Combining small changes to foods to achieve a sustained decrease in energy intake: a Randomised Controlled Trial (RCT) [a]

Natalie R. Evans[1], Danielle Ferriday[1], Roya O. Shahrokni[1], Susan A. Jebb[2], Jeffrey M. Brunstrom[1], Peter J. Rogers[1]

[1] Nutrition and Behaviour Unit, School of Experimental Psychology, University of Bristol, Bristol UK

[2] Nuffield Department of Primary Care Health Sciences, University of Oxford, Oxford UK

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Introduction

Since the 1970s, there has been a clear increase in portion size of both packaged and served foods (Nielsen & Popkin, 2003). Within a single meal, there is ample evidence that portion size affects energy intake with larger meals promoting greater energy intake (Ello-Martin, Ledikwe, & Rolls, 2005; Hollands et al., 2015). Further, research suggests a cumulative effect when larger portions are served repeatedly over multiple days and weeks (Rolls, Roe, & Meengs, 2007; Jeffery et al., 2007). In addition, exposure to large portions of food alters an individual's perception of what constitutes a 'normal' serving size (Robinson et al., 2016). Increasing portion size might therefore be a key factor in the substantial rise in obesity rates seen across the Western world (Hennegan, Loxton, & Mattar, 2013). On this basis, many authors have advocated that portion size interventions are required. There are a broad range of intervention options available to address the portion size effect (Marteau, Hollands, Shemilt, & Jebb, 2015; Steenhuis & Vermeer, 2009). These interventions can be directed at an individual (e.g., increasing education and awareness of appropriate portion sizes) or at the environment (e.g., reducing portion sizes, providing a wider range of available portion sizes, pricing strategies to encourage the selection of smaller portions, and serving size labelling) (Steenhuis & Vermeer, 2009). However, there is limited evidence concerning the acceptability of smaller portion sizes and the effect on energy intake.

This randomised controlled trial (RCT) will use an intervention directed at the environment to explore strategies to increase the acceptability of smaller portions. First, it will explore whether a 50% reduction in portion size at a single meal (lunch) is effective in decreasing total 24-hour energy intake and whether any effect on 24-hour energy intake is sustained over 10 days. Second, it will explore whether small enhancements to foods are successful in offsetting the reduction in meal satisfaction seen after eating a 50% smaller lunch and the extent to which this is preserved over 10 days of exposure. Third, it will explore the effect these small meal enhancements have on meal enjoyment.

In relation to the first aim, there is a paucity of research examining the effect of smaller portions of food on energy intake. One of the barriers to the success of portion size reduction is compensatory eating behaviour; a preliminary study in our lab indicated that participants show compensatory eating when given the opportunity to snack immediately after a smaller meal (Rogers, Ferriday, McCaig, & Brunstrom, 2017). However, this study found no evidence of compensatory eating two and a half hours after consumption of the smaller meal; this is reassuring so long as further eating can be minimised or avoided at the end or soon after the end of the meal.

Two further aims of this investigation are to increase the satisfaction and enjoyment of a reduced portion meal. In a number of experiments in our laboratory satisfaction was found to fall significantly when portion sizes were reduced by 50%. Further, Pelchat and Schaefer (2000) demonstrated that food restriction increased cravings in humans – a factor which could result in decreased adherence to reduced portion meal plans. These results indicate the importance of

maintaining satisfaction in a reduced portion meal to encourage adherence to this intervention. To address this, we explored findings from a previous study which found that satisfaction was positively predicted by a combination of both enjoyment and satiety (Rogers, Ferriday, Jebb, & Brunstrom, 2016). It would stand to reason that one way to increase satisfaction for a meal is to increase the perceived enjoyment. Previous investigations within our labs have suggested two potential interventions which can be effective in increasing the enjoyment of a smaller portion: first, increasing the variety of the meal items provided; and, second, enhancing the flavour of a meal coupled with a hedonic label. These interventions could minimise the risk of lapses in reduced-portion interventions. In this randomised controlled trial, we will focus on strategies to enhance satisfaction with a smaller meal with the primary aim of decreasing energy intake in a 24-hour period that includes a smaller lunchtime meal.

Further measures are important in understanding the effects of a reduced portion intervention. For example, after consuming a reduced portion meal on several occasions, participants may show decreased satiety and/or decreased liking for that food. Evidence from relevant human studies on manipulating energy density is equivocal on this but, where learning occurs, it appears to do so after rather few exposures (Brunstrom, 2007; O'Sullivan, Alexander, Ferriday, & Brunstrom, 2010; Yeomans, 2012). Completely unknown, is the extent to which there might be longer-term adaptation to the manipulations designed to maintain meal satisfaction. This investigation will therefore collect a variety of secondary and exploratory measures to further develop our understanding of the impact of a reduced portion size; these measures will include body weight, eating rate, food reward and meal liking.

Outcomes

Primary outcomes

The three primary outcome measures of this experiment are 24-hour energy intake, ratings of meal satisfaction, and ratings of meal enjoyment. Specifically, we will test the following hypotheses:

i. Reduced portion size at lunch (Nudge and Nudge+ groups) will be only partially compensated for in subsequent energy intake compared to the larger lunch (Standard group), as measured from 24-hour energy intake on days participants are in the laboratory (Days 1, 3 and 10).
ii. Addition of manipulations designed to enhance meal satisfaction for the reduced portion (Nudge+) will increase meal satisfaction when compared to the regular reduced portion (Nudge).
iii. Addition of manipulations designed to enhance meal enjoyment for the reduced portion (Nudge+) will increase meal enjoyment when compared to the regular reduced portion (Nudge).

Secondary outcomes

The secondary research question concerns body weight as measured in the laboratory. Body weight will be measured at three points (Days 1, 3 and 10), and we will look at the change in weight over time between the three groups.

Pre-planned exploratory outcomes

We also plan to look at the relationship between portion size and eating rate (as calculated from meal duration), food reward (as measured by willingness-to-pay), meal satisfaction and meal liking.

Method

Design

This study is a randomised controlled trial (RCT) using a parallel groups design. Participants will be assigned to one of three intervention groups: receiving a 600 kcal Standard meal for lunch, receiving a 300 kcal Nudge meal for lunch or receiving a 300 kcal Nudge+ meal for lunch. The RCT will span 10 exposure days (two consecutive Monday-Friday weeks). All outcome measures will be measured on Days 1, 3 and 10 of exposure to the intervention, when participants come in to the laboratory.

Participants and Recruitment

Participants will be from the local area, recruited through the University of Bristol Nutrition and Behaviour Unit (NBU) volunteer database and the University of Bristol Experimental Psychology newsletter, which combined contain the details of over 1500 volunteers across Bristol who have agreed to be contacted with regular study adverts. A newspaper and/or radio advert will also be used to recruit participants from the local area, and the study will be advertised on the payslips of University of Bristol staff and through newsletters in other schools throughout the University.

Inclusion criteria

The inclusion criteria are: BMI $\geq$20 kg/m^2; aged between 18 and 70; willing and able to eat all foods provided and to comply with study procedures.

Exclusion criteria

The exclusion criteria are: non-English speaking; Vegetarian, Vegan, food allergies or intolerances to any of the food to be provided; smokes more than 5 cigarettes a day; drinks more than 14 units of alcohol per week (recommendation from Department of Health, 2016); has diabetes; history of eating disorders; pregnant, breastfeeding, or planning to become pregnant during the study; taking medication that may influence appetite (except for oral contraceptive pills); indicating lunch as their main meal of the day; does not indicate that they are familiar with eating sandwiches for lunch.

Participants will also be excluded if they took part in any of the preparatory studies undertaken in our laboratory which informed this research.

Sample size

We will randomise a total of 156 participants (52 in each group). This has been calculated using partial eta squared effect sizes found in our previous experiments looking at the effect of reduced portions with enhancements on meal enjoyment, which make up our manipulation for the Nudge+ group. As discussed by Levine and Hullett (2002), despite certain limitations, partial eta^2 can be more comparable than other measures of effect size if evaluating the size of an effect of the same manipulation across studies when, as in the present studies, additional manipulated and control variables are added to the design.

To calculate the sample size, we determined the effect sizes of each enhancement tested in the previous experiments on both meal enjoyment (Figure 1) and total energy intake (Figure 2). Meal enjoyment was calculated using the differences between the reduced portion (300 kcal meal) scores and the enhanced reduced portion (300 kcal meal) scores. Total energy intake of the reduced portions and the standard portions (600kcal) was compared after adding both the energy consumed in the meal, and the energy consumed in the *ad libitum* snacks post-meal; this was resolved to be the measure most comparable to the total 24-hour energy intake measure in the RCT.

The enhancements chosen for the manipulation is the combination of enhanced flavour and hedonic labelling as well as variety as these each returned effect sizes equal to or above $n^2_p = 0.06$ ($n^2_p = 0.09$ and $n^2_p = 0.06$ respectively) for increased enjoyment. Across our earlier studies, the effect size for total energy intake were large (maximum $n^2_p = 0.799$, minimum $n^2_p = 0.394$). In both cases, we selected a conservative approach and chose to power our study based on the smallest effect size, which results in a minimum of 156 participants in total, to achieve a power of 0.8 at $\alpha = 0.05$ for our portion size main effect (standard versus nudge+ versus nudge) for meal enjoyment, calculated using G*Power 3 (Faul, Erdfelder, Lang, & Buchner, 2007).

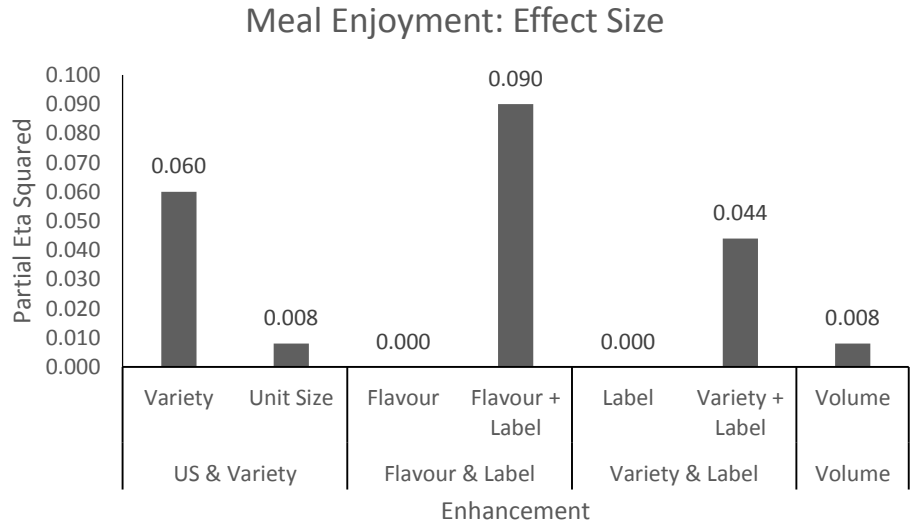

Figure 1. Partial eta squared effect sizes of meal enjoyment separated by experiment and enhancement.

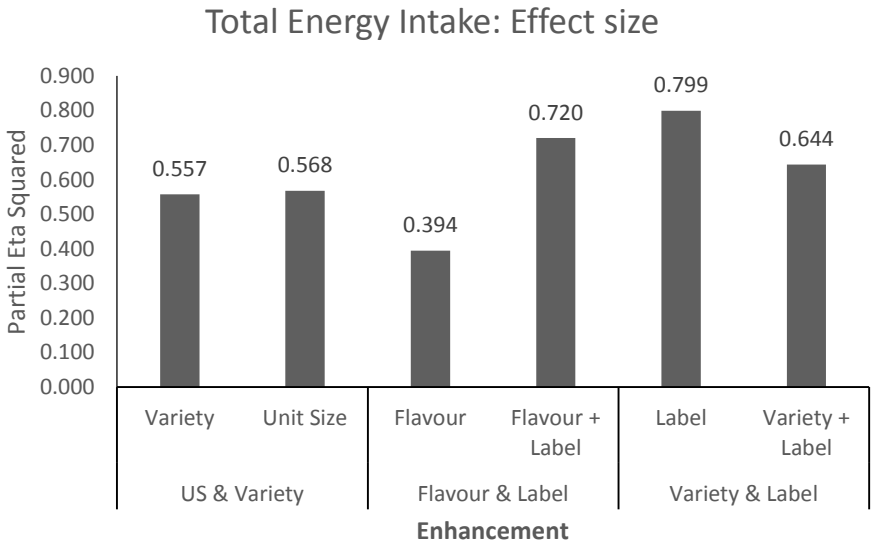

Figure 2. Partial eta squared effect sizes of Total Energy Intake separated by experiment and enhancement. The volume manipulation seen in Figure 1 is not included in Figure 2, as the experimental design did not include a Standard portion against which the reduced portions could be compared.

Randomisation

During the first session, a member of the research team will detail the trial procedures to participants, ensuring that each participant fully understands the requirements of the trial. The researcher will confirm eligibility and obtain written consent. Participant details will be put into a randomisation formula to ensure each group is balanced for gender, age, predicted energy requirements (Scientific Advisory Committee on Nutrition, 2011) and dieting status. Randomisation will be conducted using a minimisation method (Pocock & Simon, 1975), using a 4:1 element of chance. This will be automated using Microsoft Excel for pseudo-random allocation of groups (Turton, O'Leary, Gabb, Woodward, & Gilchrist, 2010)

Withdrawal

Participants are free to withdraw from this trial at any time without needing to provide a reason and any data previously collected from these participants will be excluded from analysis (we will not have obtained final consent to be able to use this data). Participants who withdraw from the study will be offered reimbursement of an amount equal to the proportion of hours they have participated in the study. These participants will be replaced.

Intervention

Participants will be assigned to one of three groups (Standard, Nudge or Nudge+); the standard group will receive a 600 kcal lunch for 10 days, the Nudge group will receive a 300 kcal lunch for 10 days and the Nudge+ group will receive a 300 kcal lunch with enhancements designed to increase meal enjoyment for 10 days. Participants will consume this lunch in the laboratory on Days 1, 3 and 10 of the trial; for Days 2 and 4-9, participants will collect this meal from the laboratory and consume it at a location of their choice.

The appropriate energy content for the standard lunch was determined to be 600 kcal using the recommended energy intake for females and after establishing lunch as 30% of the daily energy intake. Providing separate portion sizes to male and female participants was considered however discussions with industry indicated portion sizes are typically based on female energy intake recommendations. As such, these recommendations have also been used to calculate the standard meal size for this investigation. Additionally, this standard lunch size of 600 kcal is consistent with our previous experiments looking at the enhancements to increase meal enjoyment. The ingredients for the meals given to the Standard arm can be found in Appendix A.

Throughout our previous experiments, the energy content of the reduced portion lunches were a 50% reduction of the standard portion; 300 kcal. Rogers et al. (2017) suggest a 50% reduction in portion size achieved a much larger reduction in *ad libitum* intake and meal satisfaction at short inter-meal interval compared to a 25% reduction in portion size. As the aim of the RCT is to offset this reduction in *ad libitum* intake and meal satisfaction, a 50% reduced portion is being used. Participants in both the Nudge and Nudge+ arm will therefore consume a lunch meal of 300 kcal for 10 days. Participants in the Nudge arm will receive a meal using the same recipe as those in the Standard arm, as a 50% reduced portion, representing a single, simple dietary change (recipes in Appendix A). Meals in both the Standard and Nudge arms will be accompanied by a simple label describing the meal (e.g., ham and tomato sandwich with a chocolate flapjack). The participants in the Nudge+ arm will receive a meal made of similar components to those in the Standard and Nudge arms (i.e., sandwich and dessert items), but the meal will be enhanced with a stronger flavour, more variety and accompanied by a hedonic label highlighting these enhancements. The recipes for the Nudge+ arm, and phrasing for all labels, can be found in Appendix A. All participants will receive 300ml of water to accompany their meal on days in which they consume their lunch in the laboratory.

For the variety enhancement in the Nudge+ arm participants will receive enhanced versions of two types of sandwich and two types of dessert item. The participants will receive one half of a Ham and Mustard sandwich with a Dark Chocolate and Orange flapjack and one half of a Cheese and Tomato Relish sandwich with a Dark Chocolate and Mint covered wafer biscuit. Due to this increase in variety, the Standard and Nudge groups will use two different meals. Within each group (standard and nudge), half will receive Meal A (an unenhanced Ham and Tomato sandwich with a chocolate flapjack) and half will receive Meal B (an unenhanced Cheese and Tomato sandwich with a white chocolate covered wafer biscuit).

The chosen recipes are based on those used in the previous enhancement studies, all of which used versions of cheese and ham sandwiches with flapjack pieces. In a pilot study, participants were served 'taster' portions and asked to consume each item on their plate; they were asked to rate liking and flavour intensity within the meal on 100mm Visual Analogue Scales with anchor points of "Not at all" and "Extremely". Liking was consistent across meals (Meal A mean = 58.75, Standard deviation = 20.71, Meal B mean = 57.50, SD = 21.93, Nudge+ Meal mean = 60.80, SD = 10.60, $F=0.109$, $p=0.897$), and flavour intensity was rated higher for the Nudge+ meals (Meal A mean = 38.50, SD = 20.14, Meal B mean = 48.88, SD = 18.89, Nudge+ Meal mean = 61.00, SD = 19.57, $F=3.6$, $p=0.041$)

Each meal will be presented to the participants in a professional custom-made cardboard lunch box of an appropriate size containing both the sandwich and dessert item with a label on the lid of this box. On Days 2 and 4-9, when participants are not required to consume their meals in the laboratory, they will be required attend the laboratory in the morning to collect their lunches.

Procedure

A schematic of the entire procedure can be found in Appendix C.

Pre-screening questionnaire

Individuals who are interested in taking part in the experiment will complete a pre-screening questionnaire online (made using Qualtrics) containing a variety of questions which will allow researchers to analyse eligibility. The study will be presented to participants using the title *"Investigating the acceptability of commercial foods."* The front page of this questionnaire will provide a link to an online copy of information sheet which participants will be asked to read before continuing.

The following information will be collected in this survey: contact information (name, email address, mobile number); demographic information (gender, age, self-reported height and weight); what their main meal of the day is (breakfast, lunch or dinner); typically consumed lunchtime meals (verifying whether the test meals will be an appropriate alternative to their routine); activity level

using the International Physical Activity Questionnaire (will be used to calculate energy requirements); dieting status (currently on a diet to lose weight; yes or no); weight fluctuation in the last month (from -5 or more kgs to +5 or more kgs).

Pre-screening session

Those who register an interest in participation in the study and who are determined eligible will be invited to a pre-screening session where their eligibility and suitability will be verified, similar to (Hardman, Herbert, Brunstrom, Munafò, & Rogers, 2012); the pre-screening session will take place the week before each test cycle. The experimental procedures and necessary commitments will be explained to potential participants in detail, for example maintaining consistent activity levels throughout the 10-day trial (e.g. no excessive exercising not part of their usual routine). If participants confirm their commitment, they will give written consent and be scheduled to take part in the next test cycle.

Other information collected in this session will be as follows: measures of height and weight; baseline eating measures which will be calculated by providing participants with an *ad libitum* dinner of Spaghetti Bolognese (details of this *ad libitum* meal can be found in the foods section) and preferred time slots for Breakfast, Lunch and Dinner on days measuring 24-hour energy intake (Days 1, 3 and 10), as these will be kept consistent across test days. The session will take place at either 5:00pm or 6:00pm and will last no longer than one hour. Following this session, participants will be allocated to their test group (Standard, Nudge or Nudge+).

Trial

The participants will consume their allocated lunch on 10 consecutive weekdays, attending the Nutrition and Behaviour Laboratory on Days 1, 3 and 10. On these days, participants will come into the laboratory for an *ad libitum* breakfast between 7:30am and 9:00am, the fixed portion test lunch between 11:30pm and 2:30pm, and an *ad libitum* dinner between 6pm and 7:30pm. Participants will be given the opportunity to take snacks and drinks to sustain them throughout the day. The snacks chosen by each participant will be recorded and participants will be asked to indicate at what time each snack and drink was consumed. In between these meals participants will be free to return to their personal schedules but will be asked not to eat or drink any items except the snacks and drinks provided by the laboratory. A similar semi-naturalistic procedure has been used successfully in previous studies (Smit et al., 2012; Smit et al., 2011). The timing of these laboratory visits for measurements of repeated exposure effects is based on (O'Sullivan et al., 2010). Any immediate adaptation should be expressed between Days 1 and 3, and any longer-term adaptation will be measured on day 10.

On Days 1, 3 and 10, participants will be weighed before breakfast in the laboratory. 24-hour energy intake will be measured using the food consumed by participants during the *ad libitum* meals, the lunchtime meal and any snack foods and drinks provided by researchers. Ratings of appetite (e.g., hunger and fullness), food liking, desire to eat, meal enjoyment, meal satisfaction, expected satiety, food reward and willingness to pay will be collected with respect to the test lunches eaten in the laboratory. Participants will complete a survey at the end of each day asking them to detail the snacks they consumed in the evening, and to detail any alcohol intake.

On Days 2 and 4-9, where participants do not consume their lunch in the laboratory environment, they will be required to collect the lunches from the laboratory and consume these for lunch each day; food is not otherwise restricted or recorded on these days. Participants will be sent a survey to complete at the end of each day to monitor compliance with the experimental procedure (i.e., if they consumed their designated meal at lunchtime).

Post-Trial Session

On the first Tuesday following the 10-day trial, participants will attend a final session. In this session, participants will complete both the restraint scale from the Dutch Eating Behaviour Questionnaire (DEBQ) (Van Strien, Frijters, Bergers, & Defares, 1986) and the disinhibition scale from the Three-Factor Eating Questionnaire (TFEQ) (Stunkard & Messick, 1985). This session will take place between 11:30am and 1:30pm and will last no longer than 30 minutes.

In this session, participants will also be debriefed provide both final consent and the necessary details to organise reimbursement.

Foods on Test Days 1, 3, and 10

24-hour energy intake will be measured from midnight to midnight which will require participants to fast from midnight the evening before the test day. Except for their allocated fixed portion lunch (details of which can be found in the intervention section and in Appendix A), all other food provided to participants on Days 1, 3 and 10 will be *ad libitum*. The participants will be provided with large quantities food and instructed to serve themselves, from which we will calculate the weight of food eaten and thus the energy intake.

Breakfast

Participants will be provided with Kellogg's Crunchy Nut Cornflakes and Semi-Skimmed Milk to eat *ad libitum* for breakfast on Days 1, 3 and 10 (nutritional information can be found in Appendix D). According to Mintel market research (as described by Baimbridge, 2011), Kellogg's Crunchy Nut Cornflakes are the 3rd best bestselling cereal in the UK, as ranked by both value sales and share of the market, suggesting they are commonly consumed within the UK and will be familiar to participants.

To accompany their breakfast, participants will be given water and offered tea, coffee and orange juice. Participants will be offered 450g of cereal (15x recommended portion of 30g) and 500ml milk to consume *ad libitum*. This is consistent with previous breakfast studies in our laboratory and is deemed a large enough portion that the possibility of ceiling effects is appropriately minimised.

Dinner

Participants will be provided with Sainsbury's Taste The Difference Spaghetti Bolognese to eat *ad libitum* on Days 1, 3 and 10 (nutritional information can be found in Appendix D). O'Sullivan et al. (2010) suggested that Spaghetti Bolognese continued to be well liked after repeated exposure, suggesting this food will suitable to provide participants on multiple occasions in a short time span. Participants will be offered 3 times the recommended serving size (a total of 1200g) of this meal to minimise the chances of ceiling effects. An *ad libitum* dessert item will also be provided to participants. This will be made up of one sachet of Angel Delight Strawberry Flavour dessert (nutritional information can be found in Appendix D), which amounts to four recommended servings (4 x 92g, a total of 368g).

Snacks between meals

To enable us to measure 24-hour energy intake, we will provide snack and drink options which can be taken away to provide sustenance between meal times (i.e. between breakfast and lunch, between lunch and dinner, and after dinner). The items taken by participants will be recorded, and participants will be asked to make note of when/if each item was consumed. We will ask for this list plus any uneaten snacks and the wrappers of the eaten snacks to be returned when participants next attend the laboratory, consistent with Rolls et al. (2007). Details of all snacks and drinks offered to participants can be found in Appendix E. These snacks were chosen based on the most popular item sold in Sainsbury's across the snack-food categories.

The participants will also be provided with an assortment of teabags, coffee, milk, sugar and sweeteners to make hot drinks with throughout the day. They will be asked to record if/when they consume these items and return this information to us. We will not provide alcohol to participants, but we will not restrict alcohol intake, instead asking participants to detail any alcohol they have consumed in the end-of-day survey sent to them each evening.

Measures on Test Days 1, 3 and 10

The following ratings, unless otherwise specified, will be assessed using 100mm Visual Analogue Scales. Liking and satisfaction scales are based on research indicating that sensory satisfaction while eating a food (i.e., liking of appearance and taste) influenced subsequent food satisfaction (i.e. the generalised hedonic response to food) (Vad Andersen & Hyldig, 2015).

Appetite ratings. These assess the extent to which participants feel thirsty, hungry, full, bloated, nauseous/sick/queasy, sluggish/sleepy/lethargic, and mentally alert/clearheaded. These ratings are based on a mixture of commonly used measures within our research group and other ratings concerning aversive viscerally-inferred states.

Meal ratings before eating the meal. Participants will be asked in a random order:

- *"How much do you LIKE the APPEARANCE of your MEAL (sandwich and dessert items)?"*
- *"How much do you EXPECT to LIKE the TASTE of your MEAL (sandwich and dessert items)?"*
- *"How STRONG is your DESIRE TO EAT your MEAL (sandwich and dessert items) RIGHT NOW?"*
- *"How FULL do you EXPECT your stomach to be after you have eaten your MEAL (sandwich and dessert items)?"* This is a measure of expected satiation.
- *"Imagine that you are going to eat this meal and no other food will be available until dinner time. How well do you EXPECT that your MEAL (sandwich and dessert items) will STAVE OFF your HUNGER?"* This is a measure of expected satiety.

Meal ratings after consumption. Participants will be asked in a random order:

- *"How much did you LIKE the TASTE of your MEAL (sandwich and dessert items) today?"*
- *"From the first bite to the last, how much did you ENJOY EATING your MEAL (sandwich and dessert items) today?" This measure is thought to assess experienced food reward.*
- *"How STRONG were the FLAVOURS in your MEAL (sandwich and dessert items) today?"*
- *"Overall how SATISFYING did you find your MEAL (sandwich and dessert items) today?"*
- *"How VARIED did you find the assortment of foods in your MEAL today?"*

Willingness to Pay rating. Before and after consuming the preload, participants will indicate how much they would be willing to pay for the food they were served. The participants will be asked to choose a price on a slider with anchor points of £0.00 and £6.50. The participants will be able to see the price change as they move the slider and see their chosen price. We determined that common meal deals (Tesco, Sainsbury's, Boots, Co-op etc.) fall between £3 and £3.50, and as such these prices are the approximate centre of the anchor points. These ratings will be made before and after lunch consumption to assess whether there is any change in the reward value of the food. Before consuming their lunch, participants will be asked "*Please indicate the maximum you would be willing to pay for this meal (sandwich and dessert items) if you were buying it for lunch right now"*. After consuming

their lunch, participants will be asked "*Imagine it is lunchtime tomorrow. Please indicate the maximum you would be willing to pay for this meal to have it again for lunch."*

Meal Duration. The time taken for participants to eat their lunch-time meal will be recorded.

Weight. At the start of each test day (day 1, day 3 and day 10), the participants will be weighed. They will be asked to wear light clothing (no jackets or jumpers) and to remove their shoes.

End-of-Day survey. To collect information regarding the snacks participants consumed after the dinner session, participants will be sent a survey (made on Qualtrics) which they will be required to complete before they go to bed. In this survey, participants will be asked to detail any snacks they have eaten since the dinner session, and to detail any alcohol they have consumed that day.

A measure of memory for recent eating was discussed for inclusion, however it was decided that this would prompt too much focus on the size of the meal given to participants, and that this may influence behaviour towards the lunchtime meal.

Measures on Day 2 and Days 4-9.

End of day survey. Participants will be sent a link to an end of day survey (made using Qualtrics) at 9pm each day to complete before retiring for the night. Participants will observe the label for the provided lunch and will be asked to indicate if this was consumed for lunch this day. This will be a measure of compliance with the experimental protocol. Participants will also be asked to tell us if they ate anything out of the ordinary on that day.

An electronic or paper food diary was considered to monitor food intake, however, it was considered to require a very high level of engagement from participants to obtain accurate data. It would also highlight to participants their daily consumption which has been used as a weight-loss intervention in previous research (Carter, Burley, Nykjaer, & Cade, 2012). Therefore, it was decided food intake would not be monitored on the days in which participants are not in the laboratory.

Reimbursement

Participants who complete the pre-screening session, but will not be continuing with the full trial due to ineligibility or because they decide they do not want to continue with the full experiment will receive £10 in compensation.

To complete the entire experiment, participants will need to spend a minimum of 6 hours in the laboratory across Days 1, 3 and 10, and it is estimated that they will spend at maximum one hour of their time each day outside the laboratory completing the tasks required of them. It was therefore determined that participants will be reimbursed £150 for their participation in the study. This will be provided to participants in the form of a cheque, as University regulations state that participant reimbursements of over £50 cannot be presented as cash. Because of this, there may be a gap between participants completing the experiment and getting paid for their time. This will be explained clearly to participants before they take part in the experiment.

If participants withdraw before completing the experiment, they will be reimbursed an amount equal to the proportion of hours they have completed in the study.

Summary of procedures

1. Initial pre-screening questionnaire using Qualtrics

1. Asked to agree they will abide by each eligibility requirement.
2. Demographics and other details:
    a. Name, Contact Information, Gender, Age, Self-reported height and weight.
3. Dieting Status (yes/no).
4. International Physical Activity Questionnaire (Craig et al., 2003).
5. Indicate their typical lunchtime meal.
6. Familiarity with foods.
7. Indicate availability for trial.

2. Screening session in the laboratory (5pm or 6pm).

1. Participants are informed the procedures of the study both verbally and in writing.
2. Participants give informed consent.
3. Experimenter-measured height and weight.
4. Participants are provided with *ad libitum* dinner.

3.1. Randomised Controlled Trial: Day 1, Day 3 and Day 10 (in the laboratory).

Breakfast (7:30am-9am):

1. Participants are weighed by researchers when they arrive to the laboratory.
2. Indicate time since last ate.
3. Experimenter gives breakfast to participants for *ad libitum* consumption.
4. Participants are provided the opportunity to take snacks to eat between breakfast and lunch. Participants are also give the option of tea, coffee, milk, sugar and low-calorie sweeteners for hot drinks.

Lunch (11:30pm-2:30pm):

1. Appetite and body sensation ratings 1:
    a. Thirsty, hungry, full, bloated, nauseous/sick/queasy, sluggish/sleepy/lethargic, mentally alert/clearheaded.
2. Experimenter places meal.
    a. Meal ratings 1:

        i. Liking of appearance, expected liking of taste, expected post-prandial fullness, desire to eat the meal, expected satiety.
    b. Willingness-to-pay 1.
    c. Consume entire lunch (meal duration is recorded).
    d. Meal ratings 2:
        i. Meal Enjoyment, liking of taste, meal satisfaction, flavour intensity.
    e. Willingness-to-pay 2.
    f. Appetite and body sensation ratings 2.
3. Participants are provided with the opportunity to take snacks to eat between lunch and dinner.

Dinner (6pm-7:30pm):

1. Experimenter provides dinner to participants for *ad libitum* consumption.
2. Participants are provided with the opportunity to take snacks to eat after dinner.
3. Participants are provided with lunches to take away from the lab to last until their next session.

3.2. Randomised Controlled Trial: Day 2, Days 4-9 (outside of the laboratory)

1. Participants collect the lunches from the NBU Laboratory between 8am and 12pm (except day 6, where collection will be between 9am and 12pm).
2. Participants eat the designated lunch given to them by researchers. They are not restricted on any other food intake throughout the day.
3. Participants complete 'end of day survey' each evening, sent to them by researchers at 5pm.

4. Post-trial session

1. DEBQ Restraint scale.
2. TFEQ Disinhibition Scale.
3. Participants will be asked if they ate anything outside of the snack box on Days 1, 3, and 10 (compliance check).
4. Demand awareness check.
5. Final consent.
6. Confirm details of reimbursement.

Statistical Analysis

Descriptive statistics will be used to compare the randomised groups at baseline. We will use a mixed model ANOVA for each outcome variable, using time (with three levels - Day 1, Day 3 and Day 10) as the within-subjects factor and condition (with three levels - Standard, Nudge and Nudge+) as the between-subjects factor. We will conduct planned contrast analyses at each time point (Day 1, Day 3 and Day 10) for each outcome variable. These planned contrast analyses for each variable are as follows.

Primary Outcomes

Energy Intake

We plan to compare the Standard and Nudge groups, expecting the Nudge group to consume less energy. We also plan to compare the Standard and Nudge+ groups, expecting a difference the Nudge+

groups to consume less energy. Finally, we plan to compare the Nudge and Nudge+ groups and do not expect to see a difference in intake.

Satisfaction

We will compare the Standard and Nudge group and expect to see a reduction in satisfaction in the Nudge group. We will also compare the Standard and Nudge+ groups, and we hope to find that these groups rate the meals as similarly satisfying. Additionally, we plan to compare the Nudge and Nudge+ groups and expect that the Nudge+ group will rate the meal as more satisfying.

Enjoyment

We will compare the Standard and Nudge group and expect the nudge group to reported lower meal enjoyment. We will also compare the Standard and Nudge+ groups and, like satisfaction, hope that the two groups provide similar ratings of enjoyment. We also plan to compare the Nudge and Nudge+ groups and expect that the Nudge+ group will rate the meal as more enjoyable.

Secondary Outcomes

For our secondary outcome of body weight, we plan to compare the Standard and Nudge groups, expecting a reduction in body weight in the Nudge group. We also plan to compare the Standard and Nudge+ groups, expecting a reduction in body weight in the Nudge+ group. We also plan to compare the Nudge and Nudge+ groups and do not expect to see a difference in body weight.

Exploratory Outcomes

We plan to conduct a similar approach to analyses on the exploratory outcomes. We expect Food Reward to follow the same pattern as the enjoyment data. We also expect that Eating rate will show a portion size effect; the Standard group will eat faster than the Nudge and Nudge+ groups. Finally, we hope there will be no effect on liking of the meals across the three conditions (Standard, Nudge and Nudge+).

Ethical Considerations

This study has been approved by the Faculty of Science Research Ethics Committee (Approval Number: 58961) at the University of Bristol. The study will be carried out according to the revised Declaration of Helsinki (2013) and the 1996 ICH Guidelines for Good Clinical Practice E6 (R1).

Data management and anonymised study data.

All aspects of the Data Protection Act will be adhered to. Consent forms will be retained by the School of Experimental Psychology for a period of 10 years after study completion. Participants are

free to withdraw from this trial at any time without needing to provide a reasoning and any data previously collected from these participants will be excluded from analysis (we will not have obtained final consent to be able to use this data). Participants who withdraw from the study will be offered reimbursement of an amount equal to the proportion of hours they have participated in the study. These participants will be replaced

Electronic data will be anonymised by a unique numeric identifier. There will be no record that links the data collected from the participant with personal data from which he/she could be identified. Upon completion of the test sessions, participants will be asked to provide final consent to include their data in further analyses.

Screening documents, participant contact details and participant identifier logs will be stored separately in a study master folder and kept confidential. These will be kept in the study master folder for one year after study completion or until data are made open (whichever comes first), after which these documents will be destroyed.

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Appendices

Appendix A

Nutritional information per meal for each lunch type.

Standard Meal A*									
Ingredient	Weight (g)	kcal	Protein	Fat	Sat.	Carbs	Sugars	Fibre	Salt
Hovis Wholemeal Medium Sliced Bread	83.00	183.43	8.30	1.49	0.33	31.37	3.40	5.64	0.75
Sainsbury's British mild Cheddar Cheese	31.60	131.46	8.03	11.03	6.86	0.16	0.16	0.00	0.57
Sainsbury's Classic Round Tomatoes	15.00	3.00	0.11	0.08	0.02	0.47	0.47	0.15	0.00
Anchor Spreadable	10.50	73.08	0.03	8.09	3.26	0.03	0.03	0.00	0.12
Cookies and Cream KitKat	41.40	209.90	3.15	10.52	5.96	25.21	20.49	0.58	0.10
STANDARD A TOTAL	181.50	600.86	19.61	31.20	16.42	57.24	24.55	6.37	1.54

Standard Meal B*									
Ingredient	Weight (g)	kcal	Protein	Fat	Sat.	Carbs	Sugars	Fibre	Salt
Hovis Soft White Bread, Medium Sliced	85.00	198.05	7.40	1.45	0.26	37.91	2.98	2.04	0.77
Sainsbury's British ham slices	45.00	53.10	10.04	1.26	0.45	0.41	0.41	0.23	0.73
Sainsbury's Classic Round Tomatoes	25.00	5.00	0.18	0.13	0.03	0.78	0.78	0.25	0.01
Anchor Spreadable	12.00	83.52	0.06	9.24	3.72	0.06	0.06	0.00	0.13
Chocolate Flapjack	57.80	261.26	3.24	13.87	6.94	33.52	14.45	3.35	0.06
STANDARD B TOTAL	224.80	600.93	20.90	25.94	11.39	72.67	18.67	5.87	1.69

Nudge Meal A**									
Ingredient	Weight (g)	kcal	Protein	Fat	Sat.	Carbs	Sugars	Fibre	Salt
Hovis Wholemeal Medium Sliced Bread	41.50	91.72	4.15	0.75	0.17	15.69	1.70	2.82	0.37
Sainsbury's British mild Cheddar Cheese	15.80	65.73	4.01	5.51	3.43	0.08	0.08	0.00	0.28
Sainsbury's Classic Round Tomatoes	7.50	1.50	0.05	0.04	0.01	0.23	0.23	0.08	0.00
Anchor Spreadable	5.25	36.54	0.03	4.04	1.63	0.03	0.03	0.00	0.06
Cookies & Cream KitKat	20.70	104.95	1.57	5.26	2.98	12.61	10.25	0.29	0.05
NUDGE A TOTAL	90.75	300.43	9.82	15.60	8.21	28.63	12.29	3.19	0.77

Nudge Meal B**									
Ingredient	Weight (g)	kcal	Protein	Fat	Sat.	Carbs	Sugars	Fibre	Salt
Hovis Soft White Bread, Medium Sliced	42.50	99.03	3.70	0.72	0.13	18.96	1.49	1.02	0.38
Sainsbury's British ham slices	22.50	26.55	5.02	0.63	0.23	0.20	0.20	0.11	0.37
Sainsbury's Classic Round Tomatoes	12.50	2.50	0.09	0.06	0.01	0.39	0.39	0.13	0.00
Anchor Spreadable	6.00	41.76	0.03	4.62	1.86	0.03	0.03	0.00	0.07
Chocolate Flapjack	28.90	130.63	1.62	6.94	3.47	16.76	7.23	1.68	0.03
NUDGE B TOTAL	112.40	300.46	10.45	12.97	5.69	36.34	9.33	2.93	0.85

Nudge+									
Half A Ingredients	Weight (g)	kcal	Protein	Fat	Sat.	Carbs	Sugars	Fibre	Salt
Hovis Wholemeal Medium Sliced Bread	18.50	40.89	1.85	0.33	0.07	6.99	0.76	1.26	0.17
Wyke Farms Simply Gorgeous Vintage Cheddar Cheese	8.80	36.08	2.24	3.03	1.91	0.01	0.01	0.00	0.16
Anchor Spreadable	2.50	17.40	0.01	1.93	0.78	0.01	0.01	0.00	0.03

Cottage Delight Burger Relish Chutney	2.50	4.13	0.04	0.01	0.00	0.98	0.94	0.00	0.04
Mint Dark Chocolate KitKat	10.40	52.21	0.56	2.63	1.45	6.30	4.82	0.55	0.01
Half B Ingredients	Weight (g)	kcal	Protein	Fat	Sat.	Carbs	Sugars	Fibre	Salt
Hovis Soft White Bread, Medium Sliced	20.00	46.60	1.74	0.34	0.06	8.92	0.70	0.48	0.18
Sainsbury's Italian Prosciutto Cotto Slices	13.00	20.67	2.56	1.16	0.42	0.07	0.07	0.07	0.25
Sainsbury's Classic Round Tomatoes	7.00	1.40	0.05	0.04	0.01	0.22	0.22	0.07	0.00
Anchor Spreadable	2.50	17.40	0.01	1.93	0.78	0.01	0.01	0.00	0.03
Sainsbury's Mustard	2.00	3.82	0.12	0.20	0.01	0.37	0.27	0.05	0.17
Blackfriars Mint Choc Chip flapjack	13.00	59.80	0.75	2.89	1.69	7.94	4.23	0.52	0.05
NUDGE+ TOTAL	100.20	300.39	9.94	14.46	7.16	31.82	12.02	2.99	1.06

*Lunches received by the Standard group. Half of the group (26 participants) will receive standard meal A, half of the group (26 participants) will receive standard meal B.

**Lunches received by the Nudge group. Half of the group (26 participants) will receive nudge meal A, half of the group (26 participants) will receive nudge meal B.

***Lunches received by the Nudge+ group. The whole group (52 participants) will receive both Half A and Half B.

Appendix B

Labels presented to participants for each type of Sandwich.

Standard Meal A*/Nudge Meal A**

Cheese and tomato sandwich with a white chocolate covered wafer biscuit

Standard Meal B*/Nudge Meal B**

Ham and tomato sandwich with a chocolate flavoured flapjack

Nudge+ Meal***

The ingredients of this meal have been carefully selected to contain a variety of tastes and to be full of flavour.

Your meal includes:

A delicious duo of sandwiches containing;

- Award-winning vintage cheddar and sun-ripened Greek tomato relish served on soft wholemeal bread
- Italian prosciutto ham with English mustard and vine-ripened tomatoes on soft white bread.

These are accompanied by an oaty flapjack topped with a decadent layer of orange flavoured dark chocolate and a crispy wafer biscuit covered with mint flavoured dark chocolate.

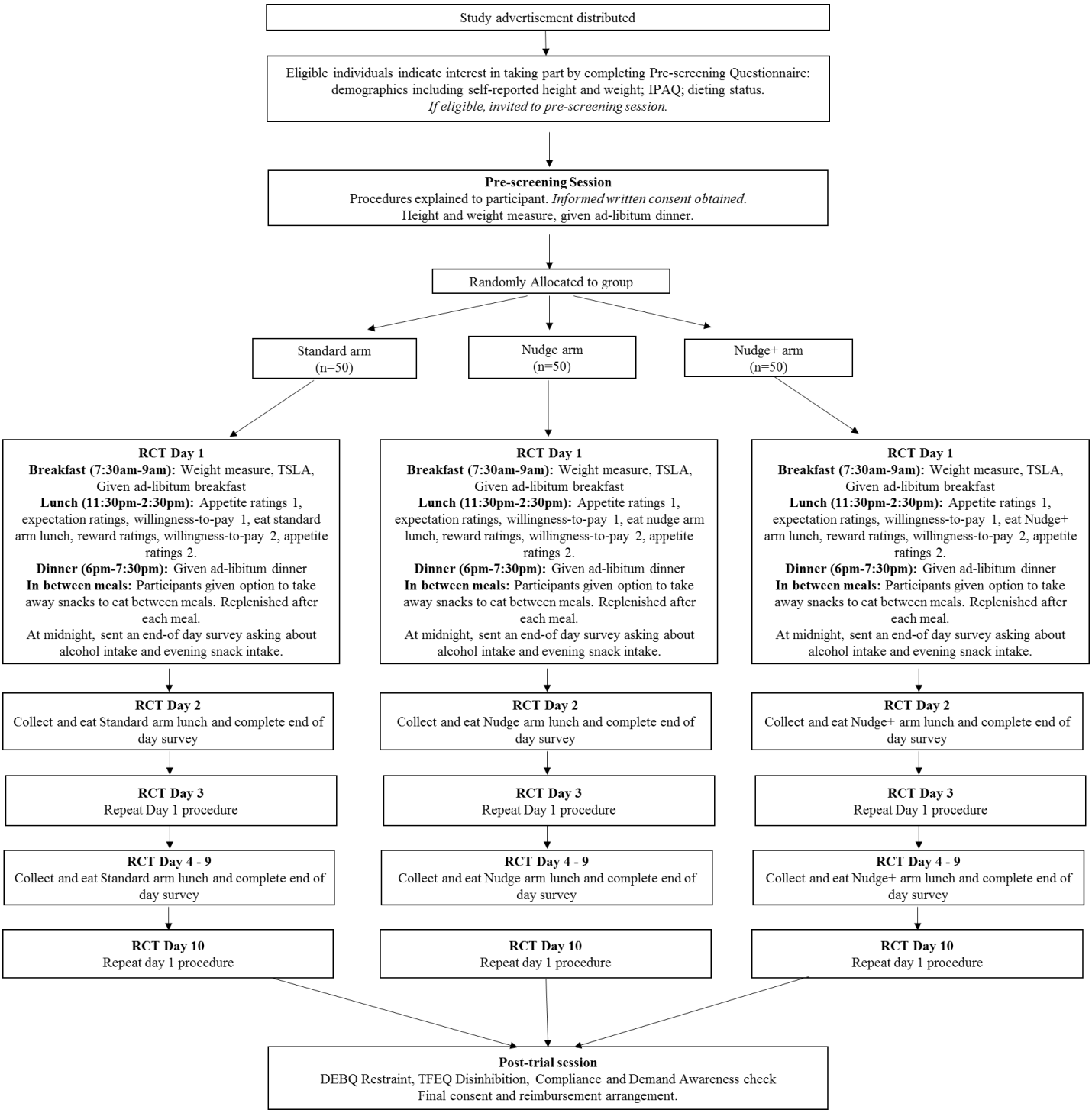
*Lunches received by the Standard group. Half of the group (26 participants) will receive Standard meal A, and half of the group (26 participants) will receive Standard meal B.

**Lunches received by the Nudge group. Half of the group (26 participants) will receive Nudge meal A, half of the group (26 participants) will receive Nudge meal B.

***Lunches received by the Nudge+ group. The whole group (52 participants) will receive the Nudge+ meal.

Appendix C

Schematic of the experimental procedure



Appendix D

Nutritional information per 100g (or 100ml when stated) for breakfast and dinner options given to participants on Days 1, 3 and 10.

Breakfast	Kcal	Protein	Fat	Sat.	Carbs	Sugar	Fibre	Salt
Kellogg's Crunchy Nut Cornflakes	398	6.0	4.5	0.7	82.0	35.0	2.5	0.75
Semi Skimmed Milk (per 100ml)	50	3.6	1.8	1.1	4.8	4.8	0	0.11

Dinner	Kcal	Protein	Fat	Sat.	Carbs	Sugar	Fibre	Salt
Sainsbury's Taste the Difference Slow Cooked Spaghetti Bolognese	148	8.8	7.2	2.8	10.8	1.8	2.5	0.39
Angel Delight Strawberry flavour dessert (as prepared per instructions)	120	3.5	4.6	3.4	16.2	13.8	<0.5	0.48

Appendix E

Nutritional information per pack of each snack item and drink item offered to participants on Days 1, 3 and 10.

Food	Weight (g)	Kcal	Protein	Fat	Sat.	Carbs	Sugar	Fibre	Salt
Walkers Ready Salted Crisps	25	132	1.5	8.0	0.7	12.9	0.1	1.1	0.35
Maryland Minis Chocolate Chip Cookies	25	125	1.4	5.8	2.8	16.5	7.6	0.6	0.2
Cadbury Brunch Bar Chocolate Chip	32	140	1.7	4.9	2.6	21	13.0	1.5	0.18
Graze Snack Box Punchy Protein Nuts	35	246	8.9	20.0	2.8	8.8	2.0	2.9	0.4
McVities Penguin Biscuits	25	130	1.3	6.8	3.9	15.6	10	0.6	0.06
Braeburn Apple (per 100g)		47	<0.5	<0.5	<0.1	12.0	12.0	1.8	<0.5
Banana (per 100g)		100	1.2	<0.5	<0.1	23.2	20.9	1.2	0

Drinks	Weight (ml)	Kcal	Protein	Fat	Sat.	Carbs	Sugar	Fibre	Salt
Sainsbury's Still Water	500	0	0	0	0	0	0	0	0
Sainsbury's Sparkling Water	500	0	0	0	0	0	0	0	0
Tropicana Smooth Orange Juice	250	107.5	2	0	0	22.25	22.25	1.5	0
Coca Cola	250	105	0	0	0	27	27	0	0
Diet Coca Cola	250	1	0	0	0	0	0	0	0
Oasis Summer Fruits	250	43	0	0	0	10	10		0.2