Sustainable dietary choices improved by reflection before a nudge in an online experiment

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Abstract

Current food choices have a high carbon footprint and are incompatible with climate goals. Transitioning to more environmentally friendly diets is therefore important. Behavioural "nudges" have been widely used to reduce meat-based food demand, subtly altering choice presentation without banning or raising costs. However, scaling up nudges has proven challenging, sometimes raising ethical concerns. To address this, behavioural science proposes empowering individuals to reflect on their choices, fostering meaningful and more environmentally friendly behavioural changes. In an experimental study with 3074 UK participants, we compared three agency-enhancing tools ("boost", "think", and "nudge+") with classic nudges (opt-out default and labelling) to promote sustainable dietary intentions. All behavioural interventions increased intentions for sustainable foods but encouraging reflection on dietary preferences before defaulting people into greener diets yielded the best results. Adding a pledge before the default nudge, as in nudge+ (pledge+ default), additionally reduced emissions from intended orders of meals by 40%. Our research suggests that food companies can enhance their sustainability efforts by prompting customers to think before nudging them into consuming more sustainable food.

Meat-based diets contribute substantially to greenhouse gas emissions [1]. Adopting sustainable diets can help mitigate climate change and meet the United Nations Sustainable Development Goals for climate action [2]. We define sustainable diets as diets with low climate impact – sustainable diets have low carbon emissions associated with their production and consumption. "Nudges" have been deployed widely to reduce demand for meat-based foods [3–6]: a nudge alters how choices are presented to people, but does not ban them or make them more costly [7]. Nudges steer people towards behaviours that are deemed welfare-improving by policymakers. Recent evidence shows nudging climate-friendly behaviours can be hard to scale–up [8]. There are also challenges in delivering climate-based nudges ethically [9, 10]. These shortcomings relate to problems of "human agency" [11, p. 20] – people's capabilities to form intentions and act freely on them – to motivate meaningful, sustainable behaviours. There is ongoing discussion on ways to look beyond nudges [12] for climate sustainability [13]. Recent contributions aim to empower people to change behaviour by encouraging them to reflect on their choices [14]. We test this proposition by systematically comparing three agency-enhancing behavioural tools, namely "boost", "think", and "nudge+", with classic nudges, in promoting sustainable dietary intentions.

We administered a preregistered online survey experiment (see pre-registration plan here) to 3,074 participants in November 2020 [15]. The survey (available online) was designed in Qualtrics and distributed to a pool of 127,488 eligible participants registered on Prolific in two waves – on 12^{th} November, 2020 at lunchtime and 19^{th} November, 2020 at dinner time [16]. We used preset filters to exclude (1) experienced participants who had participated in two prior pilot studies and/or (2) non–residents of the United Kingdom (UK). All participants were paid for their participation time on an hourly basis, based on Prolific rates. The average survey completion time was 24 minutes (σ=10.4 minutes) and the average reward was £3.35 GBP. Participants were entered into a consequential experimental task, where they had to place an order for an online meal delivery. It took place in four stages.

Stage 1. Participants were informed of the rules of the task. They were told they would be presented with a restaurant menu and will have to place an order for an online meal delivery. They were also informed that they had a chance to win a food voucher to make their choice. Responses were collected at lunch time in wave 1 and dinner time in wave 2.

Stage 2. Participants were randomly assigned to one control or nine treatment groups. In the control, participants were shown a restaurant menu which had 36 main course items. These items were chosen from Deliveroo's and Just Eat's top 100 items ordered in the UK in 2019 adjusted following pilot surveys. Each menu item was priced at £20. A fixed price was chosen to avoid income effects. 1 in 20 participants were randomly awarded the food voucher. 18 items each were vegetarian and non-vegetarian. The treatment conditions varied the restaurant menu in the control condition. Treatment details appear below with corresponding menus in Methods section.

Stage 3. Participants were redirected to a check-out screen to place their intended order for an online meal delivery.

Stage 4. Participants were given the option to donate to a charity. They were reminded that, if successful, their final voucher payment will be adjusted for any donations.

Treatments in stage 2 were types of behavioural tools, namely nudge, think, boost, and nudge+. The first nudge was a green default (hereinafter "Nudge 1 (Default)"). Participants were automatically opted in to a shorter menu consisting of 18 sustainable food items selected from the regular menu, with the possibility to opt-out for the regular menu. Our second nudge was a carbon-labelled menu ("Nudge 2 (Labelling)") which used a traffic lighting scheme – red, amber, green – to colour code food items by the carbon intensiveness of the main ingredient in the dish. We tested two "boosts". Boosts enhance people's skills to make better decisions [17]. Our first boost was a set of quick rules (hereinafter "Boost 1 (Quick rules)"). Participants in this treatment were provided with three shortcuts to choose better vegetarian items from the control menu. Our second boost presented people with implementation intention plans (hereinafter "Boost 2 (Implementation intentions)"), through which they could design their own if-then goal plans to choose sustainably from the control menu. We also tested "thinks". A think encourages people to reflect on their choices before making decisions [18]. In our sustainable food pledge ("Think (Pledge)"), we prompted people to reflect on their decision to commit to eating sustainably, and then on ways to comply with their commitment, if they pledged or were indifferent to it. In this second decision, individuals could comply by self-selecting themselves into the "Nudge 1 (Default)", "Nudge 2 (Labelling)", or simply the control menu. In this way, the "Think (Pledge)" enabled participants to customise their own menu. We tested four "nudge+" interventions. Nudge+ interventions are hybrid nudge–think policies that inform people about the nudge or enable them to reflect alongside it [14], adding consciousness to the nudge. To test the effect of transparency [19, 20], we combined the "Nudge 1 (Default)" and "Nudge 2 (Labelling)" with an information disclosure that explained to participants the purpose and the construct of nudge ("Nudge+ 1 (Default+Info)" and "Nudge+ 2 (Labelling+Info)"). To test the role of reflection, we combined the "Think (Pledge)" with the "Nudge 1 (Default)", such that participants could reflect on the decision to pledge before being defaulted into the sustainable menu (hereinafter "Nudge+ 3 (Pledge+Default)"). The "Nudge+ 3 (Pledge+Default)" differs from the "Think (Pledge)" as it does not allow people, willing to eat sustainably, choose their best way to comply. It assumes that once the willing have revealed their preferences, we can simply nudge them to their goals (with the default). We also tested the opposite sequence whereby participants were defaulted first and then encouraged to reflect on the pledge ("Nudge+ 4 (Default+ Pledge)") to assess if the benefits of reflection were attenuated when participants were nudged first, as reflecting on those nudged preferences would be cognitively harder afterwards. This follows claims that a nudge affects people's abilities

to form preferences freely [21, 22]. Due to budgetary limitations, we were unable to test the combination of the "Nudge 2 (Labelling)" with the "Pledge". Table 1 below summarises these ten different experimental conditions.

[INSERT TABLE 1 HERE]

First, we find that all the behavioural interventions, namely the nudge, boost, think, and nudge+, significantly promote sustainable dietary intentions compared to the control group. This reaffirms the credibility of behaviour change strategies to mitigate carbon emissions from food consumption in the transition towards net–zero climate targets [23, 24]. Second, we find that encouraging reflection before nudging ("nudge+ 3 (pledge+default)") improves the effectiveness of the default nudge and works best versus all other treatments. When citizens are given an opportunity to reflect on their own sustainable dietary preferences through the pledge, before being defaulted into sustainable food items, their intentions to choose sustainable diets improve substantially: the "nudge+ 3 (pledge+default)" intervention reduces carbon emissions by an additional 40% compared to the nudge. Third, we do not find any evidence of negative behavioural spillovers, as measured by participants' charitable donations.

Our research has two main contributions. We design and administer the first stylised experimental comparison of these behavioural policies. We also add to an emerging literature on comparative behaviour change [25], by extending tests of these behavioural policies to sustainable food choices: while nudges and boosts have been tested jointly in other decision-making contexts, these four tools have not been systematically compared in promoting sustainable diets. Although there remain limits to how much all of this can be immediately scaled-up, the findings show new possibilities for food companies to nudge customers after encouraging deliberation. We call for research exploring the potential of reflection in (dietary) nudges.

Results

Sustainable diets intentions promoted by all interventions

Our first finding suggests that, compared to the control, nudges, boosts, thinks, and nudge+ are all significantly effective in reducing the emissions over intended orders of meals. Figure 1 plots the (raw) mean emissions across the different experimental conditions – one control and nine treatments.

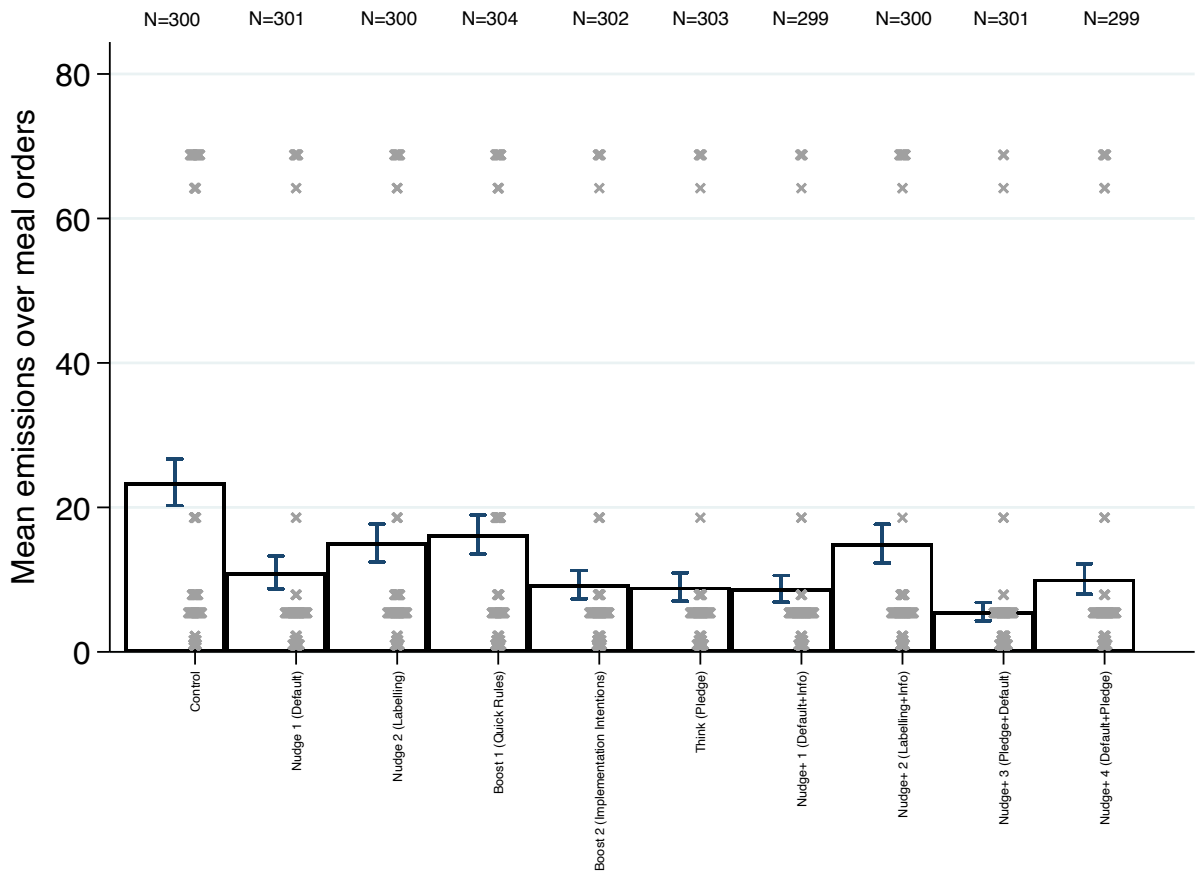

Figure 1: Average emissions over intended meal orders across the ten experimental conditions (N = 3,009). Bar graph indicates mean emissions with 95% confidence intervals and visualizes the distribution of data (using x). The corresponding sample size of each experimental condition is displayed at the top of each bar.

Table 2 summarises these average treatment (intent–to–treat) effects of being assigned randomly to one of the nine treatments, versus the control, on the *greenhouse gas emissions*. Column 1 reports findings from a linear regression, while column 2 robustly controls for covariates in the linear regression using an adaptive LASSO.

Nudge 1 (Default) reduces emissions over intended meal choices by 53% (μ=-12.475, σ=1.669) compared to the control, on average. Similarly, Nudge 2 (Labelling) reduces emissions by 35% (μ=-8.497, σ=1.671) relative to the control, on average. Simply altering how choices are presented to people using nudges increases intentions to consume sustainable food items meaningfully.

Boost 1 (Quick Rules) reduces emissions over intended meal choices by 31% (μ=-7.23, σ=1.666) relative to the control. This is comparable to the effect of the Nudge 2 (Labelling) versus the control. Boost 2 (Implementation Intentions) reduces emissions by 60% (μ=-14.176, σ=1.668) compared to the control. This effect is greater than the average treatment effect produced by the Nudge 1 (Default) or Nudge 2 (Labelling), versus the control.

[INSERT TABLE 2 HERE]

The Think (Pledge) has a comparable effect to the Boost 2 (Implementation Intention), versus the control. The Think (Pledge) reduces emissions by 61% (μ=-14.505, σ=1.667), relative to the control, on average.

Finally, consider the four nudge+ interventions. We find that nudge+ interventions that add information disclosures alongside the nudge are somewhat comparable to, if not better than, the standalone nudges in terms of their average treatment effects versus the control. Nudge+ 1 (Default+Info) reduces emissions by 63% (μ=-14.768, σ= 1.673) relative to the control, which is greater than the reduction offered by Nudge 1 (Default) in absolute terms. The nudge+ 2 (Labelling+Info) reduces emissions by 36% (μ=-8.497, σ=1.671), almost equivalent to the absolute reductions offered by the Nudge 2 (Labelling) versus the control. Nudge+ interventions that combine reflection and nudging offer greater absolute reductions (versus the control) than their nudge counterparts. This depends on the sequence in which they are combined. For example, encouraging reflection before defaulting people into sustainable foods, as in the case of the Nudge+ 3 (Pledge+Default) reduces emissions by 76% (μ=-17.905, σ=1.669) relative to the control. When the sequence is reversed (participants are first defaulted into the sustainable options and then encouraged to reflect on their own preferences and revisit these choices) as in the case of the Nudge+ 4 (Default+Pledge), the intent-to-treat effect is attenuated. Nudge+ 4 (Default+Pledge) reduces emissions by 57% (μ=-13.396, σ=1.673) versus the control.

Sustainable diets intentions improved by pledge before nudge

When ranking these behavioural interventions in terms of their absolute effectiveness versus the control, Nudge+ 3 (Pledge+Default) fares the best. Comparisons of Nudge+ 3 (Pledge+Default) with the other experimental conditions are shown in Table 3 below. Column 3 reports findings from a linear regression, while column 4 robustly controls for covariates in the linear regression using an adaptive LASSO.

[ENTER TABLE 3 HERE]

Combining reflection with the nudge, as in the Nudge+ 3 (Pledge+ Default), reduces emissions meaningfully over intended meal orders relative to all the remaining experimental conditions. Nudge+ 3 (Pledge+Default) reduces emissions versus the nudges [nudge 1 (default): p=0.00259; nudge (labelling): p=0.0004], the boosts [boost 1 (quick rules): 0.0005; boost 2 (implementation intentions: p=0.004], the think [think (pledge): p=0.013], and the other nudge+ interventions as well [nudge+ 1 (default+info): 0.037; nudge+ 2 (labelling+info): p=0.0006; nudge+ 4 (default+pledge): p=0.012].

To assess the effectiveness of reflection, we compare the Think (Pledge) to the Nudge 1 (Default): we fail to find any measurable differences between them. Reflection by itself does not scale-up emission reductions, but when combined with nudges, they offer substantial benefits over classic nudges. Reflecting without a nudge implies people must deliberate at different moments (like whether or not to take the pledge and which type of choice architecture to use). They can choose their diets sustainably, but this is cognitively costly. When a nudge is added to the (part of the) think, people must only decide about doing the right thing (eat sustainably) at one point, and then they can rely on the nudge to guide their decisions.

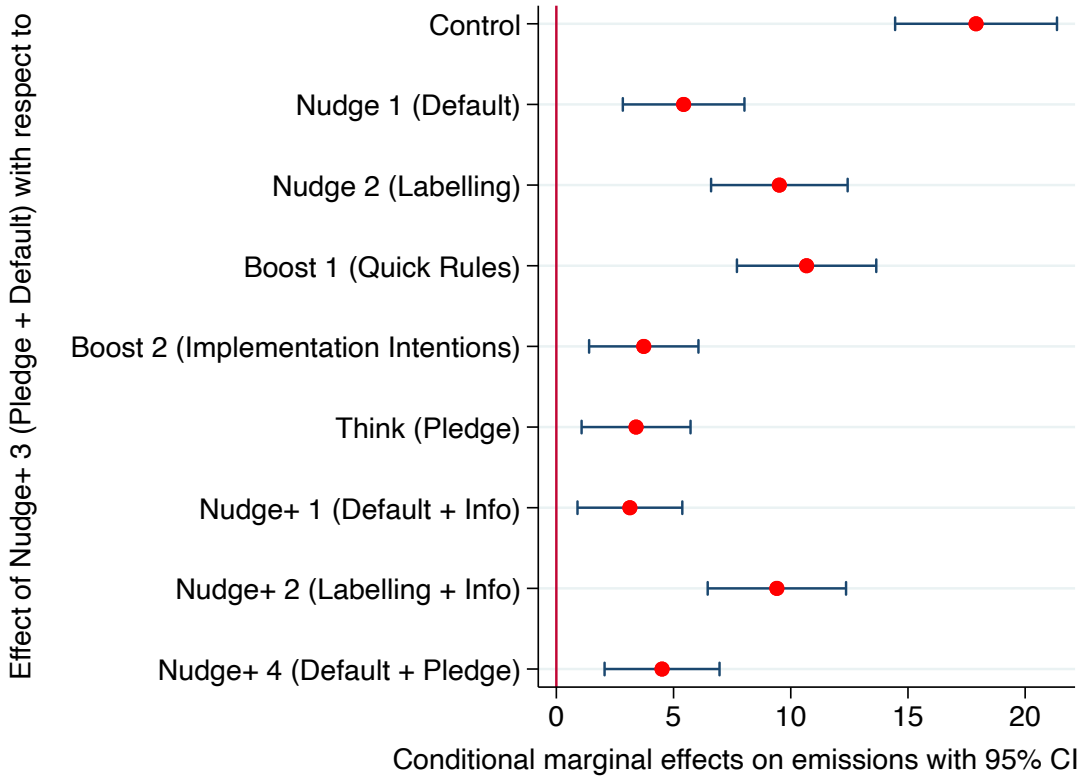

Figure 2: Average treatment effect on emissions from meal orders compared to the 'Nudge+ 3 (pledge+default)' experimental condition. Simple difference of means between an experimental condition versus the 'nudge+ 3 (pledge+default)' treatment along with 95% confidence intervals. Estimates correspond to a simple linear regression of GHG emission on dummies for experimental conditions with robust standard errors using a sample of N = 3,009 participants. The P values are reported for each condition and correspond to a two-sided t-test.

Encouraging participants to reflect on their own preferences is effective only when it precedes the nudge. When people are nudged first, any reflection that follows this nudge fails to modify initial choices, as with the Nudge+ 4 (Default+ Pledge) intervention. Further nudge+ which adds only information to the nudge – Nudge+ 1 (Default+Info) and Nudge+ 2 (Labelling+Info) – is no different from the nudge (p=0.3962 and p=0.9923, respectively). Such nudge+ interventions are no different from boosts or thinks, with the only exception of the Nudge+ 1 (Default+ Info) which is better than the Boost 1 (Quick Rules) (p=0.0009).

These findings indicate that transparent nudging can be as effective as nudging without information and does not necessarily induce reactance from citizens. These additional pairwise comparisons are summarised in Table S2 available in the SI file (columns 2-4), which correspond to linear regressions, controlling for covariates as selected by an adaptive lasso–based technique. Average treatment effects of an experimental condition with respect to the *default+information* (column 1), *labelling+information* (column 2), *pledge+default* (column 3) and *default+pledge* (column 4), respectively.

Treatment effects are not driven by participant's time spent on the survey. Being randomly assigned to a treatment condition does not significantly correlate with the time taken to complete the survey. We do not find any evidence of heterogeneity in treatment effects of these behavioural interventions by the baseline mood levels of participants, as conjectured in our pre-analysis plan (see Methods). Being exposed to these treatments does not change participants' self–reported levels of perceived autonomy. We did not pre-register, and therefore do not report, any other moderation analysis.

No negative behavioural spillovers caused by interventions

Measurement of behavioural spillover, which occurs when a behavioural change in one domain leads to a subsequent behavioural change in another, is gaining more attention [26–28], but there is limited agreement on identification of causal pathways. We estimate spillovers for charitable donations using different identification techniques.

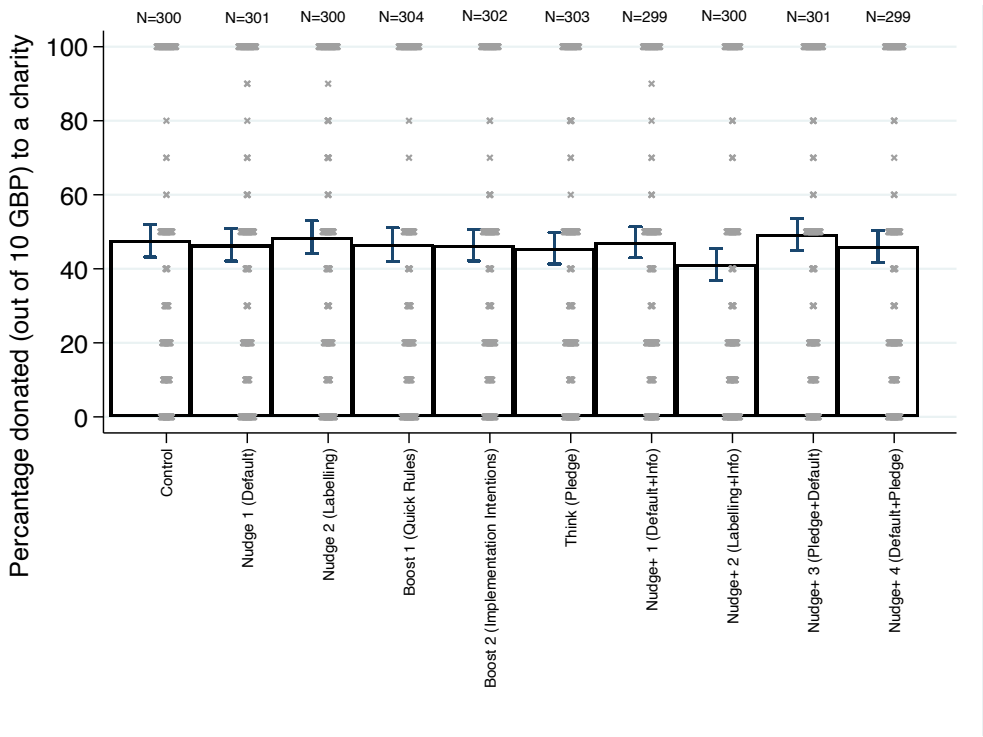

Figure 3: Average donations across the ten experimental conditions (N = 3,009). Bar graph indicates mean donations with 95% confidence intervals and visualizes the distribution of data (using x). The corresponding sample size of each experimental condition is displayed at the top of each bar.

In our sample, donations are distributed with three clear peaks: participants are likely to donate nothing, half their endowments or mostly everything. People who donate their monetary earnings from the risk and time preference tasks are more likely (ρ=0.495; p<0.0001) to donate in the post-treatment task. 29% of our sample chose to donate to an environmental charity (WWF, Keep Britain Tidy, Greenpeace, PETA, and Friends of Earth), whereas the remaining donate to pro-social charities (British Heart Foundation, Samaritans, Children in Need, UNICEF, LGBT Foundation and Abortion Rights). Figure 3 plots the average donations across the experimental conditions.

We use two commonly accepted definitions of spillover effects (see Methods). First, we consider behavioural spillover as the direct causal effect of a policy intervention on an indirect behaviour. We test this using linear regression of *Charitable Donations* on *Treatment Indicator*. We do not find any statistically significant evidence to suggest that random assignment to a behavioural policy leads to any significant difference in charitable contributions relative to the control. While this first definition proposes a direct causal estimate of behavioural spillovers resulting from intervention, it fails to identify the pathway of this indirect behaviour change (via a change in the targeted behaviour). Behavioural spillover effects are best thought of as cascading or ripple effects, mediated by a change in direct behaviours [29, 30]. We re–test for spillovers using a two–stage least–squares regression–based

approach, where initial random assignment to an experimental condition is used to instrument for changes in emissions and thereby causally infer effects on donations to charities. Using this definition, we also do not find any evidence of behavioural spillovers on charitable donations (see here).

Discussion

We evaluate different behavioural interventions, such as nudges, boosts, thinks, and nudge+, in promoting sustainable dietary intentions, using an online randomised controlled trial in the UK. All behavioural interventions significantly increase intentions for sustainable diets compared to the control. Encouraging people to reflect before nudging them works best, as seen with "Nudge+ 3 (Pledge+Default)". We find no evidence for negative behavioural spillovers on charitable donations. Based on our findings, we propose a new way to improve citizen's sustainable dietary intentions by encouraging them to reflect before nudges.

Our findings generate new insights for different stakeholders in the food industry, such as online food–delivery companies and public institutions (schools, universities, hospitals) that use food menus regularly. The "nudge+ 3 (pledge+default)" intervention is readily implementable through push–in prompts on ordering kiosks currently used in many cafeterias, which can be programmed to provide customers with short thinking prompts that enable them to reflect on their sustainable dietary preferences as they are navigating the food menu. Introducing "think" prompts should be relatively low-cost, both for suppliers, as these prompts are technically easy to program into the existing kiosks, and for consumers, who do not need any longer time to order than they otherwise do (as we show in the experiment). Building long–term customer rewards can further incentivise in–app interactions. It is plausible that trade-offs can limit food companies and institutions from adopting such reflective interventions. Companies might be worried that reflective and transparent nudging could upset their customers, generating reactance, which could harm their reputation and reduce revenues. Transparent nudging does not lead to any backfires as we find (also, see [31]). In fact, firms are likely to benefit in the long-term by using these agency-enhancing interventions. As more people become health-conscious and concerned about the environmental impact of their diets, food companies might want to cater to these changing preferences to remain relevant and competitive in the market long-term. By promoting healthier eating habits, food companies can align themselves with health and wellness trends, potentially attracting a wider customer base. Food companies can also position themselves as environmentally responsible by promoting plant-based alternatives. Investing in newer marketing techniques to develop these "think" prompts that sell plant-based diets can drive innovation within food companies. This innovation can enhance a company's reputation in the market and also attract newer attention. Finally, food companies are increasingly under pressure

to demonstrate corporate social responsibility (CSR). By promoting healthier and more sustainable diets, companies can enhance their CSR image and show commitment to addressing public health and environmental concerns, which can ultimately increase their revenues.

These findings contribute to an emerging scholarly literature on "behavioural economics for sustainability" [32] to show there is more to behaviour change than nudging. The policy toolkit of a sustainability scientist to change human behaviours is wider than has been traditionally thought. Understanding the importance of this wider toolkit and adopting it is important, particularly as behaviour change is expected to play a crucial role in achieving climate goals [13, 33, 34]. Policy makers should consider interventions, such as boosts, thinks, and nudge+, which speak to the agency of human beings. Restoring faith in human agency, by encouraging people to reflect on their own motivations, is imperative to drive major environmental transformations of the scale needed today. While nudging is effective, it may be difficult to scale up in its current form [8]. This was evident in earlier evaluations of nudging [35], as well as in recent findings accounting for publication bias [36]. Our work is also relevant to the recent scholarly debate on the individual (i) versus the systemic (s) frame [12]. While we agree that systems-level changes are desirable, we do not prescribe moving away from the i-frame completely. Instead, we suggest that relying on tools which encourage citizen reflection to improve the traction of nudges can be a promising approach. There is also demand from citizens to engage with behaviour change interventions. Contrary to the perception that nudges work best when they are in the dark [9], informing people transparently about sustainable diets nudges does not reduce their effectiveness. This reaffirms findings in the literature that transparent nudging is as good as nudging [19, 20] and does not necessarily cause reactance from citizens. If so, we should not need to deny citizens the right to engage with nudges. The nudge+ programme builds on these developments to modify the nudge in ways that will enable us to scale–up our actions. Some modification of the nudge, such as our nudge+ 3 (pledge+default), where citizens are encouraged to reflect before nudged, are capable of delivering transparent and reflective behaviour change. Further, enabling people to reflect on nudges can also limit concerns of 'permitting' or compensating behavioural spillovers, as we show.

Our research has two main limitations: findings should be interpreted carefully and also validated externally. First, the experimental set-up relies on intended behaviours and we are unable to test whether dietary intentions in the experiment translate into actual behaviours ("intention-behaviour gap"). There is evidence that contextual factors can drive this wedge between intentions and behaviours [37]. We acknowledge this possibility, and call on future research to investigate this with fully consequential dietary behaviours. Second, dietary behaviours could be subject to normative pressures. While recent experimental evidence suggests limited possibilities of experimenter demand effects [38], it is not possible to test this in this experiment. It is plausible that any attempt to nudge people towards

plant-based diets will suffer from some degree of experimenter-demand effect, so we call on future research to explore if reflective treatments unduly affect decision-making by inducing additional normative pressures.

While our findings are promising for the future of sustainable diets policies, scaled–up agency-promoting nudges need to be developed and evaluated rigorously to understand their long-run effects. While our stylised experiment offers insights into real-life applications of these interventions, such uses will have to be carefully developed and tested in future. An agency-enhancing intervention, like the boost, think or nudge+, will be effective only when people are motivated to change behaviours. If reflection makes preferences stronger, then a nudge+ will do worse. These welfare effects should be theorised and empirically tested. The extent to which these reflective treatments prompt deliberation should also be measured, by building compliance checks, for example. More research is needed on the market acceptability of nudge+ interventions [39]. Finally, it is important to note that while we focus on only one aspect of environmental sustainability (climate), nudge+ interventions can be applied more generally across other aspects of food sustainability, such as for improving animal welfare and promoting health benefits. Future studies should also be attentive to trade-offs between multiple sustainability goals, such as those between low-carbon diets and animal welfare (for a discussion, see [40]). Despite these limitations, we are confident that if we design nudges transparently and reflectively, we can prove them even more effective to help achieving long-term sustainable diets.

Methods

The survey had four parts. The experiment took place in the third part. In the first part, after seeking explicit consent and informing participants about study details, we measured their mood, attitudes and beliefs. In the second part, participants revealed their risk and time preferences using incentive-compatible monetary tasks. Participants were randomly selected to receive an Amazon voucher (up to £80) equivalent to their earnings in the risk and time preference task. In this part, we also measured altruism as participants were asked to donate a part of these monetary earnings to a charity of their choice. In the last part, we measured participants palatability towards the food menus in the experiment, and re-assessed their mood. Standard socio-demographic characteristics were also measured.

Interventions

In the third part, we used different menu designs for our stylised experiment. These are outlined below.

Control. The control group received a regular menu in which we presented 36 items, which included 18 vegetarian and 18 non-vegetarian items. This control menu represents an a-la-carte menu in a restaurant setting from which people can choose freely and is shown as Figure S1 in the SI file.

Nudge. A nudge intervention works by changing *any aspect of the choice architecture that alters people's behavior in a predictable way without forbidding any options or significantly changing their economic incentives* [7, p6]. We designed two different variants of the regular menu with modifications to how the choices were presented to the participants. Our first nudge was a default. The default nudge works by changing the status-quo, so people go with the flow of what's made available to them. These default nudges simply draw people's attention to a subset of choices within their choice set. There is evidence that defaulting individuals into pension plans with higher saving rates increases lifetime savings [41] or into greener diets increases the uptake of such diets [3]. Based on this our default nudge was designed to be a shorter version of the regular menu. This included only half of all the available menu items on the regular menu. Included items were environmentally friendly , such that it had total emissions lower than the average emissions of all food items on the regular menu. People who were randomised into this "green default nudge"condition were automatically shown this reduced menu and were given a chance to opt-out of this to choose the regular menu. The green default nudge menu is shown as Figure S2 in the SI file. The second nudge was labelling. A labelling nudge works by automatically drawing people's attention to what's good and bad. It plays on people's abilities to unconsciously relate to their conditioned reflexes developed from an experience of responding to traffic lights while driving. There is evidence that such labelling strategies for climate-friendly

diets reduces the uptake of meat-based products [4]. The labelling nudge thus changes one's perceived choice-set by increasing their salience towards some items through colour coding, while keeping the actual choice-set unchanged. Based on this, we designed our labelling nudge to include a traffic light coding scheme on the regular menu – items on the regular menu which had individual emissions higher than average emissions of all menu items was coded red (meaning environmentally unsustainable), items with individual emissions less than average emissions but more than median emissions were coded amber (meaning between environmentally friendly and unsustainable cases), and items with individual emissions lower than median emissions were coded green (meaning environmentally friendly). Participants randomised in this "labelling nudge" experimental condition were shown a menu which is shown as Figure S3 in the SI file.

Boost. We designed two boost treatments which were followed by the regular menu. A boost enhances people's skills to make better decisions. We outline the two boosts below. The first boost was quick rules. Quick rules are a form of uncertainty management boosts which help people to develop new shortcuts in making decisions. By changing these shortcuts, people are effectively endowed with a new set of heuristics to use in choosing from their original choice-sets. For example, Pollan [42] lists many food rules which help people to re-direct their attention to newer and better choice alternatives, overwriting prior ways of choosing their food. We designed a "quick rules"condition in which participants were first shown a set of three quick rules which they were asked to memorise. These quick rules were (1) Eat a balanced diet (2) Eat meat occasionally, and (3) Eat mostly vegetarian items. Then people were asked if they remember these quick rules. If someone self-reported not remembering these rules, they were given the chance to see the rules once again. Otherwise, all participants were then exposed to the regular menu. The second boost was implementation intentions, which are long-term, motivational boosts. Unlike a pledge, which allows people to evaluate whether they agree with their desired end goal, implementation intentions set these goals as given for all people. Then, they proceed by eliciting people's motivations for realising this end-goal, and encouraging people to evaluate different strategies to realise these outcomes. Based on this, we designed an "implementation intentions" condition, in which participants were exposed to an environmental sustainable pledge but they were not given any options to make a decision on the pledge (see Figure S4 in the SI file). Then participants were asked about their motivations to comply with this pledge (see Figure S5 in the SI file), before asking them to evaluate multiple perceived choices in their available choice set by forming their own "if-then" implementation intention plans. Every participant in this condition was prompted to make 2 sets of 3 goal plans, for lunch and dinner (see Figure S6 in the SI file). This worked as follows: participants were provided with pre-determined if and then scenarios, which they could customise to form their own plans. Following these plans, all participants were exposed to the regular menu.

Think (Pledge). A think treatment works by enabling people to reflect widely on decisions. We choose the pledge to design this think. The think (pledge) is an active mechanism design which works in two implicit stages. In the first stage, people are encouraged to reflect on the end goals of the pledge, that is whether their decisions under the pledge, are considerate to their own preferences without the pledge. If yes, then people are encouraged to reflect on the best ways to achieve the goals of the pledge in the second stage. Based on this conceptualisation, we designed the experimental condition where first people were exposed to an environmental sustainable pledge that had certain pre-determined outcomes i.e. the pledge asked people to eat sustainably. Then people were asked if they wanted to take this pledge (first stage) and report their motivations to comply with this pledge. After this, if people accepted the pledge or were indifferent to it, then they were further given a choice of three different menus, either the regular menu, or the Nudge 1 (Default) menu, or the Nudge 2 (Labelling) menu. People were encouraged to evaluate different choice-sets to find a way to comply with the desired outcome of the pledge (second stage). The "Think (Pledge)" enabled participants to customise their own menu. Note, it is possible here that even after choosing a certain menu, people would make unsustainable food choices. The two different stages of this "pledge" experimental condition are shown as Figures S7-S9 in the SI file.

Nudge+. Nudge+ interventions combine an element of reflection into the nudge [14]. These interventions have been theorised to work by combining fast and slow processes [43], in ways that enable individuals to reflect slowly about the nudge. These can be of two types mainly. First, nudge+ with information represents a combination of nudges with an information disclosure explaining how and why the nudge was constructed. The other type, nudge+ with reflection, combines a nudge with an active reflective mechanism like the Think (Pledge) sequentially to offer easy compliance with the desired end goals of the thinks. Based on this, we designed four nudge+ treatments. Nudge+ 1 (Default+Info) participants received an information disclosure which informed them how the Nudge 1 (Default) menu was constructed (see Figure S10 in the SI file). Basically participants received a modified green default menu (see Figure S11 in the SI file). This menu was different to the Nudge 1 (Default) menu as it had an additional legend to explain the short length of the menu based on the information disclosure shown earlier. Nudge+ 2 (Labelling+Info) participants received an information disclosure which informed them how the Nudge 2 (Labelling) menu was constructed (see Figure S12 in the SI file). Participants received a modified labelling menu (see Figure S13 in the SI file). This menu was different to the Nudge 2 (Labelling) menu as it had an additional legend to explain the carbon labelling used for coding the food items on the menu. Nudge+ 3 (Pledge+Default) participants were first exposed to the pledge and asked to elicit their motivations, as in the first stage of the Think (Pledge) intervention. Then, if participants accepted the pledge, then instead of encouraging them to consider multiple perceived choice-sets like in case of the Think (Pledge), participants' compliance with their chosen end goals would be eased with the Nudge 1 (Default). This modified structure rendered the nudge+ as a tool

that was partly endowed with characteristics of the Nudge 1 (Default) and Think (Pledge). The cognitive mechanism between Think (Pledge) and the Nudge+ 3 (Pledge+Default) is shown as Figures S14-S15 in the SI file. Finally, in nudge+ 4 (Default+Pledge), we reversed the order of the nudge-think combination. So participants were first presented with a Nudge 1 (Default) menu. After they made a choice, they were presented with the first half of the Think (Pledge) intervention where participants had to deliberate about accepting, rejecting or being indifferent to the sustainable food pledge. Finally, those who accepted or reported being indifferent to the pledge were given an opportunity to revisit their choices made under the influence of the Nudge 1 (Default) menu.

Testable hypothesis

One can consider nudge+ as an attempt to upgrade nudges and scale them up by making citizens a part of it. The ability to reflect slowly about the nudge, in fact, can improve the uptake of the nudge, particularly when the nudge is effective (i.e. leads to positive treatment effects). A nudge+ is conjectured to be more effective than its standalone nudge counterpart, such as the Nudge 1 (Default) and the Nudge 2 (Labelling). A nudge+ is also fully transparent to the receiver. Hence, it should improve people's self-perceived autonomy. Thinking through the nudge and owning it reduces moral warm-glow effects as people are no longer tricked into good behaviours. For those who respond positively to a nudge+, they truly want to improve their intentions, actions and behaviours. Such interventions save people substantial cognitive effort when compared to thinks and boosts. Hence, a nudge+ is also conjectured to produce more effective outcomes compared to the Boost 1 (Quick Rules), Boost 2 (Implementation Intentions) and Think (Pledge). We expect nudge+ to produce the most effective behaviour change when compared to all other experimental conditions.

Whilst nudge+ effects are conjectured to hold true for the population on average, increased deliberation comes at substantial cognitive costs to people (and economic costs to the society). Hence, the effectiveness of these policies will increase cognitive fatigue. By extension, people who are cognitively fatigued should be less responsive to nudge+. In validating this theory of nudge+, we preregistered the following hypotheses (slightly adapted for clarity).

Research Question 1: Do behavioural policies promote climate-friendly behaviours compared to doing nothing?

- Hypothesis 1: A behavioural policy will significantly improve pro-environmental behaviours compared to the control.

Research Question 2: Does adding reflection in the nudge improve climate-friendly behavioural outcomes?

- Hypothesis 2: A nudge+ will be more effective than its standalone nudge.
- Hypothesis 3: A nudge+ with reflection will be more effective than its standalone think.
- Hypothesis 4: A nudge+ with reflection will be more effective than a nudge+ with information.

Research Question 3: Do behavioural policies promoting climate-friendly behaviours lead to any adverse behavioural spillovers?

- Hypothesis 5: A behavioural policy will not produce adverse behavioural spillovers compared to the control condition.

Research Question 4: Are some people more responsive to behavioural policies than others?

- Hypothesis 6: Treatment effects of behavioural policies will vary by participant's prior level of (a) anxiety (b) tiredness and (c) calmness.

Research Question 5: Do behavioural policies lead to loss of autonomy?

- Hypothesis 7: A behavioural policy will lead to no change in self-perceived autonomy of people compared to the control condition.

Variables

We use *Greenhouse gas emissions (GHGe)* as a proxy for participants' dietary choices. In particular, the outcome measure corresponds to the life cycle emissions of the main ingredient in their chosen food item. This variable was constructed as follows: we identify the primary food type and ingredient of each dish on our menu using the McCance and Widdowson's CoFID user guide [44]. Each food item is assigned a carbon score (in kgCO2e) using the UK Greenhouse gas emissions scale developed by Scarborough and colleagues [45]. The GHGe variable ranges from 0.8 to 68.8 kilos of CO2e, with an average emissions score of 17.1 kilos of CO2e. For robustness, we also measure such choices discretely with an ordinal variable called *Carbon Intensity(CI)*. The GHGe variable has discrete jumps due to measurement of carbon intensiveness of each food item. To account for these value breaks, we further discretise the GHGe outcome into an ordinal variable. CI is an ordered categorical transformation of the GHGe outcome variable. It has nine categories, starting with the food type: beans, and lentils at the lowest level (0) of carbon emissions, to the food type: ruminant meat at the highest level (8). We measure indirect behaviours as participants' level of *Charitable Donations* in stage 4 of the experimental task. This is a continuous variable and reflects pro-social charitable contributions by participants.

Our main explanatory variables are dummy variables, called $Treatment_i$, indicating experimental conditions to which participants were randomly assigned to, such that

$$Treatment_i = 1, \{\text{if participant is in } i^{th} \text{ experimental condition, 0 otherwise}\}$$
$$\forall i = Treatment_{default}, ..., Treatment_{nudge+reflection}$$

Further, we construct variables for participants' mood measures, namely *anxiety*, *tiredness*, and *calmness*, measured on a 5-point likert scale. To measure differences in levels of autonomy, we construct $diff_{autonomy} = autonomy_{posttreat} - autonomy_{pretreat}$, where we measure $autonomy_t$ on a 5-point likert scale $\forall t = \{pretreat, posttreat\}$. We also construct other pre-registered covariates to use as controls in regressions and to check for balance of means in assessing randomisation (for details, see here).

Empirical Strategy

We test hypothesis H1 by measuring the average treatment (intent–to–treat) effect of being assigned to an experimental condition, relative to the control group (two-sided). We do so using a regression-based least-square approach, which in its simple form corresponds to a means-comparison of *greenhouse gas emissions* between the treatment and control group, as outlined by specification [1].

$$\text{GHGe} = \alpha + \sum \beta_i \text{Treatment}_i + \epsilon \quad [1]$$
$$\forall i = Treatment_2, ..., Treatment_{10}$$

For robustness, we then control for n covariates, selected using a lasso-based regression technique [46], outlined by specification [2]. For additional robustness, we use a generalised ordered logistic regression approach, using *Carbon Intensity*. Our findings are robust, and these results are available in the Supplementary Information.

$$\text{GHGe} = \alpha + \sum \beta_i \text{Treatment}_i + \sum \delta_k \text{Control}_\text{k} + \epsilon \quad [2]$$
$$\forall i = Treatment_2, ..., Treatment_{10} \quad \& \quad k = Control_1, ..., Control_n$$

Finally, in order to test hypotheses H2-H4, which compares a nudge+ to its corresponding nudge condition, we re–use model specification [2] by setting the nudge+ condition as our reference category, instead of the control group (two-sided).

Next, we test for behavioural spillovers to validate hypothesis H5 (two-sided). In its first definition, behavioural spillovers are considered as the direct causal effects of an intervention on people's indirect behaviours. In following this definition, we use model specification [2] with *Charitable Donations* as our outcome variable of interest. This corresponds to specification [3].

$$\text{CharitableDonations} = \alpha + \sum \beta_i \text{Treatment}_i + \sum \delta_k \text{Control}_\text{k} + \epsilon \quad [3]$$
$$\forall i = Treatment_2, ..., Treatment_{10} \quad \& \quad k = Control_1, ..., Control_n$$

In its second definition, we re-estimate behavioural spillovers as the effect of changes in *GHGe* on *Charitable Donations*. To account for endogeneity in the measurement of the *GHGe* variable, we use a two-stage least-square regression-based approach. Here, we use our initial random assignment to experimental conditions to instrument for changes in emissions, which are then used to predict any charitable donations. Set up this way, we can use model specification [2] as our first-stage reduced-form equation. The TSLS estimator can be estimated from a second-stage model specification as outlined in [4].

$$\text{CharitableDonations} = \alpha + \sum \beta_i^{TSLS} \widehat{\text{GHGe}}_i + \sum \delta_k \text{Control}_\text{k} + \epsilon \quad [4]$$
$$\forall k = Control_1, ..., Control_n$$

While the first definition proposes a direct causal estimate of behavioural spillovers resulting from policy intervention, the second definition identifies the pathway of this indirect behaviour change. This is because spillovers effects are best thought of as cascading or ripple effects mediated by a change in direct behaviours [29, 30].

We also test for any heterogeneity in our average treatment effects. In order to test hypotheses H6a-c, we use model specification [2] by adding a linear interaction with our pre-specified mood measures, namely, *anxiety*, *tiredness*, and *calmness*. This is outlined in specification [5].

$$\text{GHGe} =$$
$$\alpha + \sum \beta_i \text{Treatment}_i + \sum \gamma_{ij} (\text{Treatment}_\text{i} * \text{Mood}_\text{j}) + \sum \delta_k \text{Control}_\text{k} + \sum \rho_j \text{Mood}_\text{j} + \epsilon \quad [5]$$
$$\forall i = Treatment_2, ..., Treatment_{10} \quad \& \quad k = Control_1, ..., Control_n \quad \& \quad j = Mood_{anxiety}, Mood_{tired}, Mood_{calm}$$

Finally, we assess if any of these experimental conditions lead to a change in participants' levels of self-perceived autonomy, as set out in hypothesis H7. In this, we use model specification [2] once again, by using $diff_{autonomy}$ as our outcome variable. We outline this in specification [6].

$$\text{diff}_\text{autonomy} = \alpha + \sum \beta_i \text{Treatment}_i + \sum \delta_k \text{Control}_\text{k} + \epsilon \quad [6]$$
$$\forall i = Treatment_2, ..., Treatment_{10} \quad \& \quad k = Control_1, ..., Control_n$$

We follow [47] to account for joint and multiple hypotheses testing. All analysis has been performed using Stata 17.1.

Ethics

The study was subject to departmental review (Department of Geography and Environment) and was approved by the Research Ethics Committee of The London School of Economics Political Science (reference number 28723). The study complies with the Research Ethics Code and the Code of Research Conduct of LSE. Informed consent was sought before participation.

Data Availability Statement

The datasets generated by the survey research during and/or analyzed during the current study are available in the Figshare repository, https://doi.org/10.6084/m9.figshare.23536983.

Code Availability

The analytic codes used for data cleaning and analysis during the current study are available in OSF, https://osf.io/5by4k/?view_only=7011ecec70f94772b51a59f965c40a67

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Author Contribution Statement

SB – Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing; MG – Funding acquisition, Supervision, Validation, Writing – review & editing; PJ – Funding acquisition, Supervision, Validation, Writing – review & editing; SM – Funding acquisition, Supervision, Validation, Writing – review & editing.

Competing Interests Statement

The authors declare no competing interests.

Tables

Behavioural public policy	Experimental condition	Vignette Description
No-intervention	**Control**	Participants were shown a regular menu with 36 items, including 18 vegetarian and 18 non-vegetarian items.
Nudge: alters how choices are presented to people	**Nudge 1 (Default)**	Participants were defaulted into a shorter menu with 18 sustainable food items from the regular menu. Of these, 12 were vegetarian and 6 were non-vegetarian. Participants could opt-out for the regular menu.
	Nudge 2 (Labelling)	Participants were shown the regular menu with 36 items, which were colour coded using a traffic-lighting scheme: red (high emissions), amber (medium emissions) and green (low emissions).
Boost: enhances people's skills	**Boost 1 (Quick rules)**	Participants were asked to consider three food rules (Rule #1: Eat a balanced diet; Rule #2: Eat meat occasionally; Rule #3: Eat mostly vegetarian items), before being presented with the regular menu.
	Boost 2 (Implementation intentions)	Participants were asked to design six 'if-then' implementation plans (three for lunch and three for dinner), before being presented with the regular menu.
Think: encourages people to reflect widely before decisions	**Think (Pledge)**	Participants were shown a pledge to commit to eating an environmentally friendly diet. Following their decision to pledge or not, they were asked to reflect and choose from a regular, "Nudge 1 (Default)", or "Nudge 2 (Labelling)" menu to comply with the pledge.
Nudge+: hybrid nudge–think policies that inform people about a nudge and enable them to reflect alongside it	**Nudge+ 1 (Default+Info)**	Participants were shown the "Nudge 1 (Default)" menu with an information disclosure about the construct and purpose of it.
	Nudge+ 2 (Labelling+Info)	Participants were shown the "Nudge 2 (Labelling)" menu with an information disclosure about the construct and purpose of it.
	Nudge+ 3 (Pledge+Default)	Participants were shown a pledge for an environmentally friendly diet. Post-pledge decision, they were automatically provided with the "Nudge 1 (Default)" menu to help them comply with the pledge.
	Nudge+ 4 (Default+Pledge)	Participants were shown the "Nudge 1 (Default)" menu. Post-menu choice, they were shown a pledge for an environmentally friendly diet. A choice to revisit their online order was also provided to those who took the pledge.

Table 1: Summary of experimental conditions

GHG emissions (versus control)	(1)	(2)
Nudge 1 (Default)	-12.475	-12.230
	(1.669)	(1.622)
	[0.00045]	[0.00044]
Nudge 2 (Labelling)	-8.497	-7.493
	(1.671)	(1.629)
	[0.00087]	[0.00016]
Boost 1 (Quick rules)	-7.23	-6.983
	(1.666)	(1.623)
	[0.00084]	[0.00077]
Boost 2 (Implementation Intentions)	-14.176	-12.031
	(1.668)	(1.669)
	[0.00014]	[0.00083]
Think (Pledge)	-14.505	-12.807
	(1.667)	(1.642)
	[0.00097]	[0.00086]
Nudge+ 1 (Default+Info)	-14.768	-13.583
	(1.673)	(1.628)
	[0.00041]	[0.00081]
Nudge+ 2 (Labelling+Info)	-8.497	-7.507
	(1.671)	(1.655)
	[0.00077]	[0.00022]
Nudge+ 3 (Pledge+Default)	-17.905	-16.996
	(1.669)	(1.643)
	[0.00071]	[0.004]
Nudge+ 4 (Default+Pledge)	-13.396	-12.849
	(1.673)	(1.632)
	[0.00028]	[0.00044]
Constant	23.477	35.113
	(1.182)	(7.896)
Observations	3009	2991
R-squared	0.0544	0.1298
Controls	No	Yes

Table 2: Summary of average treatment effects across 9 treatments

Notes: Intent to Treat effects. OLS estimates of specification [1] in columns 1 and 2. We report mean differences from a two-sided t-test. Robust standard errors reported in parentheses. Young's [47] randomisation-t p-values (corrected for multiple comparisons) in box brackets. Column 2 includes control variables. Controls were selected by LASSO, and include indicators of palatability towards menu, dietary styles, pro-conservation beliefs, gender, climate change scepticism, age, scores on healthy eating index, ONS measures of anxiety and life satisfaction, beliefs for command and control regulation, religious beliefs, effect of COVID-19 on income, and whether one's favour the environment over economic growth. We follow Young (2019) to account for joint and multiple hypotheses testing.

GHG emissions (versus "Nudge+ 3 (Pledge+Default)"	(3)	(4)
Control	17.905	16.996
	(1.761)	(1.644)
	[p<0.0001]	[0.00067]
Nudge 1 (Default)	5.430	7.766
	(1.323)	(1.623)
	[p<0.0001]	[0.00259]
Nudge 2 (Labelling)	9.514	9.503
	(1.486)	(1.621)
	[p<0.0001]	[0.00037]
Boost 1 (Quick Rules)	10.675	10.013
	(1.515)	(1.612)
	[p<0.0001]	[0.00048]
Boost 2 (Implementation Intentions)	3.729	4.964
	(1.190)	(1.623)
	[0.002]	[0.00384]
Think (Pledge)	3.401	4.189
	(1.185)	(1.612)
	[0.004]	[0.01272]
Nudge+ 1 (Default+Info)	3.138	3.413
	1.140	(1.624)
	[0.006]	[0.03632]
Nudge+ 2 (Labelling+Info)	9.408	9.489
	(1.505)	(1.624)
	[p<0.0001]	[0.00062]
Nudge+ 3 (Pledge+Default)	Baseline	Baseline
	-	-
	-	-
Nudge+ 4 (Default+Pledge)	4.509	4.167
	(1.250)	(1.623)
	[p<0.0001]	[0.01223]
Constant	5.572	18.117
	(0.065)	(7.917)
Observations	3009	2991
R-squared	0.0544	0.1298
Controls	No	Yes

Table 3: Pairwise difference of means of experimental conditions versus Nudge+ 3 (Pledge+Default)

Notes: Intent to Treat effects. OLS estimates of specification [1] in columns 3 and 4. We report mean differences from a two-sided t-test. Robust standard errors reported in parentheses. Standard p-values in column 3 and Young's [47] randomisation-t p-values (corrected for multiple comparisons) in box brackets for column 4. Column 4 includes control variables. Controls were selected by LASSO, and include indicators of palatability towards menu, dietary styles, pro-conservation beliefs, gender, climate change scepticism, age, scores on healthy eating index, ONS measures of anxiety and life satisfaction, beliefs for command and

control regulation, religious beliefs, effect of COVID-19 on income, and whether one's favour the environment over economic growth.

Figure Legends/Captions

Figure 1: Average emissions over intended meal orders across the ten experimental conditions (N=3,009). Figure 1 plots a bar graph to indicate mean emissions with 95% confidence intervals and visualises the distribution of data (using small X). The corresponding sample size of each experimental condition is displayed at the top of each bar.

Figure 2: Average treatment effect on emissions from meal orders compared to the "Nudge+ 3 (Pledge+Default)" experimental condition. Figure plots the simple difference of means between an experimental condition versus the "nudge+ 3 (pledge+default)" treatment along with 95% confidence intervals. Estimates correspond to a simple linear regression of GHG emission on dummies for experimental conditions with robust standard errors using a sample of N=3,009 participants. The p-values are reported for each condition and correspond to a two-sided t-test.

Figure 3: Average donations across the ten experimental conditions (N=3,009). Figure 1 plots a bar graph to indicate mean donations with 95% confidence intervals and visualises the distribution of data (using small X). The corresponding sample size of each experimental condition is displayed at the top of each bar.

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A Supplementary Information

A.1 Menu Designs

Figure S 1: Menu shown to control group participants consisting of 18 vegetarian and 18 non-vegetarian items. Picture ©Lisa Fotios from Pexels via Canva.com.

Figure S 2: Menu shown to Nudge 1 (Default) group participants consisting of 18 items only. Each item on this menu has an individual emission lower than the average emission of all 36 items in the control group menu. Picture ©Lisa Fotios from Pexels via Canva.com.

Figure S 3: Menu shown to Nudge 2 (Labelling) group participants, consisting of 18 vegetarian and 18 non-vegetarian items labelled into red, amber and green. Picture ©Lisa Fotios from Pexels via Canva.com. Footprints ©Giuseppe Ramos J via Canva.com.

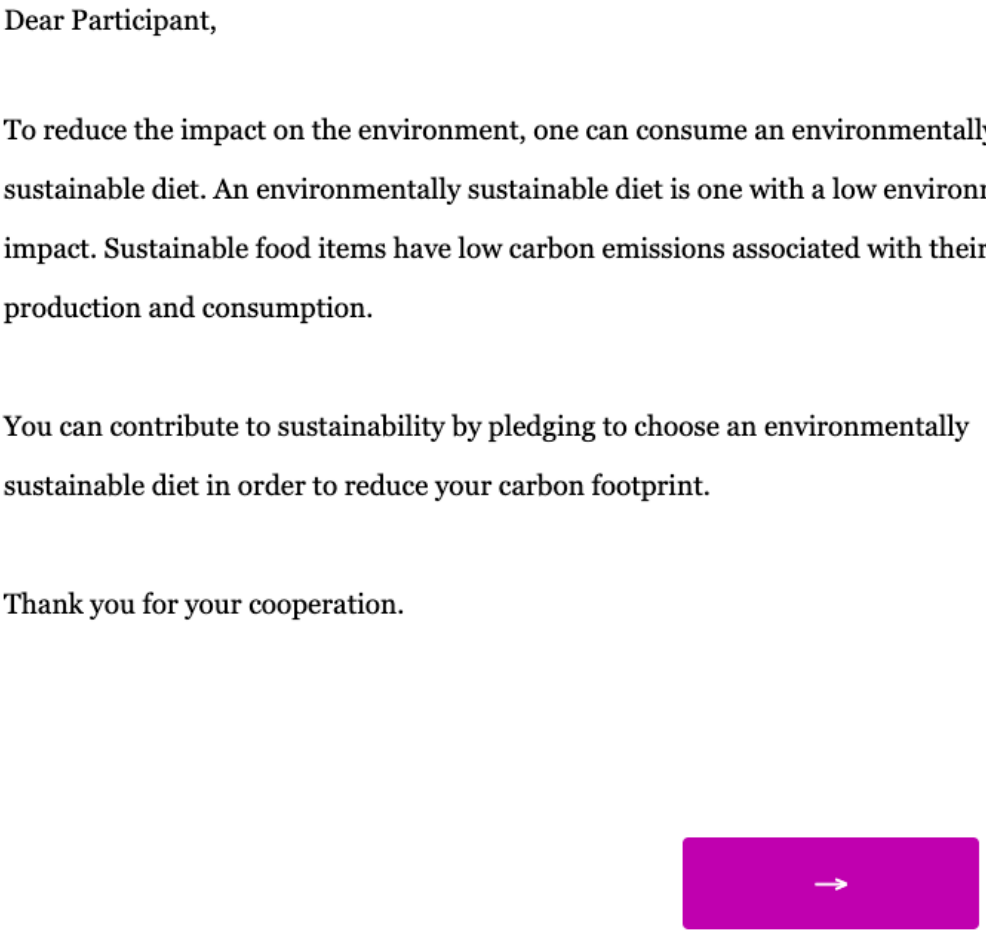

Figure S 4: Description of the pledge in the Boost 1 (Implementations Intentions) experimental condition.

Figure S 5: Eliciting people's motivations in the Boost 1 (Implementations Intentions) experimental condition.

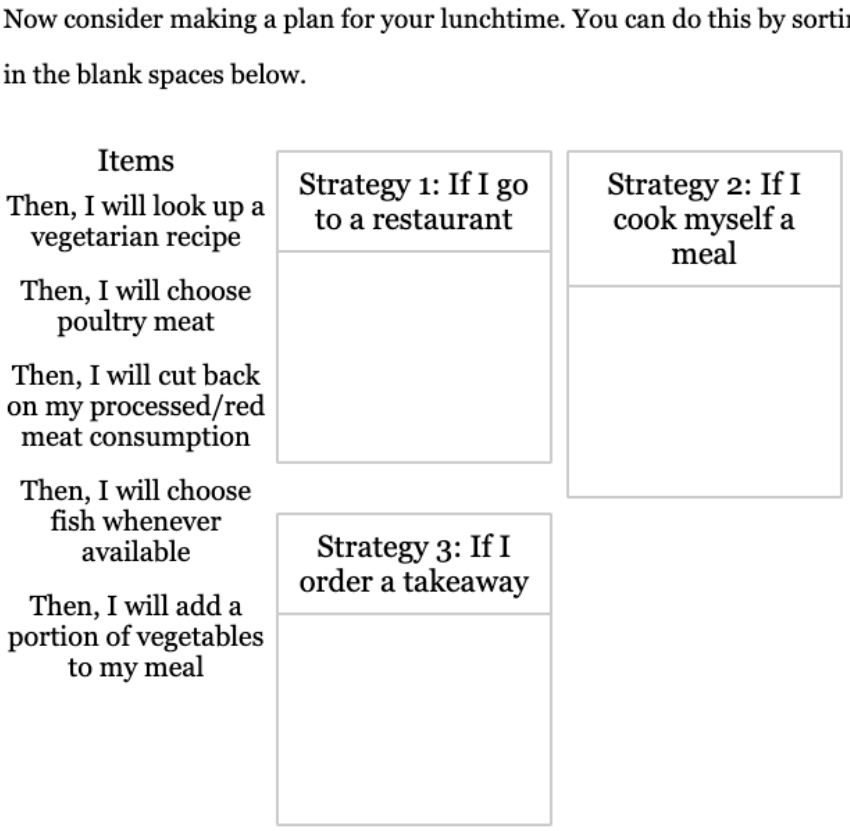

Figure S 6: Encouraging people to consider multiple compliance options for the Boost 1 (Implementations Intentions) condition.

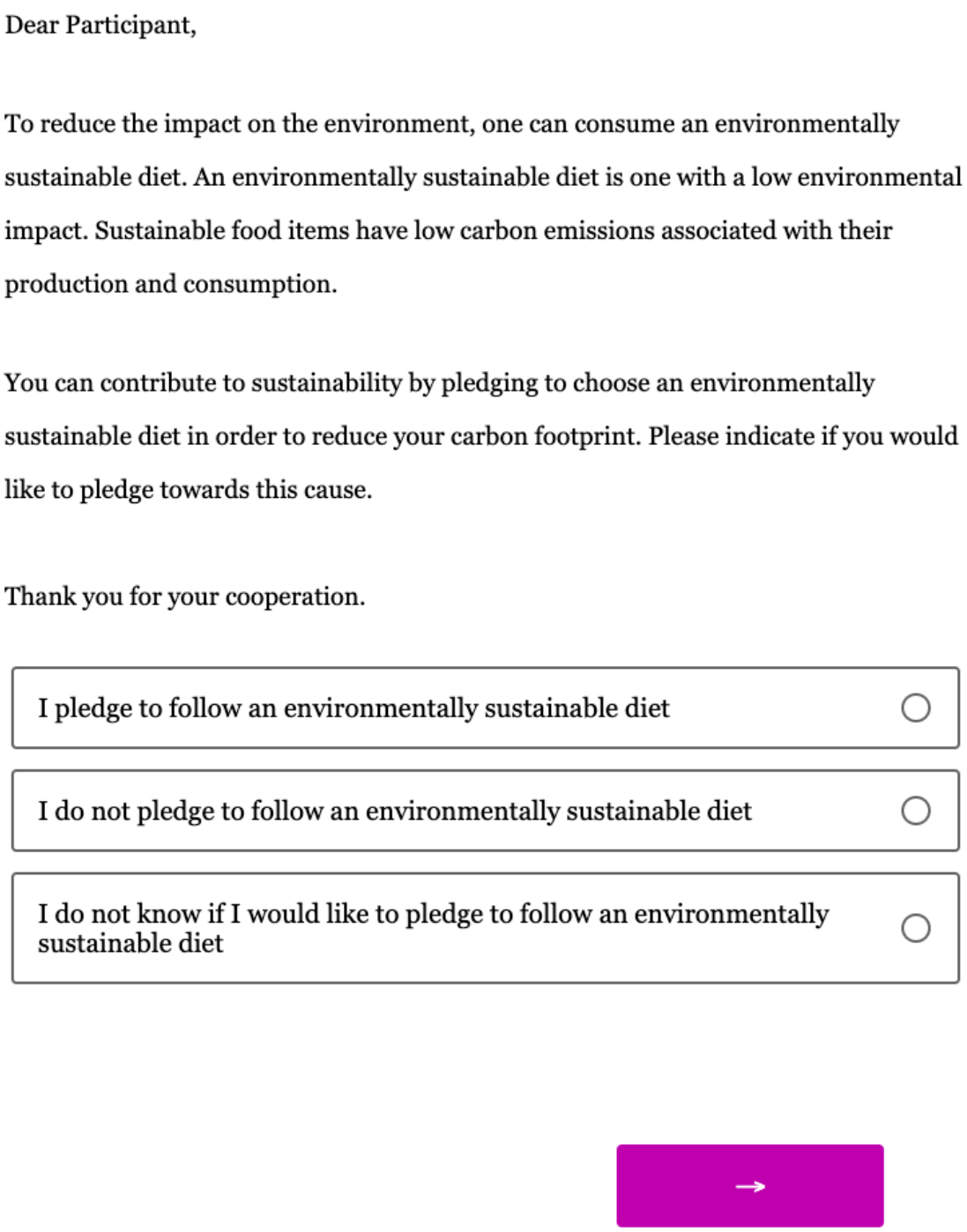

Figure S 7: Description of pledge in the Think (Pledge) experimental condition.

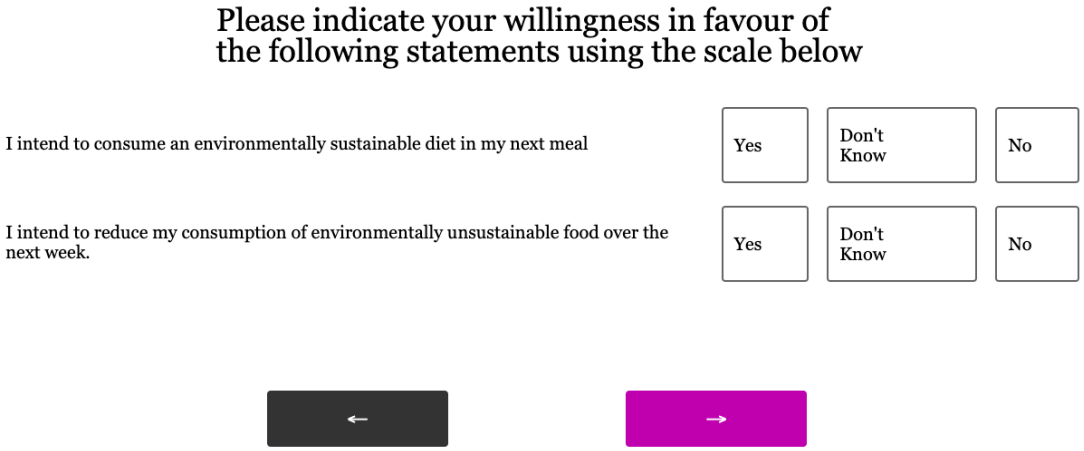

Figure S 8: Eliciting people's motivations in the Think (Pledge) experimental condition.

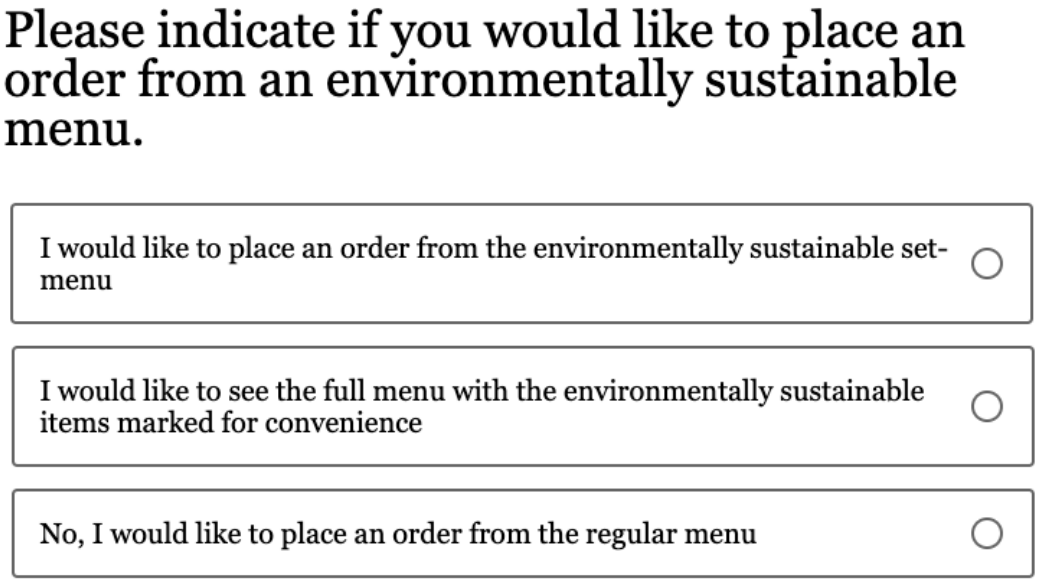

Figure S 9: Encouraging people to consider multiple compliance options for the Think (Pledge) experimental condition.

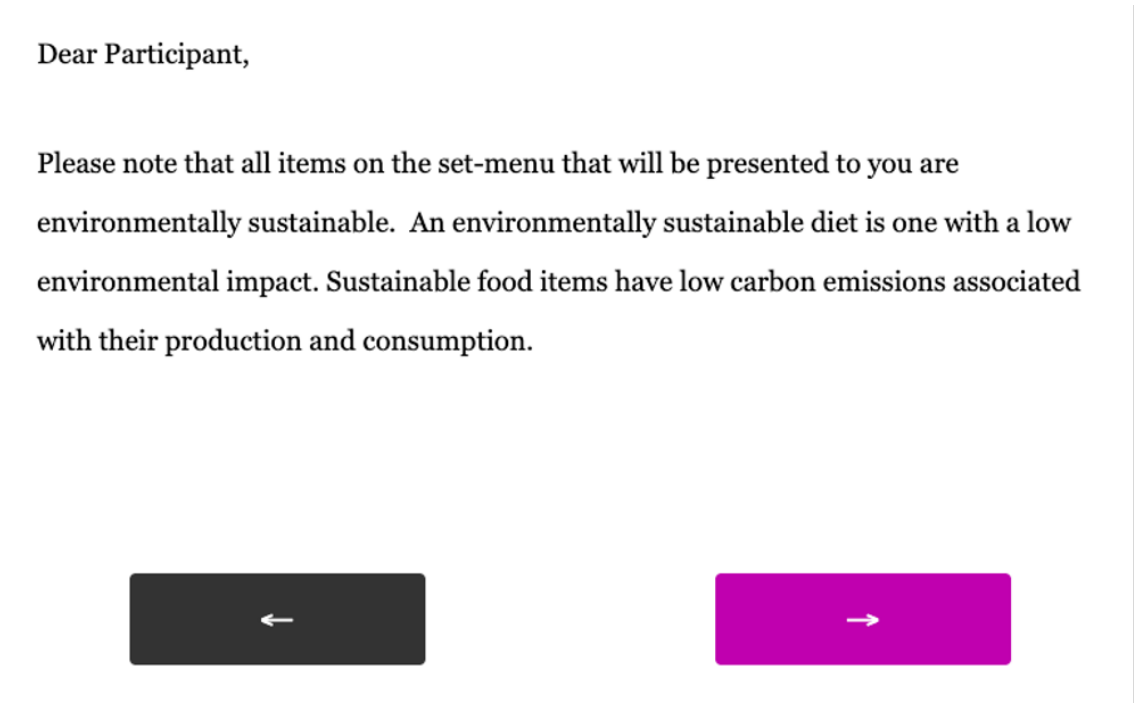

Figure S 10: Information disclosure preceding the nudge in the Nudge+ 1 (Default + Information) experimental condition.

Figure S 11: The modified default nudge shown to participants in the Nudge+ 1 (Default + Information) experimental condition. Picture ©Lisa Fotios from Pexels via Canva.com.

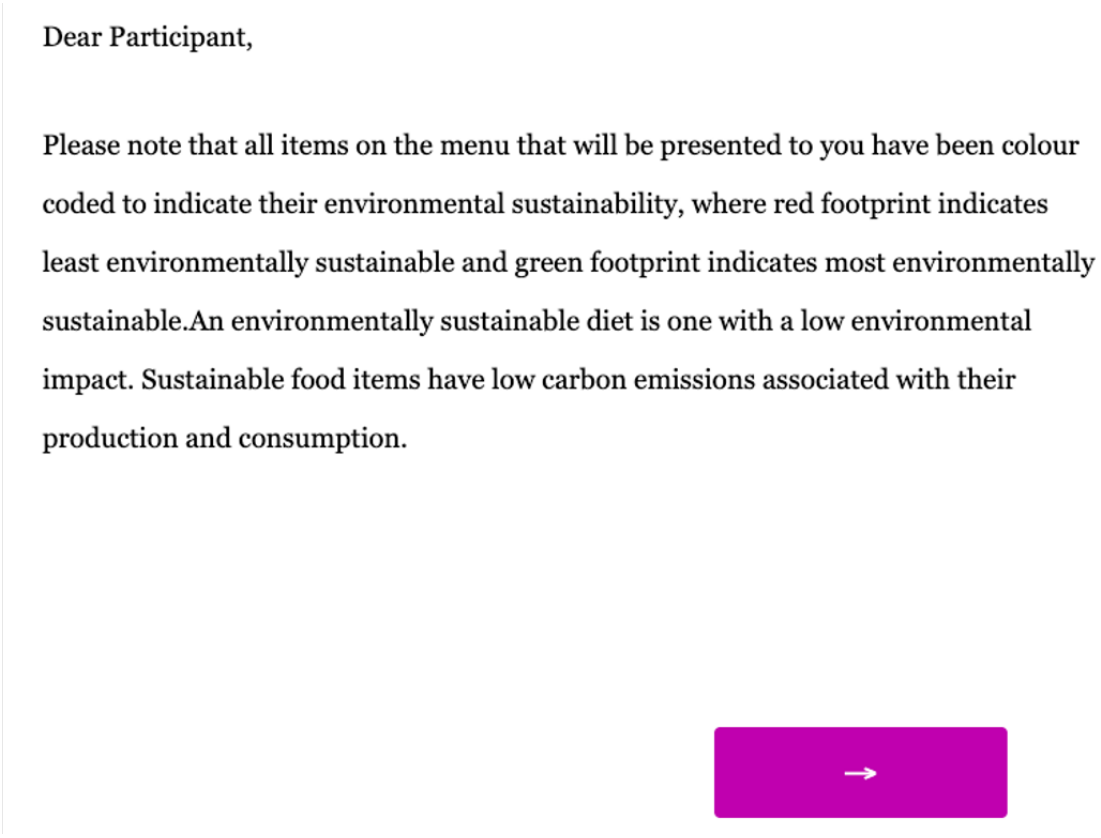

Figure S 12: Information disclosure preceding the nudge in the Nudge+ 2 (Labelling + Information) experimental condition.

Figure S 13: The modified labelling nudge shown to participants in the Nudge+ 2 (Labelling + Information) experimental condition. Picture ©Lisa Fotios from Pexels via Canva.com. Footprints ©Giuseppe Ramos J via Canva.com.

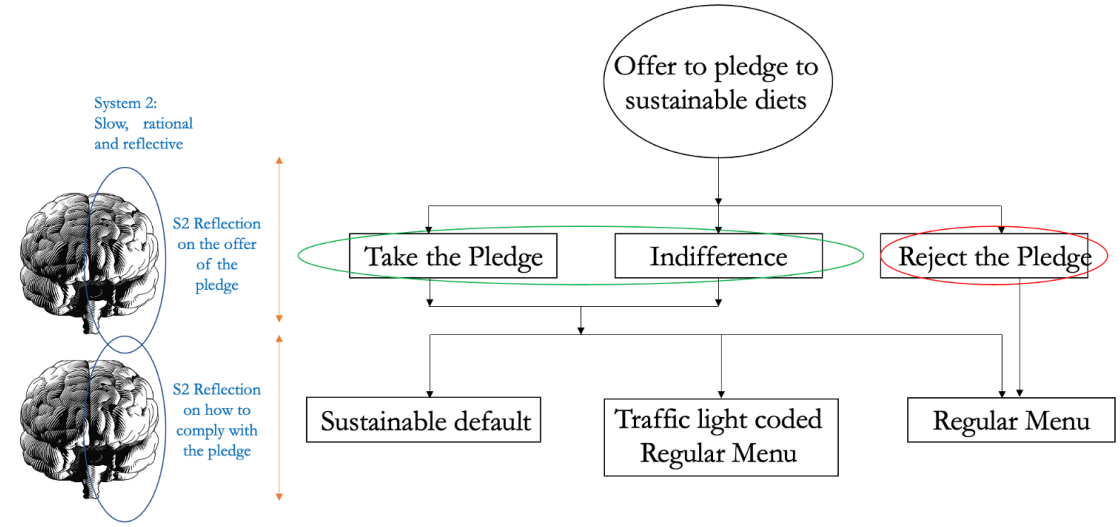

Figure S 14: The theorised causal mechanism of the Think (Pledge) intervention. Source: Banerjee et al., (2023) [31].

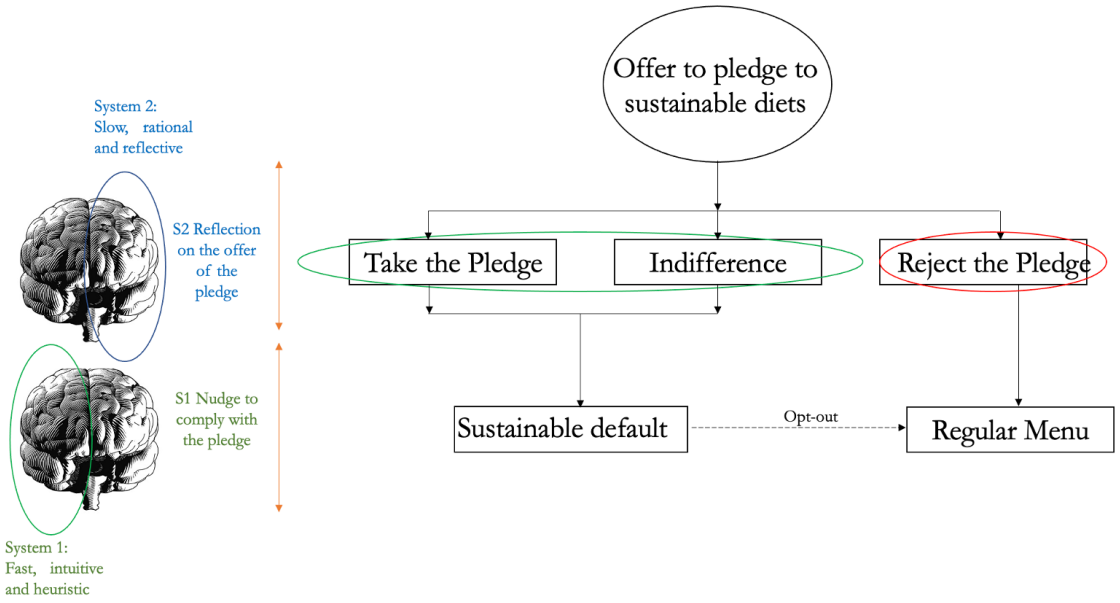

Figure S 15: The theorised causal mechanism of the Nudge+ 3 (Pledge + Default) experimental condition. Source: Banerjee et al., (2023) [31].

A.2 Descriptive Statistics

We follow Hadi [48] in identifying and removing 65 outliers by the age of participants and their time taken to complete the survey[1]. The remaining sample consists of 3,009 participants, of which 2,494 participants are residents of the United Kingdom. Our sample consists of

[1]Our sample has young adults, representative of age of online food delivery customers. We remove older adults who can be outliers.

young adults with a mean age of 29 years (σ=10.73). It is relatively balanced by gender with 52% male and 46% female representation. More than a half of the participants are in full- or part-time employment, and 44% of them are students. We recruit only English-speaking participants, with 29% of them self-reporting English as their first language. Furthermore, all participants are highly-educated with at least 50% having a first degree from the university or more. The sample is pre-dominantly white in ethnic origin, and 85% of them have religious affiliations. These sample characteristics by the broad treatment categories[2] are provided in Table S1.

All participants were randomised effectively into the ten different experimental conditions[3]. We satisfied our ex-ante sampling requirements[4]. As such, our study is powered to test our pre-registered confirmatory hypotheses (see Methods). All measurements, reported and analysed below, use the sample of 3,009 participants.

The mean level of emissions from all intended meal orders is 12.34 kilos of carbon–equivalent (CO_2e) and the modal food type consumed is white fish and poultry, consistent across all treatments including the control condition. We find that convergence to this modal food category is further exacerbated by our treatments[5] (see Figure S16 in Supplementary Information). This has implications for our average treatment effects, since a simple shift from a ruminant–based food item to a poultry– or fish–based food item can reduce emissions by ten times or more [45, 49]. We also report robustness checks using an ordered logistic regression specification where the outcome variable is categorical and is measured by the main ingredient of each food item, for details see Figure S17 in Supplementary Information.

[2]Heuristic category includes default nudge, labelling nudge and quick rules. Reflective category includes think and implementation intentions. Nudge+ includes default plus information, default plus pledge, pledge plus default and labelling plus information. Married also includes those in civil partnership. Units of measurement: GHG emissions in kgCO2 per kg; Donations in percentage donated out of 10 GBP; Age in years, Score out of 100 and measures participation score on Prolific; Completion time in minutes.

[3]For balancing checks, see here.

[4]For sensitivity analysis, please see here.

[5]A two-way tabulation test of the type of food consumed and treatments returns a chi^2=468.9978 at p< 0.00001.

Table S 1: Descriptive statistics by treatment categories

	Control	**Heuristic**	**Reflective**	**Hybrid**	**All**
			Outcomes		
GHG emissions	$\mu = 23.48$	$\mu = 12.12$	$\mu = 9.14$	$\mu = 9.83$	$\mu = 12.34$
	$\sigma = 28.35$	$\sigma = 22.49$	$\sigma = 17.27$	$\sigma = 18.21$	$\sigma = 21.34$
Donations	47.6%	47.15%	45.93%	45.88%	46.45%
			Demographics		
Age	$\mu = 29.12$	$\mu = 29.55$	$\mu = 28.60$	$\mu = 29.14$	$\mu = 29.17$
	$\sigma = 10.51$	$\sigma = 11.001$	$\sigma = 10.15$	$\sigma = 10.84$	$\sigma = 10.73$
Male	51.33%	51.60%	51.40%	53.04%	52.11%
First Degree or more	55.67%	52.27%	54.71%	51.38%	52.74%
Employed	49%	51.93%	50.91%	52.38%	51.61%
Student	41.67%	42.76%	45.45%	44.45%	43.87%
Christian	41%	39.78%	46.12%	45.62%	43.50%
White-UK	35.67%	32.38%	32.73%	32.86%	32.97%
Married	27.33%	31.05%	27.93%	27.86%	27.86%
			Survey characteristics		
Score	99.55	99.44	99.44	99.47	99.46
Completion time	23.76	24.16	25.27	24.22	24.37
Observations	298	902	600	1,191	3,009

A.3 ATE with respect to Nudge+ categories

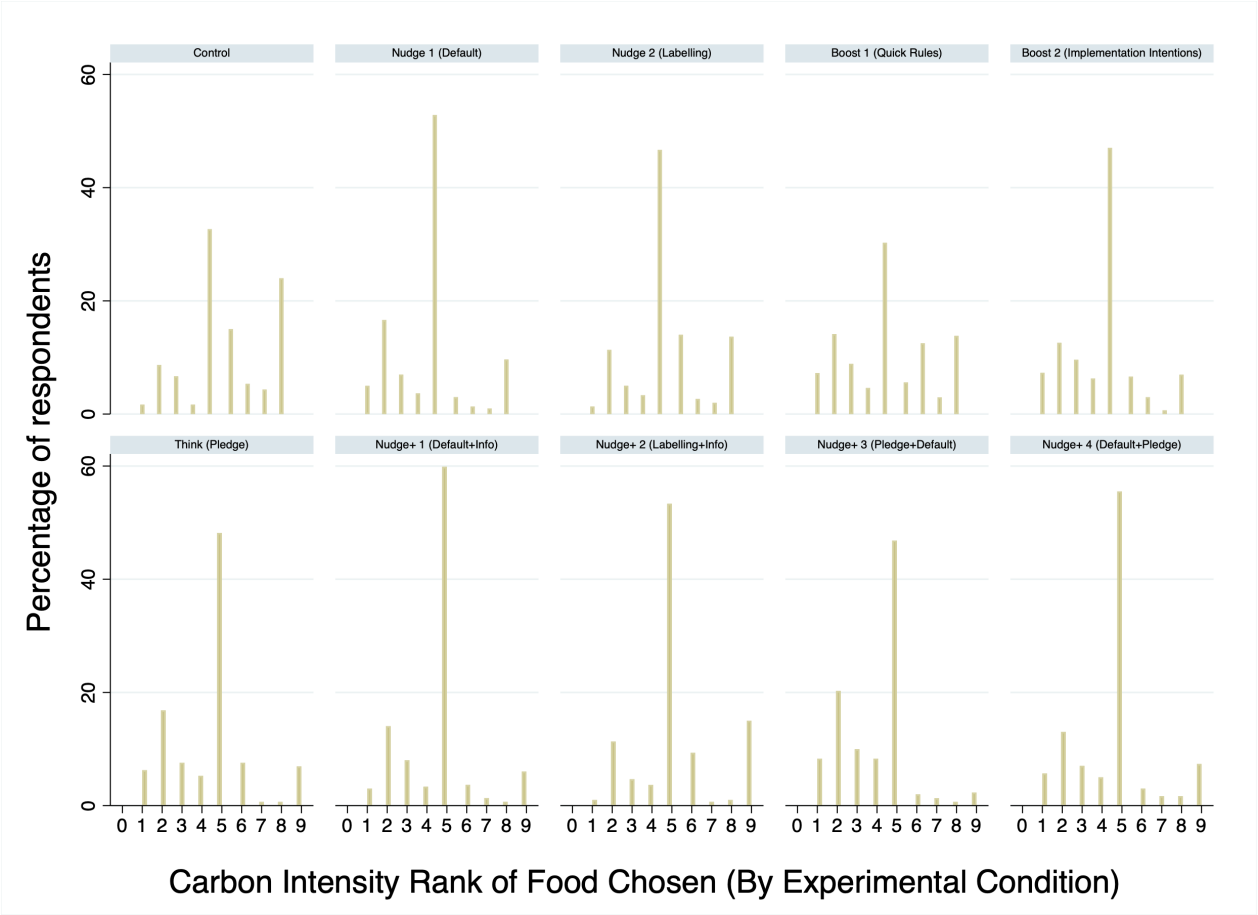

Figure S 16: Frequency plot of meal orders across experimental conditions. Notes: Histogram by 10 experimental conditions. In each graph, Y-axis shows percentage of respondents who ordered a particular meal type whereas X-axis orders these meal types by carbon intensity rank of their main ingredient type (1=Beans & Lentils; 2=Pasta; 3=Vegetable Dishes; 4=Nuts & Seeds; 5=White Fish and Poultry; 6=Pork; 7=Cheese and Dairy; 8=Lamb; 9=Beef).

GHG emissions	(1)	(2)	(3)	(4)	(5)	(6)
Control	Baseline	Baseline	13.583	7.506	16.996	12.849
	-	-	(1.628)	(1.655)	(1.644)	(1.632)
	-	-	[0.0052]	[0.00067]	[0.00067]	[0.00098]
Nudge 1 (Default)	-12.475	-12.230	1.353	-4.724	7.766	0.618
	(1.669)	(1.622)	(1.619)	(1.636)	(1.623)	(1.621)
	[0.00045]	[0.00044]	[0.39618]	[0.00226]	[0.00259]	[0.69587]
Nudge 2 (Labelling)	-8.497	-7.493	6.089	0.013	9.503	5.356
	(1.671)	(1.629)	(1.619)	(1.626)	(1.621)	(1.621)
	[0.00087]	[0.00016]	[0.00092]	[0.99229]	[0.00037]	[0.00148]
Boost 1 (Quick Rules)	-7.23	-6.983	6.599	0.523	10.013	5.866
	(1.666)	(1.623)	(1.618)	(1.630)	(1.612)	(1.616)
	[0.00084]	[0.00077]	[0.00091]	[0.78169]	[0.00048]	[0.00245]
Boost 2 (Implementation Intentions)	-14.176	-12.031	1.551	-4.524	4.964	0.818
	(1.668)	(1.669)	(1.639)	(1.631)	(1.623)	(1.633)
	[0.00014]	[0.00083]	[0.35944]	[0.00774]	[0.00384]	[0.64819]
Think (Pledge)	-14.505	-12.807	0.776	-5.3	4.189	0.042
	(1.667)	(1.642)	(1.619)	(1.612)	(1.612)	(1.618)
	[0.00097]	[0.00086]	[0.63899]	[0.00247]	[0.01272]	[0.97657]
Nudge+ 1 (Default+Info)	-14.768	-13.583	Baseline	-6.076	3.413	-0.734
	(1.673)	(1.628)	-	(1.632)	(1.624)	(1.621)
	[0.00041]	[0.00081]	-	[0.00038]	[0.03632]	[0.63466]
Nudge+ 2 (Labelling+Info)	-8.497	-7.507	6.077	Baseline	9.489	5.343
	(1.671)	(1.655)	(1.632)	-	(1.624)	(1.628)
	[0.00077]	[0.00022]	[0.000001]	-	[0.00062]	[0.00097]
Nudge+ 3 (Pledge + Default)	-17.905	-16.996	-3.412	-9.489	Baseline	-4.147
	(1.669)	(1.643)	(1.624)	(1.624)	-	(1.623)
	[0.00071]	[0.004]	[0.03657]	[0.00069]	-	[0.0125]
Nudge+ 4 (Default + Pledge)	-13.396	-12.849	0.724	-5.342	4.167	Baseline
	(1.673)	(1.632)	(1.621)	(1.627)	(1.623)	-
	[0.00028]	[0.00044]	[0.6347]	[0.00093]	[0.01223]	-
Constant	23.477	35.113	21.53	27.607	18.117	22.264
	(1.182)	(7.896)	(7.957)	(7.956)	(7.917)	(7.953)
Observations	3009	2991	2991	2991	2991	2991
R-squared	0.0544	0.1298	0.1298	0.1298	0.1298	0.1298
Controls	No	Yes	Yes	Yes	Yes	Yes

Table S 2: Intent to Treat effects: Pairwise comparison of experimental conditions versus (column 1) control group without LASSO; (column 2) control group with LASSO; (column 3) Nudge+ 1 (Default + Info); (column 4) Nudge+ 2 (Labelling + Info); (column 5) Nudge+ 3 (Pledge + Default); (column 6) Nudge+ (Default + Pledge)

A.4 Ordered Logistic Regression

		Behavioural Intervention Categories (baseline: Control) Odds Ratio (se)								
CoFID Food Group Type	**Carbon Intensity Rank (relative to all higher levels)**	**Nudge 1 (Default)**	**Nudge 2 (Labelling)**	**Boost 1 (Quick Rules)**	**Boost 2 (Implementation Intentions)**	**Think (Pledge)**	**Nudge+ 1 (Default+Info)**	**Nudge+ 2 (Labelling+ Info)**	**Nudge+ 3 (Pledge+ Default)**	**Nudge+ 4 (Default + Pledge)**
Beans and Lentils	**0**	0.327 (0.105) [0.0005]	Odds Ratio= 0.571; σ= 0.086; p=0.0002	**0.220** (0.063) [0.00001]	Odds Ratio= 0.276; σ= 0.043; p=0.00001	Odds Ratio= **0.260**; σ= 0.040; p=0.00001	0.552 (0.212) [0.1224]	1.697 (1.032) [0.3844]	0.189 (0.052) [0.00001]	0.284 (0.088) [0.00001]
Pasta	**1**	0.291 (0.056) [0.00001]		0.295 (0.057) [0.00001]			0.390 (0.079) [0.00001]	0.5790 (0.126) [0.0107]	0.200 (0.037) [0.00001]	0.348 (0.069) [0.00001]
Vegetable Dishes	**2**	0.318 (0.057) [0.00001]		0.294 (0.052) [0.00001]			0.380 (0.070) [0.00001]	0.622 (0.123) [0.0171]	0.203 (0.035) [0.00001]	0.367 (0.067) [0.00001]
Nuts and seeds	**3**	0.335 (0.059) [0.00001]		0.298 (0.052) [0.00001]			0.401 (0.072) [0.00001]	0.612 (0.116) [0.0094]	0.181 (0.031) [0.00001]	0.359 (0.063) [0.00001]
Poultry and Fish	**4**	**0.208** (0.041) [0.00001]		0.620 (0.103) [0.0051]			**0.157** (0.033) [0.00001]	**0.415** (0.071) [0.00001]	**0.080** (0.021) [0.021]	**0.188** (0.038) [0.00001]
Pork	**5**	0.311 (0.066) [0.00001]		0.948 (0.161) [0.7544]			0.200 (0.048) [0.00001]	0.458 (0.088) [0.00001]	0.103 (0.032) [0.00001]	0.275 (0.060) [0.00001]
Cheese	**6**	0.342 (0.075) [0.00001]		0.579 (0.112) [0.0046]			0.206 (0.053) [0.00001]	0.547 (0.107) [0.0021]	0.089 (0.032) [0.00001]	0.285 (0.066) [0.00001]
Lamb	**7**	0.363 (0.083) [0.00001]		0.545 (0.112) [0.0030]			0.218 (0.059) [0.00001]	0.600 (0.121) [0.00001]	0.081 (0.032) [0.00001]	0.270 (0.068) [0.00001]
Pseudo R^2		0.0384								
N		3009								

Figure S 17: Generalised ordered logistic regression with ordinal outcome variable called "Carbon Rank" measured by the carbon intensity rank of their main ingredient type of a food item (1=Beans & Lentils; 2=Pasta; 3=Vegetable Dishes; 4=Nuts & Seeds; 5=White Fish and Poultry; 6=Pork; 7=Cheese and Dairy; 8=Lamb; 9=Beef). Coefficients represent odds ratio (or exponentiated beta from regression). Standard errors in parentheses. Raw p-values in box brackets or as indicated by p. Coefficients in bold represent lowest odds ratio within an intervention type.