0, 83.0]	45.0 [18.0, 94.0]	45.0 [18.0, 94.0]
Gender			
Female	198 (50.0%)	190 (48.3%)	388 (49.2%)
Male	193 (48.7%)	203 (51.7%)	396 (50.2%)
Other/prefer not to say	5 (1.3%)	0 (0%)	5 (0.6%)
Political party preference			
Democrat	195 (49.2%)	194 (49.4%)	389 (49.3%)
Other	4 (1.0%)	3 (0.8%)	7 (0.9%)
Republican	197 (49.7%)	196 (49.9%)	393 (49.8%)

blocks was counterbalanced between participants. We kept the amount of emissions constant at 7kg (≈ 15lbs) for the non-sustainable option. We increased the visibility of emission information in the One-off label condition by adding a black frame around it in the first round of each block. This was done to reduce the chance that emission information will be overlooked. We also counterbalanced between participants two aspects of the presentation of the choice options: whether the position of the Safe option was on the left- or right-hand side of the screen and whether in the second block, the payoff or the carbon attribute switched sides. This was done to preclude alternative explanations of our results, e.g., as being due to the spatial position of information on the screen (Nisbett and Wilson, 1977).

Before starting the repeated choice task, each participant was asked to choose their preferred option without any emissions. Participants then read the introduction of the choice task, entered the emissions per option as comprehension checks and continued to the choice task completing 2 blocks with 20 rounds each. After completing all 40 rounds, an incentivized surprise recall task was presented to participants, asking to freely recall emissions from both options in both blocks (Figure S4 in the Supplementary Material, shows a screenshot of the free recall task with four text boxes). The additional 20 bonus points were awarded for perfect emission recall if all four emissions were recalled correctly (minimum score was 0, maximum score was 4 correct answers). Participants then reported party preference and climate change concern, and were informed about the outcomes (payoff and carbon emissions) of their choice in one randomly selected round. Screenshots of instructions and materials can be found in the Supplementary Material. Median completion time was 13:10 minutes and the base compensation was £1.50. On top of that, participants received a bonus calculated from their initial endowment (£1), the realized gain or loss from their choice in the payoff-relevant round, and their memory task performance. Mean bonus was £1.12 (95% CI [1.10, 1.13]).

3.2. Results

As in Study 1, on average, participants preferred the carbon-neutral option over the carbon-emitting option in both experimental conditions. Preference for carbon-neutral options was observed when either the Risky or Safe option was carbon neutral, irrespective of participant's political party preference (Figure 4 and Table 2). In the Recurrent label condition, mean carbon neutral choice rates were 76.1% (95% CI [72.9,79.3]) for Democrats and 68.3% (95% CI [64.8, 71.8]) for Republicans. In the One-off label Condition, mean carbon neutral choice rates were 72.6% (95% CI [69.2, 75.9]) for Democrats and 62.7% (95% CI [59.3, 66.2]) for Republicans. Descriptively, the difference in mean choice rates between conditions was 5.6% for Republicans and 3.6% for Democrats (see Table 2). A non-preregistered analysis

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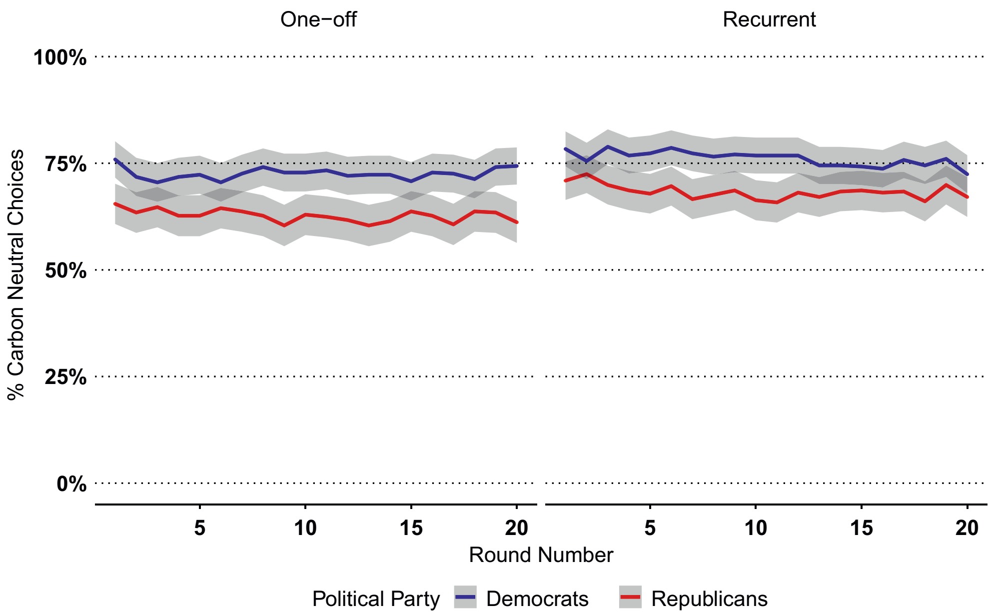

Figure 4. *Carbon neutral choice rate by round number, experimental condition, and voter group in Study 2. Shaded areas show 95% CIs of the mean.*

of post-hoc contrasts with Holm's method adjusting p-values for multiple comparison found that the difference between the Recurrent and One-off label condition was significant for Republican voters ($t(392) = 2.43$, $p = .016$), but not for Democratic voters ($t(387) = 1.54$, $p = .12$).

Following the preregistration, we tested the effects of political party preference (Democrats/ Republicans) and carbon label (One-off/Recurring) controlling for round number (1–20 continuous variable, z-standardized), block (Block 1/Block 2) and block order (Risky emits in 1st block vs. Risky emits in 2nd block) on sustainable choices (choice of carbon neutral) with logistic mixed effect models with random intercepts per participant. The effect of round number within a block was statistically significant and negative, suggesting that carbon-neutral choices declined over time within each block ($\chi^2(1) = 8.25, \mathrm{OR}_{\mathrm{Round}} = 0.96, 95\%$ CI $[0.93, 0.99]$, $p = 0.004$). There was a significant main effect of political party with Democrats choosing the carbon-neutral option more often than Republicans ($\chi^2(1) = 32.09, \mathrm{OR}_{\mathrm{Republican}} = 0.43, 95\%$ CI $[0.33, 0.57]$, $p < .001$). The effect of the Recurring label condition was statistically significant and positive ($\chi^2(1) = 6.70, \mathrm{OR}_{\mathrm{Recurring}} = 1.45, 95\%$ CI $[1.10, 1.92]$, $p = 0.009$) suggesting more carbon-neutral choices with recurrent compared to one-off labels. In an additional step, we added the preregistered interaction of carbon label and round number, which was not significant ($\chi^2(1) = 3.44$, $p = .064$).

Following the preregistration, we next tested whether sustainable choices varied as a function of whether participants' decisions were aligned with their initial preferences. To this end, we added the fixed effect denoting whether carbon neutral choices were aligned or not aligned with initial preferences (i.e., indicated by participants as their naïve choice without carbon emissions at the beginning of the study) as well as the two-way interactions of alignment with initial preferences and political affiliation. There was a significant main effect for aligned vs. non-aligned decisions with lower carbon-neutral choice rates for non-aligned than for aligned choice situations ($\chi^2(1) = 1521.38, \mathrm{OR}_{\mathrm{Non\text{-}aligned}} = 0.32, 95\%$ CI $[0.30, 0.34]$, $p < .001$). There was also a significant interaction between decision alignment and political orientation ($\chi^2(1) = 7.60, \mathrm{OR}_{\mathrm{Non\text{-}alignedXRepublican}} = 0.85, 95\%$ CI $[0.75, 0.95]$, $p = .005$). As expected, this indicated that for non-aligned choices, the difference between Republicans and Democrats in carbon neutral choice rates was greater than for

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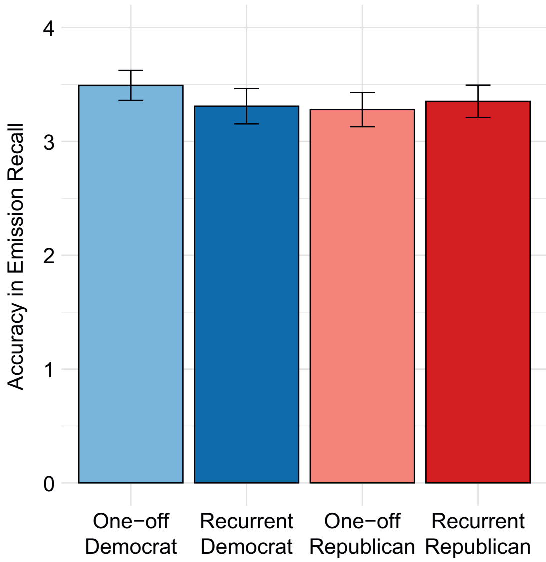

Figure 5. *Mean score for emission recall by participant group. Number of correctly answered questions in the emission recall (range from 0 to 4). Error bars show 95% CI of the mean.*

aligned choices. Finally, we exploratively added the interaction between alignment with initial preference and carbon label, which was not significant ($\chi^2(1) = 0.98,\ p = .322$).

3.2.1. Emissions from participant choices

Analogous to Study 1, we assessed the effects of label timing and voter group on sustainable decisions in terms of CO_2 emissions from choices. For Study 2, average emissions per round ranged between 3.58 kg CO_2 (95% CI [3.08, 4.09]) for Democrats in the Recurring label condition to 5.59 kg CO_2 (95% CI [5.16, 6.03]) for Republicans in the One-off condition. For each subgroup, emissions were significantly lower than the expected 7.5kg CO_2 per round had participants chosen their preferred payoff option while being indifferent toward the emission attribute. Thus, emissions from aggregated actual choices were around 25% to 50% lower than they would have been under indifference toward the emission outcome (Figure 3B). Recurrent labels yielded an 18% and 15% reduction (for Republican and Democrat participants respectively) in carbon emissions compared to the One-off labels.

3.2.2. Carbon emission recall

Mean performance in the incentivized emission recall task by carbon label condition and political orientation is depicted in Figure 5. We ran a linear regression model with sum of correctly recalled answers as dependent variable. As predictors we included carbon label condition and political party preference and, in a second step, their interaction. Other than expected, we found no differences in performance between label conditions ($\beta_{\text{Recurrent}} = -0.05, 95\%\ \text{CI}\ [-0.20, 0.09],\ p = .460$). There was no main effect in recall for political party preference ($\beta_{\text{Republican}} = -0.09, 95\%\ \text{CI}\ [-0.23, 0.06],\ p = .246$) and other than expected, there was no significant interaction between political party preference and label condition ($\beta_{\text{RecurrentXRepublican}} = 0.26, 95\%\ \text{CI}\ [-0.03, 0.54],\ p = .082$).

3.3. Discussion

Study 2 replicated the results of Study 1, showing that participants preferred carbon neutral options in an incentivized repeated choice task. Even in situations where choosing the carbon-neutral option conflicted with participants' initial preferences, both voter groups still predominantly chose in favor of the carbon

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neutral option. We also found partisan differences with higher proportions of sustainable choices for Democrat than for Republican leaning participants (Hypothesis 4). Again, recurring carbon labels had a significant effect compared to a one-off presentation of carbon emission information (Hypothesis 5). Other than expected, there were no differences in emission information recall for the Recurring vs. One-off label condition (Hypothesis 6). In the One-off label Condition, participants remembered carbon emission information equally well as participants who had received repeated reminders about emissions in every round of the task. This suggests that the differences in carbon neutral choices between the label-timing conditions were driven by attentional rather than informational effects: Despite an equal retention of the carbon information across label conditions, the climate attribute may have received a greater decision weight when presented repeatedly compared to a one-off presentation.

4. General discussion

Across two preregistered experiments (total N = 1286), we investigated people's choices between two fully described payoff distributions that included both realized monetary and climate consequences. In both studies, we found that when facing repeated tradeoffs between personal monetary outcomes and externalized climate outcomes, participants predominantly chose the sustainable option. In line with our hypotheses, we consistently found that recurrent carbon labels, shown at each decision, significantly reduced carbon emissions compared to a single, one-off label with carbon emission information. Recurrent carbon labels increased sustainable choices by 12.2% in Study 1 and by 4.6% in Study 2. The heterogeneity in effect sizes may have been due to the research designs (a within vs. a between participant design and 2 blocks of 20 rounds vs. 1 block with 40 rounds) or the already high sustainable choice rate in the One-off label condition in Study 2 at 67.6%. Considerable heterogeneity in effect sizes has often been observed across similar interventions, cross-cultural variation or on different dependent variables (Alt et al., 2024; Vlasceanu et al., 2024). Our effect sizes are also in line with a recent meta-analysis on nudging interventions finding an average increase in behavior uptake of 8.7 percentage points in academic studies compared to a 1.4% increase in comparable field studies (DellaVigna and Linos, 2022). Future research can clarify the effects driving this heterogeneity.

While all participants tended to show preferences for sustainable options, we also found strong partisan differences. Republican leaning participants made significantly less carbon neutral choices compared to Democrat leaning participants while there was no difference in choice rates observed in the Control condition of Study 1. Republicans were also less climate change concerned than Democrat leaning participants (Figures S7 and S8 in the Supplementary Material). The strong correlation between political preferences and climate change attitudes is consistent with evidence illustrating that the partisan divide in climate change beliefs and climate policy support is substantial and increasing in Western countries, especially the US (Bolsen and Shapiro, 2018; Egan and Mullin, 2017). Yet, sustainable choice rates for Republicans were higher than they would have been for a decision maker who is indifferent toward carbon emissions. Additionally, the recurrent label intervention was equally effective for Republicans as for Democrats in reducing emissions compared to one-off labels. If anything, the recurrent labels may have even had a slightly larger effect for Republicans than for Democrats as indicated by the descriptive results and the post-hoc contrasts. This suggests that there is no backlash of a repeated label intervention for Republican leaning voters. Instead, recurrent labels were at least as effective for Republicans as for Democrats. Our results add to previous findings that choice architecture, e.g., highlighting climate externality information in the choice situation, can be used to encourage higher preferences for more sustainable choice options (Howell, 2018).

Our findings contribute to a better understanding of the psychological mechanisms underlying carbon label effects, suggesting that recurring labels exerted an effect on sustainable choices over and above their mere informational value. Participants from both label conditions recalled the emissions from the choice options equally well, demonstrating high awareness of the emission impacts in both conditions. Yet despite recalling information equally, participants in the Recurrent label condition chose the carbon

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neutral option significantly more often. Furthermore, we did not find an interaction between label condition and round number. With increasing round number, the temporal distance to the emission information increased in the One-off label condition, while information was constantly refreshed in the Recurring label condition. Research on memory indicates that more recently acquired information is better retrieved than previous information, indicating a recency effect in memory retrieval (Howard and Kahana, 1999). It has also been observed that more recent outcomes in decision from experience settings exert a stronger impact on choices (Hertwig et al. (2004); but see Erev et al. (2022) for a more nuanced discussion). The lower temporal distance to carbon emission information, however, did not increase carbon neutral choices in our studies. We interpret this as another indication that not memory effects, but rather attentional effects were driving the impact of carbon label timing: By increasing attention to the climate attribute, this attribute gained more weight in the decision-making process. While our results suggest the importance of close temporal proximity of the carbon label to the decision situation, they cannot fully disentangle the effects of timing and frequency. Future research could directly test whether labels are more effective when presented right before or during the decision, or when they are presented frequently (e.g., through ads) independent of the decision timing.

Motivational theories might offer another possible explanation for the observed effects of recurrent labels. Moral wiggle room theory suggests that decision-makers prefer selfish choices if they can justify them to maintain a positive self-image (Dana et al., 2007). According to this theory, recurring carbon labeling should increase sustainable decisions, especially when choices involve personal sacrifices, because they limit the possibility to justify non-sustainable choices with deliberate ignorance. Our research design did not allow to conclusively test for motivational effects of carbon label timing and our findings are at least partially consistent with moral wiggle room theory (Fahrenwaldt et al., 2024). However, from a motivational perspective, one might expect greater effects of recurrent labels a) for Democrats than for Republicans and b) in situations where the sustainable choice conflicted with participants' initial preferences. This is because Democrats tend to identify themselves more strongly with sustainable and climate protecting attitudes than Republicans (Correlation for partisanship and climate change concern was $r = .64$ in Study and $r = .56$ in Study 2 as reported in the Supplemental Material, Table S1; see also Fielding and Hornsey, 2016), and should therefore feel greater pressure to justify selfish over sustainable decisions. However, we did not find that recurrent labels had a stronger effect for Democrat leaning participants. Second, in non-aligned decision situations, the difference between the One-off and Recurring label conditions should be greater because decision makers should exploit moral wiggle room to justify selfish choices. We found no differences for naïvely aligned vs. non-aligned decisions in Study 2 which deviates from the prediction that recurrent labels should be more effective in choices involving personal tradeoffs. Recent work by Stoetzer and Zimmermann (2024) tested more directly for motivational effects and found no evidence of motivated cognition to exploit moral wiggle room after making unsustainable choices.

Our findings also conceptually replicate some aspects of Magnitude Neglect (Asutay et al., 2023; Berger and Bregulla, 2023): In Study 1, choice patterns did not differ when the climate consequences were low (5kg) or high (25kg). The abstract, complex, and intangible nature of climate emissions has been suggested as one potential explanation for magnitude neglect (Cologna et al., 2022). Notably, participants were insensitive to the emission magnitude even though they were provided with attribute translations to car miles, which aimed to facilitate the information processing through more familiar units (Ungemach et al., 2018). Low climate literacy and (carbon) impact insensitivity pose a challenge to promoting high impact sustainable behavior (Markowitz et al., 2013). Carbon labels may serve as a remedy here: while participants were insensitive to the absolute emission amounts, they were very much influenced by the comparative information that clearly indicated the more sustainable choice. Thereby, carbon labels helped generate practically relevant climate literacy (Thøgersen, 2021; van Bussel et al., 2022).

A potential limitation of our research is that we used an abstract choice task in an experimental setting. This may limit the generalizability of our findings to high impact behaviors in the real world that are personally costly like avoiding flying or adopting a plant-based diet (Bosshard et al., 2024). Given our

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broad definition of carbon labels as comparative information, our research also does not inform about the effect of different design features of physical carbon labels in real world settings, e.g., its size, colors or graphical illustration. However, abstract experimental paradigms allow to quantify the magnitude of behavioral effects and can shed light upon the mechanisms of interventions. It has also been argued that decision from experience paradigms more closely resemble the way humans learn about risky choices in real life compared to one-shot choices with descriptions of probability distributions (Hertwig and Erev, 2009). A potential concern is that the memory task may have been too easy to elicit different memory retrieval between the label conditions. However, an informational account would predict no differences in sustainable choice rates if retention of relevant emission information does not differ between conditions. That is, (however trivial) retention of emission information is a sufficient condition for predicting sustainable choices under the informational account.

Another concern might be that participants made their decisions relatively quickly and that the choice task was described as a "game" which may have caused participants to take the decisions less seriously than they would in real-world scenarios. The quality of data from online samples has been subject to scientific debate. Yet, empirical results found that common online sample providers, especially Prolific, seems to provide high quality respondents, e.g., with respect to attention, comprehension and honesty (Peer et al., 2021). To prompt sincere participation, we emphasized in the task instructions that the choices would have real-world emission and monetary consequences. To support participants' understanding of the instructions, we implemented comprehension checks, alongside several attention checks (see Supplementary Material) to ensure focused and attentive participation. Further, the payout mechanism was incentive-compatible and the task provided high potential payoffs to ensure participants' engagement (Lonati et al., 2018). Fast reaction times are typical in repeated choices-from-experience tasks (e.g., Cohen et al., 2020, p.153; Yakobi et al., 2020, p.267) and do not necessarily compromise a choice experiment's internal validity, as they reflect natural convergence in decision-making over repeated choices. Further, several researchers demonstrate that excluding too fast or too slow responses lacks theoretical justification and does not improve data quality, advising against it (Lerche and Voss, 2019; Miller, 2023). It is also worth noting that habitual and daily-life decisions are often made rapidly and with limited time due to costs-benefit considerations.

Another limitation is that we sampled U.S. American participants only. Across different countries and cultural contexts, effects of political identity and recurrent labels on sustainable behavior might differ (Vlasceanu et al., 2024). The political polarization of climate change is particularly large in the U.S (Egan and Mullin, 2017). The relationship between political identity and climate change concern and by extension, also sustainable behaviors, is often heterogeneous across nations (Hornsey et al., 2018). However, in most Western countries, there is some political polarization of climate change and world views tend to be predictive for climate beliefs (Kahan et al., 2011). Encouragingly, the effectiveness of recurrent carbon labels did not diminish among less climate-concerned participants. Given that we found high correlation between political attitudes, partisanship, worldviews, climate concern, and sustainable choices (see Table S1 in the Supplementary Material), future research could address if similar patterns can be found across nations. It is also important to note that both between and within countries, a main driver of carbon footprints is socioeconomic status (SES; Chancel, 2022; Moser and Kleinhückelkotten, 2018). As individuals with higher SES have the capacity to consume and invest more, their lifestyle causes disproportionately high emissions (Khalfan et al., 2023). Since their sensitivity to climate-related interventions may differ, it is crucial for future research to identify which strategies or interventions are effective in reducing the carbon footprint of high SES individuals (Nielsen et al., 2021).

Our research demonstrates the effectiveness of presenting carbon information within the choice situation in close temporal proximity to the decision. This may be at the point of purchase, for instance during grocery shopping or when choosing a meal from different menu items. It also underscores the effectiveness of real-time feedback and provision of emission information during the point of use, for example during electricity or warm water usage (Lange and Dewitte, 2023; Tiefenbeck et al., 2019). For example, an information campaign might raise awareness of the climate costs of different transportation choices by comparing the climate impacts of car and tram commutes. This campaign may impact

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decision-makers differently than emission information featured in a navigation app that is used to check public transport connections and traffic before every commute. For instance, the navigation app could highlight the most climate-friendly mode of transportation or provide color-coded labels on the expected emissions of the different options. Future field studies are needed to test which specific design features may be most effective and viable.

Our research moreover illustrates that recurring and salient information on climate externalities can drive sustainable choices over and above their informational value and across partisan groups associated with different climate change attitudes. Information campaigns and labels should be visible in the immediate decision situation and contain actionable information on the direct environmental impacts of one's actions. This research adds to the understanding of the mechanisms underlying the effects of carbon labels, and can serve as a starting point to design information interventions for sustainable behavior.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/jdm.2024.42.

Data availability statement. The supplementary material, data, and analysis scripts for this article can be found at https://osf.io/e78da/. All implemented experimental conditions and all measured variables and materials are disclosed.

Author contributions. Conceptualization: Z.R.A., D.C., U.J.J.H.; Data curation: Z.R.A.; Data visualization: Z.R.A.; Formal analysis: Z.R.A.; Funding acquisition: U.J.J.H.; Methodology: Z.R.A., D.C., U.J.J.H.; Software: Z.R.A.; Writing—original draft: Z.R.A.; Writing—review and editing: Z.R.A., D.C., U.J.J.H.; Supervision: D.C., U.J.J.H. All authors approved the final submitted draft.

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Competing interests. The authors declare none.

Ethical standards. The research meets all ethical guidelines, including adherence to the legal requirements of the study country and was approved by the ethics committee of the University of Basel (003-23-1).

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