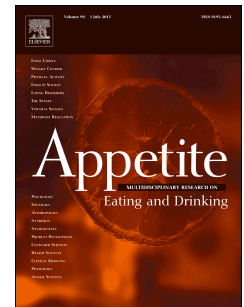


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The effect of messaging on the acceptance of swaps to reduce the energy content of snacks and non-alcoholic drinks ordered in an experimental online workplace canteen: a randomised controlled trial

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Abstract

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The effect of messaging on the acceptance of swaps to reduce the energy content of snacks and non-alcoholic drinks ordered in an experimental online workplace canteen: a randomised controlled trial

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Abstract

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Key words: Food-swaps; lower-energy; Physical Activity Calorie Equivalents (PACE); workplace; canteen; online RCT.

1. Background

Overweight and obesity affect about 40% of adults globally and increase the risk of morbidity and mortality (World Health Organisation, 2020). Excess energy intake is a leading determinant of weight gain. Modelling studies indicate that reducing energy intake or increasing energy expenditure by just 50-100 kcal per person per day would be sufficient to offset weight gain at the population level (Hill, 2003; Rodearmel et al., 2007). Offering swaps has been shown to successfully reduce the saturated fat (Koutoukidis et al., 2019) and salt (Payne Riches, Aveyard, Piernas, Rayner, & Jebb, 2019) content, but not the energy density, of grocery baskets in experimental online settings (Forwood, Ahern, Marteau, & Jebb, 2015). Previous research has also pointed to the potential for category-specific effects of swaps. Findings from a recent study indicated that swaps for cheese, butter, and sweets and desserts may have been more acceptable than those for milk or meat (Koutoukidis et al., 2019). Offering swaps for discretionary items, such as snacks and high-energy drinks, may be a promising strategy to achieve improvements in overall dietary quality and, importantly, be part of successful strategies to achieve a daily 50-100 kcal reduction at the population level. Workplace canteens with pre-ordering systems might be particularly suitable environments to ensure such interventions have wide reach, because more than one third of calories are consumed in the workplace (Vasiljevic et al., 2018).

When considering methods to encourage people to accept suggested food and drink swaps, the messaging and framing around the prompt may influence the choices made. Energy savings yielded from the acceptance of lower-energy swaps will range in size depending on the nature of the originally selected item and the suggested alternative. If energy savings are perceived as small (often the case when focusing on discretionary items where the suggested alternative is matched as closely as possible on taste and price), a message highlighting the exact amount of energy saved may discourage consumers from accepting the swap offered. Consumers may decide that the cost

75 of forgoing the rewarding taste of their chosen item is not worth the small energy saving. In this
76 case, a message simply stating that the swap contains fewer calories may be most effective.
77 However, vague information may be less salient and, therefore, more difficult to process (Higgins,
78 1996; Wilson, Buckley, Buckley, & Bogomolova, 2016) than a message quantifying the exact
79 amount of energy saved, even if small.

80 Providing consumers with information on the exact energy content of items (i.e. calorie labelling),
81 has shown mixed efficacy. A Cochrane systematic review and meta-analysis concluded that calorie
82 information on menus may reduce calories ordered but this was based on low-quality evidence
83 (Crockett et al., 2018). The limited efficacy of calorie labelling to influence consumer choice has
84 prompted researchers to test strategies for enhancing its potential effect.

85 One such strategy is to translate calories into more salient and interpretable information, such as
86 physical activity calorie equivalents or 'PACE' labels (Blumenthal, 2010; Fitch et al., 2009). PACE
87 labels provide information on the amount of physical activity that would be required to expend
88 the energy contained in a food or drink. PACE messages also have the benefit of reminding
89 consumers to stay active (Royal Society of Public Health, 2016). PACE labels on product packaging
90 and menus significantly reduce calories consumed when other labelling formats and no labels
91 were the combined comparator (Daley, McGee, Bayliss, Coombe, & Parretti, 2020). Accompanying
92 suggested swaps with PACE messaging might, therefore, enhance the overall effectiveness of a
93 swap-based intervention. While previous studies have examined the benefit of suggesting swaps,
94 this has been tested neither in a pre-ordering context nor accompanied by information perceived
95 as more or less tangible.

96 The aim of this trial was to examine whether incrementally increasing the tangibility of
97 information provided increased the acceptance of swaps offered. We tested the effect of three

calorie-focused messages (a vague calorie message, an exact numeric-calories message, and a PACE message) on the acceptance of lower-energy swaps offered within the context of an experimental online workplace canteen. Given the potential for category-specific effects of swaps offered, we examine swap acceptance separately for each product category; sweet snack, savoury snacks and non-alcoholic drinks.

2. Methods

2.1 Design and setting

This was a prospectively registered (AsPredicted: 32783) 4-arm randomised controlled trial conducted in a simulated online canteen developed using REDCap (Research Electronic Data Capture), an electronic data capture tool hosted at University College London (Harris et al., 2009). The design of the platform was based on a custom-made simulated online supermarket platform, used in previous studies (Forwood et al., 2015; Koutoukidis et al., 2019) but was adapted to emulate an online canteen for pre-ordering (Additional file 1, pg. 6).

The online canteen pre-ordering system was a website that displayed the canteen's menu of sweet snacks (n=17), savoury snacks (n=9), and drinks (n=25) and allowed employees to hypothetically pre-order their drink and snacks for the workday. Menu items were selected by searching through the sweet snack, savoury snack and non-alcoholic drinks sections of the websites of three major UK retailers; Tesco, Sainsbury's, and Waitrose. Higher energy items were selected and paired with lower-energy equivalents meeting the energy reduction threshold described in Section 2.5. Items were only selected if they were (i) widely available and commonly consumed in the UK and (ii) sold individually packaged and as a single serving (Additional file 1, pg. 9).

2.2 Participants

Participants were recruited between December 2019 and January 2020 through Prolific Academic, an online participant sourcing platform (Palan & Schitter, 2018). Participants were pre-screened by Prolific Academic for eligibility, and invitations were sent to a random subsample of a pool of 9,356. Invitation and response rates are not recorded by the platform, therefore, this information was unavailable. Participants were eligible if they lived in the UK, spoke English fluently, were aged between 18 and 65 years and were in full or part-time employment. The employment and age requirements were in place to help us recruit a sample similar to the target population of the intervention. People were not eligible if they were following any restricted diet, such as a vegan, dairy-free, sugar-free, or gluten-free as this would influence the appropriateness of swaps offered. A link to the study appeared on the Prolific Academic dashboard of eligible participants. Interested participants were directed to a survey platform via the link where they could read the information sheet and provide consent by ticking a box.

2.3 Randomisation & blinding

Simple randomisation was performed using the survey platform SmartSurvey which automatically randomised participants (1:1:1:1) by allocating them with a random integer between 1 and 4, corresponding to each of the four trial arms. Investigators were not blinded to intervention allocation, but they were not able to manipulate any study parameters following the initial study set up, as all study procedures took place in the online platform (see Additional file 1, pg. 8).

2.4 Online ordering task

Following randomisation, participants were redirected to REDCap where they completed a short demographic survey. The survey collected information on gender, age, ethnicity, education, and income. Eligibility questions regarding employment status and dietary restrictions were also included to ensure participants met the eligibility criteria at the time the task was completed (i.e.

to account for any changes in status not updated in Prolific Academic's system). After completing this questionnaire, participants were directed to the online canteen which presented the following vignette: "We'd like you to imagine that you arrive at work on Monday morning to receive this email... *Hi Team, We've set-up a new online ordering system for the canteen. Please login to your account and choose your drink and snacks for today. The canteen will have your order ready for collection. Thank you, The Canteen Manager*". After reading this, participants were asked to select 3 items (one sweet snack, one savoury snack, and one drink) that they would like to consume during their working day. Table 1 provides a summary of each menu, for complete menus see Additional File 1 (pg. 25). Participants were offered swaps to alternative products from those originally presented if a suitable swap was available.

Table 1: Summary of menus with examples of swaps offered for initially selected items in each category. The proportion of swaps available, means and variance of energy content (in kcal) by menu is also provided.

Menu	Type of items offered	Initially selected item	Swap offered	% Swaps available	Mean (range) energy kcal
Sweet (n=17)	1.Chocolate bar 2.Biscuit 3.Muffin 4.Flapjack 5.Cereal bar 6.Fruit	1.Cadbury Dairy Milk (240 kcal) 2. Cadbury Dairy Milk Buttons (160 kcal)	1.Cadbury Dairy Milk Buttons (160 kcal) 2. Apple & grape snack pack (45 kcal)	94% (16/17)	195 kcal (45-393 Kcal)
Savoury (n=9)	1.Crisps 2.Nuts/trail-mix 3.Vegetable snack	1.Kettle Chips Salt and Vinegar (204 kcal) 2. Popchips Salt & Vinegar (95 kcal)	1. Popchips Salt & Vinegar (95 kcal) 2. Carrot sticks (17 kcal)	89% (8/9)	157 kcal (17-250 Kcal)
Drinks (n=25)	1.Carbonated Soft Drink 2.Still & Juice Drink 3.Fruit Juice 4.Sports & Energy Drink 5.Water	1. Oasis Summer Fruits (86 kcal) 2. Oasis Summer Fruits Zero (17 kcal)	1. Oasis Summer Fruits Zero (17 kcal) 2. No swap offered	48% (12/25)	76 kcal (0-237 kcal)

2.5 Swaps offered

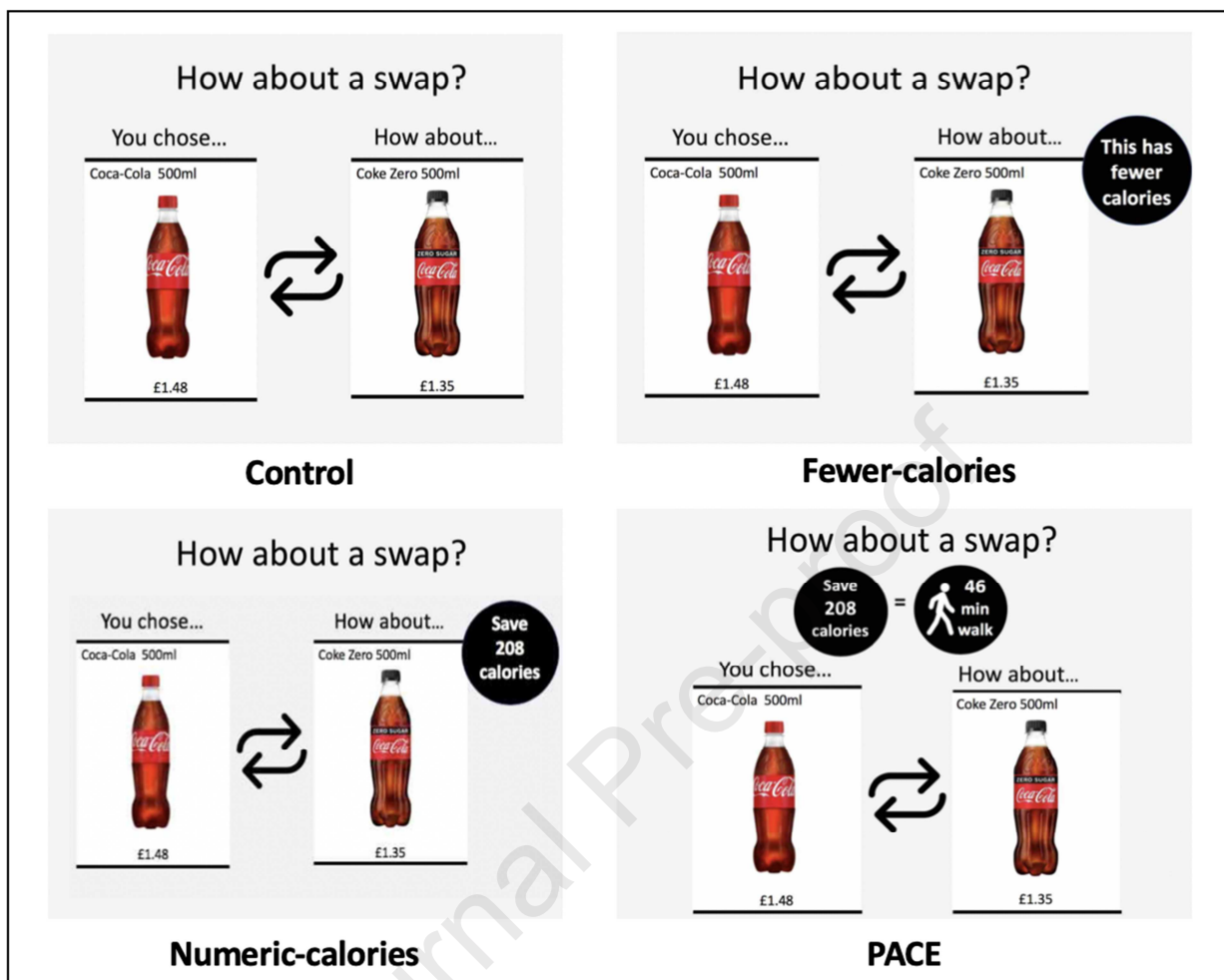
Potential swaps were created by identifying high-energy snacks (e.g. Hula Hoops) and pairing them with lower-energy alternatives (e.g. Walkers Baked crisps). Swaps offered were at least 50 kcal lower than the originally selected item. This calorie threshold was based on evidence that identified a 50-100kcal reduction per-person per-day as being clinically relevant (Hill, 2003; Rodearmel et al., 2007). Swaps offered were as close in nature to the originally selected item as possible. Some participants were offered chopped ready-to-eat fruit or carrot sticks (i.e. a dissimilar swap) if a more similar swap was not available. Swaps offered for drinks were almost always the lower-energy version of the originally selected drink (e.g. Coke Zero for Classic Coca-Cola). A lower-energy alternative existed for 63% of products (92% of snacks and 50% of drinks). Participants were offered swaps immediately after making each selection. Participants could decline or accept the swap by clicking either “No, I will stick with my choice” or “Yes, I would like to swap” (Additional file 1, pg. 9,10).

2.6 Interventions

Participants were randomly allocated to receive one of the following messages when swaps were offered (Figure 1):

- Control: “How about a swap?”
- Fewer-calories: “How about a swap? This has fewer calories”.
- Numeric-calories: “How about a swap? Save [x] calories”.
- PACE: “How about a swap? Save [x] calories = [y] min walk”.

178 **Figure 1:** An example of the intervention when a Coca-Cola was selected.



179

180 2.7 Post-trial survey

181 At the end of the trial, participants completed a short exit survey. The exit survey was used to
 182 explore the acceptability of the intervention and the messages accompanying the intervention. To
 183 measure acceptability, participants were asked to indicate the extent to which they agreed with
 184 the following statement: "I would find being offered swaps for my food choices in my workplace
 185 canteen acceptable". To assess beliefs about future behavioural consequences participants in the
 186 three intervention groups were then asked to indicate the extent to which they agreed with the
 187 following statement: "The calories message would make me want to count calories excessively".
 188 Participants in the PACE group were also asked about the extent to which they agreed with the
 189 following statement "The physical activity message would make me want to exercise excessively".

Response options were on a scale from 1 (strongly disagree) to 5 (strongly agree). Finally, participants completed the Dietary Intent Scale (Stice, Shaw, & Nemeroff, 1998), a 9-item measure of dietary restraint. Upon completion, participants were debriefed and reimbursed with £0.50 for their participation. The protocol (Additional file 1) was implemented without changes and the CONSORT checklist is available in Additional file 2.

2.8 Primary outcomes

We decided a priori to analyse the three product categories separately because previous research has pointed to variation in average swap acceptance by the type of product (Koutoukidis et al., 2019). Comparison of:

- (a) Acceptance of swaps offered between groups separately for each of the three categories (i) sweet snacks (ii) savoury snacks and; (iii) drinks.
- (b) The energy (kcal) of ordered products between groups for those offered swaps separately in each of the three categories (i) sweet snacks (ii) savoury snacks (iii) drinks.

2.9 Secondary outcomes

- (a) The difference in the total energy (kcal) of products finally ordered between groups across the three categories combined.
- (b) The difference in the total energy (kcal) between products finally ordered and those initially selected in the whole sample.
- (c) The difference in acceptability of the intervention between each of the groups.

2.10 Exploratory outcomes

- (a) Difference in the belief about future excessive calorie counting between groups.

(b) Belief about future excessive physical activity and; the acceptability, helpfulness and appropriateness of the PACE message in the PACE group.

Methodological details of additional secondary and exploratory outcomes can be found in Addition File 1 pg. 16.

2.11 Sample size

The study would require 807 participants per arm to detect a 5.5 percentage point (based on a pilot study we conducted details of which can be found in Additional File 1 pg. 14) or greater difference in the proportion of participants accepting a swap between groups (22.5% compared to 17%) at the 5% level. We used the minimum widely acceptable and widely used power cut-off in clinical trials of 80% (Cook et al., 2018). To account for participants not being offered a swap, this number was inflated by 15% bringing the target sample size to a total of 3,712. This sample size will also be sufficiently powered to detect a 10kcal difference in primary outcome (b) with 80% power at a Bonferroni-adjusted 0.85% level (see Additional file 1, pg. 13). This minimum detectable effect size was selected based on previous research that a persistent daily 10kcal change would lead to significant changes in weight over time (Hall et al., 2011).

2.12 Statistical analysis

Data was analysed based on a pre-specified statistical plan (AsPredicted: 32783). To be included in the study, participants had to meet the eligibility criteria and complete the ordering task (i.e., order a sweet snack, a savoury snack, and a drink). There was some missing data for the post-trial questions [i.e., exploratory outcomes (a) and (b)], because these questions were added later in the data collection process. We did not impute missing data as the dropout rate was small (3.7%) and there was no evidence of differential attrition. There were 37 participants (1%) who were not offered any swaps because they initially selected the lowest energy items in all three product

categories. These participants were excluded from all analyses except for the analysis of secondary outcome (b) because this outcome examines differences in total energy ordered for the sample as a whole. For all other outcomes, only those offered swap were included in the analyses because these outcomes are related to prompts to swap. As the primary analyses were conducted separately for each product category, only those offered a swap within the relevant category were included (Figure 2).

Primary outcome (a) was analysed using logistic regression. A series of regressions were run within each category, changing the reference group to allow us to examine differences between the intervention groups as well as comparing each of these to the control. Primary outcome (b) was analysed using a one-way analysis of covariance (ANCOVA) adjusting for the energy content of the initially selected item. Post-hoc tests were run.

Secondary outcome (a) was analysed using ANCOVA in the same way as primary outcome (b).

Secondary outcome (b) was analysed using a paired t-test and secondary outcome (c) was analysed using ANOVA with post-hoc tests. When reporting proportions, Likert scale ratings of 4 or 5 were considered agreement with the statement.

Exploratory outcome (a) was analysed using ANOVA with post-hoc tests. Exploratory outcome (b) was analysed descriptively. Likert scale ratings of 4 or 5 were considered agreement with the statement.

Primary analysis (a) was repeated including the ineligible participants that completed the study, as a sensitivity analysis (Additional File 3, Table 34). Although post-hoc adjustments are not required when making pre-defined comparisons (Li et al., 2017), a conservative approach was taken.

Statistical significance was set at $P < 0.05$, adjusted with Bonferroni correction for the ANCOVA and ANOVA models. For consistency, statistical significance was set at $P < 0.008$ only in the logistic

257 regression models. Estimates of comparative effectiveness are reported as either odds ratios or
258 mean differences with 95% confidence intervals (CI). Statistical analyses were conducted in Stata
259 (version 13) or SPSS (version 25).

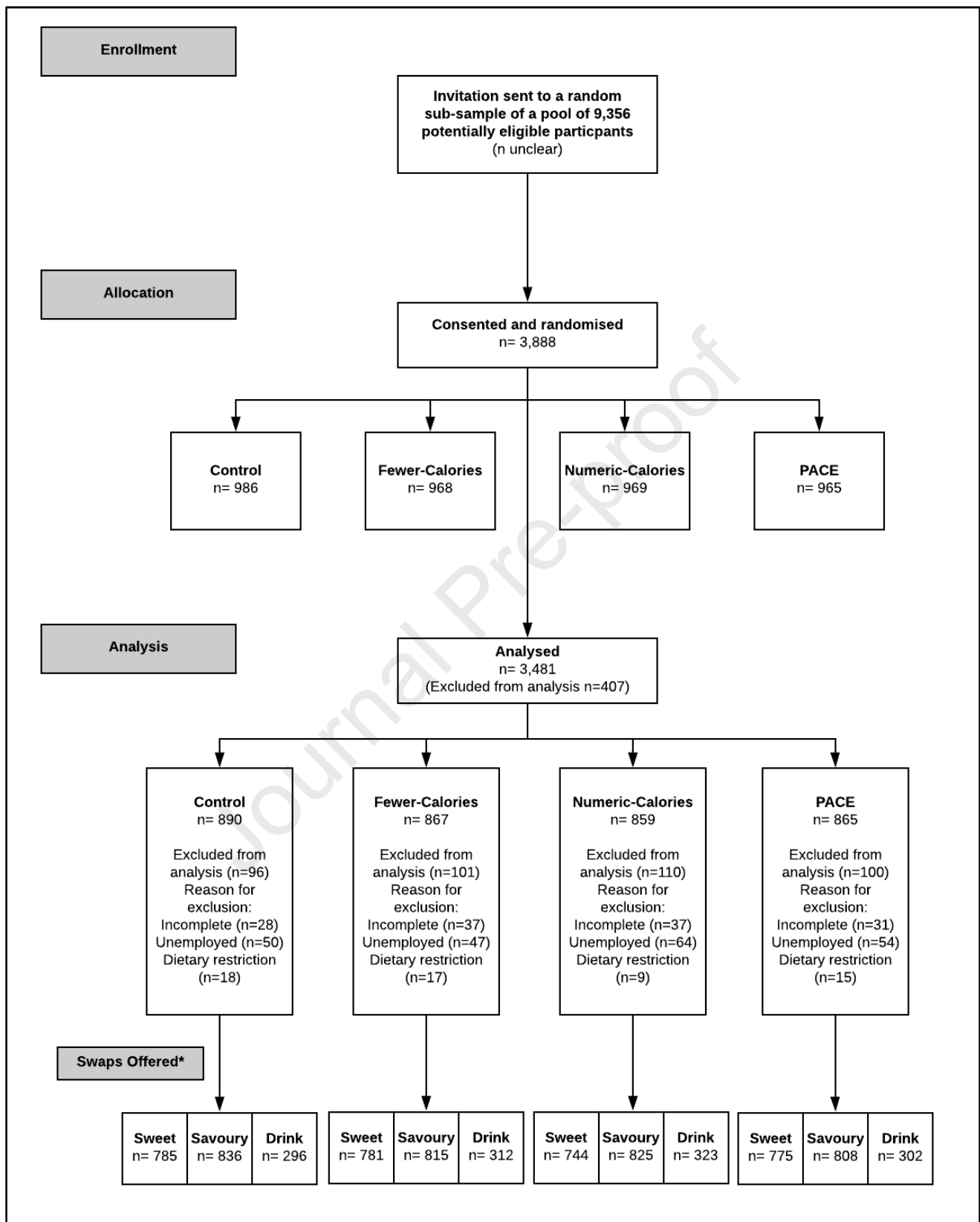
260

261 **3. Results**

262 Out of the 9,356 participants deemed eligible by Prolific Academic, 3,888 (42%) participants
263 consented and were randomised to one of four groups. Of those, 3,481, 90% of participants were
264 included in the analysis (Figure 2).

265

266 **Figure 2:** CONSORT Flow diagram



267

268 ***Note:** The swaps offered section above provides a breakdown of the number of participants in each group
 269 that were offered swaps for their initial selections in each product.

270

Participants were on average 35.6 (SD = 10.5) years old. Just under two-thirds (63%) of the sample was female, 91% identified as white, and 61% had completed some form of tertiary-level education. About half (51%) of the sample had an annual salary in excess of £25,000. Average completion time for the study was 4 minutes 8 seconds (SD= 1m 9s) and attention checks showed sufficient engagement with the task (Additional file 3, Tables 1-2).

Table 2: Baseline characteristics of trial participants.

	Control (n = 890)	Fewer- calories (n = 867)	Numeric- calories (n = 859)	PACE (n = 865)	Total (n = 3,481) n (%)
Age, years, mean \pm SD	35.8 \pm 10.2	35.6 \pm 10.6	35.8 \pm 10.7	35.3 \pm 10.6	
Sex, female, n (%)	586 (65.8)	558 (64.4)	515 (60.0)	548 (63.4)	2,207 (63%)
Ethnic group, n (%)					
White	815 (91.6)	780 (90.0)	779 (90.7)	779 (90.1)	3,153 (91%)
Mixed/Other	19 (2.1)	33 (3.8)	25 (2.9)	25 (2.9)	102 (3%)
Asian/Black	56 (6.3)	54 (6.2)	55 (6.4)	61 (7.0)	226 (6%)
Education, n (%)					
None-Secondary	98 (11.0)	100 (11.5)	88 (10.2)	80 (9.3)	366 (11%)
College / A-level	211 (23.7)	258 (29.8)	267 (31.1)	239 (27.6)	975 (28%)
Undergraduate	370 (41.6)	336 (38.7)	330 (38.4)	346 (40.0)	1,382 (40%)
Graduate & higher	211 (23.7)	173 (20.0)	174 (20.3)	200 (23.1)	758 (21%)
Income, n (%)					
Below £15.5K	173 (19.4)	159 (18.3)	171 (19.9)	164 (19.0)	667 (19%)
£15.5K - £25K	256 (28.8)	274 (31.6)	249 (29.0)	262 (30.3)	1,041 (30%)
£26K - £39K	301 (33.8)	257 (29.7)	256 (29.8)	264 (30.5)	1,078 (31%)
£40K or above	140 (15.7)	152 (17.5)	152 (17.7)	149 (17.2)	593 (17%)
Prefer not to say	20 (2.3)	25 (2.9)	31 (3.6)	26 (3.0)	102 (3%)
DIS score, mean \pm SD	21 \pm 7	20 \pm 7	21 \pm 7	21 \pm 7	

277 PACE: Physical Activity Calorie Equivalent; DIS: Dietary Intent Scale

278 Of the three food and drink selections made by participants, almost everyone (99%) in the sample
 279 was offered at least one lower-energy swap during the study. Table 2 shows the percentage
 280 acceptance rate of swaps across groups. Of the 7,602 swaps offered, 1,617 (21%) were accepted
 281 overall. Table 3 shows the proportion of participants in each group offered and accepting swaps
 282 for each product category.

283 **Table 3:** Number of participants offered and accepting swaps for each product category by group.

	Control (n=890)	Fewer-calories (n=867)	Numeric-calories (n=859)	PACE (n=865)	Total (n=3,481)
No swaps offered	12 (1%)	9 (1%)	7 (1%)	9 (1%)	37 (1%)
1 swap offered	109 (12%)	79 (9%)	91 (11%)	99 (12%)	378 (11%)
2 swaps offered	499 (56%)	508 (59%)	482 (56%)	485 (56%)	1,974 (57%)
3 swaps offered	270 (31%)	271 (31%)	279 (32%)	272 (31%)	1,092 (31%)
Total swaps offered	1,917	1,908	1,892	1,885	7,602
No swaps accepted	637 (72%)	553 (64%)	509 (59%)	464 (54%)	2,163 (62%)
1 swap accepted	224 (25%)	259 (30%)	269 (31%)	289 (33%)	1,041 (30%)
2 swaps accepted	28 (3%)	51 (6%)	77 (9%)	99 (11%)	255 (7%)
3 swaps accepted	1 (<1%)	4 (<1%)	4 (<1%)	13 (2%)	22 (<1%)
Total swaps accepted	283	373	435	526	1,617

284

285 **Table 4:** Number of participants offered and accepting swaps for each product category by group.

	Control	Fewer-calories	Numeric-calories	PACE	Total
Sweet snacks					
Swaps offered n	785	781	744	775	3,085
Swaps accepted n (%)	107 (14%)	144 (18%)	170 (23%)	207 (27%)	628 (20%)
Savoury snacks					

Swaps offered n	836	815	825	808	3,284
Swaps accepted n (%)	102 (12%)	149 (18%)	170 (21%)	207 (26%)	628 (19%)

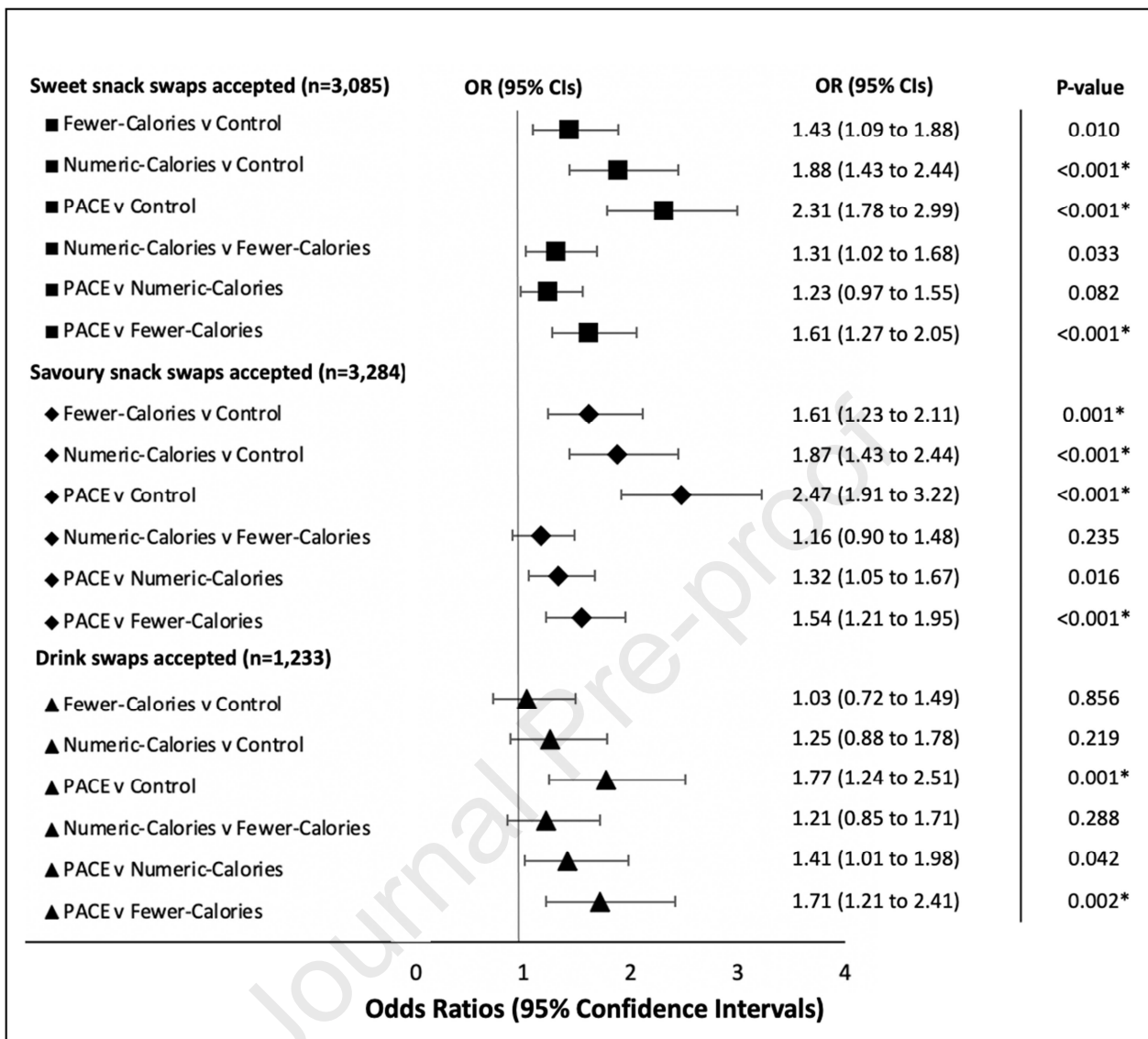
Drinks

Swaps offered n	296	312	323	302	1,233
Swaps accepted n (%)	74 (25%)	80 (26%)	95 (29%)	112 (37%)	361 (29%)

Proportions accepting swaps in parentheses. Fewer swaps were offered for drinks because a lower-energy alternative only existed for 48% of drinks on offer.

3.1 Swap Acceptance

Compared with control, the numeric-calories and PACE messages significantly increased the odds of accepting a sweet snack swap. All interventions also significantly increased the odds of accepting savoury swaps compared with control. Only the PACE message significantly increased the odds of accepting a drink swap compared with control (Figure 3). The PACE group also significantly outperformed the fewer-calories group in every swap category.

Figure 3: Odds of a sweet, savoury or drink swap being accepted by group.

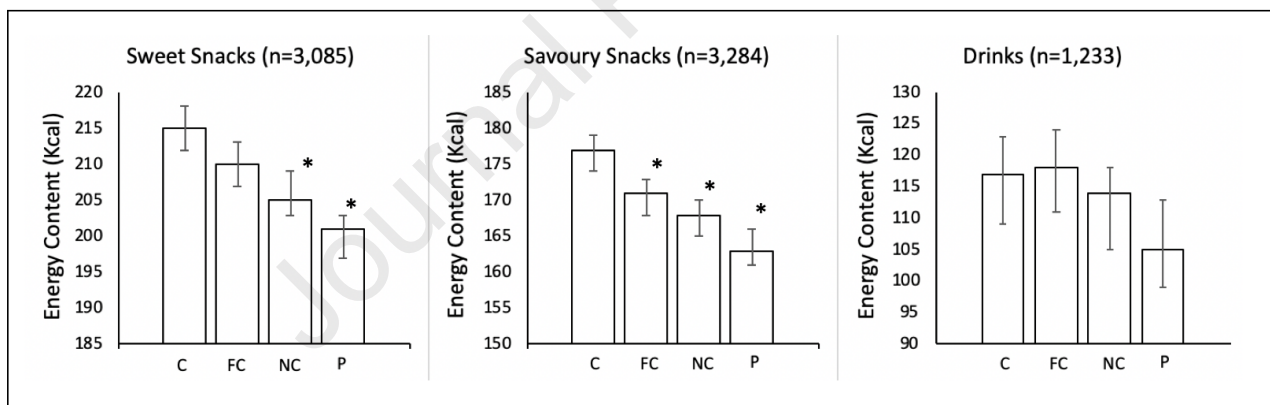
Odds ratios (OR), 95% Confidence Intervals and P-values. *P<0.008

3.2 Energy content

Regarding the energy content of sweet snacks ordered, both the numeric-calories messaging and the PACE messaging significantly reduced the energy content of sweet snacks ordered compared with control (mean=215 kcal) by -10kcal (95% CI: -16 to -4) and by -14kcal (95% CI: -20 to -8), respectively. The fewer-calories messaging did not significantly reduce the energy content of sweet snacks compared with the control (mean difference: -5kcal, 95% CI: -11 to 1). When

comparing between intervention groups, the only significant difference in energy ordered was observed between the PACE group and the fewer-calories message group. All three intervention messages significantly reduced the energy content of savoury snacks ordered compared with the control (mean = 177kcal); the fewer-calorie messaging by -6kcal (95% CI: -11 to -1), the numeric-calories messaging by -9kcal (95% CI: -14 to -4) and the PACE messaging by -14 kcal (95% CI: -20 to -9). The PACE messaging also significantly reduced energy when compared with both the fewer-calories (mean difference: -8kcal, 95% CI: -14 to -3) and numeric-calories message (mean difference: -5kcal, 95% CI: -10 to -1). None of the intervention messages significantly reduced the energy content of drinks ordered compared with the control (Figure 4 and Additional file 3 Tables 3-5).

Figure 4: Means and 95% confidence intervals for final calories ordered controlling for initial calories ordered.



C= Control; FC= Fewer-calories; NC= Numeric-calories; P=PACE. Comparisons with the control group as reference. * Bonferroni-adjusted $P < 0.05$.

Compared with control, both the PACE message (mean difference= -30kcal, 95% CI: -39 to -21), and the numeric-calories message (mean difference= -19kcal, 95% CI: -28 to -10) significantly reduced total energy ordered. When comparing between intervention groups, the PACE group ordered significantly fewer calories overall than both the fewer-calories group (mean difference= -20kcal, 95% CI: -29 to -10) and the numeric-calories group (mean difference= -11kcal, 95% CI: -21

to -2) (Additional file 3, Table 6). When compared with total energy initially selected in the whole cohort, participants ordered significantly fewer calories overall after swaps were offered (mean difference= -49kcal; 95% CI: -51 to -46).

3.3 Exploratory sub-group analysis

Sub-group analyses of acceptance and energy content by sex, age, ethnicity, income and education showed no evidence of clear differences (Addition File 3, Tables 11-30).

3.4 Acceptability, helpfulness, appropriateness, and potential adverse effects

On average, 67% of participants agreed that being offered swaps for their food choices at work would be acceptable. Compared with the control group (mean=3.45, SD=1.07), those in the PACE (mean=3.74, SD=1.08, $P<0.001$) and numeric-calories (mean=3.63, SD=1.08, $P=0.003$) groups rated the intervention as significantly more acceptable. However, there was no significant difference between the fewer-calories group (mean=3.56, SD=1.07, $P=0.235$) and the control group (Additional File 3, Table 7).

In the PACE group, 25% of participants agreed that the message they saw would encourage them to count calories excessively. This was significantly higher than the 15% of participants exposed to the numeric-calories message and the 11% of participants exposed to the fewer-calories message who agreed that the message would encourage this behaviour (Additional file 3, Tables 9a-10). Of those presented with PACE information ($n=860$), 15% reported that it would make them want to exercise excessively. Most participants in this group, however, agreed that the PACE message was acceptable (78%), helpful (66%), and appropriate (64%).

4. Discussion

Almost all of the messages significantly increased the likelihood that a sweet or savoury snack

347 swap would be accepted compared with the control where a swap was offered with no specific
348 message. There was evidence that the likelihood of acceptance increased in line with the addition
349 of more tangible information. We use the word 'tangible' here to refer to information that is easily
350 interpretable, concrete, and meaningful to the public. The most tangible PACE message
351 significantly outperformed the control and fewer-calories message in every swap category. The
352 PACE message was also the only message to increase the likelihood of a drink swap being
353 accepted. Almost all of the messages significantly reduced the energy content of sweet and
354 savoury snacks, but none of the interventions led to significant energy reductions in drinks.

355 Although the evidence for the efficacy of nutrition labelling in reducing calorie consumption is
356 mixed (Crockett et al., 2018), we found that compared with offering a swap with no specific
357 information, calorie-focused messages significantly increased the acceptance of lower-calorie
358 snack swaps. The findings were slightly different for drinks. Our results show that participants
359 were more willing to accept swaps for drinks even in the control condition where no specific
360 information was presented. This high baseline acceptance rate of drink swaps creates a potential
361 ceiling effect. It is possible that a higher number of drink swaps were accepted in the control
362 condition because the low-energy drinks were often like-for-like (e.g., Coke Zero for classic Coca-
363 Cola) and therefore much closer to the original choice. This was not always the case for snacks.

364 Although we attempted to match snacks as closely as possible, like-for-like swaps were not always
365 possible. The addition of PACE information did, however, increase swap acceptance presumably by
366 making the energy information provided more tangible. For both snacks, swap acceptance
367 followed a more gradual increase as the messaging made the benefits of swapping more tangible
368 across the groups.

369 While the differences in effect size between messages, particularly between numeric-calories and
370 PACE were not always statistically significant, the direction of effect sizes indicates an

371 incrementally stronger effect of messages that provide more tangible information. This is in line
372 with previous research which finds consumer nutrition knowledge to be moderate or low and
373 recommends the addition of interpretational aids to enhance understanding (Blumenthal, 2010;
374 Cadario & Chandon, 2020). Providing such aids to consumers at the point of choice simplifies
375 cross-product comparisons for consumers and reduces energy-purchased (Allan & Powell, 2020).
376 The PACE message typically performed the best overall, followed by the numeric-calories message
377 and then the fewer-calories message. The consistently larger effect of the PACE messaging was in
378 line with evidence pointing to the increased efficacy of PACE messaging over other types of
379 labelling (Daley et al., 2020). Providing information about the amount of physical activity that
380 would be required to expend the energy contained in a given food or drink may aid consumer
381 understanding of calorie information by translating it into a more tangible and familiar metric
382 (Bleich & Pollack, 2010; Blumenthal, 2010; Fitch et al., 2009). Indeed, almost half of those
383 participants presented with the PACE messages accepted at least one swap. This is slightly higher
384 than the figures reported in previous supermarket-based studies (Koutoukidis et al., 2019) despite
385 participants in the current study being offered fewer swaps on average from the outset. With
386 respect to the magnitude of the effect, the PACE message used in the current study doubled the
387 odds of at least 1 swap being accepted. A previous online trial testing the effect of messaging on
388 the selection of lower-energy items over higher-energy alternatives reported an almost identical
389 effect size for a PACE label compared with a no label control (Masic, Christiansen, & Boyland,
390 2017).

391 The intervention led to significant reductions in energy intake which were small, as expected,
392 given the small difference in calories between initially selected and offered products. Previous
393 studies (Masic et al., 2017; Viera et al., 2019) have found larger differences but these were likely
394 due to higher energy content at baseline and larger differences in swaps offered. Offering such

395 tailored swaps was widely acceptable across all groups and in line with previous studies
396 (Koutoukidis et al., 2019). The highest acceptability ratings were observed among participants
397 presented with the PACE message. This messaging brought the acceptance rate in line with
398 previous studies (Koutoukidis et al., 2019). However, some researchers have argued that calorie
399 labelling may cause harm especially to those with eating disorders (McGeown, 2019). Responses
400 to the post-trial questions provided some support for the argument that PACE messaging may be
401 more likely to trigger excessive calorie counting than a calories-only message, however this is only
402 a reflection of participant's perception of their potential future behaviours. To our knowledge, this
403 is the first study that has examined the evidence of potential harm from PACE labelling. Further
404 studies should examine the impact of PACE labelling on long-term outcomes.

405 Strengths of the study include the randomised design and the large sample of working adults. In
406 contrast with some previous studies, where participants selected between pre-determined pairs
407 of high and low energy foods (Masic et al., 2017), participants in the current study were presented
408 with a wide range of popular snacks and drinks from which they made their selections. This design
409 more closely mirrors the way in which choices would be made when using a real online canteen,
410 increasing the ecological validity of the findings. Furthermore, prior to making their first selection
411 (or prior to being offered a swap), participants in this study were unaware that they would be
412 offered lower-energy swaps, which reduced demand characteristics.

413 This study has some limitations. Firstly, this was a hypothetical choice experiment. Real-world
414 purchasing decisions are often driven by taste preferences and financial considerations. In this
415 study participants did not have the opportunity to try the swaps that were being offered nor did
416 they spend their own money. This means that the effect sizes seen in artificial settings are likely to
417 be larger than those seen in real-world contexts (Clarke et al., 2020). This study aimed to mitigate
418 these concerns by asking participants to only select what they would normally buy and by only

419 using very common food and drinks that would be familiar to most people. Finally, the sample was
420 highly educated which might limit the generalisability of the results. Although it remains unclear if
421 the tested interventions would increase inequity if implemented widely, exploratory analysis by
422 socioeconomic status and demographic characteristics did not show clear differences. Recent
423 research testing the effect of labelling on energy ordered, also found no evidence that the
424 effectiveness of a similar swap-based intervention differed for people of low or high socio-
425 economic status (Marty, Cook, Piernas, Jebb, & Robinson, 2020). Adequately powered trials are
426 required to definitely test if differences exist.

427 There is a lack of interventions that can effectively reduce energy intake in the workplace. Given
428 the growth of online grocery shopping (Munson, Tiropanis, & Lowe, 2017) and the introduction of
429 pre-ordering within schools (Wolfenden et al., 2017), it is reasonable to expect that many
430 workplace canteens may implement such systems soon. Across the groups, only 37 (1%)
431 participants initially selected the lowest energy choices in all 3 categories of products (e.g. fruit,
432 carrot sticks and water) indicating that snack and drink choices are a good target for intervention.
433 When examining the difference between average energy initially selected and finally ordered
434 within the PACE group, our results suggest that accompanying lower-energy swaps offered for
435 snack and drinks with a PACE message could translate to an average energy savings of 63kcal per
436 person per day, if changes are enacted consistently over time and if consumers don't compensate
437 for reductions in calorie intake at work at a later point. Given that 50-100kcal energy reduction per
438 person per day may prevent weight gain, this can be part of the effective interventions to tackle
439 obesity at population level (Hill, 2003; Rodearmel et al., 2007). More widely such labelling has the
440 potential to incentivise the food industry to reformulate foods and drinks or reduce their size so
441 that they contain less energy. However, this needs to be balanced against any potential harm from
442 PACE labelling. This will enable public health agencies to make informed decisions regarding

implementation. In the context of a workplace intervention, however, the pre-ordering system could be designed, so that staff could opt-in or out of receiving certain messages protecting vulnerable individuals from being triggered. Future research should also aim to test these messages and the swap-based intervention using real online canteens systems over extended periods of time to explore the effect of repeated exposure.

Conclusion

Increasing the tangibility of information provided when offering swaps increased swap acceptance, with the PACE messaging being the most effective. PACE messaging may be the most promising way to increase the acceptance of offered swaps for snack foods and drinks.

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Author contributions

SB, DAK, PL and CHL designed the study; SB conducted the research, the data cleaning and statistical analysis; DB provided support with the statistical analysis. SB, DAK, PL, DB, AS and CHL interpreted the data. SB drafted the manuscript and had primary responsibility for the final content. AS acquired funding to run the study. All authors read, critically revised, and approved the final manuscript.

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466 **Ethical statement**

467 The study was approved by the Research Ethics Committee of University College London
 468 (Reference:12861/002). All participants provided informed consent.

469 **Data statement**

470 The datasets used and/or analysed during the current study are available from the corresponding
 471 author on reasonable request.

473 **References**

- 474 Allan, J. L., & Powell, D. J. (2020). Prompting consumers to make healthier food choices in
 475 hospitals: A cluster randomised controlled trial. *International Journal of Behavioral Nutrition*
 476 *and Physical Activity*. <https://doi.org/10.1186/s12966-020-00990-z>
- 477 Bleich, S. N., & Pollack, K. M. (2010). The publics' understanding of daily caloric recommendations
 478 and their perceptions of calorie posting in chain restaurants. *BMC Public Health*, *10*(1), 121.
 479 <https://doi.org/10.1186/1471-2458-10-121>
- 480 Blumenthal, K. (2010). Enhancing the Effectiveness of Food Labeling in Restaurants. *JAMA*, *303*(6),
 481 553. <https://doi.org/10.1001/jama.2010.85>
- 482 Cadario, R., & Chandon, P. (2020). Which healthy eating nudges work best? A meta-analysis of
 483 field experiments. *Marketing Science*. <https://doi.org/10.1287/mksc.2018.1128>
- 484 Clarke, N., Pechey, E., Kosıte, D., König, L. M., Mantzari, E., Blackwell, A. K. M., ... Hollands, G. J.
 485 (2020). Impact of health warning labels on selection and consumption of food and alcohol
 486 products: systematic review with meta-analysis. *Health Psychology Review*.
 487 <https://doi.org/10.1080/17437199.2020.1780147>

- 488 Cook, J. A., Julious, S. A., Sones, W., Hampson, L. V., Hewitt, C., Berlin, J. A., ... Vale, L. D. (2018).
 489 DELTA 2 guidance on choosing the target difference and undertaking and reporting the
 490 sample size calculation for a randomised controlled trial Suzie Cro. *Trials*.
 491 <https://doi.org/10.1186/s13063-018-2884-0>
- 492 Crockett, R. A., King, S. E., Marteau, T. M., Prevost, A. T., Bignardi, G., Roberts, N. W., ... Jebb, S. A.
 493 (2018). Nutritional labelling for healthier food or non-alcoholic drink purchasing and
 494 consumption. *Cochrane Database of Systematic Reviews*.
 495 <https://doi.org/10.1002/14651858.CD009315.pub2>
- 496 Daley, A. J., McGee, E., Bayliss, S., Coombe, A., & Parretti, H. M. (2020). Effects of physical activity
 497 calorie equivalent food labelling to reduce food selection and consumption: systematic
 498 review and meta-analysis of randomised controlled studies. *Journal of Epidemiology and*
 499 *Community Health*, 74(3), 269–275. <https://doi.org/10.1136/jech-2019-213216>
- 500 Fitch, R. C., Harnack, L. J., Neumark-Sztainer, D. R., Story, M. T., French, S. A., Oakes, J. M., &
 501 Rydell, S. A. (2009). Providing Calorie Information on Fast-Food Restaurant Menu Boards:
 502 Consumer Views. *American Journal of Health Promotion*, 24(2), 129–132.
 503 <https://doi.org/10.4278/ajhp.08031426>
- 504 Forwood, S. E., Ahern, A. L., Marteau, T. M., & Jebb, S. A. (2015). Offering within-category food
 505 swaps to reduce energy density of food purchases: a study using an experimental online
 506 supermarket. *International Journal of Behavioral Nutrition and Physical Activity*, 12(1), 85.
 507 <https://doi.org/10.1186/s12966-015-0241-1>
- 508 Hall, K. D., Sacks, G., Chandramohan, D., Chow, C. C., Wang, Y. C., Gortmaker, S. L., & Swinburn, B.
 509 A. (2011). Quantification of the effect of energy imbalance on bodyweight. *The Lancet*.
 510 [https://doi.org/10.1016/S0140-6736\(11\)60812-X](https://doi.org/10.1016/S0140-6736(11)60812-X)
- 511 Harris, P. A., Taylor, R., Thielke, R., Payne, J., Gonzalez, N., & Conde, J. G. (2009). Research
 512 electronic data capture (REDCap)—A metadata-driven methodology and workflow process for

- 513 providing translational research informatics support. *Journal of Biomedical Informatics*, 42(2),
 514 377–381. <https://doi.org/10.1016/j.jbi.2008.08.010>
- 515 Higgins, E. T. (1996). Knowledge Activation: Accessibility, Applicability, and Salience. In Higgins E
 516 Tori & Kruglanski Arie W (Eds.), *Social psychology: Handbook of basic principles* (pp. 133–168).
 517 New York: Guilford Press.
- 518 Hill, J. O. (2003). Obesity and the Environment: Where Do We Go from Here? *Science*, 299(5608),
 519 853–855. <https://doi.org/10.1126/science.1079857>
- 520 Koutoukidis, D. A., Jebb, S. A., Ordóñez-Mena, J. M., Noreik, M., Tsiountsioura, M., Kennedy, S., ...
 521 Piernas, C. (2019). Prominent positioning and food swaps are effective interventions to
 522 reduce the saturated fat content of the shopping basket in an experimental online
 523 supermarket: a randomized controlled trial. *International Journal of Behavioral Nutrition and*
 524 *Physical Activity*, 16(50). <https://doi.org/10.1186/s12966-019-0810-9>
- 525 Li, G., Taljaard, M., Van den Heuvel, E. R., Levine, M. A. H., Cook, D. J., Wells, G. A., ... Thabane, L.
 526 (2017). An introduction to multiplicity issues in clinical trials: the what, why, when and how.
 527 *International Journal of Epidemiology*, 46(2), 746–756. <https://doi.org/10.1093/ije/dyw320>
- 528 Marty, L., Cook, B., Piernas, C., Jebb, S. A., & Robinson, E. (2020). Effects of Labelling and
 529 Increasing the Proportion of Lower-Energy Density Products on Online Food Shopping: A
 530 Randomised Control Trial in High- and Low-Socioeconomic Position Participants. *Nutrients*,
 531 12(12), 3618. <https://doi.org/10.3390/nu12123618>
- 532 Masic, U., Christiansen, P., & Boyland, E. J. (2017). The influence of calorie and physical activity
 533 labelling on snack and beverage choices. *Appetite*, 112(1), 52–58.
 534 <https://doi.org/10.1016/j.appet.2017.01.007>
- 535 McGeown, L. (2019). The calorie counter-intuitive effect of restaurant menu calorie labelling.
 536 *Canadian Journal of Public Health*, 110(6), 816–820. [https://doi.org/10.17269/s41997-019-](https://doi.org/10.17269/s41997-019-00183-7)
 537 00183-7

- 538 Munson, J., Tiropanis, T., & Lowe, M. (2017). Online Grocery Shopping: Identifying Change in
 539 Consumption Practices. In *Lecture Notes in Computer Science (including subseries Lecture*
 540 *Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)* (pp. 192–211).
 541 https://doi.org/10.1007/978-3-319-70284-1_16
- 542 Palan, S., & Schitter, C. (2018). Prolific.ac—A subject pool for online experiments. *Journal of*
 543 *Behavioral and Experimental Finance*, 17, 22–27. <https://doi.org/10.1016/j.jbef.2017.12.004>
- 544 Payne Riches, S., Aveyard, P., Piernas, C., Rayner, M., & Jebb, S. A. (2019). Optimising swaps to
 545 reduce the salt content of food purchases in a virtual online supermarket: A randomised
 546 controlled trial. *Appetite*, 133, 378–386. <https://doi.org/10.1016/j.appet.2018.11.028>
- 547 Rodearmel, S. J., Wyatt, H. R., Stroebele, N., Smith, S. M., Ogden, L. G., & Hill, J. O. (2007). Small
 548 changes in dietary sugar and physical activity as an approach to preventing excessive weight
 549 gain: the America on the Move family study. *Pediatrics*, 120(4), e869-79.
 550 <https://doi.org/10.1542/peds.2006-2927>
- 551 Royal Society of Public Health. (2016). Introducing “activity equivalent” calorie labelling to tackle
 552 obesity.
- 553 Stice, E., Shaw, H., & Nemeroff, C. (1998). Dual Pathway Model of Bulimia Nervosa: Longitudinal
 554 Support for Dietary Restraint and Affect-Regulation Mechanisms. *Journal of Social and Clinical*
 555 *Psychology*, 17(2), 129–149. <https://doi.org/10.1521/jscp.1998.17.2.129>
- 556 Vasiljevic, M., Cartwright, E., Pilling, M., Lee, M.-M., Bignardi, G., Pechey, R., ... Marteau, T. M.
 557 (2018). Impact of calorie labelling in worksite cafeterias: a stepped wedge randomised
 558 controlled pilot trial. *International Journal of Behavioral Nutrition and Physical Activity*, 15(1),
 559 41. <https://doi.org/10.1186/s12966-018-0671-7>
- 560 Viera, A. J., Gizlice, Z., Tuttle, L., Olsson, E., Gras-Najjar, J., Hales, D., ... Ammerman, A. (2019).
 561 Effect of calories-only vs physical activity calorie expenditure labeling on lunch calories
 562 purchased in worksite cafeterias. *BMC Public Health*, 19(1), 107.

- 563 <https://doi.org/10.1186/s12889-019-6433-x>
- 564 Wilson, A. L., Buckley, E., Buckley, J. D., & Bogomolova, S. (2016). Nudging healthier food and
565 beverage choices through salience and priming. Evidence from a systematic review. *Food*
566 *Quality and Preference*, 51, 47–64. <https://doi.org/10.1016/j.foodqual.2016.02.009>
- 567 Wolfenden, L., Nathan, N., Janssen, L. M., Wiggers, J., Reilly, K., Delaney, T., ... Yoong, S. L. (2017).
568 Multi-strategic intervention to enhance implementation of healthy canteen policy: a
569 randomised controlled trial. *Implementation Science*, 12(1), 6.
570 <https://doi.org/10.1186/s13012-016-0537-9>
- 571 World Health Organisation. (2020). Obesity and Overweight. Retrieved May 1, 2020, from
572 <https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight>

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Ethical Statement

The study was approved by the Research Ethics Committee of University College London (Reference:12861/002). All participants provided informed consent prior to participating.