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Nudging the Food Basket Green: The Effects of Commitment and Badges on the Carbon Footprint of Food Shopping

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Abstract
We use an incentive-compatible experimental online supermarket to test the role of commitment and badges in reducing the carbon footprint of grocery shopping. In the experiment, some participants had the opportunity to voluntarily commit to a low carbon footprint basket before their online grocery shopping; the commitment was forced upon other participants. We also study the impact of an online badge as a soft reward for the achievement of a low carbon footprint basket. Participants from the general population shopped over two weeks, with the experimental stimuli only in week 2; and received their shopping baskets and any unspent budget. Results indicate that requesting a commitment prior to entering the store leads to a reduction in carbon footprint of 9–12%. When the commitment is voluntary, reductions are driven by consumers who accept the commitment. Commitments also reduced the consumption of fats and, for forced commitments, that of salt by 18%. Badges did not significantly impact consumer behaviour. Commitment mechanisms, either forced or voluntary, appear effective in motivating an environmental goal and search for low-carbon options, particularly in those accepting the commitment.

Keywords Sustainable consumption · Healthy and sustainable diets · Commitment · Field experiment · Carbon footprint · Food consumption

JEL Classification C54 · C93 · D12 · D91 · Q18 · Q56

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1 Introduction

Global environmental agendas are putting increasing policy efforts to keep global temperatures below the target of 1.5 °C above pre-industrial levels advocated by the IPCC.[1] Human consumption plays an important role in these agendas: the production, delivery, and storage of all products available in the marketplace require the emission of greenhouse gases (GHG) (Camilleri et al. 2019; Manderson and Considine 2018; Panzone et al. 2020; Vermeulen et al. 2012). At household level, estimates indicate that food alone accounts for up to 37% of GHG emissions (Poore and Nemecek 2018; Springmann et al. 2018), that is their total carbon footprint measured in grams of carbon dioxide (CO_2) equivalent[2] (gCO_2e). The challenges of changing households' choices and behaviour have led to calls for interventions targeting consumer behaviour specifically (Dietz et al. 2009; Vandenbergh and Steinemann 2007).

However, consumers have limited incentives to reduce the carbon emissions from their consumption: in the case of a global public good, the environmental impact of present consumption will be felt by society sometime in the future and often far away in space (Gifford 2011; Steg 2016; Weber 2006, 2018). At the same time, occasional changes in behaviour are unlikely to keep the increase in global temperatures below the 1.5 °C target: the achievement of this ambitious goal requires consumers to consistently privilege behaviours that have the least environmental impact (Galizzi and Whitmarsh 2019; Truelove et al. 2014; Ulph et al. 2023). This is particularly important for the case of grocery shopping, where shopping trips consist of a sequence of choices targeting a range of consumption goals (Panzone et al. 2021a; Sheehan and Van Ittersum 2018).

A key research question in this area is how to motivate consistent sustainable behaviour. Literature studying consumer decision-making retail environments presents three main tools to drive more sustainable consumer choices: carbon labelling (Muller et al. 2019; Potter et al. 2022; Suchier et al. 2023), carbon (or meat) taxation (Panzone et al. 2021b, c), and environmental nudges (Demarque et al. 2015; Kanay et al. 2021). Nudges could be an effective tool to motivate consistent sustainable consumption by strengthening self-control and focusing consumer attention to the environmental impact of their choices (Carlsson et al. 2021; Sunstein and Reisch 2014). Appropriate nudges could also facilitate consistent behaviour by activating relevant constructs that drive choices during the consumption process.

This study uses an incentive-compatible framed field experiment (Harrison and List 2004), to explore the effectiveness of commitments nudges and badges in increasing the environmental sustainability of consumer behaviour in the food domain. In this experiment, consumers shop in an online store that provides real-time basket-level carbon footprint and nutrition data. The store, containing over 900 products commonly consumed by the study population, allowed consumers to shop at any time (within a week) and from any location, with no interactions with the experimenter. Understanding the environmental impact of consumer choices in retail environment is increasingly considered key to the design of interventions that can increase the sustainability of consumption by driving large-scale changes in consumer behaviour (Macfadyen et al. 2015; Vadakkepatt et al. 2021). We focus on online shopping as this is a fast-growing retail segment in the UK (Panzone, Larcom,

[1] See https://www.ipcc.ch/sr15/.

[2] This represents the total GHG (for instance, CO_2, methane, CFCs) emitted directly and indirectly to supply the product to the marketplace (Carbon Trust 2018).

and She 2021a, b, c, d); moreover, online retail lends itself to significantly more engagement between retailers and consumers *during* the shopping trip, through stimuli that can adapt to consumer choices (Todd et al. 2013), leading to interventions that can be implemented at low-cost.

Results indicate that presenting consumers with a voluntary or forced commitments leads to a reduction in the carbon footprint of shopping baskets, also recording a drop in the amount of fats in the food baskets; the reduction in carbon footprint is of similar magnitude for both commitments. We find additional benefits in terms of consumption of fats and, for forced commitments, that of salt by 18%. However, a badge does not have a significant effect on behaviour. In the group where commitment is voluntary, the reduction is driven by those consumers who accept the commitment, who move towards the sustainability goal early in their shopping trip. The reductions observed in the commitment groups occur primarily through an increase in the budget allocated to the purchase of fruit and vegetables, and a reduction in the budget for dairy and eggs. Finally, Participants in the commitment groups were recorded as spending more time reading environmental labels, and were more likely to report an environmental goal.

This article contributes to the existing literature on sustainable food consumption by exploring ways to nudge consumers directly when making choices. Compared to previous research, this study focuses on the design of a motivational nudge, which is designed to increase consumer motivation to reduce the carbon emissions of their food baskets. In particular, we link the literature on goal pursuit (Fishbach and Dhar 2007) and bounded willpower (Baumeister 2002; Jolls et al. 1998) to the existing literature on sustainable consumer behaviour to design a behavioural intervention that aims at increasing the sustainability of food shopping in retail environments. Using an experimental approach, we are able to determine the causal relationship between a commitment or a badge, and the resulting change in the carbon footprint of the food basket in an online supermarket.

The next section presents some relevant theoretical background and experimental hypotheses, and a stylised model of behaviour. Section 3 outlines the data collection process, which used an experimental online supermarket to measure the carbon footprint of consumer choices. Section 4 explains the econometric model used in the analysis, with results presented in Sect. 5. Section 6 discusses the results, and Sect. 7 concludes.

2 Theoretical Background

2.1 Consumer Choices and Bounded Willpower

The pursuit of a consumption goal requires an individual to ensure all decisions are conducive to the achievement of this goal, exerting willpower when facing a conflict between short-term interests and the long-term objective (Baumeister 2002; Fishbach and Dhar 2007; Zhong et al. 2009). For instance, consumers aiming at minimising the carbon footprint of their food basket need willpower to prefer low-carbon options (e.g., vegetarian burger) when other high-carbon alternatives (e.g., beef burger) are more appealing. However, willpower is costly to exert, because it consumes physical and cognitive resources, which are finite. As a result, consumers often display *bounded willpower*, which leads individuals to prioritise short-term interest over long-term goals in some of their decisions (Gino et al. 2011; Jolls et al. 1998). Bounded willpower can be problematic from a policy perspective because it shows dynamic inconsistency (Baca-Motes et al. 2013; Gneezy et al.

2012; Sadoff et al. 2020; Ulph et al. 2023): consumers will mix high-carbon and low-carbon options in their shopping basket, particularly as willpower depletes, leading to baskets that have higher carbon footprint compared to a scenario with unlimited willpower. This problem may be solved by intervening directly when consumers make choices.

2.2 Commitment as a Tool to Motivate Pro-environmental Behaviour

A commitment to a clear, actionable goal can be a suitable strategy to motivate pro-social behaviour, and counter the depletion of willpower (Brocas et al. 2004; Bryan et al. 2010; Burke et al. 2018; Himmler et al. 2019). The literature presents several theoretical explanations of why commitments can reduce the carbon footprint of grocery shopping. First, research indicates consumers start shopping with fuzzy goals (Lee and Ariely 2006); in the presence of conflicting goals, a commitment increases the motivation to pursue a focal goal over others (Fishbach and Dhar 2005; Rogers et al. 2014). Second, a commitment may activate self-image concerns, which motivate consumers to respond by behaving in line with the core values of their self-image (Ariely et al. 2009; Baca-Motes et al. 2013; Falk 2021; Mazar et al. 2008). Third, commitments may activate the need to comply with social norms, leading to feelings of guilt if such social norms are broken (Charness and Dufwenberg 2006; Matthies et al. 2006; Theotokis and Manganari 2015). Fourth, individuals may have innate preferences for promise-keeping (Ellingsen and Johannesson 2004; van der Werff et al. 2019; Vanberg 2008), experiencing—or expecting—guilt when breaking promises (Charness and Dufwenberg 2006; Ellingsen et al. 2010). Finally, when the opportunity or requirement of a commitment is seen as coming from an authority, there may be a desire to comply (Karakostas and Zizzo 2016).

In our experiment, consumers were asked to commit to keeping their overall carbon footprint below an ambitious threshold (the bottom 20% of the pre-intervention distribution). We hypothesize that a commitment to a clear, actionable goal, whether voluntary or forced, can be a suitable strategy to nudge more consistent sustainable (low-carbon) consumer behaviour. Our first hypotheses are:

H_1: A voluntary commitment leads to a lower carbon footprint than a control group with no commitment.
H_2: A forced commitment leads to a lower carbon footprint than a control group with no commitment.

In support of these hypotheses, previous research in the environmental domain has shown that consumers who committed to an environmental goal were more likely to use public transport (Matthies et al. 2006); conserve water by taking shorter showers (Dickerson et al. 1992); reduce their energy consumption (van der Werff et al. 2019); and re-use their hotel bath towels (Baca-Motes et al. 2013). In a meta-analysis, Lokhorst et al. (2013) also shows that commitment motivates a range of environmental behaviours, with an effect that can last over time, although their study does not include examples in the food domain.

In our study, we focus on two types of commitment, which differ on whether the origin of this decision is internal or external to the decision-maker (in the same spirit as Gino et al. 2013). In a *voluntary* commitment, the participant *chooses* to commit or not. By gathering the interest on environmental preservation in motivated consumers, the commitment is expected to lead to a reduction in the carbon footprint of the food baskets, compared to a

control with no commitment.[3] In a *forced* commitment, the participant is forced to commit to the goal in order to continue shopping online, and the decision is *imposed* externally, for instance by a paternalistic policymaker (or the research team in our online supermarket). Note that, while we use the term 'forced' to describe such a commitment, this exercise uses a soft commitment, which imposed only psychological (i.e., non-monetary) rewards (costs) for keeping (violating) a commitment (Brocas et al. 2004; Bryan et al. 2010; Burke et al. 2018; Himmler et al. 2019) and was not actually enforced; participants unwilling to commit could opt out from the experiment.

It is not clear *ex ante* what prediction can be made in terms of the relative performance of the two forms of commitment. The rejection of hypotheses H_1 or H_2 can include the lack of an effect (no change in carbon footprint), as well as an increase in carbon footprint if consumers experience reactance (Espinosa and Treich 2021; Sunstein 2017). Reactance refers to a psychological state experienced by individuals when they perceive their freedom of choice or decisional autonomy to be threatened or restricted by external influences. Consumers may feel this restriction when the commitment is forced; but also in the voluntary commitment, if they feel that the request violates their individual freedom to determine what is good for them. If they experienced reactance, consumers would respond by doing the opposite of what is requested to them as a way to assert their autonomy (Botti et al. 2008; Espinosa and Treich 2021; Sunstein 2017): in the case of this article, by increasing, rather than decreasing, the carbon footprint of their basket.

Putting the possibility of reactance aside, voluntary commitment may be less effective than forced commitment if those individuals who commit are already more sustainable than the average consumer: in this case, the marginal costs of reducing the carbon footprint of those who commit are high, leading to smaller changes compared to a commitment requested to those consumers with lower carbon abatement costs. The same effect may be observed in consumers where the commitment causes significant consumption losses (e.g., in consumers attaching a high value to the consumption of high-carbon goods, for instance meat), who will have the ability to refuse the commitment if voluntary (in line with Gino et al. 2013). At the same time, forced commitment may encourage motivated participants to explore alternatives that they do not usually consider (Larcom et al. 2017), as well as make a stronger case for the existence of a social norm to comply to. This leads to hypothesis H_{3a}:

> *H_{3a}: A voluntary commitment is less effective in reducing carbon footprint than a forced commitment.*

However, if the failure to be sustainable is due to personal limitations, e.g., lack of knowledge, a voluntary commitment may be more effective than a forced commitment, because those who commit voluntarily are more motivated to search harder for low-carbon options. This point is particularly relevant for the case of carbon footprint, which consumers do not know well (Camilleri et al. 2019; Panzone et al. 2016, 2020). Moreover, as noted above, a forced commitment might cause reactance (Botti et al.

[3] Consumers who have an interest in environmental preservation are those more likely to commit to a low-carbon basket because the cause align well with their personal interests (Baca-Motes et al. 2013; Matthies, Klöckner, and Preißner 2006; Schwartz et al. 2014). Consumers may also accept the commitment because they recognise they have limited willpower (Ariely and Wertenbroch 2002; O'Donoghue and Rabin 2001), choosing to constrain their behaviour. Additionally, consumers may accept a commitment to pre-empt a negative emotional state—such as feelings of guilt for damaging for the environment—after the decision has been made (Weber and Johnson 2009).

2008; Sunstein 2017), therefore reducing the effectiveness relative to a voluntary decision. Then, hypothesis H_{3a} becomes:

H_{3b}: A voluntary commitment is more effective in reducing carbon footprint than a forced commitment.

Gino et al. (2013) provide evidence to support H_{3a}: allowing individuals to accept monitoring of their behaviour on a voluntary basis increases the likelihood of cheating relative to imposing monitoring or not monitoring at all. However, Gino et al. (2013) requested participants to accept third-party monitoring of their compliance to a goal, while our study asks consumers to accept a goal and self-monitor, a less intrusive request.

2.3 Rewarding Environmentally Friendly Behaviour Through Dynamic Badges

Along with commitments, in this study we also explore badges as a tool to reduce the carbon footprint of food shopping. Willpower can be motivated by providing (monetary or non-monetary) incentives for self-control (Dhar and Wertenbroch 2012; Fishbach and Hofmann 2015; Schmeichel and Vohs 2009; Walsh 2014); among these, of relevance to this study is the use of signalling pins and bracelets (Baca-Motes et al. 2013; van der Weele and von Siemens 2020). Badges are a gamification element that provides a soft (that is, psychological) reward when a specific goal is achieved (Edwards et al. 2016; Hamari 2017; Sailer et al. 2017). Gamification, which includes the use of badges in online settings, is becoming an important element of human–computer interactions (Hamari 2017; Hock et al. 2019; Sailer et al. 2017; Whittaker et al. 2021).

In the context of this article, badges may operate through four main pathways. First, a badge may increase the *awareness* of an environmental goal, effectively priming goal pursuit (Tate et al. 2014; Walsh 2014). Second, badges self-signal pure *achievement* of a goal (Sailer et al. 2017; Whittaker et al. 2021). Third, a badge may allow consumers to *self-monitor* behaviour (Edwards et al. 2016): the presence of a dynamic badge that appears when a basket is low in GHG signals to the individual that behaviour aligns with their own values of environmental preservation, and willpower to refrain from purchasing high-carbon items is not needed. Finally, a badge provides *feedback* on the behaviour being monitored (Sailer et al. 2017): the consumer learns of having done something "desirable" when the badge is present (a low-carbon basket), or "undesirable" when the badge is absent (a high-carbon basket).

Based on the literature presented above, our fourth hypothesis is:

H_4: A visible badge leads to a lower carbon footprint than the control group.

Prior research presents mixed findings on the effectiveness of badges in other settings. Baca-Motes et al. (2013) show that signalling, in the form of a pin that has a specific meaning to the consumer only, but which is visible to others, had a significant, if relatively small, effect on the reuse of hotel towels. Conversely, van der Weele and von Siemens (2020) found that bracelets reminding of pro-social behaviour (e.g., donations to the Red Cross), visible to the decision maker only, failed to motivate further pro-social behaviour. In our setting, badges are only visible to the decision maker, a point we will return to in discussing the results.

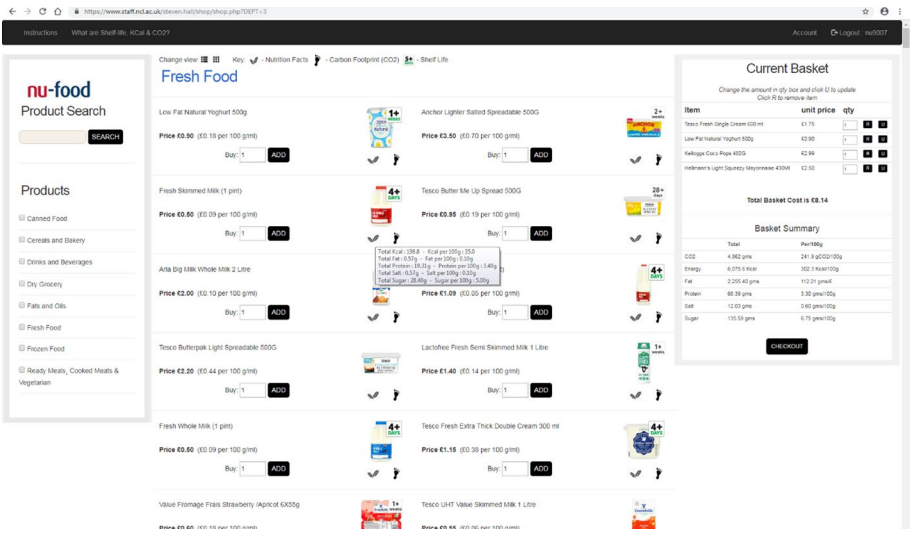

Fig. 1 Graphical representation of the NU-food supermarket. *Note* The information on CO_2e and macronutrients data was only visible to participants when they hovered over the respective icon with the mouse

3 Methodological Approach

3.1 NU-Food Portal

Sales data for all participants were collected using Newcastle University's NU-food online supermarket. The store contains 908 different stock-keeping units (SKUs). For each SKU, the store contains information including: the name and image of the product; its price; its macro-nutritional information; and the carbon footprint from published sources, as in (Panzone et al. 2021c), Clune et al. (2017), Drewnowski et al. (2015), Scarborough et al. (2014). Carbon footprint is presented at product level, with varying granularity across food categories: for some categories, for instance eggs, carbon emissions vary by product, and substitution requires trading off GHG with other characteristics; for other categories, such as fresh beef, the carbon footprint per gram is the same for all products, although products will have different carbon footprint depending on their weight; finally, other categories, such as jam or ice cream, have no intra-category variability in carbon footprint, and products differ only in other attributes (e.g., flavour, price), making substitution random with respect to GHG.

Consumers could access the carbon footprint and nutritional composition of each product by moving a cursor onto a specific icon (Fig. 1); the system recorded how long the window with the information remained open. Consumers could search for products using a search box. The carbon and nutritional content of the basket was always accessible, and updated in real-time as consumers added or removed products. The NU-food portal could be accessed from anywhere and on any type of electronic device with Internet (computer, tablet, or phone), and consumers had no interaction with the research team during their experiment (other than via email for technical queries). These features were available to all participants in all weeks.

3.2 Experimental Procedure

In a framed field experiment (Harrison and List 2004), for two consecutive weeks participants were given a virtual weekly budget of £25.00 to shop on NU-food.[4] Participants could enter the store as many times as they wanted during each experimental week (from 9 am on Monday to midnight on Sunday), but they could only complete each week's overall transaction once. To ensure this was the case, the check-out functionality was automatically de-activated once the transaction was completed, and re-activated at 9 am on the following Monday. Participants could spend as much as they wanted from the £25 budget, knowing that any unspent budget would be given to them. After the second shopping session (including the final questionnaire) was submitted, one of the two weeks of shopping was randomly chosen by the computer for the participant to collect at Newcastle University; any unspent budget for the randomly selected week only was also returned to participants upon collection. Participants were told that their shopping collection would be at least one week after their second week of shopping.

3.3 Participant Recruitment

The experiment was advertised by posters in offices and leisure facilities, such as cafés and community centres, around the city of Newcastle upon Tyne (UK). 1355 people from the general public registered interest to participate in an online shopping study. Of these, 1206 were randomly chosen to participate, and randomly assigned to an experimental group (participants were unaware of group allocations until week 2 started). 780 consumers finished shopping in week 1, while 677 participants completed the two weeks of shopping in the main experiment. An additional 48 participants completed the experiment in a separate group, used to test whether information on carbon footprint in the store primed choices; results in Appendix 1 fails to reject the null hypothesis of no priming effects.

Each participant was paid a £5 show up fee. Before starting the experiment, participants had to register; at this stage, they were given an anonymous login, and could choose a personal password. Once registered, participants had to give explicit consent by filling an online form outlining the terms and conditions of the experiment.

3.4 The Sustainability Threshold and the Shopping Goal

The manipulations proposed in this research require the definition of a threshold that defines sustainability in terms of carbon footprint, measured in gCO_2e, at a basket level, for both the badge and the commitment. The threshold was defined as $180gCO_2e/100$ g: food baskets were classified as low-carbon when below this threshold; and high-carbon if above the threshold. The value of $180gCO_2e/100$ g was identified as it refers to around the bottom 30% of the carbon footprint distribution in the baseline week of Panzone et al. (2021c); in this study, it corresponds to the bottom 20% of the baseline week.

[4] The present store contains a large choice set, with both private labels and known brands: > 900 products vs < 600 in Panzone et al. (2021b) and Panzone et al. (2021c); < 300 in Muller, Lacroix, and Ruffieux (2019); and < 200 in Demarque et al. (2015) and Hilton et al. (2014). In our study, all participants received one of their two food baskets in full, while Kanay et al. (2021) and Demarque et al. (2015) sold baskets to 20–25% of the participants, and Muller et al. (2019) sold to participants one quarter of the food in their basket.

Fig. 2 Experimental design of the main treatments

		Commitment		
		No	**Voluntary**	**Forced**
Badge	**No**	*Control* n=127	*Voluntary* n=100	*Forced* n=116
	Yes	*Badge* n=106	*Voluntary + Badge* n=110	*Forced + Badge* n=118

The definition of a threshold in $gCO_2e/100$ g of food gives consumers a goal in terms of carbon footprint per weight. Conversely, the policy aim of the interventions is to reduce the *total* carbon footprint of the food baskets consumers purchase in the experimental store. The normalisation of the goal by weight ensures the incentive provided with the consumer aligns with the goals of the retailer as well as the policymaker. In fact, a goal defined in terms of absolute carbon reduction (e.g., buy less than 20,000 gCO_2e) in the experimental supermarket can be achieved by spending less during the experiment, cashing in more of the budget and use it to buy high-carbon options (e.g., meat) outside the experimental store. The same would apply in real life if a single retailer in a competitive marketplace was encouraging consumers to reduce their carbon emissions in *their* stores. On the other hand, the optimal strategy for consumers to reduce their carbon footprint per weight is buying low-carbon goods: buying less can decrease as well as increase the carbon footprint of the basket, depending on the composition of the basket, and the normalised goal can be only met by buying low-carbon items. This adjustment also has real-life appeal for retailers, because the normalised goal ensures that consumers reduce their carbon footprint whilst buying the same amount of goods.

3.5 Experimental Manipulations

The experimental design consists of a mixed design, using 2 (virtual badge vs. no virtual badge) × 3 (no commitment vs. voluntary commitment vs. forced commitment) orthogonal between-participants design (Fig. 2), over two experimental weeks (the within component). In week 1 of the experiment, participants shopped without any intervention in place; consumers were then randomly allocated to an experimental group in week 2. The three experimental stimuli are as follows. (Fig. 2).

3.5.1 Voluntary Commitment

A voluntary commitment is the voluntary decision to accept the promise to keep the carbon footprint of the food basket below the sustainable threshold. In this group, participants were asked "Will you commit to check out with a low carbon footprint basket?", whilst being told that "Based on previous studies, a low carbon shopping basket is one which is lower than $180gCO_2/100$ g". Participants could only proceed to the store after ticking either the acceptance of the commitment ("I am interested in protecting the environment; therefore, I commit to keeping the carbon footprint of my basket below $180gCO_2/100$ g") or the rejection of the commitment ("I do not want to commit myself to keeping the carbon footprint below $180gCO_2/100$ g") box, respectively (Fig. 3). The threshold was not enforced, and participants could check out independently of whether they exceeded the threshold or not.

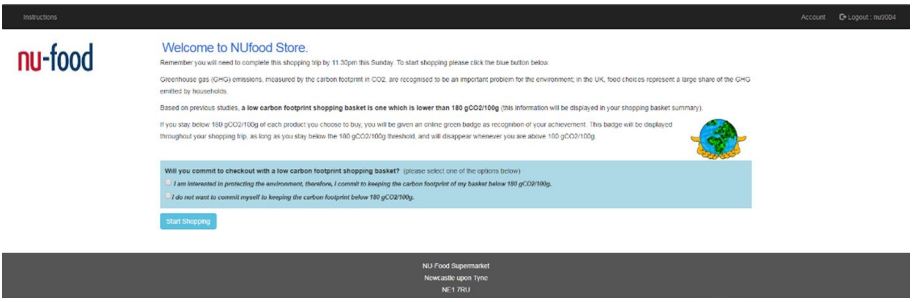

Fig. 3 Graphical representation of the Voluntary Commitment with Badge

3.5.2 Forced Commitment

A forced commitment required the consumer to accept the promise to keep the carbon footprint of the food basket below the sustainable threshold. The manipulation was identical to the voluntary commitment indicated above; however, participants could only tick the commitment acceptance box ("I am interested in protecting the environment; therefore, I commit to keeping the carbon footprint of my basket below 180gCO_2/100 g") to proceed into the store. Participants could not proceed without ticking the commitment box, and could not reject the commitment (Fig. 4), although they could simply leave the online supermarket if they did not want to commit. Participants who would try clicking on "Start shopping" to continue without accepting the commitment would receive an error window asking them to tick the box before proceeding (the software recorded this information). The threshold was not enforced, and participants could check out independently of whether they exceeded the threshold or not.

3.5.3 Badge

In week 2, participants in the Badge treatment were told that a badge would appear on the screen whenever they had a low-carbon basket. They were explained that "Based on previous studies, a low carbon shopping basket is one which is lower than 180gCO_2/100 g". Whilst shopping, the participant would see the badge[5] (Fig. 5) whenever their carbon footprint was equal to or below 180 g CO_2e/100 g, and would disappear if basket was above the threshold and only to return if the shopping basket was below (or equal to) the threshold.

3.6 Final Questionnaires

After submitting their basket, each week participants completed a questionnaire. In both weeks, they were asked about their shopping trip (e.g., shopping goals, type of shopping trip), inventory, and recorded their self-control scale (Tangney et al. 2004) and moral self-image (Jordan et al. 2015). In addition, the questionnaire in week 1 collected demographic

[5] The badge was chosen in a pilot to 136 participants, who had to rate eight potential images using a scale of 0–100 on their ability to convey a message of "being friendly to the environment", and to motivate them to act in an environmentally friendly manner. This image scored first in both instances, with 76/100 on its ability to give an environmentally friendly message; and 70/100 on its ability to motivate environmentally friendly behaviour.

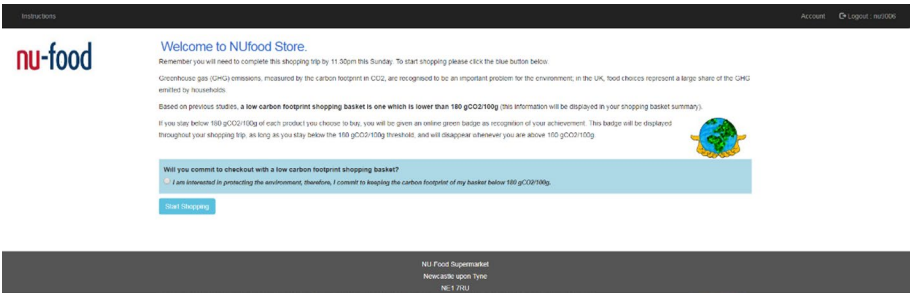

Fig. 4 Graphical representation of the Forced Commitment with Badge

Fig. 5 The virtual badge

information (gender, age, postcode, education, income, household size); in week 2, it also collected attitudes and self-perception towards health and the environment (Cornelissen et al. 2008), health and environmental social and self-signalling (own elaborations, based on Bem 1967; Dubé et al. 2017), health and environmental identity (Aquino and Reed 2002), and their ethical mindset (Cornelissen et al. 2013).[6] Finally, a follow-up questionnaire was handed to participants when they came to collect their food, to explore whether consumers felt the commitment was binding, as explained in Appendix 2.

4 Econometric Model

The econometric estimation of the average treatment effect of a manipulation follows Panzone et al. (2021a), who use a Difference-in-difference (DID) estimator (Bertrand et al. 2004; Imbens and Wooldridge 2009; Wing et al. 2018). In the experiment, participants shopped over 2 successive weeks. Week 1 is a baseline week, where no intervention is in place. In week 2 participants are allocated to a treatment $k=0, 1, \ldots, 5$, where $k=0$ is the control group, and $k=1, \ldots, 5$ are the experimental groups. Within each week $t=1, 2$,

[6] We also added the questions of the short social desirability scale (Stöber 2001), but due to a software glitch this data was not collected.

participants i purchase a basket with total normalised carbon footprint C_{it} (in gCO_2e): we label this as the consumer's *carbon footprint* for short. The average treatment effect is then estimated as difference between the average change observed in the treated individuals and the change in individuals in the control group over the same time (Imbens and Wooldridge 2009), or

$$\phi_{k2} \equiv \left[\overline{C}_{k2} - \overline{C}_{k1}\right] - \left[\overline{C}_{02} - \overline{C}_{01}\right] \quad k = 1, ..., 5 \tag{1}$$

where $\overline{C}_{kt}$ is average carbon footprint of individuals in experimental group k in week t.

This approach acknowledges that changes in behaviour between groups from the baseline week to the experimental week could be driven by factors other than the experimental stimuli (e.g., social media, interaction between participants), which the experimenter cannot see. Equation (1) removes all unobservable effects by removing the change that would have occurred in the absence of stimuli: this item corresponds to the change in the control group, captured by the term $\left(\overline{C}_{02} - \overline{C}_{01}\right)$. Crucially, because the treatment is randomly allocated, there is no self-selection into a treatment, ensuring the absence of endogeneity in the DID estimator. In our analyses, we estimated the log-linear panel regression:

$$\ln(C_{it}) = \alpha_{0i} + \sum\nolimits_{k=1}^{k=5} \alpha_{1k} G_{ik} + \alpha_2 W_t + \sum\nolimits_{k=1}^{k=5} \pi_k W_t G_{ik} + \nu_{it} \tag{2}$$

where W_t refers to a dummy equal 1 if $t = 2$ (zero otherwise); and G_{ik} refers to a set of dummies capturing the experimental stimuli (zero for the control group). Finally, α_{0i} refers to individual-specific fixed effects, which capture any time-invariant personal attitudes and characteristics. The average treatment effect for the treated (ATT), ϕ_k, is estimated as in Puhani (2012).

5 Results

5.1 Demographic and Shopping Characteristics of the Sample

Table 1 presents the summary characteristics of the 677 participants who shopped and completed the final questionnaire. The sample is characterised by a majority of professional (non-student) workers (84%), females (69%), primarily in the 25–44 year-old range (60%), most commonly in possession of an undergraduate degree or above (70%) and with a relatively high income. The sample is broadly comparable to that of the local population from the North-East of England in terms of total family size and income, but included younger individuals, with slightly less children, and more likely to have a graduate education. The sample also has more women, a feature typical of store-level data, where women are more likely to have responsibility for the family shopping within a household.

A series of χ^2 tests shows that participants across treatments did not differ significantly in their demographic composition (Table 1), and their week-1 personal attitudes and beliefs (Table 2). All treatments register comparable in-store expenditures in week 1, with the only exception of the forced commitment treatment, whose expenditures are slightly larger than the control group only in week 1. All other summary basket characteristics, including carbon footprint, do not differ significantly across groups in week 1 (Table 3). Overall,

Table 1 Average demographics of the sample, by group

	Treatments							Comparisons		
	Control	Badge	Voluntary Comm	Voluntary Comm. + Badge	Forced Comm	Forced Comm + Badge	χ^2	This sample	North–East England	UK
Male (%)	0.30	0.34	0.22	0.31	0.32	0.31	3.47	0.30	0.49†	0.49†
Average age	35.37	38.36	37.06	36.55	35.42	36.95	4.20	36.6	41.8†	40.3†
Family size	2.31	2.30	2.26	2.25	2.52	2.29	17.61	2.40	2.23†	2.37†
Children—age < 17	0.51	0.49	0.53	0.56	0.64	0.60	18.55	0.55 (< 17yo)	0.8† (< 16)	0.8† (< 16)
Adults (age: 18 +)	1.87	1.86	1.87	1.76	1.96	1.77	7.70	1.85	2.1†	2.2†
Education										
– % aged 25–64 with PG or UG degree	0.69 (N = 104)	0.75 (N = 93)	0.79 (N = 98)	0.66 (N = 94)	0.63 (N = 79)	0.63 (N = 93)	17.75***	0.70% (N = 561)	0.34‡	0.45‡
– % with a PG or UG degree	0.69	0.75	0.78	0.66	0.64	0.65	16.70***	–	–	–
Income (mode)	£32,000–£47,999	£32,000–£47,999	£32,000–£47,999	£32,000–£47,999	£32,000–£47,999	£32,000–£47,999	–	£32,000–£47,999	£37,296† Equivalised gross income	£47,856† Equivalised gross income
Observations	127	106	116	118	100	110		677		

N = 677. For gender, age, and family size variables, the χ^2 statistics refers to a Kruskal–Wallis equality-of-populations rank test; while for education and income, the χ^2 statistics refers to a Pearson χ^2 test of association. Statistical significance is indicated as follows * = $p < 0.10$; ** = $p < 0.05$; *** = $p < 0.01$. Source: † = ONS; ‡ = Eurostat

Table 2 Average attitudes of the sample, by group

	Week	Control	Badge	Voluntary Comm	Voluntary Comm. + Badge	Forced Comm	Forced Comm. + Badge	α	χ^2
Self-signalling	**1**	3.75	3.63	3.84	3.66	3.43	3.75	0.78	5.11
	2	3.51**	3.64	3.81	3.72	3.74*	3.98	0.81	6.71
Social-signalling	**1**	3.33	3.49	3.46	3.53	3.25	3.36	–	1.88
	2	3.31	3.43	3.47	3.57	3.40	3.45	–	1.65
Environmental	**1**	3.57	3.51	3.50	3.50	3.53	3.55	–	0.50
self-image	**2**	3.63	3.51	3.56	3.63	3.53	3.63	–	0.87
Self-control	**1**	3.18	3.10	3.08	3.20	3.10	3.04	0.81	4.94
	2	3.17	3.00***	3.05	3.19	3.11	3.05	0.84	8.75
Environmental	**1**	4.80	4.77	4.96	5.02	5.02	4.87	–	2.92
Attitudes	**2**	4.81	4.74	4.98	4.76***	4.82	4.71	–	0.85
Environmental	**1**	3.76	3.73	3.98	3.74	3.73	3.87	–	2.12
Self-perception	**2**	3.85	3.67	3.94	3.83	4.06**	4.02	–	5.06
Env. Identity									
– Internalization	**2**	2.51	2.50	2.56	2.47	2.53	2.51	0.68	2.38
– Symbolization	**2**	1.46	1.44	1.54	1.53	1.57	1.55	0.81	3.94
Observations		127	106	116	118	100	110		

N = 677. Weekly within-participant comparisons are based on a Wilcoxon sign-rank test (the test is not available for the identity variables as they were collected only once). The χ^2 statistics refers to a Kruskal–Wallis equality-of-populations rank test. The term α refers to Crobach alpha, which is only available for scales with at least 2 items. Statistical significance is indicated as follows * = $p < 0.10$; ** = $p < 0.05$; *** = $p < 0.01$

these summary statistics indicate that the random assignment of subjects to treatments was effective.[7]

At the same time, we find no evidence that attrition (that is, dropout rates) differed across treatment groups: a Pearson χ^2 test performed on the 780 consumers who completed

[7] The Difference-in-difference approach we use (see Sect. 4) corrects for unobservable time-invariant characteristics, and for purely time-varying factors via the week dummies. In some specifications, we also correct for key time- and individual-varying characteristics (e.g., attitudes), to remove as much heterogeneity as possible.

Table 3 Summary basket characteristics, averages by week and treatment group

	Week	Control	Badge	Voluntary Comm	Voluntary Comm. + Badge	Forced Comm	Forced Comm. + Badge	Kruskal–Wallis χ^2
Total GHG	**1**	22,680	23,844	22,885	23,731	23,290	23,961	2.06
(gCO_2e)	**2**	22,457	22,928	20,617**	21,206***	21,496**	20,341***	7.03
Total energy	**1**	14,301	15,341	15,182	14,084	14,252	14,533	3.39
(kcal)	**2**	13,535	14,127	13,624***	13,504	13,537	12,384***	5.50
Basket weight	**1**	8.733	9.472	9.039	9.248	9.479	9.012	3.093
(Kg)	**2**	8.249	8.995	8.545	8.506	8.525	8.429	2.815
Expenditure	**1**	23.01	23.68	23.33	23.47	23.85[a]	23.59	11.56**
(£)	**2**	22.73	23.54	22.73	22.99	23.22***	22.88	2.34
Observations		127	106	116	118	100	110	

Weekly within-participant comparisons are based on a Wilcoxon sign-rank test. N = 677. Statistical significance is indicated as follows * = $p < 0.10$; ** = $p < 0.05$; *** = $p < 0.01$. [a]: this group differs from the Control group (only) at $p < 0.05$, based on a Dunn test with Bonferroni adjustment; no other pairing has a significant difference at $p < 0.05$

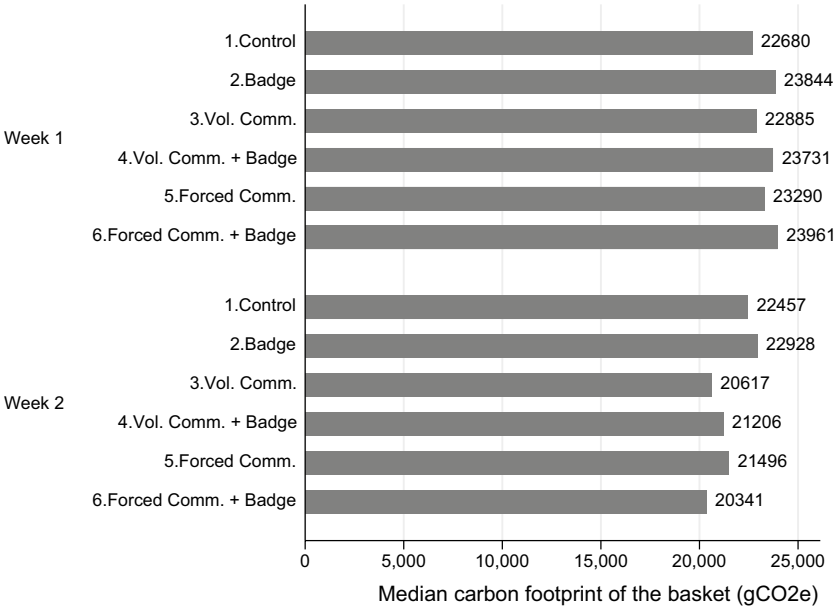

Fig. 6 Median carbon footprint, by week and group

the shopping trip in week 1 indicated that the probability of dropping out in week 2 is unrelated to treatment group membership (χ^2 (5) = 5.01, p = 0.415).

Table 3 indicates that the mean average spend in the overall sample was £23.47 in week 1 (range: £1.15–£25, N = 677), with 90% of participants spending £20.18 or more; and £23.00 in week 2 (range: £0.59–£25, N = 677), with 90% of participants spending £19.09 or more. Most shoppers saw this exercise as a top-up shopping trip (26% in week 1, 28% in week 2) or part of a full weekly shopping trip (58% in week 1, 57% in week 2); while for a minority of consumers this occasion was a full-size weekly shopping trip (12% in week 1, 9% in in week 2), or as an "unusual" weekly shopping trip (4% in week 1 and 6% in week 2).

Table 3 and Fig. 6 show that, apart from the control and the badge treatments, there was a reduction in the average total carbon footprint of shopping baskets in week 2, compared to week 1, with a leftward shift of the distribution for the whole sample across week (Kolmogorov–Smirnov test: D = 0.10, p < 0.001). An analysis of the carbon footprint in week 1 indicates that the low-carbon footprint threshold (180 gCO_2e/100 g of basket) represents the bottom quintile of the distribution, representing an ambitious goal. The drop in carbon footprint came with no significant change in basket weight; while the voluntary commitment group, and the forced commitment with badge group recorded a drop in kilocalories (Table 3). Finally, while the forced commitment group spent slightly more than other groups in week 1, expenditures were in line with the rest of the sample in week 2 (Table 3).

The commitment manipulation also had an impact on goal pursuit and search. ANOVA-style tests (Table 4) reveal that participants in both commitment groups were more likely to indicate that they had an environmental goal in their shopping trip; Probit regression (Table 15) estimate the probability of reporting an environmental goal increased by 16–20%. Table 4 also indicates that participants in the commitment groups spent more time looking at the carbon footprint of products, searching for this information on more

Table 4 Repeated measure ANOVA, chi2 values

Reading	Environmental goal	CO_2 information		Nutrients information	
	Yes vs No	Seconds	Nr SKUs	Seconds	Nr SKUs
	Panel probit	Panel Tobit	Panel Tobit	Panel Tobit	Panel Tobit
Badge x week	0.01	2.17	1.33	1.02	0.22
Voluntary Comm. x week	12.22***	4.96**	5.78**	1.41	0.07
Forced Comm. x week	18.72*** (increase)	10.55*** (increase)	15.17*** (increase)	1.55	0.66
Voluntary Comm. x Badge x week	1.01	0.42	0.04	0.72	0.40
Forced Comm. x Badge x week	2.14	0.30	0.93	2.23	0.87

All panel regressions refer to random-effects estimators. Regressions used no covariates besides treatment dummies. Statistical significance is as follows * = $p < 0.10$; ** = $p < 0.05$; *** = $p < 0.01$

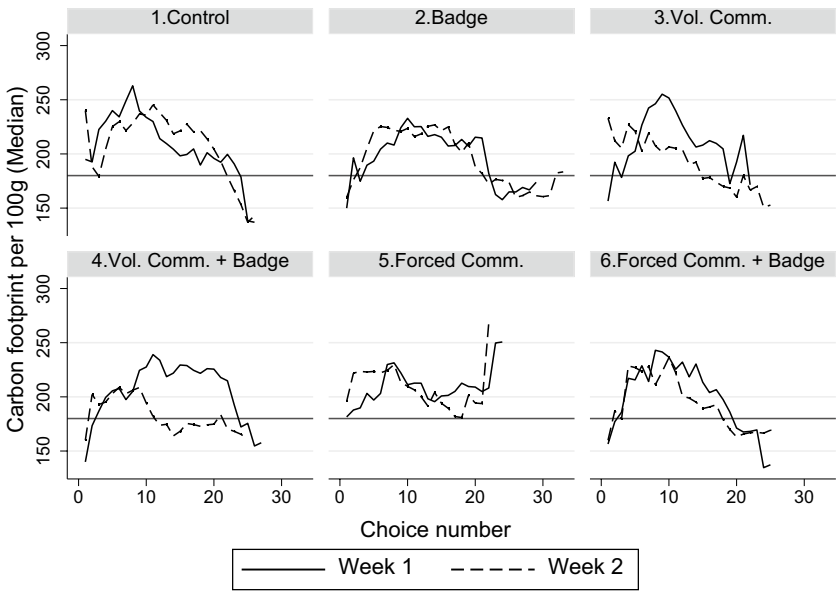

Fig. 7 Median cumulative gCO_2e/100 g of basket, by group and week. *Note* the horizontal black line refers to the low carbon threshold of 180 gCO_2e/100g basket weight. Note that from choice 20 onwards, the number of consumers is always below 20 in each treatment, and less than 2 people per group make more than 25 decisions

products. Finally, participants facing a forced commitment scored higher in self-signalling and, marginally, on self-control (Table 15).

Finally, Fig. 7 shows how the consumer goal (in gCO_2e/100 g) changed as participants added items to their baskets: in all groups, the median cumulative carbon footprint per 100g tended to start relatively low and grow, then declining towards the end of the shopping trip; in week 2, the commitment groups show an earlier decline in the carbon footprint by weight. Figure 8 shows that this decline happened particularly early for those who

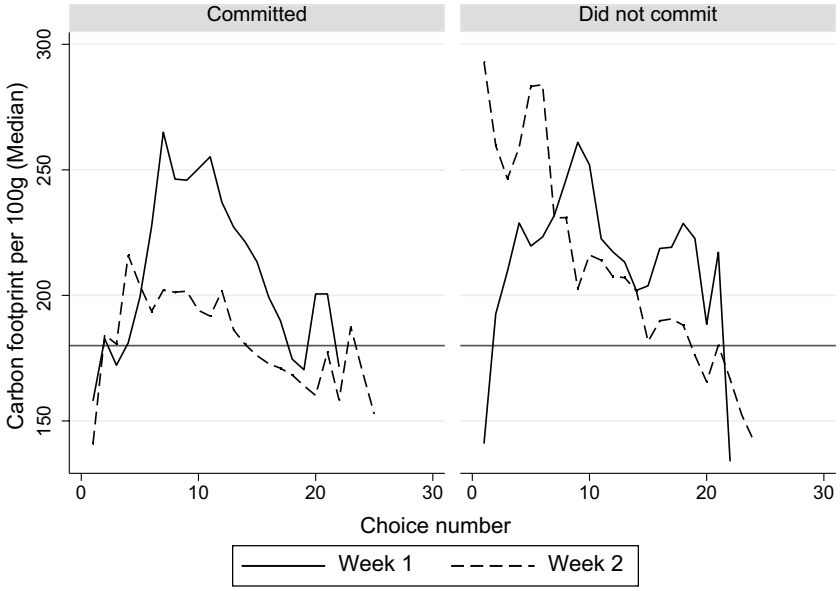

Fig. 8 Median cumulative gCO_2e/100 g of basket, by group, week and commitment. *Note* the horizontal black line refers to the low carbon threshold of 180 gCO_2e/100g basket weight

committed to the goal, for whom the median food basket remained below 200 gCO_2e/100 g most of the time, and started moving towards the threshold from the fourth choice.

5.2 The impact of Commitment and Badges on the Carbon Footprint of Food Baskets

We now use the econometric model presented in Sect. 4 to test our hypotheses. The dependent variable is the natural logarithm of the total CO_2e in the basket of the consumer in the experimental week, in gCO_2e. Results refer to a fixed-effects panel Difference-in-difference (DID) estimator, with bootstrapped standard errors clustered at individual consumer level, and stratified by treatment group.[8] This approach estimates the change in carbon footprint in the presence of the experimental stimuli over time, removing the change over the same period observed in the control group. Coefficients refer to half-elasticities, which measures the % change in carbon footprint when the treatment dummy is 1.

Table 5 presents the key results. A regression with simple treatment effects is reported in Table 17 in Appendix 3 for reference; while results with all the interactions are available in Table 18 in the Appendix. Finally, Table 19 in Appendix 3 presents the same set of regressions using ln(CO_2e/100 g) as the dependent variable.[9]

In Table 5 (and Table 18 in Appendix 3), model A regresses the carbon footprint of the food basket over a single joint commitment variable, equal to one for participants in any commitment group. Model B measures the average treatment effects of both voluntary and

[8] Hausman tests indicate that random and fixed effects are equivalent; we retain a fixed effects estimator for consistency with the DID literature.

[9] The results in Table A9 in the appendix does not include basket weight as an independent variable, as the regression adjusts for basket size directly in the dependent variable.

Table 5 DID estimates

	No attitudes			With attitudes		
	A	B	C	A	B	C
Intercept	9.9596***	9.9596***	9.9596***	8.8824***	8.8801***	8.8784***
S.E	0.0193	0.0193	0.0193	0.2495	0.2506	0.2498
Week 2 (W2)	−0.0346	−0.0347	−0.0343	0.0082	0.0082	0.0088
S.E	0.0373	0.0373	0.0373	0.0313	0.0313	0.0312
Badge x W2	−0.0362	−0.0358	−0.0367	−0.0323	−0.0321	−0.0332
S.E	0.0373	0.0372	0.0373	0.0328	0.0328	0.0327
All comm. x W2	−0.1063***			−0.0950***		
S.E	0.0374			0.0335		
Vol. comm. x W2		−0.0922**			−0.0868**	
S.E		0.0414			0.0372	
Forced Comm. x W2		−0.1219**	−0.1219**		−0.1044**	−0.1048**
S.E		0.0485	0.0485		0.0425	0.0425
Vol. Comm. (Y) x W2			−0.1553***			−0.1515***
S.E			0.0552			0.0489
Vol. Comm. (N) x W2			−0.0146			−0.0075
S.E			0.0446			0.0404
Self-control				0.0041	0.0046	0.0027
S.E				0.0388	0.0390	0.0388
Self-image				−0.0006	−0.0007	−0.0005
S.E				0.0106	0.0106	0.0105
Self-signalling				−0.0163	−0.0159	−0.0143
S.E				0.0148	0.0149	0.0148
Social signalling				−0.0085	−0.0085	−0.0088
S.E				0.0102	0.0103	0.0104
ln(basket weight)				0.5542***	0.5540***	0.5549***

Table 5 (continued)

	No attitudes			With attitudes		
	A	B	C	A	B	C
S.E				0.0869	0.0866	0.0866
Observations	1354	1354	1354	1354	1354	1354
Participants	677	677	677	677	677	677
Overall R^2	0.0151	0.0150	0.0241	0.3388	0.3388	0.3471
Log-likelihood	−60.87	−60.49	−56.01	136.49	136.67	142.95
χ^2	49.83***	50.79***	51.37***	96.63***	98.91***	99.84***
Vol. Comm. = Forced Comm		0.36			0.17	
Vol. Comm. (Y) = Forced Comm			0.29			0.74
Vol. Comm. (N) = Forced Comm			4.47**			4.80**
ATT						
Badge	−726.25	−718.62	−688.15	−690.27	−686.01	−668.23
All comm	−2059.94***			−1971.10***		
Vol. Comm		−1799.86**			−1807.63**	
Forced Comm		−2345.58**	−2235.43***		−2157.03**	−2071.68**
Vol. Comm. (Y)			−2778.36***			−2913.41***
Vol. Comm. (N)			−273.41			−149.97

Model A regresses the carbon footprint over a single joint commitment variable; model B treats the two sources of commitment—voluntary vs forced—separately; while model C separates those who voluntarily accepted vs rejected the commitment. Parameters have been estimated using a within panel estimator, which omits group membership because it is fixed at consumer level. Statistical significance is as follows * = $p < 0.10$; ** = $p < 0.05$; *** = $p < 0.01$

forced commitment separately, as well as that of the badge. It is the key model for testing all of our hypotheses. Model C separates those who voluntarily accepted and those who voluntarily rejected the voluntary commitment, to observe whether the two groups behaved differently. Importantly, in model C individuals self-selected in or out of the commitment group driven by personal preferences (as shown in the next section), and the results should not be interpreted as the causal impact of the commitment, but rather as the change in carbon footprint in the segment of consumers with strong preferences for an environmental commitment. All the three regressions are estimated with and without time-varying personal characteristics to remove unobserved heterogeneity: the weight of the basket (in kilograms); self-control; environmental self-image, self-signalling, and social signalling. Across all models, a 1% increase in basket weight is associated to an increase in carbon emissions by 0.55%; while the psychological scales do not explain differences in carbon footprint in any regression.

Model A indicates that the presence of a commitment (either forced or voluntary) reduces the carbon footprint of the food baskets by 10–11% (a net reduction of ~ 2 $kgCO_2e$). Model B indicates that both commitments contribute to comparable reductions in carbon footprint: the voluntary commitment leads to a 9% reduction in carbon footprint (~ 1.8 $kgCO_2e$); while the forced commitment causes a 10–12% reduction (~ 2.1 $kgCO_2e$). The difference between each type of commitment is not statistically significant.

Result 1: Both a voluntary and a forced commitment lead to a lower carbon footprint than a control group with no commitment, in support with H_1 and H_2.
Result 2: There is no statistically significant difference in effectiveness between voluntary and forced commitments, not supporting H_{3a} and H_{3b}.

Model C indicates that the reduction caused by a voluntary commitment is driven by those consumers who accepted the commitment: they reduced their carbon footprint by over 15% (~ 2.7–2.9 $kgCO_2e$), while those who refused recorded a small reduction, around 0.8–1.5% (− 0.15–0.27 $kgCO_2e$), not significantly different from zero. In model C, a forced commitment caused a 11–12% reduction in carbon footprint (~ 2.1–2.2 $kgCO_2e$). Effect sizes change slightly when interaction terms are included, with a particularly large increase in the size of the standard errors (Table 18, Appendix 3). To put the results into perspective,[10] driving 1 mile with an average passenger vehicle emits 398 gCO_2e; while charging one smartphone emits 8.22 gCO_2e. Overall, these results provide support to hypotheses H_1 and H_2. Wald tests found no statistical difference between the two types of commitments, providing no support for H_{3a} and H_{3b}.

We do not detect any statistically significant effect of introducing a badge on the carbon footprint: the presence of the badge led to a non-significant reduction of around 3.2–3.7% (0.67–0.72 $kgCO_2e$) across all models. This result does not support hypothesis H_4.

Result 3: A visible badge does not lead to a lower carbon footprint than the control group.

Table 6 summarises how consumers allocated their £25 across food categories and savings. This table indicates that in week 2 consumers in the voluntary commitment groups consumed more fruit and vegetables, and reduced their consumption of dairy and eggs, other products of vegetarian origin, and drinks. Those in the forced commitment treatment increased savings, and reduced consumption of dairy and eggs, and other products.

[10] See https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references.

Table 6 Share of the £25 budget allocated for each food category and savings

Treatment	Week	Fruit & Vegetables	Other Vegetarian	Meat & fish	Eggs & Dairy	Drinks	Other	Savings
Control	1	0.20	0.17	0.29	0.11	0.05	0.10	0.08
	2	0.19*	0.17	0.31	0.09***	0.05	0.11	0.09
Badge	1	0.21	0.20	0.29	0.09	0.06	0.10	0.05
	2	0.22	0.20	0.27	0.10	0.07	0.09	0.06*
Voluntary Comm	1	0.23	0.17	0.29	0.10	0.05	0.10	0.07
	2	0.27***	0.15***	0.28	0.07**	0.04	0.09	0.09
Voluntary Comm. + Badge	1	0.20	0.18	0.28	0.10	0.06	0.12	0.06
	2	0.24**	0.17	0.29	0.07***	0.04**	0.11	0.08
Forced Comm	1	0.24	0.17	0.31	0.09	0.06	0.09	0.05
	2	0.26	0.18	0.29	0.08	0.04	0.08	0.07***
Forced Comm. + Badge	1	0.20	0.18	0.30	0.10	0.06	0.11	0.06
	2	0.22	0.16	0.29	0.07***	0.07	0.09**	0.08
χ^2	1	4.14	4.31	1.27	1.61	4.81	7.16	11.57**
	2	13.79**	9.98*	2.21	7.36	8.80	6.40	2.34

N = 677. Values refer to mean expenditure shares of the £25 budget. Weekly within-participant comparisons are based on a Wilcoxon sign-rank test (the test is not available for the identity variables as they were collected only once). The χ^2 statistics refers to a Kruskal–Wallis equality-of-populations rank test. Statistical significance is indicated as follows * = $p < 0.10$; ** = $p < 0.05$; *** = $p < 0.01$

Categories are defined as follows: Fruit & Vegetables = pulses, vegetables, and fruit (incl. nuts), fresh, canned, dried, or frozen; Other vegetarian = pasta, rice, breakfast cereal, bread and bakery products, margarine, oils, meat-free products (e.g., Quorn, frozen or refrigerated); Meat & fish = all fish and meat, fresh, canned, chilled, or frozen; Dairy & eggs = all dairy products (e.g., cheese, milk, yogurt), eggs; Drinks = non-dairy milk, soft drinks, bottled water, fruit juice; Others = cupboard goods, tea and coffee, packet soup, frozen desserts, soup, crisps, jam, honey & peanut butter, confectionery

Table 7 DID for total kilocalories and nutrients in the final basket

Dependent variable	ln(Kcal)	ln(fat)	ln(protein)	ln(salt)	ln(sugar)
Intercept	9.4404***	7.3161***	6.1825***	3.3255***	5.8744***
S.E	0.0235	0.0419	0.0208	0.0348	0.0379
Week 2 (W2)	−0.0375	0.0211	−0.0784*	−0.0061	−0.0031
S.E	0.0478	0.0955	0.0456	0.0730	0.0568
Badge x W2	−0.0196	−0.0991	0.0053	−0.0095	−0.1010
S.E	0.0412	0.0874	0.0383	0.0686	0.0690
Vol. comm. x W2	−0.0605	−0.2728***	0.0126	−0.1133	−0.0023
S.E	0.0499	0.1061	0.0476	0.0913	0.0773
Forced Comm. x W2	−0.0820	−0.2560**	−0.0165	−0.1821**	−0.0350
S.E	0.0542	0.1160	0.0483	0.0801	0.0859
Observations	1,354	1,354	1,354	1,354	1,351
Participants	677	677	677	677	676
Overall R2	0.0063	0.0107	0.0048	0.0046	0.0001
$\chi 2$	26.85***	33.93***	16.36***	16.88***	6.11***

Dependent variables refer to the total amount of nutrients and kilocalories in the shopping basket. Statistical significance is indicated as follows * = $p < 0.10$; ** = $p < 0.05$; *** = $p < 0.01$

Table 8 Commitment rates by group

Treatment	Participants	Accepting commitment	Acceptance rates	Threshold met	Success rate[§]
Voluntary commitment	116	65	56%	38	33%
Voluntary commitment + Badge	118	64	54%	45	38%
Forced commitment	100	79[†]	79%	34	34%
Forced commitment + Badge	110	90[†]	82%	39	35%

[†] In the case of the voluntary commitment treatments, the failure to accept is intended as whether the individual willingly or mistakenly tried to avoid the commitment, clicking to proceed without ticking the commitment box

[§] In the control group in week 2, 19% of participants met the low-carbon footprint threshold

Interestingly, consumers did not reduce their consumption of meat, despite the large potential carbon savings in this category (Poore and Nemecek 2018). Finally, Table 7 indicates that a forced commitment had an impact on the total amount of fats and salt in the food basket, which dropped by 26% and 18%, respectively, with no impact on the amount of sugar, proteins, and kilocalories in the basket; a voluntary commitment reduced total fats in the basket by 27%.

5.3 Who Commits?

Table 8 shows the commitment rates by treatment group. When consumers were asked to voluntarily commit, 54–56% accepted. When commitment was forced, 79–82% of participants ticked the box straight away; while 18–21% of consumers tried to proceed without ticking the commitment box, and ticked it once they were reminded. As a result, the forced commitment group presented no sample selection; whereas in the voluntary commitment group, interested participants self-selected into a commitment.[11]

To understand self-selection in the decision to commit to a lower carbon footprint, we explore what drives individual commitment. A Probit regression (Table 9) indicates that the decision to voluntarily commit correlates with the symbolisation component of the environmental identity, and is higher in households with teenagers; the decision is unrelated to self-control, self-image, self-signalling or social signalling. Conversely, in the forced commitment treatment, those who try to proceed without ticking are older consumers, who may have low computer literacy, and consumers scoring low in the symbolised component of environmental identity. It is important to note that these results are correlational, not causal, due to endogeneity of these variables; they simply indicate that environmental preferences were related to the decision to commit. Finally, knowing that a badge will be present does not affect the likelihood of making a commitment.

A χ^2 test shows that consumers who committed voluntarily were more likely to meet the low-carbon footprint threshold in week 2 than those who voluntarily did not commit ($\chi^2 = 10.71$, $p = 0.001$). A Probit regression (Table 10) shows that in week 2 the

[11] Note, however, that the results of Table 5 remove this self-selection by estimating the impact of the voluntary impact on everyone in the treatment (the target population), irrespective of whether the selection was chosen or not—that is, it estimates the average treatment effects.

Table 9 Probit regressions on the likelihood of commitment, by commitment type

	Voluntary commitment		Forced commitment	
	Coefficient	S.E	Coefficient	S.E
Intercept	−3.2754***	0.8407	−0.2057	0.9659
Badge	0.0276	0.1795	0.0275	0.2397
Male	−0.0516	0.2082	−0.2771	0.2303
Age	0.0078	0.0081	−0.0320***	0.0101
Children age: 0–5	−0.0831	0.1816	0.0818	0.2448
Children age:6–10 years	−0.1491	0.2100	−0.1496	0.1827
Teenagers age:11–17	0.4126**	0.2036	0.0363	0.1670
Adults age: 18+	0.0167	0.1135	0.1124	0.1926
Self-control	0.0298	0.1496	0.1249	0.1618
Env. self-image	−0.0058	0.0587	−0.0344	0.0776
Env. self-signalling	0.1134	0.0867	−0.1808	0.1172
Env. social signalling	−0.0226	0.0741	0.1788*	0.1053
Env. Identity—Internalization	0.8386***	0.2291	0.6859***	0.2640
Env. Identity—Symbolization	0.2054	0.1878	0.4317*	0.2350
Income dummies	Yes		Yes	
Observations	234		210	
Pseudo R2	0.1383		0.1932	
Log-likelihood	−138.71		−83.647	
χ^2	43.463***		45.003***	

Statistical significance is as follows *=$p<0.10$; **=$p<0.05$; ***=$p<0.01$. Self-image, self-signalling, social signalling, and identity variables refer to the week-1 measurements, that is, prior to the request of a commitment. Note that in two regressions the dependent variables are not capturing the same behaviour: in the voluntary commitment regression, the dependent variable measures whether the individual decided to commit or not; in the forced commitment regression, the dependent variable refers to whether the participant ticked the box straight away, with respondents given a zero if they tried to proceed without ticking the commitment box and ticked it only once they were reminded

voluntary commitment increases the likelihood of meeting the low-carbon footprint threshold by around+17%, relative to the control group, while a forced commitment increases this probability by+14–15%. The presence of a badge has no impact on the likelihood of meeting the threshold. Finally, while males, older consumers and households with more adults are less likely to meet the threshold, consumers with high internalised environmental identity are more likely to meet it.

Table 10 Determinants of the achievement of the sustainability threshold, probit regression

	No personal information		With personal information	
	Interaction	No interaction	Interaction	No interaction
Intercept	−0.8817***	−0.9057***	−1.3968***	−1.4187***
S.E	0.1285	0.1067	0.5174	0.5134
Badge	−0.0011	0.0514	0.0588	0.0978
S.E	0.1906	0.1032	0.1944	0.1082
Voluntary Comm	0.4351**	0.4954***	0.4953***	0.5583***
S.E	0.1764	0.1269	0.1812	0.1315
Voluntary Comm. x Badge	0.1235		0.1275	
S.E	0.2545		0.2596	
Forced Comm	0.4418**	0.4480***	0.5037***	0.4855***
S.E	0.1828	0.1307	0.1871	0.1345
Forced Comm. x Badge	0.0186		−0.0295	
S.E	0.2617		0.2728	
Male			−0.2608**	−0.2561**
S.E			0.1235	0.1237
Age			−0.0111**	−0.0113**
S.E			0.0052	0.0052
Children age: 0–5			−0.0319	−0.0273
S.E			0.1139	0.1136
Children age:6–10 years			−0.1347	−0.1391
S.E			0.1140	0.1135
Teenagers age:11–17			0.1417	0.1474
S.E			0.1110	0.1110
Adults age: 18 +			−0.2236***	−0.2239***
S.E			0.0767	0.0765
Self-control			−0.1279	−0.1229
S.E			0.0886	0.0886
Env. self-image			0.0154	0.0154
S.E			0.0355	0.0356
Env. self-signalling			0.0795	0.0767
S.E			0.0520	0.0519
Env. social signalling			−0.0547	−0.0536
S.E			0.0454	0.0453
Env. Identity—Internalization			0.6245***	0.6234***
S.E			0.1453	0.1449
Env. Identity—Symbolization			−0.0729	−0.0714
S.E			0.1191	0.1193
Income dummies			Yes	Yes
Voluntary Comm = Forced Comm, χ^2	0.00	0.15		
Marginal effects				
Badge	0.0175	0.0171	0.0302	0.0303
S.E	0.0344	0.0344	0.0334	0.0334
Voluntary Comm	0.1659***	0.1654***	0.1728***	0.1727***
S.E	0.0412	0.0411	0.0396	0.0395

Table 10 (continued)

	No personal information		With personal information	
	Interaction	No interaction	Interaction	No interaction
Forced Comm	0.1505***	0.1495***	0.1512***	0.1502***
S.E	0.0427	0.0426	0.0407	0.0407
Observations	677	677	677	677
Pseudo R^2	0.0233	0.023	0.0913	0.0908
Log-likelihood	−397.86	−398.01	−370.1700	−370.3800
χ^2	18.44***	18.08***	71.80***	71.11***

Statistical significance is as follows *=$p<0.10$; **=$p<0.05$; ***=$p<0.01$. Self-image, self-signalling, social signalling, and identity variables refer to the week-1 measurements, that is, prior to the request of a commitment

6 Discussion

This research studied the role of commitment and badges in driving lower carbon footprint food choices. Being an exploratory study, we did not pre-register our hypotheses.[12] Results indicate that making a commitment prior to entering the store leads to a reduction in carbon footprint of around 9% when the commitment is voluntary, and 10–11% when this is forced. In the group where commitment is voluntary, the reduction is driven by those consumers who accept the commitment, which record a reduction of around 15% in carbon footprint. Compared to previous research, the effect of these intervention sits somewhere in the middle: manipulations that altered the architecture of a choice or prices (Panzone et al. 2021b, 2021c) show larger effects (reductions greater than 15%), while information (Kanay et al. 2021; Muller et al. 2019; Potter et al. 2022; Suchier et al. 2023) show the smallest reductions (even less than 5%), and significant variability depending on the information provided (Muller et al. 2019 report reductions of 8–12%). On the other hand, the goal-setting tasks in Kanay et al. (2021) indicate reductions (relative to the control group) of ~ 10–15%, close to the values observed in this study. Overall, this comparison is in line with Cadario and Chandon (2019), who find that affectively-oriented nudges are more effective than information provision, but less effective than structural changes in store (e.g., smaller portion sizes). This section summarises these results in more detail.

6.1 How Goal Commitment Influences Consumer Decisions

This study shows that asking consumers to commit prior to entering the online retailer increased the sustainability of their decisions. Compliance to the commitment is high even in the absence of any enforcement. Everyone committed when forced to do so, with no self-selection into the commitment. In the voluntary commitment, participants could self-select into the commitment, and unsurprisingly the largest correlation with a reduction in carbon footprint is with the subjects with environmental preferences who accept the commitment.

[12] It is not common for exploratory studies to pre-register hypotheses (Arpinon and Espinosa 2023), though we actually did pre-register a set of hypotheses close to the one we employed in this study (see Appendix 4 for details).

The average treatment effect of the voluntary commitment, which includes both those who accepted and rejected the commitment (therefore unaffected by self-selection), is comparable to that in the forced treatment.

The mere presence of the commitment coming from a favourable authority (in this case, a trusted academic institution) might have been enough to motivate compliance (see also Karakostas and Zizzo 2016). This effect may have been especially evident in Kanay et al. (2021), because the way the goal is set is a representation of how an experimenter may demand a result from their subjects (de Quidt et al. 2018; Zizzo 2010). While insightful, this manipulation may be harder to replicate in natural world grocery shopping than our commitment.[13] The manipulation of Kanay et al. (2021), as well as our commitment manipulation, may operate also through a social norm compliance channel (as reviewed in Sect. 2). Thirdly, our commitment manipulation may specifically elicit a preference for promise-keeping (Vanberg 2008) or compliance to a social norm of promise keeping (Ellingsen and Johannesson 2004; van der Werff et al. 2019). On the other hand, we find no evidence that commitments operated by altering the self-image of the consumer.

Conversely, badges do not cause a significant reduction in carbon footprint, or in the likelihood of achieving the threshold for having a badge. While badges can increase self-efficacy (Sailer et al. 2017) and engagement (Hamari 2017), the limited impact indicates that consumers may not need a soft reward to motivate their compliance to a commitment. We conjecture that this result is likely linked to the private nature of the badge: in Baca-Motes et al. (2013), consumers received a signalling pin visible to third parties, therefore allowing for social signalling, which had a significantly positive impact on the reuse of hotel bath towels; on the other hand, van der Weele and von Siemens (2020) show that a bracelet—which cannot be seen by third parties—does not motivate pro-social behaviour. Our results support the latter research, suggesting that consumers use signalling badges to communicate their pro-social preferences to others, rather than to themselves. An alternative explanation is that the badge had no actual meaning to consumers: while respondents to a pilot survey viewed this badge as motivating, a more recognisable badge (e.g., a WWF badge) might have been more effective. Further research is needed to better understand the behavioural implications of soft rewards like badges.

6.2 Limitations and Future Research

A limitation of this research, typical of experimental work, is the short time window (two weeks), which limits the ability to observe the impact of a nudge over time. Having this article established the effectiveness of commitment in the short term, future research should look at having a longer time horizon. Another potential limitation refers to the ecological validity of the experiment. While the experimental procedure implemented an ecological context by delivering one food basket and removing interactions with the experimenter, it remains difficult to fully determine the external validity of this study, on two grounds. Firstly, many participants used the £25 budget; this decision may be a reflection of the preferences of participants, but may be also due to a desirability bias, whereby consumers expected their task was to reduce carbon emissions. Secondly, consumers may have

[13] In our study, one way we limited the extent to which a commitment could be interpreted as a request by the experimenter was to provide nutritional as well as environmental information on the products, a feature which we see as ecologically valid given the ubiquitous nature of health information being provided on food.

reduced their carbon emissions in the experimental shop, using their own money to buy high-carbon food elsewhere, particularly as many participants considered this exercise part of a weekly shop. As commonly in experimental supermarkets, we are unable to control for such potential substitution between grocery shopping in the experiment and grocery shopping outside the experiment. As a result, our results may overestimate somewhat the absolute impact of the interventions we test. We note however that (Zizzo et al. 2021) provide evidence that the results of their supermarket interventions were unaffected by such substitution effects. Questions also remain over the scalability of the results in this article (Al-Ubaydli et al. 2019): moving from students (Panzone et al. 2021a, c) to the general population (in this study) gives slightly smaller effects, and research is needed to further explore the effect size in the real world.

Linked to incentive-compatibility, the 'free' £25 budget may have caused a house money effect (Thaler and Johnson 1990): participants may have felt the budget was a gift, which they spent on goods they would not normally buy (e.g., relative luxury goods). Experimental research shows this effect may not affect public goods (Clark 2002), and it did not occur in the pilot of another study using an experimental online supermarket (Zizzo et al. 2021).

6.3 Policy Implications: Retail Design and the Protection of the Public Good

The key policy implication of this research is that carbon footprint from grocery shopping can be reduced effectively through store design, designing motivating nudges that can be implemented quickly in store. Online environments are particularly suitable to the design of nudges and interventions targeting large-scale changes in behaviour (Lorenz-Spreen et al. 2020; Rogers et al. 2014; Todd et al. 2013). The commitments presented in this study can be easily implemented in online shops, in conjunction with rewards (a discount following a successful commitment in Schwartz et al. 2014), penalties (blocked withdrawals in Burke et al. 2018), or within a more complex gamified environment (Hamari et al. 2014; Hock et al. 2019; Whittaker et al. 2021). This is a promising area for further research. For instance, Schwartz et al. (2014) show that conditioning a promotion on the achievement of a health goal that consumers voluntarily commit to can increase fruit and vegetables sales. While Schwartz et al. (2014) enforced the commitment by linking it to the reward, our article shows that a soft commitment has the potential to be effective at scale (as in Burke et al. 2018; Himmler et al. 2019). Our commitment manipulations also have health benefits, particularly in terms of reduced purchased of fats but also, for forced commitments, that of salt.

Finally, the voluntary commitment nudge presented in this work can be seen as a hyper-nudge. Hyper-nudging refers to the use of nudges that are personalised around the user in either the choice task, or the method of nudging (Mills 2020; Yeung 2017). As an example, online retailers often target consumers with incentives (e.g., a discount on diapers for babies) based on past, related behaviour observed in the store (e.g., the purchase of baby food), using past purchases to reveal information (the household has a baby) otherwise unobservable to the marketeer. Hyper-nudges allow for more precise targeting in settings with large preference heterogeneity, optimising the use of resources. Compared with the forced commitment, the voluntary commitment contains information on the environmental preferences of the user, which the marketer can use to identify environmentally motivated individuals within the market. This information could be used to design different promotions that further reduce carbon footprint in the same domain (food) or in other environmental domains (e.g., energy).

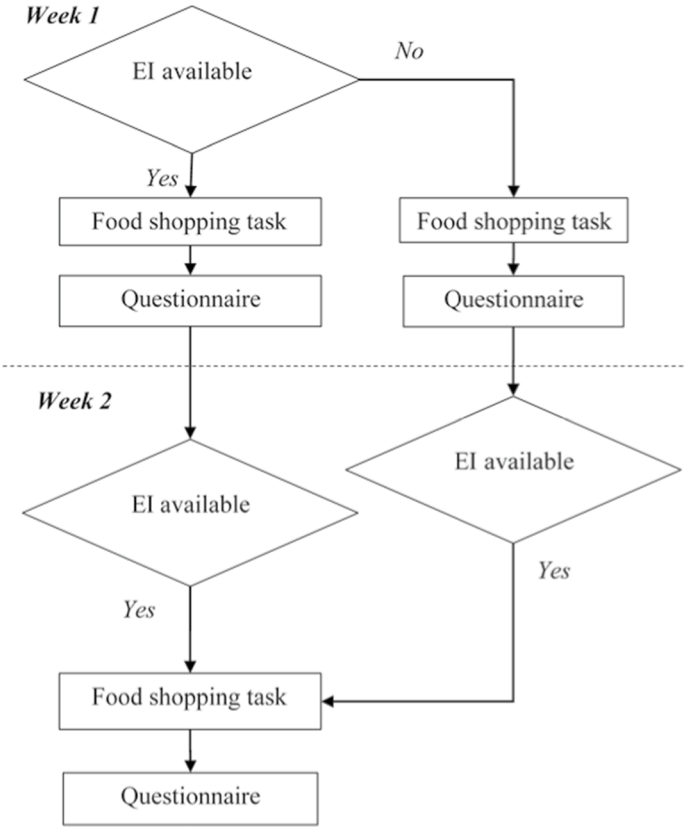

Fig. 9 flowchart of the test of the role of information on consumer behaviour. *Note* EI = Environmental Information

7 Conclusion

This article reports the results from an experiment testing the role of commitments and badges promoting the reduction in carbon footprint from online food shopping. Using an experimental online supermarket and general public sample from the Northeast of England, we show that non-binding commitments can be significant in reducing the carbon footprint from food consumption. The findings presented in this article show that the design of the retail environment has an important impact on what consumers choose, and on the carbon footprint of their basket.

Appendix 1: Environmental Information (EI) did not Prime Consumers

A "No carbon information" treatment (n = 48) was used to test whether the presence of information on carbon footprint affected the behaviour of consumers by priming (Forwood et al. 2015; Papies 2016; Walsh 2014), or purely through the presence of relevant

Table 11 Summary demographics of the "No-Carbon information" group

		Mean	χ^2
Male (%)		0.38	0.84
Average age		35.27	0.23
Family size		2.38	0.97
Children—age < 17		0.60	0.73
Adults (age: 18 +)		1.81	0.02
Education	– % aged 25–64 with PG or UG degree	0.59 (N = 39)	1.34
	– % with PG or UG degree	0.60	1.02
Income (mode)		£48,000– £64,999	–
Observations		48	

For gender, age, and family size variables, the χ^2 statistics refers to a Kruskal–Wallis equality-of-populations rank test comparing of this group with the Control group; while for education and income, the χ^2 statistics refers to a Pearson χ^2 test of association, including only this group and the Control group. The statistics for the Control group are reported in Table 1. Statistical significance is indicated as follows * = $p < 0.10$; ** = $p < 0.05$; *** = $p < 0.01$

Table 12 Descriptive statistics comparing attitudes across treatments in week 1

	Week 1		Week 2	
	Mean	χ^2	Mean	χ^2
Self-signalling	4.13	2.03	3.84*	1.97
Social-signalling	3.60	0.81	3.63	1.58
Environmental self-image	4.00	2.19	3.94	0.97
Self-control	3.19	0.06	3.14	0.06
Environmental attitudes	5.17	2.19	4.60***	1.10
Environmental Self-perception	4.44	6.21**	3.81***	0.04
Env. Identity—Internalization			2.43	1.05
Env. Identity—Symbolization			1.55	0.24
Observations	48			

The χ^2 statistics refers to a Kruskal–Wallis equality-of-populations rank test comparing of this group with the Control group, the statistics of which are reported in Table 1. The comparison of means across weeks is based on a Wilcoxon sign-rank test (the test is not available for the identity variables as they were collected only once). Statistical significance is indicated as follows: * = $p < 0.10$; ** = $p < 0.05$; *** = $p < 0.01$

Table 13 Mean basket statistics of the "No Carbon Information" group

Mean	Week 1	Week 2
Carbon footprint	20,620	20,945
Expenditures	23.44	23.44
Kilocalories	12,318	11,846

Means are not significantly different across week on the basis of a Wilcoxon sign-rank

information during the choice task. In this group, information on the carbon footprint of the products and of the baskets, and the explanation on what carbon footprint is, was unavailable to shoppers in week one, and only appeared in week 2. The behaviour of this group is then compared against the control of the main experiment, for whom information was available in both weeks. The flowchart of the test is presented in Fig. 9. The descriptive characteristics of the participants in this group are reported in Tables 11 and 12; these do not differ from the control group. Table 13 indicates that this information did not change behaviour significantly. Rather, Table 13 shows that the "No carbon information" group showed a slight increase in the carbon footprint of the shopping basket in week 2 relative to week1; however, a Kruskal–Wallis rank test indicates that the carbon footprint was not significantly different across the two groups in both weeks (week 1: $\chi^2(1) = 1.939$, $p = 0.1638$; week 2: $\chi^2(1) = 1.080$, $p = 0.2986$).

Appendix 2: Follow-Up Survey

When collecting the basket, participants were handed a short feedback questionnaire, which asked them whether they understood what the commitment meant. The question posed was.

Thank you very much for participating in our research.

Whilst shopping in the second week, you may have been asked if you would commit to a low carbon footprint shopping basket—that is, a basket below 180 gCO_2/100 g.

Did you believe that ticking "I am interested in protecting the environment, therefore, I commit to keeping the carbon footprint of my basket below 180 gCO_2/100 g" meant that you could **only** checkout if you had a carbon footprint below 180 gCO_2/100 g?

Please tick one of the boxes:

- **NO,** I did **not** believe that by clicking "I commit to keeping the carbon footprint of my basket below 180 gCO_2/100 g" I would be allowed to checkout **only** if I had a shopping basket carbon footprint below 180 gCO_2/100 g.
- **YES,** I believed that by ticking "I commit to keeping the carbon footprint of my basket below 180 gCO_2/100 g" I could checkout **only** if I had a shopping basket carbon footprint below 180 gCO_2/100 g.
- I do not know

Of the 452 participants in the 4 commitment groups, 355 (78.7%) completed the questionnaire. Results (Table 14) show that only around 40% of those facing a voluntary commitment, and 41–48% of those facing a forced commitment, believed the commitment would be actually enforced. As the question was answered two weeks after the experiment, these percentages may over-rely on memory. Percentages may have been higher if collected

Table 14 Number of participants who believed commitment was enforced

Group	No	Yes	Don't Know	% Yes
Voluntary Comm	46	37	7	41.1%
Voluntary Comm. + Badge	52	36	7	37.9%
Forced Comm	34	41	10	48.2%
Forced Comm. + Badge	46	35	4	41.2%

during the experiment, as participants may have answered knowing the answer, and some may have felt "tested" on whether they saw through the experiment.

Appendix 3: Additional Analysis

See Fig. 10, Tables 15, 16, 17, 18 and 19.

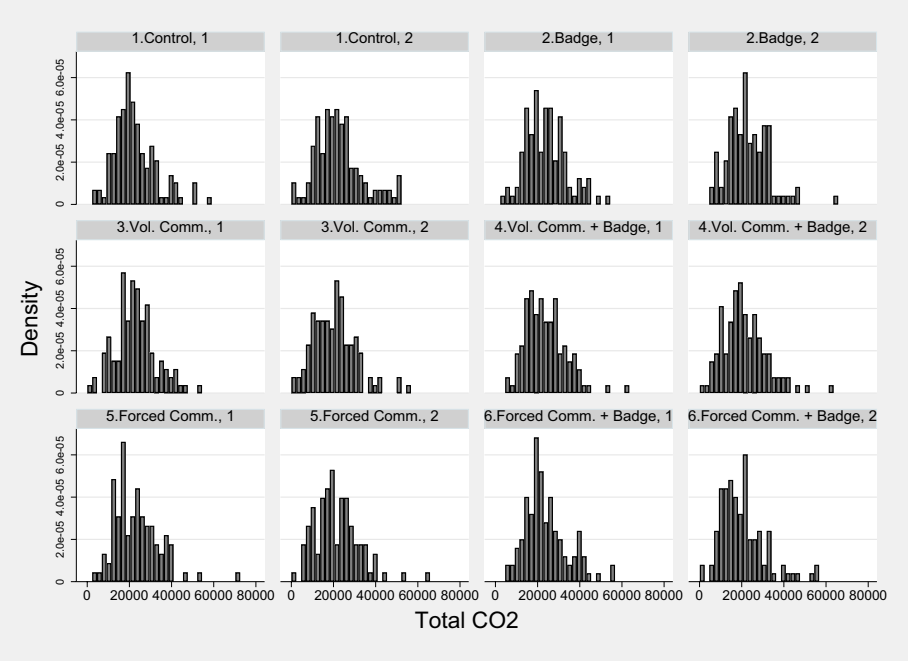

Fig. 10 Distribution of carbon footprint, by group and week

Table 15 Probability of shopping with an environmental goal, week 2

	No personal information		With personal information	
	Coefficient	S.E	Coefficient	S.E
Intercept	−0.8529***	0.1272	−2.7943	0.5050
Badge	0.0380	0.1874	0.0079	0.2026
Vol. Comm	0.5229***	0.1740	0.4118**	0.1868
Badge * Vol. Comm	0.0562	0.2506	0.2037	0.2703
Forced. Comm	0.6510***	0.1793	0.6371***	0.1927
Badge * Forced. Comm	−0.1368	0.2566	−0.1931	0.2761
Self-control			−0.0709	0.0884
Env. self-image			0.0314	0.0378
Env. self-signalling			0.2100***	0.0557
Env. social signalling			−0.0386	0.0483
Env. Identity—Symbolization			0.4629***	0.1401
Env. Identity—Internalization			0.3355***	0.1173
Male			−0.1553	0.1236
Age			0.0033	0.0049
Young children (age: 0–5)			−0.1898	0.1234
Children (age:6–10 years)			0.0986	0.1168
Teenagers (age:11–17)			−0.0264	0.1120
Adults (age: 18 +)			−0.0936	0.0730
Income dummies	No		Yes	
Marginal effects[†]				
Badge	0.0043	0.0354	0.0056	0.0331
Vol. Comm	0.1957***	0.0432	0.1592***	0.0412
Forced. Comm	0.2095***	0.0449	0.1696***	0.0430
Observations	677		677	
$\chi 2$	27.65***		131.83***	
Log pseudolikelihood	−414.51		−362.42	
Pseudo R2	0.03		0.15	

Results are based on two probit regressions. Statistical significance is as follows * = $p < 0.10$; ** = $p < 0.05$; *** = $p < 0.01$. [†]Standard errors are calculated using the Delta method

Table 16 Repeated measure ANOVA testing the impact of the manipulations on environmental preferences

Metric	Environmental preferences							
	Self-control	Self-signalling	Self-image	Self-perception	Attitudes	Social signalling	Env. identity	
							Symbolization	Internalization
Model	Linear panel		Ordered probit				OLS	OLS
Badge	0.04	0.00	0.32	0.07	0.83	0.07	0.15	0.01
Vol. Comm	1.29	0.88	0.02	0.01	1.02	0.16	1.21	0.63
Forced Comm	3.04*							
(increase)	7.93***							
(increase)	0.11	2.57	1.95	1.00	1.95	0.09		
Vol. Comm. x Badge	2.38	0.36	0.05	1.19	1.08	0.03	0.04	0.71
Forced Comm. x Badge	1.31	1.51	0.49	0.07	0.10	0.00	0.01	0.02

Linear panels regressions refer to fixed-effects estimators, while nonlinear panel regressions refer to random-effects estimators. OLS refer to an ordinary least square estimator. Regressions used no covariates besides treatment dummies. Results refer to the main effect interacted with the week 2 dummy. Statistical significance is as follows * = $p < 0.10$; ** = $p < 0.05$; *** = $p < 0.01$

Table 17 DID estimates, treatment effects

	Treatment only		Treatment + attitudes	
	Coefficient	S.E	Coefficient	S.E
Intercept	9.9596***	0.0193	8.8783***	0.2508
Week 2	−0.0573	0.0464	−0.0089	0.0368
Badge x Week 2	0.0138	0.0591	0.0055	0.0527
Voluntary Comm. x Week 2	−0.0752	0.0638	−0.0845	0.0531
Voluntary Comm. x Badge x Week 2	−0.1000*	0.0603	−0.0871	0.0543
Forced Comm. x Week 2	−0.0642	0.0687	−0.0485	0.0606
Forced Comm. x Badge x Week 2	−0.1671**	0.0741	−0.1543***	0.0590
Self-control	–		0.0057	0.0391
Self-image	–		−0.0006	0.0106
Self-signalling	–		−0.0167	0.0148
Social signalling	–		−0.0083	0.0103
ln(basket weight)	–		0.5542***	0.0861
Observations	1,354		1,354	
Participants	677		677	
Overall R^2	0.0163		0.3392	
χ^2	50.90***		105.62***	
Wald test χ^2				
Vol. Comm = (Vol. Comm + Badge)	0.17		0.14	
Forced Comm. = (Forced Comm. + Badge)	1.67		1.74	
Vol. Comm = Forced Comm	0.02		0.07	
(Vol. Comm + Badge) = (Forced Comm. + Badge)	0.89		0.80	

Statistical significance is as follows * = $p < 0.10$; ** = $p < 0.05$; *** = $p < 0.01$

Table 18 DID estimates, with interaction effects

	No attitudes			With attitudes		
	A	B	C	A	B	C
Intercept	9.9596***	9.9596***	9.9542***	8.8782***	8.8783***	8.8651***
S.E	0.0193	0.0193	0.0195	0.2512	0.2508	0.2522
Week 2 (W2)	−0.0573	−0.0573		−0.0090	−0.0089	
S.E	0.0464	0.0464		0.0368	0.0368	
Badge x W2	0.0138	0.0138	−0.0435	0.0055	0.0055	−0.0033
S.E	0.0591	0.0591	0.0364	0.0527	0.0527	0.0371
All comm. x W2	−0.0701			−0.0678		
S.E	0.0559			0.0475		
All comm. x Badge x W2	−0.0761			−0.0573		
S.E	0.0779			0.0682		
Vol. comm. x W2		−0.0752			−0.0845	
S.E		0.0638			0.0531	
Vol. comm. x Badge x W2		−0.0386			−0.0081	
S.E		0.0866			0.0780	
Forced Comm. x W2		−0.0643	−0.1215**		−0.0485	−0.0575
S.E		0.0687	0.0529		0.0606	0.0478
Forced Comm. x Badge x W2		−0.1167	−0.0594		−0.1113	−0.1025
S.E		0.0995	0.0893		0.0841	0.0773
Vol. Comm. (Y) x W2			−0.2025***			−0.1820***
S.E			0.0688			0.0569
Vol. Comm. (Y) x Badge x W2			0.0328			0.0502
S.E			0.1046			0.0939
Vol. Comm. (N) x W2			−0.0432			0.0202
S.E			0.0502			0.0462
Vol. Comm. (N) x Badge x W2			−0.0043			−0.0662
S.E			0.0765			0.0743
Self-control				0.0061	0.0057	0.0059
S.E				0.0392	0.0391	0.0389
Self-image				−0.0005	−0.0006	−0.0005
S.E				0.0106	0.0106	0.0105
Self-signalling				−0.0167	−0.0167	−0.0150
S.E				0.0147	0.0148	0.0147
Social signalling				−0.0083	−0.0083	−0.0088
S.E				0.0103	0.0103	0.0104
Ln(basket weight)				0.5536***	0.5542***	0.5574***
S.E				0.0866	0.0861	0.0868
Observations	1354	1354	1354	1354	1354	1354
Participants	677	677	677	677	677	677
Overall R^2	0.0156	0.0163	0.0238	0.3386	0.3392	0.3476

Table 18 (continued)

	No attitudes			With attitudes		
	A	B	C	A	B	C
Log-likelihood	− 60.01	− 58.99	− 56.07	137.14	138.85	146.07
χ^2	49.90***	50.90***	50.64***	97.43***	105.62***	108.90***
Vol. Comm. = Forced Comm		0.02			0.34	
Vol. Comm. + Badge = Forced Comm. + Badge		0.59			1.41	
Vol. Comm. (Y) = Forced Comm			0.81			2.64
Vol. Comm. (Y) + Badge = Forced Comm. + Badge			0.51			1.90
Vol. Comm. (N) = Forced Comm			1.15			1.43
Vol. Comm. (N) + Badge = Forced Comm. + Badge			0.28			0.17
ATT						
Badge	278.02	278.02	− 816.1182	118.16	116.94	− 64.82
All comm	− 1352.83			− 1401.36		
All comm. + Badge	− 1382.85			− 1118.225		
Vol. Comm		− 1446.943			− 1732.00	
Vol. Comm. + Badge		− 711.56			− 159.48	
Forced Comm		− 1243.057	− 2201.78**		− 1011.65	− 1111.969
Forced Comm. + Badge		− 2091.52	− 990.31		− 2157.83	− 1917.355
Vol. Comm. (Y)			− 3642.895***			− 3546.94***
Vol. Comm. (Y) + Badge			516.99			873.19
Vol. Comm. (N)			− 803.7473			400.55
Vol. Comm. (N) + Badge			− 76.73			− 1307.325

Model A regresses the carbon footprint over a single joint commitment variable; model B treats the two sources of commitment—voluntary vs forced—separately; while model C separates those who voluntarily accepted vs rejected the commitment. Statistical significance is as follows * = $p < 0.10$; ** = $p < 0.05$; *** = $p < 0.00$. Parameters have been estimated using a within panel estimator, which omits group membership because it is fixed at consumer level

Table 19 DID estimates with dependent variable set as ln(GHG/100 g)

	Interacted treatments						No interacted treatments					
	No attitudes			With attitudes			No attitudes			With attitudes		
	A	B	C	A	B	C	A	B	C	A	B	C
Intercept	5.5721***	5.5721***	5.5756***	5.6101***	5.6129***	5.6132***	5.5721***	5.5721***	5.5721***	5.6139***	5.6121***	5.6123***
S.E	0.0188	0.0188	0.0185	0.1559	0.1548	0.1561	0.0188	0.0188	0.0188	0.1545	0.1551	0.1543
Week 2 (W2)	0.0373	0.0373		0.0335	0.0334		0.0476	0.0475	0.0479	0.0452	0.0452	0.0458
S.E	0.0420	0.0420		0.0416	0.0416		0.0349	0.0349	0.0348	0.0348	0.0348	0.0347
Badge x W2	−0.0092	−0.0092	0.0281	−0.0045	−0.0045	0.0289	−0.0318	−0.0316	−0.0325	−0.0303	−0.0302	−0.0313
S.E	0.0583	0.0583	0.0404	0.0592	0.0592	0.0417	0.0371	0.0372	0.0369	0.0370	0.0371	0.0369
Vol. Comm. x W2		−0.0988*			−0.0952			−0.0869**			−0.0850**	
S.E		0.0585			0.0588			0.0419			0.0423	
Vol. Comm. x Badge x W2		0.0214			0.0179							
S.E		0.0868			0.0875							
Forced Comm. x W2		−0.0545	−0.0172		−0.0450	−0.0117		−0.1032**	−0.1032**		−0.0971**	−0.0975**
S.E		0.0687	0.0557		0.0681	0.0552		0.0464	0.0465		0.0467	0.0467
Forced Comm. x Badge x W2		−0.0959	−0.1332		−0.1024	−0.1358						
S.E		0.0919	0.0822		0.0923	0.0828						
All comm. x W2	−0.0783			−0.0720			−0.0946**			−0.0906**		
S.E	0.0533			0.0529			0.0373			0.0376		

Table 19 (continued)

	Interacted treatments						No interacted treatments					
	No attitudes			With attitudes			No attitudes			With attitudes		
	A	B	C	A	B	C	A	B	C	A	B	C
All comm. x Badge x W2	−0.0343			−0.0392								
S.E	0.0756			0.0763								
Vol. Comm. (Y) x W2			−0.1674***			−0.1666***				−0.1527***	−0.1562***	
S.E			0.0609			0.0615			0.0546			0.0549
Vol. Comm. (Y) x Badge x W2			0.0584			0.0605						
S.E			0.1038			0.1041						
Vol. Comm. (N) x W2			0.0735			0.0718			−0.0016			−0.0020
S.E			0.0542			0.0546			0.0467			0.0470
Vol. Comm. (N) x Badge x W2			−0.1134			−0.1152						
S.E			0.0850			0.0863						
Self-control				0.0105	0.0098	0.0099				0.0091	0.0095	0.0075

Table 19 (continued)

	Interacted treatments						No interacted treatments					
	No attitudes			With attitudes			No attitudes			With attitudes		
	A	B	C	A	B	C	A	B	C	A	B	C
S.E				0.0454	0.0452	0.0455				0.0449	0.0451	0.0449
Self-image				0.0026	0.0026	0.0028				0.0025	0.0025	0.0027
S.E				0.0113	0.0113	0.0113				0.0113	0.0113	0.0112
Self-signalling				−0.0153	−0.0155	−0.0149				−0.0150	−0.0147	−0.0131
S.E				0.0160	0.0161	0.0160				0.0161	0.0161	0.0160
Social signalling				−0.0069	−0.0069	−0.0071				−0.0070	−0.0071	−0.0073
S.E				0.0122	0.0123	0.0123				0.0121	0.0122	0.0122
Observations	1354	1354	1354	1354	1354	1354	1354	1354	1354	1354	1354	1354
Participants	677	677	677	677	677	677	677	677	677	677	677	677
Log-likelihood	2.82	4.58	11.58	5.43	7.22	14.15	2.63	2.76	8.72	5.18	5.25	10.92
Overall R^2	0.0043	0.0048	0.0135	0.0179	0.0178	0.0258	0.0050	0.0051	0.0180	0.0190	0.0189	0.0307
$\chi 2$	9.81**	12.69**	18.33**	12.57	16.35*	23.42**	9.69**	9.71**	13.87**	12.31*	12.31	16.65*

Appendix 4. Hypotheses Pre-registration Details

While exploratory studies are not commonly pre-registered (Arpinon and Espinosa 2023), we pre-registered our study in the OSF repository (https://osf.io/acvqk/). The preregistration consisted of four hypotheses:

PR-H1 = A commitment to an environmental goal before grocery shopping motivates consumers to change behaviour and reduce their CO_2.
PR-H2 = An endogenous commitment may result in a lower carbon footprint than an exogenous commitment.
PR-H3 = A visible online badge will motivate consumers to reduce their CO_2.
PR-H4 = A visible online badge will increase the ability of consumers to keep their commitment.

In this article, PR-H3 is the same as H4. We split PR-H1 into two hypotheses H1 and H2 in this article; we did so to determine whether the quality of the commitment mattered (as this was the initial inquiry of the research, and PR-H1 was typed in incorrectly). Nonetheless, our results test PR-H1 directly in the model where both commitments are combined into a single commitment group (model A in the regression results). PR-H2 is the same as H3b in this article; we have then added H3a to allow for the possibility that the expectation was not correct, as the literature (Gino et al. 2013) suggested the opposite was also possible. Finally, the article did not include PR-H4 for simplicity and space, also due to the noise present in the data when interaction terms are included. However, this hypothesis has been tested, and the results are presented in Appendix 3, Tables 18 and 19.

In the presentation of these hypotheses in the article, we also changed terminology from endogenous/exogenous into voluntary/forced based on feedback on presentations of the results of this research in conferences and seminars, also aligning with previous research (Gino et al. 2013).

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Declarations

Conflict of interest No interests to disclose.

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