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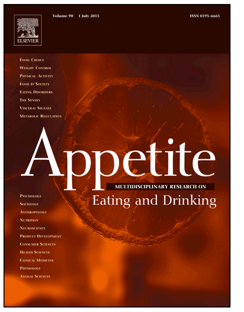

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Can Environmental Traffic Light Warning Labels Reduce Meat Meal Selection? A Randomised Experimental Study with UK Meat Consumers

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Abstract

An important area for tackling climate change and health improvement is reducing population meat consumption. Traffic light labelling has successfully been implemented to reduce the consumption of unhealthy foods and sugary drinks. The present research extends this work to meat selection. We tested 1,300 adult UK meat consumers (with quotas for age and gender to approximate a nationally representative sample). Participants were randomised into one of four experimental groups: (1) a red traffic light label with the text ‘High Climate Impact’ displayed on meat meal options only; (2) a green traffic light label with the text ‘Low Climate Impact’ displayed on vegetarian and vegan meal options only; (3) red/orange/green (ROG) traffic light labels displayed on relevant meals; and (4) control (no label present). Participants made meal selections within their randomised group across 20 meal trials. A beta-regression was performed to ascertain the change in primary outcome (proportion of meat meals selected across the 20 trials) across the different groups. The red-only label and ROG labels significantly reduced the proportion of meat meals selected compared to the unlabelled control group, by 9.2% and 9.8% respectively. The green-only label did not differ from control. Negatively framed traffic light labels seem to be effective at discouraging meat selection. The labels appeared to be moderately acceptable to meat eaters, who did not think the labels impacted the appeal of the products. These encouraging findings require replication in real-life settings.

Keywords: meat selection, meal selection task, traffic light labels, randomized experiment, environmental labelling, environmental traffic light warning label

Climate Change and Meat Consumption

The impacts of climate change are being felt globally with natural disasters across the globe including mass flooding in Pakistan (UN, 2023), drought in Europe (BBC, 2022), wildfires in USA and Australia (Copernicus Atmosphere Monitoring Service, 2023), and heatwaves in China (Stanway, 2022). Without significant intervention from governments and organisations across the world, the planet is expected to reach 2.7 °C warming by 2100 compared to pre-industrial levels (Climate Action Tracker, 2022). This level of warming is estimated to result in mass food shortages and malnutrition, up to 30% of all biodiversity being lost, and a billion people being at risk of losing their homes to coastal flooding (Intergovernmental Panel on Climate Change: IPCC, 2022). Agriculture alone makes up 26% of global greenhouse gas emissions and more than half of this is the result of meat production (Poore & Nemecek, 2018). Both the IPCC (2022) and the Committee on Climate Change (2019) recommend a 20% reduction in beef and lamb production and consumption, and the evidence base points to a transition to meat-free diets leading to reduced greenhouse gas emissions, land use, and biodiversity loss (Carey et al., 2023). However, achieving this reduction is difficult considering that the connection between meat consumption and environmental damage is not well-known amongst members of the public (Happer & Wellesley, 2019; Hielkema & Lund, 2021).

In what follows we first introduce the concept of traffic light labelling. Whilst doing so, we provide an overview of the different types of traffic light labels used to communicate dietary and environmental characteristics of products. We then review seminal studies testing traffic light labels communicating the nutritional content of foods. We then move to describe recent studies that have tested traffic light labels communicating the environmental impact of products. We wrap up the Introduction section with an outline of unanswered questions and an overview of the present study.

Traffic Light Labelling

Traffic light labelling is a commonly used methodology for influencing consumer behaviour, characterised by a colour-coded system, often used on the front of food and beverage packaging. Traffic light labels employ the colours red, orange, and green to denote high, moderate, and low levels of a specific feature respectively, thereby providing a visual aid for consumers to quickly ascertain the quality or properties of a product. Front-of-pack labelling communicating the nutritional content of foods was initially employed in the UK in the mid-2000s (Storcksdieck genannt Bonsmann et al., 2010) and the use of nutritional traffic light labelling was introduced as a voluntary scheme by the Department of Health in 2013 (Department of Health and Social Care, 2013; Wise, 2013). Numerous eye tracking studies show that the addition of colour draws attention to the labels and produces better understanding of health information about labelled products (Antúnez et al., 2015; Bialkova et al., 2014; Jones & Richardson, 2007). In particular, the common interpretation of red as a "stop" signal and green as a "go" signal as utilised in traffic light labels facilitates easier interpretation of the information presented by the label (Elliot & Maier, 2007; Mehta & Zhu, 2009; Schuldt, 2013; Zhang et al., 2020).

There are various types of traffic light labels, defined by four primary dimensions: multi-colour vs. single-colour; unified vs. comprehensive; displayed on all products vs. only favourable products vs. unfavourable products; and presence and combination of descriptors (see Figure 1 for an overview). Multi-colour labels use various colours (often red, orange, green), employing different colours to denote and compare the impact of different products. In contrast, single-colour labels use one colour to mark either a favourable or unfavourable characteristic, presented on only the most or least impactful products. A unique aspect of multi-colour labels is whether they employ a visible graded scale: some, like the Eco-Score or Nutri-Score label, show a full A-E colour scale, spotlighting the product's specific rating

(Arrazat et al., 2023; Hallez et al., 2021). Others, such as the environmental impact label, only show the product's individual rating without the full-scale context (Potter et al., 2022).

Unified labels, also known as summary indicators, use a single symbol with a composite colour to represent the overall rating of a product, summarizing its qualities in one score (Hercberg et al., 2022; Packer et al., 2021). Comprehensive labels sometimes known as specific indicators, on the other hand, use multiple-coloured symbols to detail different aspects of the product, like its salt, fat, and sugar content (Wise, 2013). Unified labels provide a quick overall assessment, while comprehensive labels offer detailed breakdowns of product contents.

The term “all products” refers to a labelling approach where every item within a specific category receives a label. For example, in the context of meal labelling, this approach would ensure that all meal types are labelled, as seen with Nutri-Score and Eco-Score labels (Hagmann & Siegrist, 2020; Hallez et al., 2021). Favourable or unfavourable products labelling is selective, targeting only specific items. This method labels either the most beneficial or detrimental products, but not both. For example, a “High In” warning label (Acton et al., 2019) indicates and appears on products with potentially harmful contents, while a “Green Tick” label (Borgmeier & Westenhoefer, 2009) signifies and is present on products that have beneficial environmental or health impacts.

Finally, the descriptor characteristic refers to what is used to inform consumers of the impact of the product beyond the colour. Common descriptors include text (Acton et al., 2019; Bernard et al., 2015; Slapø & Karevold, 2019), letter (Arrazat et al., 2023; Hallez et al., 2021; Neumayr & Moosauer, 2021), and number descriptors (Antúnez et al., 2015; Carrero et al., 2021; Krah et al., 2019). However, some labels have no descriptors (Ducrot et al., 2016; Luo, 2022; Scarborough et al., 2015) whilst others employ multiple descriptors at once. For example, one of the labels tested in Potter et al. (2022) employs text, number, and letter descriptors.

[INSERT FIGURE 1 ABOUT HERE]

i. Nutritional Traffic Light Labelling

Traffic light labels are common and have been tested both as unified nutritional labels (Acton et al., 2019; Hallez et al., 2021) but predominantly as comprehensive labels (see Figure 1). The more common comprehensive labels have been tested in Germany, Greece, and the UK for their effectiveness at signalling the nutritional aspects of foods including salt, sugar, total fat, and saturated fat content (Borgmeier & Westenhoefer, 2009; Drichoutis et al., 2009; Sacks et al., 2009). A systematic review and meta-analysis of randomised and quasi-randomised trials, and interrupted time series studies which objectively measured purchasing or consumption found that nutritional traffic light labels increased healthier food purchasing (Croker et al., 2020). Another recent systematic review synthesising evidence from experiments testing various nutritional traffic light labels demonstrated that colour-coded labelling systems reduced energy, sodium, fat and saturated fat contents of purchasing (Song et al., 2021).

A multi-colour comprehensive traffic light label on all products with no descriptor was tested in an online choice experiment of UK consumers, which found that an increase in red colour symbols (signifying unhealthy food contents) discouraged pre-packed meal selection more than an increase in green colour symbols encouraged healthier meal selection (Scarborough et al., 2015). In this study, consumers seemed to be more focused on avoiding foods with red content labels than choosing foods with green content labels.

Whilst most nutritional traffic light labels are comprehensive labels, an example of a multi-colour unified label on all products with a graded scale and letter descriptor is the Nutri-Score label (Hercberg et al., 2022). These unified labels denoting different levels of healthiness have been shown in studies with Swiss and British consumers to increase the accuracy of people's rankings of healthiness of food items (Hagmann & Siegrist, 2020; Packer et al., 2021), and the hypothetical selection of smaller portions by French consumers in food tasks (Egnell et al., 2018). However, research in Canada and Belgium suggests that the Nutri-Score label may not be effective at altering choice outside of reducing portion sizes (Acton et al., 2019; Hallez et al., 2021).

An example of a single-colour, as opposed to multi-colour, label appearing on favourable products instead of all products is the single-colour unified label on favourable products with a text descriptor that was tested on French consumers in a randomised controlled trial by Ducrot et al. (2016). In this study labelling all healthy products with a green label (a green tick) improved the nutritional quality of consumers' product selections. Additionally, a single-colour unified label on unfavourable products with a text descriptor was tested by Acton et al. (2019), who found that the "High In" label led to food purchases of reduced sodium and calorie content. It is uncertain which of these nutritional and health labelling designs might translate best to environmental labelling.

ii. Environmental Traffic Light Labelling

Environmental traffic light labelling is a relatively new phenomenon, inspired by the popularity and effectiveness of nutritional traffic light labelling. In the domain of food, Neumayr and Moosauer (2021) conducted a randomised online experiment with a German and Austrian sample, simulating the experience of shopping in an online grocery store. This study implemented a unified multi-colour label on all products with a graded scale and letter descriptor known as the "Eco-Score", similar in design to the "Nutri-Score" label. The "Eco-Score" increased choices of green rated (*vs*. control) products.

Two recent papers employed randomised controlled trial methodology to test a similarly designed unified multi-colour label on all products with a graded scale and letter descriptor within the context of a virtual reality supermarket and an online grocery store, respectively. The studies examined varieties of the ‘Eco-Score’ label, with one study amongst French adults finding that the label reduced the selection of high environmental impact meals (Arrazat et al., 2023). However, the results of the second paper were inconsistent, with one experiment finding no effects and a second experiment finding that participants composed a more sustainable meal when the label was present (Hallez et al., 2021).

Potter et al. (2022) reported two studies of UK consumers, one of which compared the effectiveness of multi-colour and single-colour environmental traffic light labels in an online hypothetical supermarket platform (Study 2). This study is important because it speaks to the choice between a single-colour unified label on either favourable or unfavourable products, or a multi-colour unified label on all products. In this study, Potter et al. (2022) examined a multi-colour unified labelling system where every product was given an "A-E" score, as well as the graded scale ‘Eco-Score’ label also tested in Hallez et al. (2021). The scores and colours represented the environmental impact of the product with a green 'A' indicating the least impact and a red 'E' the most. They compared these labels to two single-colour systems with (a) only low-impact products having a green label, or (b) only high-impact products having a red label, leaving other products without any label. This research revealed that the environmental traffic light labelling A-E score system, Eco-Score label, and single red labels signalling high climate impact, all reduced the environmental impact of consumers’ product choices to a similar extent. But, single green labels did not impact food choices.

The research on environmental traffic light labelling reviewed thus far focused on unified label designs (see Figure 1). Only one study tried to implement an eco-label that is comprehensive (Potter et al., 2022, Study 1). This label was equally effective at reducing the environmental impact of people’s choices compared to a unified label also tested in the same study. However, in follow-up focus groups the comprehensive label was deemed confusing.

Given the effectiveness of unified eco labels and the reported difficulty with understanding comprehensive eco-labels, a unified label may be one promising approach to examine when developing new labels.

A systematic review synthesising 76 studies testing some variety of eco-label on foods and drinks (Potter et al., 2021), identified only four studies testing the impact of eco-labels on meat choices more specifically. These four studies tested diverse label designs ranging from simple text to certification labels and traffic light labelling. The studies reported mixed effects, with only the traffic light labelling study carried out on Swedish consumers finding an impact on meat selection (Brunner et al., 2018). This study tested a unified multi-colour menu label on all products with a number descriptor depicting kgs of Co2. The study found that within the meat meal category, red labelled meat meal sales reduced by 4.8% whereas green labelled meat meal sales increased by 11.5%. Importantly this finding emerged by comparing effects *within* a meal category (meat *vs*. meat) as opposed to attempting to transition away from meat entirely.

Unanswered Questions

The study by Brunner et al. (2018) did not address the question whether utilising red-only, green-only, or red/orange/green (ROG) multi-colour traffic light labelling, is the best method to sway consumers. Some clues derive from Slapø and Karevold (2019), who examined the impact of traffic light symbols on menus and posters in a university cafeteria. The study employed three alternative traffic light designs: two single-colour unified symbols with text descriptors, one on favourable menu items (referred to as a single green label) and the other on unfavourable menu items (named a single red label); and a multi-colour unified symbol on all menu items with text descriptor (or red/orange/green [ROG] label) (Slapø & Karevold, 2019). This study measured the share of meat, fish, and vegetarian dishes sold, finding that single red and single green menu symbols had no impact on sales share of meat, fish, or vegetarian dishes. In contrast, the ROG symbols reduced sales of meat dishes by 9% in the initial trial period. However, this latter effect did not reach conventional levels of significance (p = .10), perhaps due to the relatively small number of dishes sold during the study period. Furthermore, in the second intervention period taking place after a break in data collection due to the Christmas holidays there was no impact of any of the menu symbols on sales shares of meat, fish, or vegetarian meals. These varied results highlight the need for further research to test the impact of unified traffic light labels. Furthermore, there is a need to extend this work from symbols on menus and posters to product labels.

There is also the question if text descriptors can enhance the potential effectiveness of environmental traffic light labels. In particular, warning labels employing text descriptors have been tested to disincentivise behaviours that lead to a variety of health consequences, such as tobacco smoking (Francis et al., 2019; Noar et al., 2016), as well as consumption of unhealthy food, alcohol, and sugar sweetened beverages (Clarke et al., 2021). Warning labels highlighting the environmental impact of food are more noticeable (Carrero et al., 2021), but studies examining the potential effectiveness of environmental warning labels at reducing consumption remain scant. One randomised experiment by Taillie et al. (2021) found the implementation of a text-only environmental warning label to be ineffective at discouraging meat-meal selection. Hughes et al. (2023) on the other hand found pictorial warning labels combining images and text communicating the adverse environmental (or health, or pandemic) consequences of meat consumption reduced the selection of meat meals compared to an unlabelled control. The effectiveness of a combined traffic light warning label with a text descriptor to both discourage undesirable behaviour and encourage desirable behaviour is currently unknown.

The Present Study

The present study evaluated the effect of three environmental traffic light warning labels: a) a red-only label; b) a green-only label; or c) a red/orange/green (ROG) label, all aimed at communicating the climate impact of meals in the context of selecting meat-based dishes versus non-meat dishes (fish, vegetarian, or vegan dishes). We focused on environmental labels as opposed to health or animal welfare labels as previous research has suggested that environmental labels are equally effective as health labels but more supported by the public when considering potential policy enactment (Hughes et al., 2023). Additionally, recent research found that animal welfare labels were less impactful at reducing meat meal choice (Herchenroeder et al., 2023; Neff et al., 2018).

Furthermore, whilst health and environmental hazards are two distinct risks, they are often perceived to be linked (Casson et al., 2023). Consistent with this, people make similar decisions when faced with environmental or health warnings (Hughes et al., 2023). Additionally, consideration of both health and the environment has been shown to increase the likelihood of purchasing organic food products (Diagourtas et al., 2022).

Bearing in mind the overview of different types of traffic light labels shown in Figure 1, our study focused on red-only labels (single-colour unified labels on unfavourable products with text descriptor), green-only (single-colour unified labels on favourable products with text descriptor), and red/orange/green [ROG] (multi-colour unified label on all products with text descriptor). Furthermore, our labels contained features of warning labels as those used on tobacco (Department of Health and Social Care, 2021), and most recently tested in the domain of meat meal selection by Hughes et al. (2023).

We also measured perceptions of the labels and labelled meals. Negative emotional arousal is an important measure that can impact the effectiveness of a label (Cho et al., 2018; Evans et al., 2015; Mantzari et al., 2018); therefore, we measured perceptions of the labels in terms of the anxiety, worry, and discomfort they induced. Studies looking at the influence of emotion on decision making have shown that negative emotional arousal can mediate the effect of health focused labels on sugar-sweetened-beverage selection (Mantzari et al., 2018). Additional research in the field of tobacco labelling suggests that the higher the levels of negative emotional arousal the more effective the labels are at discouraging undesirable behaviours (Cho et al., 2018; Hammond et al., 2006; Nonnemaker et al., 2015).

Perceived credibility of the labels was also assessed, since a previous review showed a positive association between message credibility and behaviour change (Pornpitakpan, 2004). We also assessed participants' considerations of environmental consequences when deciding on meal choices, their existing meat consumption rates, and their readiness and plans to curtail meat intake. Such measures were incorporated into the study because previous studies have pinpointed chronic environmental concerns as a factor that can impact a range of pro-environmental behaviours, including recycling and carbon-offsetting (Nigbur et al., 2010; van der Werff et al., 2013; Whitmarsh & O'Neill, 2010), while also reducing the selection of meat meal choices (Hughes et al., 2023).

The protocol for this randomised experimental study was prospectively registered on OSF: https://osf.io/hka2d/?view_only=3a5b966e8ec64793acba6e505035631b

We hypothesised that:

1. Environmental traffic light warning labels will reduce the selection of meat meals in a meal choice task compared to a control group where no labels are shown.
2. Prior research has provided mixed evidence for the relative impact of red-only, green-only, and red/orange/green (ROG) traffic light labels. We therefore refrained from postulating a directional hypothesis for the comparisons between the three labelling conditions (i.e., red-only vs. green-only vs. red/orange/green [ROG]).

Methods

Design

The study employed a between-subjects experimental design with one independent factor of four levels corresponding to the environmental traffic light labels presented alongside the meal options in the meal choice task. Participants were randomised into one of four experimental groups in a 1:1:1:1 ratio: a control group in which no labels were shown, and three experimental groups: (a) a red traffic light label with the textual message ‘High Climate Impact’ displayed on meat meal options only; (b) a green traffic light label with the textual message ‘Low Climate Impact’ displayed on vegetarian and vegan meal options only; and (c) red/orange/green (ROG) traffic light labels displayed on meals [with meat options labelled red ‘High Climate Impact’, fish options labelled orange ‘Medium Climate Impact’, and vegetarian and vegan meal options labelled green ‘Low Climate Impact’]. Random assignment to one of the four experimental groups was carried out by the Qualtrics survey software (https://www.qualtrics.com/uk/). See Box 1 for one sample trial out of the 20 trials making up the meal choice task.

[INSERT BOX 1 ABOUT HERE]

After the meal choice task participants were randomised again before completing the secondary outcomes gauging their perceptions of a sample meal and associated labels. This second randomisation split participants into eight groups: red label - meat, orange label - fish, green label - vegetarian, green label - vegan, control - meat, control - fish, control - vegetarian, and control - vegan. For a detailed description and visualisation of the randomisation process refer to the Participants section and Figure 2 showcasing participants’ flow through the study.

Meal Selection Task

Before beginning the meal choice task participants were asked to imagine being in a university dining hall at dinner time. This was further facilitated with the presentation of pictures of a dining hall/cafeteria. The setting was chosen as previous research has suggested that such a location may be an appropriate place for introducing dietary interventions focused on the environment due to the carbon footprint of university cafeterias (Graham et al., 2019; Lambrecht et al., 2023). Additionally, the established structure of university dining halls, providing diners with meat, fish, vegetarian, and vegan meal choices, matches the set-up of a hypothetical meal selection task.

Participants were presented with pictures of four different meal options (meat, fish, vegetarian, vegan) on a hot-meal counter as they would appear in real-world dining establishments, and they were told that the subsequent meal choice task will present four meal options akin to these (see Appendix I Online Supplementary Material). Past studies have shown that, in online experiments, providing participants with visual representations of the decision-making context helps in encouraging more precise and truthful responses during choice experiments (Bacon & Krpan, 2018).

The meal choice task consisted of 20 trials presented in a randomised order across participants. For each trial participants were asked to select their preferred meal to eat now or later today amongst the four meal options (meat, fish, vegetarian, vegan), presented left to right akin to a real dining hall environment. The trials consisted of varied meals; for example, one trial asked participants to choose between a meat burger, fish burger, vegetarian burger, or vegan burger, whilst another trial asked participants to choose from meat lasagna, fish lasagna, vegetarian lasagna, or vegan lasagna (see Appendix III in the Online Supplementary Materials for a full list of trials). Within a trial, all meals were of the same type and equivalent attractiveness; for example a meat burrito, fish burrito, vegetarian burrito, and a vegan burrito. In the green-only group the vegetarian and vegan options were labelled with a green “Low Climate Impact” traffic light warning label. In contrast, in the ‘red-only’ group the meat option was labelled with a red “High Climate Impact” traffic light warning label. Finally, in the ‘red/orange/green’ (ROG) group the meat, vegetarian, and vegan burritos were labelled as per their labelling in the red-only and green-only conditions, respectively, with the addition of an orange “Medium Climate Impact” traffic light warning label presented for the fish option. In the control group the meal options contained no labels (see Box 1 for a visual illustration).

Environmental Traffic Light Warning Label Design

One multi-colour unified label on all products with a text descriptor was designed alongside two single-colour unified labels on either favourable or unfavourable products with text descriptors (see also Figure 1 in Introduction). Our labels were designed to emulate warning labels found to be effective on tobacco packaging (Department of Health and Social Care, 2021; Francis et al., 2019; Noar et al., 2016), using a thick lined rectangular label divided into two sections: a text descriptor in the upper section and an image—in this case a solid colour—in the lower section (see Box 1). This design was combined with the colour scheme of established traffic light labels, with the lower section presenting one of the three traffic light colours depending on the climate impact of the associated meal (red/orange/green). As discussed previously, a unified label design was chosen as it builds on previous research testing unified environmental labels (Arrazat et al., 2023; Bernard et al., 2015; Potter et al., 2022; Slapø & Karevold, 2019) and because comprehensive environmental labels can be confusing (Potter et al., 2022). Given the evidenced effectiveness to change behaviour of both multi-colour labels on all products (Potter et al., 2022) and single-colour labels on both favourable (Brunner et al., 2018) and unfavourable products

(Potter et al., 2022), we sought to compare each of these label types. The "low", "medium", and "high" textual descriptors were selected with the intention of being easy to understand and affording easy comparisons. The phrase "climate impact" is commonly used to signal environmental friendliness and was selected due to its recognisability (Wolfson et al., 2022).

Participants

A sample of 1,300 meat consumers was recruited using Prolific – a survey distribution platform (www.prolific.com). The sample, stratified using age and gender quotas, was broadly representative of the UK adult population, although slightly overrepresenting people with a university degree. Sample size calculations were based on previous research using the same meat meal choice task (Hughes et al., 2023). We expected environmental traffic light warning labels to have a small effect on the proportion of meat meals selected, with a conservative estimate of a 7.4% reduction when comparing the control group with the experimental traffic light label groups. To detect this difference with 80% power whilst applying multiplicity correction to maintain a global p-value of .05, a total of 1,240 participants were needed (310 in each group). To account for possible attrition during data collection, we aimed for a total of 1,300 participants.

Table 1

Demographic characteristics of the sample.

Characteristic	**Experimental Group**				
	Control *n* = 324	Red *n* = 327	Green *n* = 324	ROG *n* = 325	Total N=1300
Gender					
Male	161 (49.7)	168 (51.7)	153 (47.2)	149 (45.6)	631
Female	162 (50)	155 (47.7)	168 (51.9)	174 (53.2)	659
Other	1 (0.3)	4 (1.2)	3 (0.9)	2 (0.6)	10
Age					
18-24	37 (11.4)	32 (9.8)	33 (10.2)	35 (10.7)	137
25-34	44 (13.6)	62 (19.1)	61 (18.8)	56 (17.1)	223
35-44	56 (17.3)	50 (15.4)	50 (15.4)	54 (16.5)	210
45-54	58 (17.9)	53 (16.3)	54 (16.7)	54 (16.5)	219

55-65	56 (17.3)	47 (14.5)	52 (16)	52 (15.9)	207
65+	73 (22.5)	83 (25.5)	74 (22.8)	74 (22.6)	304
Education[a]					
4 GCSE's	34 (10.5)	24 (7.4)	32 (9.9)	46 (14.1)	136
1 A Level	42 (13)	49 (15.1)	43 (13.3)	25 (7.6)	159
2+ A Level	70 (21.6)	58 (17.8)	63 (19.4)	63 (19.3)	254
University	171 (52.8)	188 (57.8)	181 (55.9)	184 (56.3)	724
N/A	7 (2.2)	8 (2.5)	5 (1.5)	7 (2.1)	27
Income[b]					
0-15.5K	35 (10.8)	40 (12.3)	30 (9.3)	42 (12.8)	147
15.5-25K	42 (13)	49 (15.1)	43 (13.3)	49 (15)	183
25K-40K	86 (26.5)	91 (28)	93 (28.7)	85 (26)	355
40K+	152 (46.9)	135 (41.5)	144 (44.4)	136 (41.6)	567
N/A	6 (1.9)	10 (3.1)	10 (3.1)	8 (2.4)	34
Social Grade[c]					
Low	129 (39.8)	122 (37.5)	133 (41)	100 (30.6)	484
Medium	145 (44.8)	144 (44.3)	149 (46)	146 (44.6)	584
High	42 (13)	57 (17.5)	38 (11.7)	68 (20.8)	204
N/A	4 (1.2)	3 (0.9)	3 (0.9)	5 (1.5)	15
Ethnicity					
White	280 (86.4)	285 (87.7)	292 (90.1)	293 (89.6)	1150
Mixed	11 (3.4)	12 (3.7)	3 (0.9)	6 (1.8)	32
Asian	22 (6.8)	19 (5.8)	18 (5.6)	17 (5.2)	76
Black	8 (2.5)	8 (2.5)	9 (2.8)	7 (2.1)	32
Other	2 (0.6)	0 (0)	2 (0.6)	2 (0.6)	6
N/A	1 (0.3)	3 (0.9)	0 (0)	0 (0)	4
BMI[d]					
Overweight and Obese	178 (54.9)	200 (61.5)	192 (59.3)	171 (52.3)	741
Healthy	134 (41.4)	117 (36)	125 (38.6)	146 (44.6)	522
Underweight	12 (3.7)	10 (3.1)	7 (2.2)	8 (2.4)	37

Note. The numbers inside brackets indicate percentages unless specified otherwise. [a]The General Certificate of Secondary Education (GCSEs) in the UK is generally pursued by students aged 15-16, while A-Levels are for those aged 17-18. [b] Income represents annual income of the Chief Income Earner in the household. [c]The National Readership Survey was used to assess social grade, where respondents specify the job role of the primary earner in their home. [d]BMI, which stands for Body Mass Index, is calculated as mass divided by height squared (mass/height^2). According to the World Health Organisation (2010), a BMI of 18.5 or below signifies underweight, while 25 or above indicates overweight or obese.

A total of 1,485 participants accessed the study link. Twenty-three withdrew their participation during the study (one after randomisation to the control condition), 115 failed the meat-eligibility screening which was assessed through the dietary habits measure (see measure "Dietary Habits" in Table 2.), whilst 47 were unable to continue with the study due to accessing the experiment using a mobile device. No participants failed the attention check question. Cumulatively, 185 participants were excluded with 1,301 participants randomised into the four groups of approximately 325 participants each at a ratio of 1:1:1:1; one of these participants then withdrew (see Figure 2).

After completion of the primary outcome participants were further randomised into eight groups (*n*s = 161 to 163) to complete the secondary outcomes. Participants within the control condition were randomised to one of the control – meat, control – fish, control – vegetarian, or control – vegan secondary outcome groups at a ratio of 1:1:1:1. Participants in the red-only label condition were randomised at a 1:1:1:1 ratio into control – fish, control – vegetarian, control – vegan, and red label – meat groups. Participants within the green-only label group were randomised at a 2:3:3 ratio to the control – meat, green label – vegetarian, and green label – vegan groups respectively. Finally, participants in the ROG label condition were randomised to the red label- meat, orange label – fish, green label – vegetarian, and green label – vegan groups at a ratio of 2:4:1:1 respectively. This randomisation process illustrated in Figure 2 ensured an approximately equal number of participants for all conditions with the proviso that participants were only randomised to a labelling condition they had previously experienced as part of the primary meal choice task.

[INSERT FIGURE 2 ABOUT HERE]

Measures

Primary Outcome

Proportion of meat meals selected served as the primary outcome. This was measured as the proportion of meat meals selected across the 20 meal selection trials. For example, a participant selecting 15 meat meals and 5 non-meat meals across the 20 trials would be assigned a value of .75.

Secondary Outcomes and Individual Difference Measures

After completing the 20 meal selection trials, participants answered a series of secondary outcome measures, with reference to a burger meal option. Burgers were chosen as they are an extremely popular food product in the UK. In 2019 it was estimated that people eat nearly 26g of burgers every single day, equating to more than 90kg of burger consumed a year (Stewart et al., 2021). Kantar (2024) estimates that £444.3 million has been spent on burgers in the 52 weeks preceding March 17th 2024. We therefore chose burgers as they are a quintessential British dish eaten in large quantities that attracts a significant expenditure in the UK. For this task, participants were randomised to see one of eight potential burger and label combinations they had previously witnessed in the meal selection task (see Design and Participants sections). For example, a participant randomised to the green-only condition could not be randomised to the meat burger red label group but could be randomised to the meat burger with no label combination as the meat burger in the green-only condition was presented without a label (for more details see CONSORT flow diagram in Figure 2). Table 2 below summarises all secondary outcome and individual difference measures. Individual difference measures and measures such as meal appeal that gauged participants' perceptions of the product were presented to all participants. The measures that gauged participants' perceptions of the labels were only presented to participants randomised to a label condition in the secondary randomisation.

Table 2

Overview of measures

Measure	Question	Scale	Reliability	Adapted from
Secondary Outcome Measures				
Meal Appeal	How much would you like to eat this meal now or later on today? This meal is appealing.	1 = not at all to 7 = very much 1 = strongly disagree to 7 = strongly agree	*r* = .878	Hughes et al. (2023)
Future Intentions to Purchase and Consume	How likely are you to buy this meal in the next 4 weeks? How likely are you to eat this meal in the next 4 weeks?	1 = not at all likely to 7 = very likely	*r* = .962	Vasiljevic et al. (2018)
Perceived Environmental Damage	How damaging to the environment do you think this meal is?	1 = not at all damaging to 7 = extremely damaging	N/A	
Negative Emotional Arousal	How anxious does the label on this meal make you feel? How worried does the label on this meal make you feel? How uncomfortable does the label on this meal make you feel?	1 = not at all; 7 = very	α = .945	Kees et al. (2006); Mantzari et al. (2018).

Label Credibility	The information presented on the label of the meal is credible. The information presented on the label of the meal is believable. The information presented on the label of the meal is trustworthy.	1 = strongly disagree to 7 = strongly agree	α = .936	Vasiljevic et al. (2024)
Attention Capture	The label presented on this meal captured my attention.	1 = strongly disagree to 7 = strongly agree	N/A	
Thought Provoking	The label presented on this meal made me think about the meal's impact on climate change.	1 = strongly disagree to 7 = strongly agree	N/A	
Perceived Influence	I would be influenced by labels that are similar to the one displayed in this study.	1 = strongly disagree to 7=strongly agree	N/A	Hughes et al. (2023)
Policy Support	Would you support or oppose a government policy requiring the label shown on this meal to be placed on food?	1 = strongly oppose; 4 = neither support	N/A	Mantzari et al. (2018)

		nor oppose; 7 = strongly support		
Individual Difference Measures				
Demographic Characteristics	Questions relating to age, sex, ethnicity, household income, education, social grade, and weight and height for BMI calculation.		N/A	Oguz & Merad (2013)
Current Levels of Meat Consumption[a]	On average how often do you consume meat or products that include meat?	1 = never to 5 = several times a day	N/A	Lentz et al. (2018)
Current Levels of Meat Restriction	I am currently making an effort to reduce my meat consumption.	1 = strongly disagree to 7 = strongly agree	N/A	Lentz et al. (2018)
Environmental Risk Consideration	In general, the impact on the environment is an important factor when deciding which foods I buy and eat.	1 = strongly disagree to 7 = strongly agree	N/A	Hughes et al. (2023)
Current Hunger	How hungry do you feel right now?	1 = very hungry to 7 = very full	N/A	Vasiljevic et al. (2015)
Attention Check[b]	This is an attention check, please select option "2" to ensure your responses are included.	1 to 7	N/A	
Pre-screen				
Dietary Habits	Which of the following describes your diet the most accurately?	Answer options included a wide range of diets, including vegetarian, vegan, Atkins	N/A	

diet, Ketogenic diet, pescatarian, and so forth.

Note. [a]Prior to answering the "Current Levels of Meat consumption" question participants were provided with the following definition of what constitutes meat: "In the questions below, the word "meat" refers to red and white meats (e.g., beef, lamb, pork, chicken, turkey, but not fish or seafood) that are either unprocessed (e.g., chicken breast, steak) or processed (e.g., sausage, salami, meat mince, chicken nuggets)." [b]For the "Attention Check" question, selection of any answer other than "2" would have resulted in the exclusion of the participant's data from analysis.

Procedure

Ethics approval for the study was granted by the ethics committee at Durham University's Department of Psychology: PSYCH-2020-10-19T14_10_29-tpfj36. Participants belonging to a panel of the sampling platform Prolific (www.prolific.co) were invited to access the study online. Participants began by reading an information sheet and gave their consent to participate in the study. Subsequently a pre-screen question about current diet was administered, whereby participants not reporting a diet that contains meat were excluded from further participation and their session was immediately terminated. Eligible participants then provided demographic information and completed a series of questions designed to measure their weight, height, current hunger levels, and their level of environmental consideration when making food selection decisions. Then followed the 20 trials of the meal selection task. Subsequently participants completed the secondary outcome measures, whilst having a picture of a burger meal and label presented alongside; the specific burger and label was dependent on how participants were randomised (see Figure 2). After completion of the meal selection task and secondary outcome measures, participants were fully debriefed and thanked for their time.

Planned Analysis

As expected, performing an Anderson-Darling test to assess the distribution of the data demonstrated statistical significance and therefore a non-normal distribution, $A = 11.609$, $p < .001$. Thus, in keeping with the study's preregistration, a beta-regression was performed to ascertain the change in primary outcome (proportion of meat meals selected across the 20 trials) across the different conditions. Experimental conditions were denoted using three dummy variables (*Control:* $D_1 = 0$, $D_2 = 0$, $D_3 = 0$; *Red Only*: $D_1 = 1$, $D_2 = 0$, $D_3 = 0$; *Green Only:* $D_1 = 0$, $D_2 = 1$, $D_3 = 0$; *Red, Orange, and Green*: $D_1 = 0$, $D_2 = 0$, $D_3 = 1$). In preparation for the analysis, we compressed the primary outcome variable by substituting proportions equating to zeros with 0.5. Following compression, we regressed the primary outcome on the three dummy variables representing the four experimental conditions. We employed percentile bootstrapping with 1,000 resamples to derive parameter estimates. Further to this, individual difference variables were included as potential moderators in subsequent exploratory analyses.

Results

Randomisation Check

There were no significant differences between conditions on any demographic characteristics presented in Table 1, $ps_{\text{bonferroni-adjusted}} \geq .214$, suggesting that participants were successfully randomised to the experimental groups (see Appendix II in Online Supplementary Materials for a detailed breakdown).

Primary Outcome

The proportion of meat meals selected across the 20 trials within each of the experimental conditions is presented visually in Figure 3. For histograms representing the distribution of data points refer to Figure S3 in Appendix IV.

[INSERT FIGURE 3 ABOUT HERE]

Table 3 indicates that there was a good fit for the final beta regression model with predicted means approximating the observed means. When comparing the control to the experimental groups, the mean proportion for the control group ($M = .639$) was significantly higher than both the red label group ($M = .547$) and the ROG label group ($M = .541$), $ps < .004$; however, there was no difference between the control and green label groups ($M = .608$), $p = .893$. Expressed as differences in proportions, the red label reduced the number of meat meals selected by 9.2% whilst the ROG label reduced meat meal selection by 9.8%. A detailed breakdown of model parameters is shown in Table 4.

Table 3.

Means and standard deviations of the primary outcome, both observed and predicted.

	Observed *M* (*SD*)	Predicted *M* (*SD*)
Control	.639 (.279)	.612 (.333)
Red	.547 (.286)	.543 (.338)
Green	.608 (.266)	.609 (.315)
ROG	.541 (.287)	.543 (.331)

An additional beta regression was run altering the reference group by substituting the control group for the ROG label group. This analysis found no significant difference between the ROG and red label groups in the proportion of meat meals selected, $p_{\text{bonferonni-adjusted}} >$ .999.

Table 4.

Final beta regression coefficients, standard errors, and significance tests.

Parameter	Coefficient	*SE*	*p*	Lower CI	Upper CI
Location submodel					
b_0	.455	.071	<.001	.316	.595
b_1 (red)	-.281	.099	.004	-.476	-.087
b_2 (green)	-.013	.099	.893	-.207	.180
b_3 (ROG)	-.281	.099	.004	-.475	-.088
Dispersion submodel					
d_0	.128	.064	.045	.003	.254
d_1 (red)	.028	.089	.756	-.147	.203
d_2 (green)	.212	.091	.200	.033	.391
d_3 (ROG)	.103	.090	.250	-.073	.279

Secondary Outcomes

To gauge whether adding labels to the meals impacted individuals' explicit assessments of the meal options, we subjected ratings of meal appeal, future intentions, and perceived environmental damage to three separate 2 (label: no label vs. label) x 4 (meal: meat vs. fish vs. veggie vs. vegan) ANOVAs. The analyses yielded no evidence for any effects of labelling, *F*s < 1. There was also no evidence of an interaction between labels and meal types, *F*s < 1. The main effect of meal type was significant in all three analyses, $F\text{s}(3, 1292) \geq 37.11$, $p\text{s} < .001$, indicating that participants found meat meals the most environmentally damaging, appealing, and also being the meal they would most likely eat in the future, followed by fish meals, and then vegetarian and vegan meals (see Table 5).

Table 5.

Means and standard deviations of secondary outcomes administered to control and experimental conditions.

	Meat Meal		Fish Meal		Veggie Meal		Vegan Meal	
Outcome	No label	Red label	No label	Orange label	No label	Green label	No label	Green label
Meal Appeal	4.95_a (1.74)	4.77_a (1.71)	3.81_b (1.80)	3.83_b (1.93)	3.80_c (1.59)	3.79_c (1.71)	3.49_d (1.72)	3.52_d (1.83)
Future Intentions	4.29_a (2.14)	4.2_a (2.11)	2.56_b (1.66)	2.46_b (1.64)	2.4_c (1.58)	2.5_c (1.77)	2.27_c (1.68)	2.41_c (1.73)
Perceived Environmental Damage	4.29_a (1.49)	4.32_a (1.57)	3.52_b (1.15)	3.7_b (1.11)	2.87_c (1.09)	2.74_c (1.16)	2.75_c (1.13)	2.74_c (1.20)

Note. Standard deviations are shown in brackets. All secondary outcomes were measured on seven-point Likert scales ranging from 1 to 7. Means with differing subscripts within rows are significantly different following Bonferroni adjustment.

Finally, we performed a series of one-way ANOVAs to examine any potential differences in how the *red*, *green*, and *ROG* labels were perceived. As shown in Table 6 and discussed next, there was evidence of some differences.

Negative Emotional Arousal

There was a statistically significant difference in negative emotional arousal, $F(3, 647) = 58.84$, $p < .001$, with the red label producing a more negative emotional response than the orange or green labels, Welch's $t\text{s} \geq 4.85$, $p\text{s}_{\text{bonferroni-adjusted}} < .001$. Furthermore, the orange label was also significantly different to the green labels, Welch's $ts \geq 5.66$, $ps_{\text{bonferonni-adjusted}} < .001$. There was no significant difference between the green (veggie) and green (vegan) labels, Welch's $ts \leq 0.33$, $ps_{\text{bonferonni-adjusted}} > .999$.

Credibility

Measures of credibility revealed no significant differences between conditions, $F(3,647) = 0.32$, $p = .808$.

Attention Capture

A separate ANOVA revealed differences in attention capture $F(3, 647) = 15.75$, $p < .001$, with the red label capturing more attention than the orange or green labels, Welch's $ts = 5.61$, $ps_{\text{bonferonni-adjusted}} < .001$. There was no difference between the orange and green labels or between the green (veggie) and green (vegan) labels, Welch's $ts \leq 0.780$, $ps_{\text{bonferonni-adjusted}} > .999$.

Thought Provoking

Some differences were also observed in terms of how thought-provoking participants found the labels $F(3, 647) = 3.76$, $p = .011$. Specifically, red labels made participants think more about the environmental impact of the meal than green labels on veggie meals did, Welch's $t(321.96) = 2.98$, $p_{\text{bonferonni-adjusted}} = .018$, but not green labels on vegan meals, Welch's $t(315.78) = 2.57$, $p_{\text{bonferonni-adjusted}} = .060$. No other significant differences emerged.

Perceived Influence

The perceived influence of the various labels also differed $F(3, 647) = 3.07$, $p = .027$, but pairwise comparisons were no longer significant after Bonferroni adjustments, $ps_{\text{bonferonni-adjusted}} \geq .062$.

Policy Support

The measure of policy support yielded no significant differences, $F(3, 647) = 1.60$, $p = .188$. However, it is worth noting that ratings of policy support were above the scale midpoint in all labelling conditions, suggesting that participants were mostly in favour of the introduction of traffic light labels, $ps_{\text{Bonferroni-adjusted}} \leq .009$.

Table 6.

Means and standard deviations of secondary outcomes comparing experimental conditions.

Outcome	Red	Orange	Green (veggie)	Green (vegan)
Negative Emotional Arousal	3.13_a (1.65)	2.31_b (1.38)	1.54_c (1.03)	1.51_c (.88)
Label Credibility	4.84_a (1.25)	4.82_a (1.25)	4.83_a (1.21)	4.94_a (1.27)
Attention Capture	5.45_a (1.47)	4.46_b (1.69)	4.39_b (1.82)	4.31_b (1.87)
Thought Provoking	4.90_a (1.68)	4.67_a (1.61)	4.32_b (1.87)	$4.38_{a,b}$ (1.95)
Perceived Influence	4.04_a (1.8)	3.79_a (1.65)	3.53_a (1.74)	3.54_a (1.83)
Policy Support	4.44_a (1.78)	4.73_a (1.52)	4.69_a (1.53)	4.80_a (1.54)

Note. All secondary outcomes were measured on seven-point Likert scales ranging from 1 to 7. Means with differing subscripts within rows are significantly different following Bonferroni adjustment.

Exploratory Analysis

In an additional exploratory analysis, we sought to establish whether the impact of traffic light labels on the hypothetical selection of meat meals differed depending on participants' age, gender, socioeconomic status, BMI, meat reduction efforts, current consumption, and environmental risk considerations. The age, meat reduction, current consumption, and environmental risk consideration variables were centred, the social grade variable was dummy coded (low social grade: $D_4 = 1$, $D_5 = 0$; medium social grade: $D_4 = 0$, $D_5 = 0$; high social grade: $D_4 = 0$, $D_5 = 1$), and gender and BMI were effect coded (female = 1, not female = -1; overweight or obese = 1, underweight or healthy = -1). We performed a beta-regression entering all main effects as well as the two-way interactions between the moderators and the condition dummies as predictors of the proportion of meat meals selected. Table S2 (see Appendix V) shows the full model estimates.

Current Consumption

The analysis revealed that participants with higher (*vs*. lower) current consumption also selected a higher proportion of meat meals in the decision task (Ms_{Observed} = 0.742 *vs*. 0.510; SEs_{Observed} 0.011 *vs*. 0.010), $p_{\text{Bonferroni-adjusted}} < .001$. However, no moderating effect was found.

Meat Reduction Efforts

In addition, participants who reported lower (*vs*. higher) meat reduction efforts also selected meat meals more frequently (Ms_{Observed} = 0.725 *vs*. 0.466; SEs_{Observed} 0.009 *vs*. 0.010), $p_{\text{Bonferroni-adjusted}} < .001$. No moderating effects were found for meat reduction efforts.

Environmental Risk Consideration

Environmental risk considerations moderated the effect of the red labels on meat meal selection, $p_{\text{Bonferroni-adjusted}} = .001$. Follow-up analysis indicated that red traffic light warning labels impacted meat meal selections for participants with high ($\bar{x}$ +1SD) environmental risk considerations, *coeff* = -0.762, *SE* = 0.171, $p < .001$. $p_{\text{Bonferroni-adjusted}} < .001$, but not for participants with low ($\bar{x}$ -1SD) environmental risk considerations, *coeff* = 0.084, SE = 0.170, $p = .620$, $p_{\text{Bonferroni-adjusted}} > .999$ (see Appendix V, Figure S4). As indicated by the primary analysis, red warning labels impacted meat meal selections for participants with average ($\bar{x}$) levels of environmental risk considerations, although this effect did not pass the threshold of significance in the exploratory analysis after applying stringent Bonferroni corrections, *coeff* = -.339, *SE* = 0.137, $p = .013$, $p_{\text{Bonferroni-adjusted}} = .475$. No other significant effects were found, $ps_{\text{Bonferroni-adjusted}} > .506$.

Discussion

Summary of Results

In a randomised online experiment testing the impact of environmental traffic light warning labels on meat meal selection amongst a representative sample of UK meat consumers we found that labelling meat products with a red-only label or a red/orange/green (ROG) label significantly decreased the hypothetical selection of meat meals when compared to a control group where no labels were shown. When presented as a percentage change, a red-only label on meat reduced hypothetical selection of meat meals by 9.2%, whilst a ROG label on all products reduced hypothetical meat meal selection by 9.8%. There was no evidence that the implementation of the green-only label on vegetarian and vegan products impacted hypothetical meat meal selection. There was also no statistically significant difference between the red-only condition and the red/orange/green (ROG) condition, meaning the two types of labelling lowered the hypothetical selection of meal meals to a similar extent.

When comparing the three labels implemented within this study, we found that the red environmental traffic light warning label induced a significantly higher level of self-reported negative emotional arousal than the orange or green labels, and it also captured significantly more attention than both the green and orange labels. The red label was also deemed more thought-provoking than the green label on veggie meals. The labels did not differ on measures of label credibility, perceived influence, or how supportive the public would be of such labelling as potential future policies. None of the labels impacted the perceived appeal or the perceived environmental damage of the meals they were presented alongside, nor did they influence participants' expressed likelihood of purchasing or consuming the meals in the near future.

Exploratory analyses demonstrated those who reported consuming less meat and those putting more effort into reducing their meat consumption selected meat meal options less frequently. More pertinent to the present discussion, the influence of the red labels on meat meal selection was moderated by environmental consideration. The higher a participant's consideration of the environment when making food choices the more effective the red-only label was. This suggests a potential for synergies between labelling interventions on food items with a high environmental impact and other interventions that increase consumers' environmental considerations. Why environmental considerations only moderated the effectiveness of the red-only label but did not moderate the effectiveness of the green-only or ROG labels remains unknown. Future research should seek to replicate and shed further light onto these novel findings.

Relationship to Extant Literature

The present research demonstrates the potential value of combining the two popular labelling designs of traffic light labels, predominantly found signalling nutritional content (Croker et al., 2020), and warning labels commonly used on tobacco products in the UK (Hammond, 2011; Noar et al., 2016), for highlighting the environmental impact of meat meals. The finding that red environmental traffic light warning labels significantly reduced hypothetical meat meal selection complements some research within the field of eco-labelling focused on more sustainable meal selection. Potter et al. (2022) found their eco-labels led to a reduction in the environmental impact of meal selections, but did not specify what proportion of that came from switching to lower impact meat choices or from a shift away from meat. Another study by Slapø and Karevold (2019) used symbols on menus to denote meat dishes as high in CO_2, fish dishes as medium in CO_2, and vegetarian dishes as low in CO_2. The study found some tentative evidence that presenting ROG symbols on menu items reduced meat meal selection, whereas red symbols on menu items did not impact meat meal selection. However, conclusions from this study were hampered by the relatively small number of meals sold. Importantly, the study also employed traffic light symbols on menus as opposed to traffic light labels on products. Finally, while Slapø and Karevold (2019) employed text descriptors, those descriptors were not warning messages. Future research should investigate the potential impact of these methodological variations.

Another important finding of our research is that the single-colour unified label on favourable products, a green-only label, placed on vegetarian and vegan products had no detectable effect on hypothetical meat meal selection. This is congruent with the findings of Slapø and Karevold (2019) where 'single green' symbols on menus did not reduce meat meal sales in a university cafeteria setting. This dovetails previous work showing that highlighting the products which have a worse environmental impact can affect the purchasing preferences of consumers more strongly than labelling environmentally friendly options (Grankvist et al., 2004; Van Dam & De Jonge, 2015). Our finding that the use of a red label promoted a shift away from unhealthy and environmentally damaging behaviour aligns with multiple previous studies (Brunner et al., 2018; Potter et al., 2021; Scarborough et al., 2015), thereby adding to a growing body of evidence that a focus on negatively framing undesirable characteristics may be a more effective persuasion tactic than positively framing the beneficial attributes of alternatives. This could explain why warning labels carrying negatively framed messages were found to impact meat selection in a hypothetical online choice task similar to the one employed in the present study (Hughes et al., 2023), but warning labels carrying positively framed messages failed to impact meat consumption in a real-world dining hall setting (Vasiljevic et al., 2024). This converges with a large body of research that has uncovered asymmetries in the impact of positive and negative information on judgement and behaviour (e.g., Ito et al., 1998; Kahneman & Tversky, 1979; Norris, 2021; Vasiljevic et al., 2015).

In line with previous research into the impact of warning labels and the mechanisms behind the effectiveness of traffic light labelling, we found that red labels were perceived to be more emotionally arousing and attention-grabbing than other labels. This dovetails previous work showing that traffic light labels induce more negative emotion as they move from green to red (Sánchez-García et al., 2018).

Red labels were also found to be more thought provoking, perhaps prompting participants to think more about the climate impact of meat. This would align with existing research suggesting that eco-labels can increase consumers' awareness of the environmental impact of their purchasing decisions by making them consider the sustainability of the product they are purchasing (Giacomarra et al., 2021). On the other hand, we found no evidence that the addition of traffic light warning labels impacted the perceived environmental damage of the meals, despite the labels effectively changing meat-meal choice. This could suggest that the behavioural impact of the labels operates outside of conscious awareness, perhaps via a stop-go mechanism associated with traffic light labelling (Elliot & Maier, 2007; Mehta & Zhu, 2009; Schuldt, 2013; Zhang et al., 2020).

Strengths, Limitations, and Future Research

This research is the first to test the effectiveness of a combined traffic light and warning label design in reducing meat meal selection in an online cafeteria setting, probing multiple plausible variations of the labels in a large sample of UK adult meat eaters, and using a randomised controlled trial methodology. Changing meat-related consumption habits can be challenging (Taillie et al., 2021; Verplanken & Whitmarsh, 2021). Using a robust methodology and design, the present work provides some initial support that traffic light warning labels, specifically a red-only or red/orange/green (ROG) label, such as the ones tested in this research, may be impactful for future implementation.

The present study goes further than other similar studies that assess the impact of labels purely through self-reported intentions on a Likert scale without asking participants to make specific choices (Pancer et al., 2017). This is important as there is often a disconnect between people's intentions and behaviours (Sniehotta et al., 2005).

This study assessed participants' meal selection choices within an online task. Consequently, there may be differences in results when attempting to implement the labels in real-world settings. Additional research in real-world cafeterias, restaurants, or other similar settings will be needed to further test the effectiveness of the labels examined in this study.

To gain a further understanding of how the impact of the labels may vary between individuals, additional moderators should be investigated. Such individual difference variables may include people's perceived impact of consuming meat on the environment, or their attachment to meat-based products and meals.

Finally, our study can only speak to the effectiveness of traffic light warning labels presenting unified information regarding the environmental impact of various meal options. Future research should explore combining warning labels with other traffic light systems (see Figure 1, for an overview).

Implications for Future Policy and Practice

The present research provides initial evidence that traffic light warning labels may be useful to shift UK meat consumption levels towards the recommended 20% reduction proposed by the Intergovernmental Panel on Climate Change (IPCC, 2022). The evidence base currently suggests that highlighting the drawbacks of consuming meat via negatively framed traffic light warning labels may be more effective at dissuading the selection and consumption of meat than highlighting favourable aspects of substitutes for meat.

Importantly, participants were not opposed to the introduction of traffic light warning labels as a potential national policy, and the labels did not impact the perceived appeal of any of the meals. This cautiously suggests that, pending further research, traffic light warning labels may be a palatable intervention for government policy. This dovetails research showing that labelling is the most acceptable governmental policy amongst an array of different governmental policies across different behavioural domains (incl. alcohol consumption, snack consumption, and tobacco use) (Reynolds et al., 2019). Furthermore, amongst policies specifically aimed at reducing meat consumption, labelling was found to be the most supported policy amongst a sample of the UK public (Pechey et al., 2022).

Conclusion

A multi-colour (ROG) unified label on all products with a warning text, and a single-colour (red only) unified label on unfavourable products with a warning text, both effectively reduced hypothetical meat meal selection. In contrast, there was no evidence that a single-colour (green only) unified label on favourable products with a text descriptor influenced participants' meat meal selection. The labels appeared to be moderately acceptable to meat eaters, who did not think the labels impacted the appeal of the products. It remains for future research to probe the effectiveness and acceptability of traffic light warning labels in real-life settings.

Figure and Box Captions:

Figure 1.

Overview of different types of Traffic Light Labels used in environmental and nutrition decision making tasks.

(Note to appear below Figure 1)
Note: This figure is an illustrative, non-exhaustive selection of label combinations. While it includes seminal and pivotal labels from multiple studies, it omits some combinations, such as a conceptually unlikely "single colour label on all products." Labels shown are representative examples that may vary in design. Environmental and Nutrition label studies are distinguished by blue and pink fill boxes, respectively.

Box 1.

Study design using wellington meal option to illustrate the four experimental between-subjects groups.

(Note to appear below Box 1)
Note. Beef Wellington image taken from pxhere.com; other wellingtons are AI generated. Images are representative of the actual images used in the study, which cannot be displayed for copyright reasons. For original images contact the corresponding authors. Labels are original designs by the research team.

Figure 2.

CONSORT Flow Diagram.

Figure 3.

Meat meal selection proportions across all 20 trials across the four experimental groups presented in a raincloud plot.

Declarations

Ethical Statement

Ethics approval for this research was granted by the Ethics Committee of the Department of Psychology at Durham University (PSYCH-2020-10-19T14_10_29-tpfj36). Participants were provided with an information sheet outlining the details of the study before participation. They were informed of their right to withdraw at any point during or after the study and were assured that all collected data would be anonymous and confidential. After reading the information sheet they provided informed consent. Participants were fully debriefed about the aims of the study at the end.

CRediT authorship contribution statement

Jack P. Hughes: Conceptualisation, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Writing – original draft, Writing – review & editing. **Mario Weick:** Conceptualisation, Formal analysis, Investigation, Methodology, Project administration, Resources, Supervision, Writing – original draft, Writing – review & editing. **Milica Vasiljevic:** Conceptualisation, Formal analysis, Investigation, Methodology, Project administration, Resources, Supervision, Writing – original draft, Writing – review & editing.

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Availability of data

The dataset and associated codebook are available within the OSF project folder:

https://osf.io/gm3pr/?view_only=6b1cc6152ee448e990f643b06b429391

Declaration of competing interest

None.

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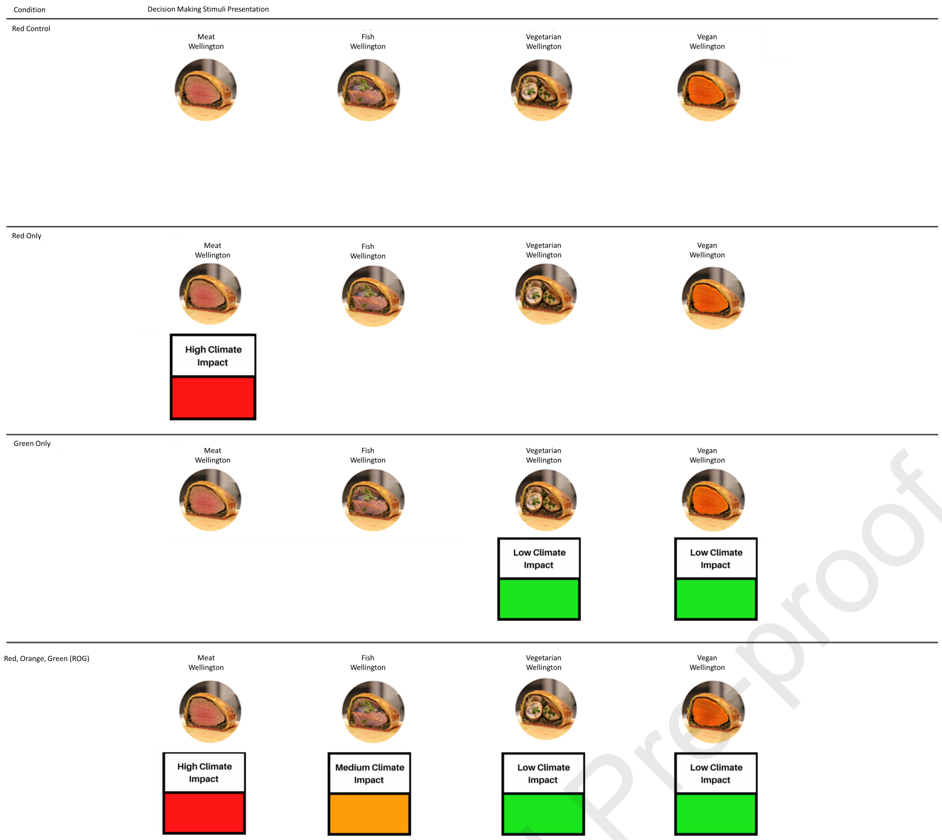
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Green Only
Meat Wellington
Fish Wellington
Vegetarian Wellington
Vegan Wellington
Low Climate Impact
Low Climate Impact
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Vegan Wellington
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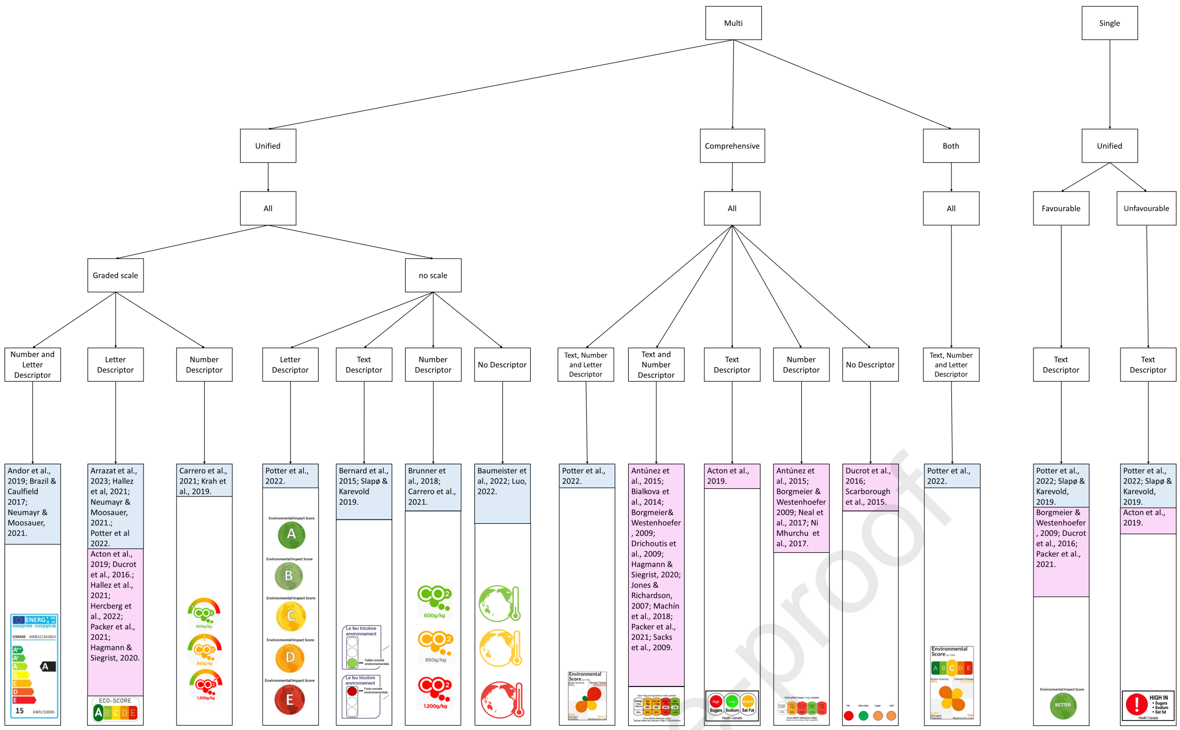
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Andor et al., 2019; Brazil & Caulfield 2017; Neumayr & Moosauer, 2021.
Arrazat et al., 2023; Hallez et al, 2021; Neumayr & Moosauer, 2021.; Potter et al 2022.
Acton et al., 2019; Ducrot et al., 2016.; Hallez et al., 2021; Hercberg et al., 2022; Packer et al., 2021; Hagmann & Siegrist, 2020.
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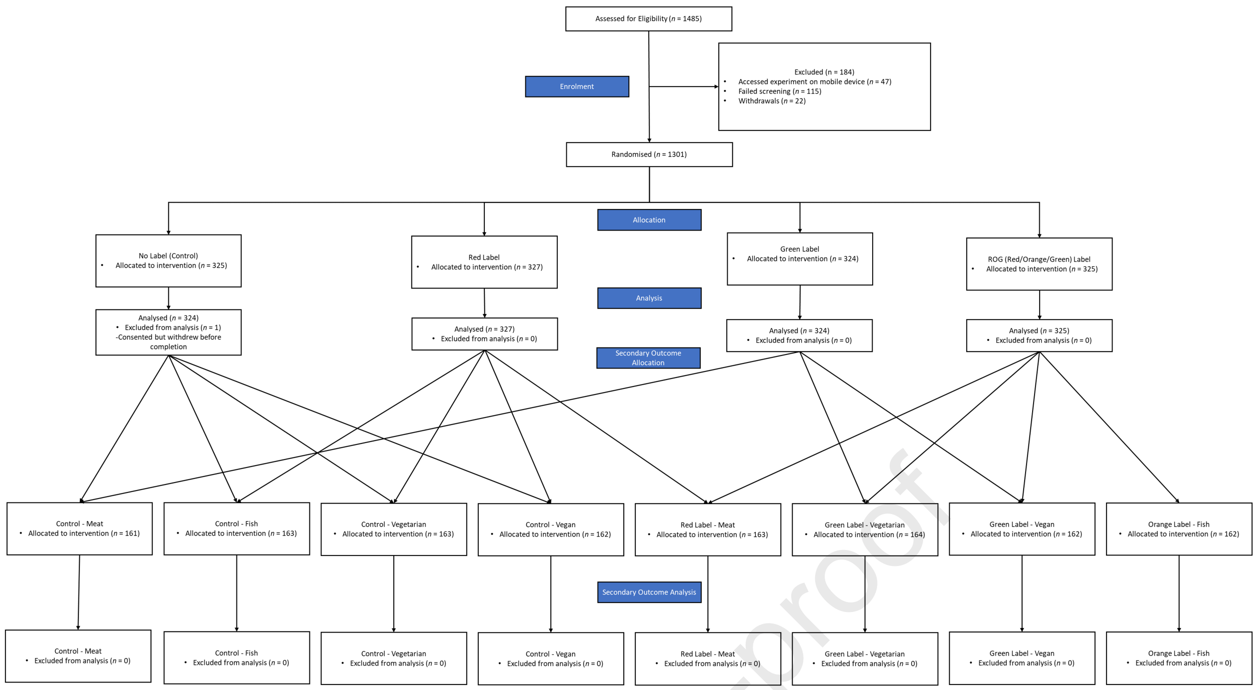
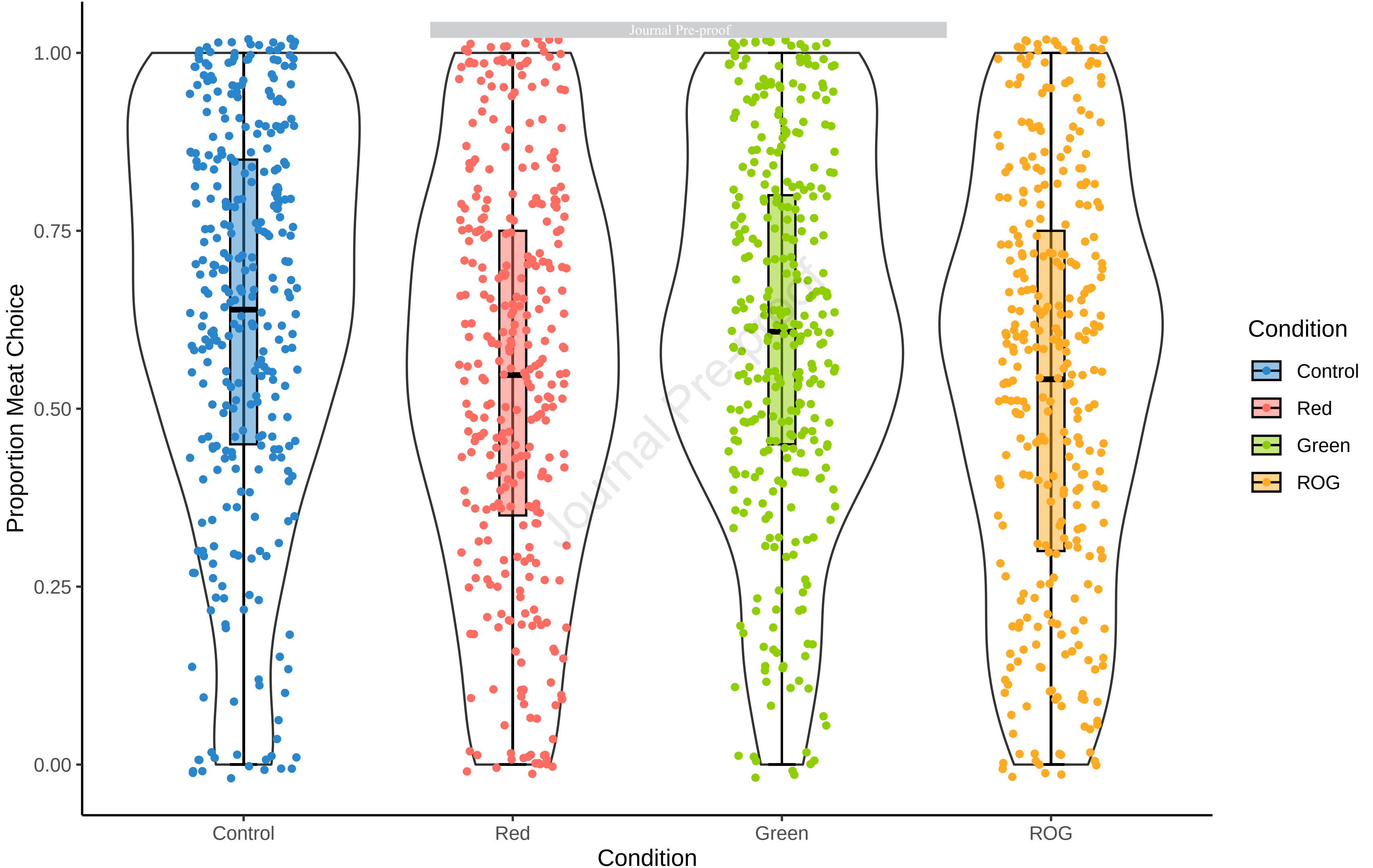
Baumeister et al., 2022; Luo, 2022.
Potter et al., 2022.
Antúnez et al., 2015; Bialkova et al., 2014; Borgmeier& Westenhoefer, 2009; Drichoutis et al., 2009; Hagmann & Siegrist, 2020; Jones & Richardson, 2007; Machín et al., 2018; Packer et al., 2021; Sacks et al., 2009.
Acton et al., 2019.
Antúnez et al., 2015; Borgmeier & Westenhoefer 2009; Neal et al., 2017; Ni Mhurchu et al., 2017.
Ducrot et al., 2016; Scarborough et al., 2015.
Potter et al., 2022.
Potter et al., 2022; Slapø & Karevold, 2019.
Borgmeier & Westenhoefer, 2009; Ducrot et al., 2016; Packer et al., 2021.
Potter et al., 2022; Slapø & Karevold, 2019.
Acton et al., 2019.
ECO-SCORE
Environmental Impact Score
Environmental Score
BETTER
HIGH IN
Health Canada


Assessed for Eligibility (n = 1485)
Enrolment
Excluded (n = 184)
• Accessed experiment on mobile device (n = 47)
• Failed screening (n = 115)
• Withdrawals (n = 22)
Randomised (n = 1301)
Allocation
No Label (Control)
• Allocated to intervention (n = 325)
Red Label
• Allocated to intervention (n = 327)
Green Label
• Allocated to intervention (n = 324)
ROG (Red/Orange/Green) Label
• Allocated to intervention (n = 325)
Analysis
Analysed (n = 324)
• Excluded from analysis (n = 1)
-Consented but withdrew before completion
Analysed (n = 327)
• Excluded from analysis (n = 0)
Analysed (n = 324)
• Excluded from analysis (n = 0)
Analysed (n = 325)
• Excluded from analysis (n = 0)
Secondary Outcome Allocation
Control - Meat
• Allocated to intervention (n = 161)
Control - Fish
• Allocated to intervention (n = 163)
Control - Vegetarian
• Allocated to intervention (n = 163)
Control - Vegan
• Allocated to intervention (n = 162)
Red Label - Meat
• Allocated to intervention (n = 163)
Green Label - Vegetarian
• Allocated to intervention (n = 164)
Green Label - Vegan
• Allocated to intervention (n = 162)
Orange Label - Fish
• Allocated to intervention (n = 162)
Secondary Outcome Analysis
Control - Meat
• Excluded from analysis (n = 0)
Control - Fish
• Excluded from analysis (n = 0)
Control - Vegetarian
• Excluded from analysis (n = 0)
Control - Vegan
• Excluded from analysis (n = 0)
Red Label - Meat
• Excluded from analysis (n = 0)
Green Label - Vegetarian
• Excluded from analysis (n = 0)
Green Label - Vegan
• Excluded from analysis (n = 0)
Orange Label - Fish
• Excluded from analysis (n = 0)


Proportion Meat Choice
1.00
0.75
0.50
0.25
0.00
Control
Red
Green
ROG
Condition
Condition
Control
Red
Green
ROG

Ethical Statement:

Ethics approval for this research was granted by the Ethics Committee of the Department of Psychology at Durham University (PSYCH-2020-10-19T14_10_29-tpfj36). Participants were provided with an information sheet outlining the details of the study before participation. They were informed of their right to withdraw at any point during or after the study and were assured that all collected data would be anonymous and confidential. After reading the information sheet they provided informed consent. Participants were fully debriefed about the aims of the study at the end.