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The 'variety effect' is anticipated in meal planning.

Laura L. Wilkinson*, Elanor C. Hinton, Stephanie H. Fay, Peter J. Rogers, and Jeffrey M. Brunstrom

Nutrition and Behaviour Unit, School of Experimental Psychology, University of Bristol, 12a Priory Road, Bristol, BS8 1TU, UK

Running head: Anticipating the 'variety effect'

*Corresponding author: Laura L. Wilkinson, telephone: +44 (0)117 331 0494, fax: +44 (0)117 928 8588, email: Laura.Wilkinson@bristol.ac.uk

Abstract

The 'variety effect' describes the greater consumption that is observed when multiple foods with different sensory characteristics are presented either simultaneously or sequentially. Variety increases the amount of food consumed in test of *ad libitum* intake. However, outside the laboratory, meals are often planned in advance and then consumed in their entirety. We sought to explore the extent to which the variety effect is anticipated in this pre-meal planning. Participants were shown two food images, each representing a first or a second course of a hypothetical meal. The two courses were either, i) exactly the same food, ii) different foods from the same sensory category (sweet or savoury) or, iii) different foods from a different sensory category. In Study 1 (N = 30) these courses comprised typical 'main meal' foods and in Study 2 (N = 30) they comprised snack foods. For each pair of images, participants rated their expected liking of the second course and selected ideal portion sizes, both for the second course and the first and second course, combined. In both studies, as the difference between the courses (from (i) same to (ii) similar to (iii) different) increased, the second course was selected in a larger portion and it was rated as more pleasant. To our knowledge, these are the first studies to show that the variety effect is evident in the energy content of self-selected meals. This work shows that effects of variety are learned and anticipated. This extends our characterisation beyond a passive process that develops towards the end of a meal.

Keywords: Variety effect; Expectations; Portion size; Meal size.

Introduction

'The variety effect' describes the observation that food intake increases when participants are offered multiple foods with different sensory characteristics (Rolls, Rowe*, et al.*, 1981; Rolls, Van Duijvenvoorde, & Rolls, 1984). These effects can be marked. For example, when a meal comprises different courses then participants consume 60% more food than in a meal that comprises identical courses (Rolls *et al.*, 1984). This phenomenon is preserved in a number of different meal contexts (for a review see Raynor & Epstein, 2001). The variety effect is thought to be underpinned by sensory specific satiety (Brondel *et al.*, 2009), the decline in rated pleasantness of a food as it is eaten relative to different foods which have not been eaten (Rolls, Rolls, Rowe, & Sweeney, 1981).

Outside the laboratory the majority of self-selected meals are planned and eaten in their entirety, and decisions around meal size tend to be resistant to modification once eating begins (Fay *et al.*, 2011). This indicates that meal size is often governed by cognitive activity (planning) before a meal begins. Consistent with this idea, pre-meal expectations and plans around a food (assessed using computer-based measures) are directly related to subsequent food intake (Wilkinson *et al.*, in press).

In this study we sought to determine whether humans anticipate the effects of variety during meal planning. This will depend on learning. Specifically, the capacity to predict the likely satiating effects of different food combinations based on prior experience. Previously, we have shown that the 'expected satiation' of a novel food can be modified by manipulating its energy density (Wilkinson & Brunstrom, 2009). This is likely to reflect a broader capacity for animals and humans to moderate intake based on a learned association that forms between the sensory characteristics of a novel food and its post-ingestive effects (Booth, Lee, & Mcaleavey, 1976), often referred to as 'conditioned satiety.'

Evidence that the effects of variety are learned and comes to govern portion selection is important, not least because it suggests that variety has the potential to influence energy intake at the point at which food is purchased, ordered from a menu, and so on. This has practical implications for the design of foods that promote satiation and the selection of smaller food portions.

The variety effect can be explored by providing participants with a two-course meal, in which the courses are presented sequentially, and the courses have either the same or different sensory characteristics. Participants are asked to eat from the first course until they are comfortably full and are then asked to follow this instruction again for the second course. The variety effect is demonstrated if a greater amount of food is consumed in the second course in a 'different' condition relative to a 'same' condition.

In the current study, we presented *photographic* meal courses (two) comprising either, (1) exactly the same food, (2) different foods with a similar sensory category (*e.g.* both sweet), or (3) different foods with different sensory categories (*e.g.* one sweet and one savoury). Participants were asked to anticipate the pleasantness of the second course. In line with an explanation of the variety effect based on sensory specific satiety, we hypothesised that increasing the difference between the courses (from (1) same to (2) similar to (3) different) would increase the rated pleasantness of the second course.

Importantly, we quantified the anticipatory variety effect using a modified version of the task outlined above. Participants were instructed to imagine that they had consumed a fixed portion of the first course and then to select an image of their 'ideal' portion for their second course. Ideal portions were selected using software that modifies the amount of food shown on a plate. In a related task we also simulated the selection of a full meal - participants were required to select ideal portions for both their first and second course.

Study 1

Method

Participants

A total of 30 participants (mean age 28.23 (*SD* = 11.9) years and BMI 23.4 (*SD* = 4.09) kg/m^2) assisted with the study. Of these, 18 were female. Participants were staff and students from the University of Bristol. They were recruited via our laboratory volunteer database. Vegetarians and vegans were excluded. The protocol for this study was approved by the local Faculty of Science Human Research Ethics Committee.

Stimuli

Based on previous studies we selected foods that are very well-known to our participants. Our photographic stimuli comprised two savoury foods (spaghetti Bolognaise and chicken tikka masala) and two sweet foods (apricot slice and lemon tart). See Table 1 for their energy density and macronutrient composition.

Measures

Anticipated pleasantness of course 2: The anticipated pleasantness of the second of two courses was assessed over a number of trials. In each trial, one of the foods was displayed on the left-hand side of a 24-inch widescreen TFT-LCD monitor and one of the foods was displayed on the right-hand side. Respectively, the foods were labelled ‘Course 1’ and ‘Course 2’.

Across trials, the four food photographs (2 sweet and 2 savoury; see Table 1) were each displayed in each position (left and right). In a ‘same’ condition the pairs of foods were identical (e.g., lemon tart on the left and lemon tart (same picture) on the right). Four different test foods rendered four trials of this kind. In a ‘similar’ condition courses 1 and 2 comprised different pairs of foods from the same sensory category (both either sweet or savoury) (*e.g.*, course 1 was lemon tart and course 2 was apricot slice). In this context the four test foods (two sweet and two savoury) produced four pairs (trials) – two sweet foods each paired with each other and two savoury foods each paired with each other. Finally, in a ‘different’ condition the food-pairs comprised different foods *and* foods from a different sensory category (*e.g.*, course 1 was chicken tikka masala and course 2 was lemon tart). Eight such pairings are possible. Therefore, across conditions, participants completed 16 trials (same = 4 trials, similar = 4 trials, and different = 8 trials).

For each person and each condition, the effect of the first course on the anticipated pleasantness of the second course was estimated by averaging pleasantness ratings across trials. Within each condition, each food was presented the same number of times as each course (once in the same and similar conditions, and twice in the different condition). By counterbalancing in this way, we were able to isolate the effects of condition type on the pleasantness of the second course and, in so doing, evaluate evidence for the anticipation of the variety effect.

In each trial, participants were asked to ‘Imagine you have just eaten course 1. How pleasant would you find the first mouthful of COURSE 2?’ They were then asked to respond on a 100-mm visual-analogue scale anchored ‘NOT at all’ and EXTREMELY’ which was displayed below course 2. For each participant, the test-food pairs were presented in a different randomized order. The code for this and all other tasks was written in Visual Basic (version 6.0).

Ideal portion size (course 2) task: The photographs in the pleasantness task were drawn from sets of images that were taken using a high-resolution digital camera. Each food was photographed 51 times (numbered 0- 50) on the same white plate (255-mm diameter). Lighting conditions and viewing angles were carefully maintained in all photographs. For each food, picture 25 corresponded with a ‘standard’ (250 kcal) portion. Respectively, picture 0 and picture 50 represented a food containing 0.333 and three times the energy of the standard. Across the range of pictures the portion sizes increased in equal logarithmic steps. The name of the food was included in the top-right corner of each photograph.

The food displayed on the left-hand side of the monitor, labelled ‘Course 1,’ was a fixed portion of food (based on the recommended serving size displayed on packaging). The size of the food displayed on the right-hand side of the monitor, labelled ‘Course 2,’ could be changed by the participant – depressing the left arrow-key (on a keyboard) caused the portion size to decrease (a smaller picture number was displayed). Depressing the right arrow-key caused the portion size to increase. The pictures were loaded with sufficient speed that continuous depression of the left or right arrow key gave the appearance that the change in portion size was ‘animated.’ Each trial started with a different and randomly selected portion size.

Participants were instructed to “Imagine you are having this two-course meal for lunch. Look at the picture on the left. Now change the amount of food on the right so that the TOTAL amount of food will fill you up (immediately after it has been eaten).” Participants were instructed to press the enter key when they had selected the appropriate portion size.

Ideal portion size (Course 1 and 2) task: Ideal portion size was assessed in exactly the same way as the 'Ideal portion (Course 2) task' except that the portion size of *both* course 1 *and* course 2 could be manipulated by the participant. For each trial, either the left- or right-hand picture was surrounded by a red box – depression of the arrow keys caused the food in this box to change in portion size. Pressing the space bar caused the red box to switch between courses. Participants were instructed to "Imagine you are having this two-course meal for lunch. Look at both pictures. Now change the amount of food on each plate so that the TOTAL amount of food will fill you up (immediately after it has been eaten)."

Procedure

Participants attended the laboratory between 11am and 2pm and were told to abstain from eating for at least 3 hours before testing. On arrival they were given an information sheet outlining the general procedure and were asked to complete a consent form. Participants were given general instructions on how to complete a 100-mm visual-analogue rating scale. They were then asked to rate their hunger and fullness (How [HUNGRY/FULL] do you feel RIGHT NOW?) on a scale with end points 'not at all' and 'extremely.' They then completed the three tasks in the order described above (individual instructions for each task were displayed on the screen). Finally, the three factor eating questionnaire (TFEQ; Stunkard & Messick, 1985) was completed and a measure of height and weight was taken by the experimenter. In total, this process took approximately 40 minutes.

Data analysis

All data were analysed using PASW Statistics version 18 (SPSS Inc., Chicago, IL, USA). For the two ideal portion-size tasks, each response was converted from a picture number to a corresponding value in kcal. Then, for the ideal portion-size course 1 and 2 task, a total value was generated by adding the energy content both courses. For each participant and each task, three average scores were calculated, one for each condition. To evaluate evidence for the anticipation of the variety effect, these scores were submitted to separate repeated-measures ANOVAs (one for each type of measure) with condition (same, similar and different) as a within-subjects factor. Planned contrasts were conducted using one-tailed paired-samples *t*-tests, with a Bonferroni correction for multiple tests ($\alpha = .016$): same < similar, similar < different, and same < different. In addition, for each task, we calculated the average amount of time taken to complete a trial.

Results

Participant characteristics

All participants were included in our analyses. Our sample had a mean initial hunger rating of 69.0 mm (SD = 19.1) and initial fullness rating of 20.3 mm (SD = 18.6). Analysis of the TFEQ revealed that our sample had a mean restraint score of 6.27 (SD = 4.49) (minimum score = 0 and maximum score = 20), a mean disinhibition score of 6.0 (SD = 3.35) (minimum score = 0 and maximum score = 16) and a mean hunger score of 5.6 (SD = 2.91) (minimum score = 0 and maximum score = 15).

Anticipated pleasantness of the second course

Our analysis revealed a significant main effect of condition ($F(2,58) = 10.25$, $p < .001$). Planned contrasts showed that the different condition had significantly higher anticipatory pleasantness ratings than the same condition ($t(29) = 3.9$, $p < .001$) and the similar condition ($t(29) = 2.81$, $p = .005$). Using our corrected alpha value the difference between the same and similar conditions narrowly missed significance ($t(29) = 2.21$, $p = .017$). Figure 1 shows mean (*SE*) rated anticipatory pleasantness of course two across conditions. The average time to complete a trial in this task was 9.4 seconds.

(Figure 1 about here)

Ideal portion size (course 2)

Ideal portion sizes differed significantly across conditions ($F(2,58) = 20.43$, $p < .001$). Planned contrasts showed that in the different condition significantly larger portions of course 2 were selected than in the similar condition ($t(29) = 4.0$, $p < .001$) and the same condition ($t(29) = 6.12$, $p < .001$). In the similar condition significantly larger portion sizes of course 2 were selected than in the same condition ($t(29) = 2.43$, $p = .011$). For each condition, Figure 2 shows the mean (*SE*) ideal portion size of course two. In this task, each trial took on average 16.3 seconds to complete.

(Figure 2 about here)

Total ideal portion size (course one and two)

The combined ideal portion size of course one and course two differed significantly across conditions ($F(2,58) = 3.80$, $p = .028$). Planned contrasts revealed that larger portion sizes of both courses 1 and 2 were selected in the different condition than in the same condition ($t(29) = 2.95$, $p = .003$). The difference between the same and similar conditions narrowly missed significance ($t(29) = 1.77$, $p = .04$), using our corrected threshold. The difference between the similar condition and the different condition failed to reach significance ($t(29) = .979$, $p = .168$). For each condition, Figure 2 shows mean (*SE*) ideal portion size of course 1 and 2. Trials in this task took an average of 17.6 seconds to complete.

Note that the statistically significant differences reported in Figures 1 and 2 are preserved when two-tailed tests are used, with the exception of one comparison – in the course two data (see Figure 2) the difference between the same and similar conditions narrowly misses significance ($p = .022$).

Interim discussion

Consistent with our hypotheses, as the difference in sensory category across the two courses increased (from same to similar to different), participants rated the second course as more pleasant, and they selected both a larger second course and a larger combined meal (course 1 and course 2). We also note that our participants found the tasks undemanding and intuitive, and each judgment was made in approximately 15 seconds. These observations indicate a correspondence with decisions that are well rehearsed and practised outside the laboratory.

This study was designed so that potentially important variables (*e.g.,* energy content, energy density, and expected satiety) are controlled for across conditions; the same four foods were arranged in every possible combination of meal pairings. However, this design has a limitation. The 'different' condition contains both unfamiliar and familiar meal pairs (respectively, sweet followed by a savoury course and savoury followed by a sweet course). In this context it is difficult to quantify the independent effect of meal-order familiarity and its contribution to the effects of variety when sweet and savoury courses are paired. In response, we note that the anticipated variety effect is also evident in the same and similar conditions. These are unaffected by familiarity with specific course-order pairings.

In a second study we sought to address these concerns by selecting sweet and savoury snacks as test foods. Culturally, these tend not to be associated with a particular course-order pairing. In other respects, Study 2 followed the same design as Study 1.

Study 2

Method

Overview

The procedure, measures, and analysis strategy were identical to those in Study 1. The only exception being that in the wording of the tasks, 'course' was replaced with the term 'snack.'

Participants

Thirty participants (mean age 26.73 (*SD* = 6.96) years and BMI 23.4 (*SD* = 3.07) kg/m^2) assisted with the study. Of these, 21 were female. Participants were staff and students from the University of Bristol. They were recruited via our laboratory volunteer database. Vegans were excluded along with anyone with a relevant allergy. The protocol for this study was approved by the local Faculty of Science Human Research Ethics Committee.

Stimuli

Based on previous studies we selected foods that are well known to our participants. Our photographic stimuli comprised two savoury snacks (ready salted Pringles (potato chips) and salted peanuts) and two sweet snacks (chocolate m & m's and iced gem biscuits). See Table 2 for their energy density and macronutrient composition.

Results

Participant characteristics

All participants were included in our analyses. Our sample had a mean initial hunger rating of 43.8 mm (SD = 25.5) and initial fullness rating of 43.7 mm (SD = 25.6). Analysis of the TFEQ revealed that our sample had a mean restraint score of 8.67 (SD = 5.62), a mean disinhibition score of 7.43 (SD = 3.76) and a mean hunger score of 6 (SD = 3.29).

Anticipated pleasantness of the second snack

Our analysis revealed a significant main effect of condition ($F(2,58) = 10.36$, $p < .001$). Planned contrasts showed that the second snack food in the same condition had significantly lower anticipated pleasantness ratings than both the second snack food in the similar condition ($t(29) = 4.48$, $p < .001$) and the second snack food in the different condition ($t(29) = 3.56$, $p < .001$). Using our corrected alpha value the difference between the similar and different conditions narrowly missed significance ($t(29) = 1.95$, $p = .03$). Figure 3 shows mean (SE) rated pleasantness of snack two across conditions.

(Figure 3 about here)

Ideal portion size of the second snack

Ideal portion sizes differed significantly across conditions ($F(2,58) = 3.22$, $p = .047$). Planned contrasts (using our corrected alpha value) showed that the difference between the same and similar conditions narrowly missed significance ($t(29) = 2.04$, $p = .026$). The difference between the same and different conditions also narrowly missed significance ($t(29) = 2.19$, $p = .019$). The difference between selected portions in the similar and different conditions failed to reach significance ($t(29) = .244$, $p = .405$). For each condition, Figure 4 shows the mean (*SE*) ideal portion size of the second snack food.

(Figure 4 about here)

Total ideal portion size of the first and second snack

The combined ideal portion size of snack one and snack two differed significantly across conditions ($F(2,58) = 9.924$, $p < .001$). Planned contrasts indicated that the combined ideal portion size of the first and second snack was smaller in the same condition than in both the similar ($t(29) = 4.214$, $p < .001$) and in the different conditions (t(29) = 3.837, p < .001). The difference between the similar condition and the different condition failed to reach significance ($t(29) = .155$, $p = .878$). For each condition, Figure 4 shows mean (*SE*) ideal portion size of snack one and snack two. Again, statistically significant differences are preserved when two-tailed tests are used.

General discussion

Findings from Study 2 support the conclusions drawn from Study 1. Participants are able to anticipate the effects of variety and that this is expressed both in the anticipated pleasantness of food and in the selection of ideal portion sizes. In study 2 we used snack foods that are unlikely to form separate courses in a main meal. Thus, our effect is preserved after removing cultural norms associated with the natural order of sweet and savoury courses in a main meal. Again, in both studies, this interpretation is also supported by significant differences across the same and similar conditions. These are not dependent on judgments based on pairings between sweet and savoury foods.

The suggestion that the variety effect is anticipated and that this is reflected in meal planning highlights an important role for the variety effect in everyday dietary behaviour. In particular, it shows that dietary variety has the potential to influence food choice and decisions around portion size in kitchens, restaurants, grocery stores, and so on. Moreover, it offers an opportunity for researchers with an interest in the development of foods that promote weight loss. Specifically, it follows that foods might be developed that minimise dietary variety, thereby reducing the number of calories that are purchased and then self-served, while preserving the immediate satiation that a meal confers.

In relation to this idea, the converse might also be the case. Anticipating variety (*e.g.,* a self-selection buffet) might promote overconsumption. In the present study we explored the effects of variety in courses that are presented consecutively. However, flavour/food variety can also have a marked effect on intake in a single course (Raynor & Epstein, 2001). For example, Spiegel and Stellar (1990) have shown that variety within a single meal can increase energy intake by 32%. The extent to which this form of variability is anticipated remains to be determined and represents an important area for future research.

The ability to anticipate the effects of variety is probably learned. Presumably, our memory for the specific sensory characteristics of a food and our memory for specific instances of varied meals inform and modify our expectations over time. Based on participant feedback it would seem unlikely that this is cognitively effortful. Rather, it would appear to represent an automatic process that is highly practiced. What remains to be determined is how information about sensory characteristics is integrated. For example, does the process involve activation of separate sensory representations of each food? Alternatively, it may be that the effect of variability is mediated by other conceptual differences, based on the degree of overlap between semantic representations. Again, these issues warrant attention in future.

Considering the relationship between sensory specific satiety and the variety effect, we note an alternative explanation for our results. Morewedge, Huh & Vosgerau (2010) found that imagining the consumption of a food causes habituation. This impacts subsequent consumption. In relation to the present study, imagining consuming the first course of the meal may activate brain regions that are associated with a dopaminergic response to reward (Hinton *et al*. 2004), which is known to habituate to food items (Rolls *et al.* 1976). This influences the evaluation of the imagined second course and its ideal portion size. This prospect remains to be tested. However, we suspect this is unlikely given that the trials were completed relatively rapidly and the order of their presentation was randomized. Thus, participants were unable to deliberate consciously and repeatedly about consuming a specific food, as was the case in Morewedge *et al*.'s, (2010) study. Presumably, this limits the opportunity for habituation to occur.

More generally, this work shows that phenomena associated with ad libitum eating can be exposed using screen-based measures of portion-size selection. These measures are portable and can be used in a range of clinical and non-clinical environments (*e.g.*, schools), including those that lack facilities to prepare and serve food for human consumption. These measures can also be implemented remotely (on a web page and on a hand-held device). Finally, food stimuli are preserved in pictorial form. Therefore, consistency can be maintained across participants and test environments.

Acknowledgements

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Table 1.

Energy density and macronutrient information for each test food separately (all values are per 100g). All values presented are taken from the information provided by the manufacturer. The spaghetti Bolognaise and Chicken tikka masala were manufactured by Tesco PLC. The lemon tart and apricot slice were manufactured by Waitrose, John Lewis Partnership.

Type of Food	Kcal	Carbohydrate (g)	Protein (g)	Fat (g)
Spaghetti Bolognaise	130	13.3	5.7	4.7
Chicken tikka masala	160	16.6	7.3	6.9
Lemon tart	338	40.8	4.6	17.4
Apricot slice	324	34.8	4.2	18.6

Table 2.

Energy density and macronutrient information for each test snack-food separately (all values are per 100g). All values presented are taken from the information provided by the manufacturer. The ready salted pringles were manufactured by Kellogg Company. The salted peanuts were manufactured by KP, United Biscuits (UK) Ltd. The chocolate m & m's were manufactured by Mars Inc. The iced gem biscuits were manufactured by Jacob Fruitfield Food Group.

Type of Food	Kcal	Carbohydrate (g)	Protein (g)	Fat (g)
Ready salted pringles	526	5.2	3.9	34
Salted peanuts	590	9.9	27.5	49
Chocolate m & m's	491	67.2	5	22.4
Iced gem biscuits	396	86.4	5.2	3.2

Figure Legends

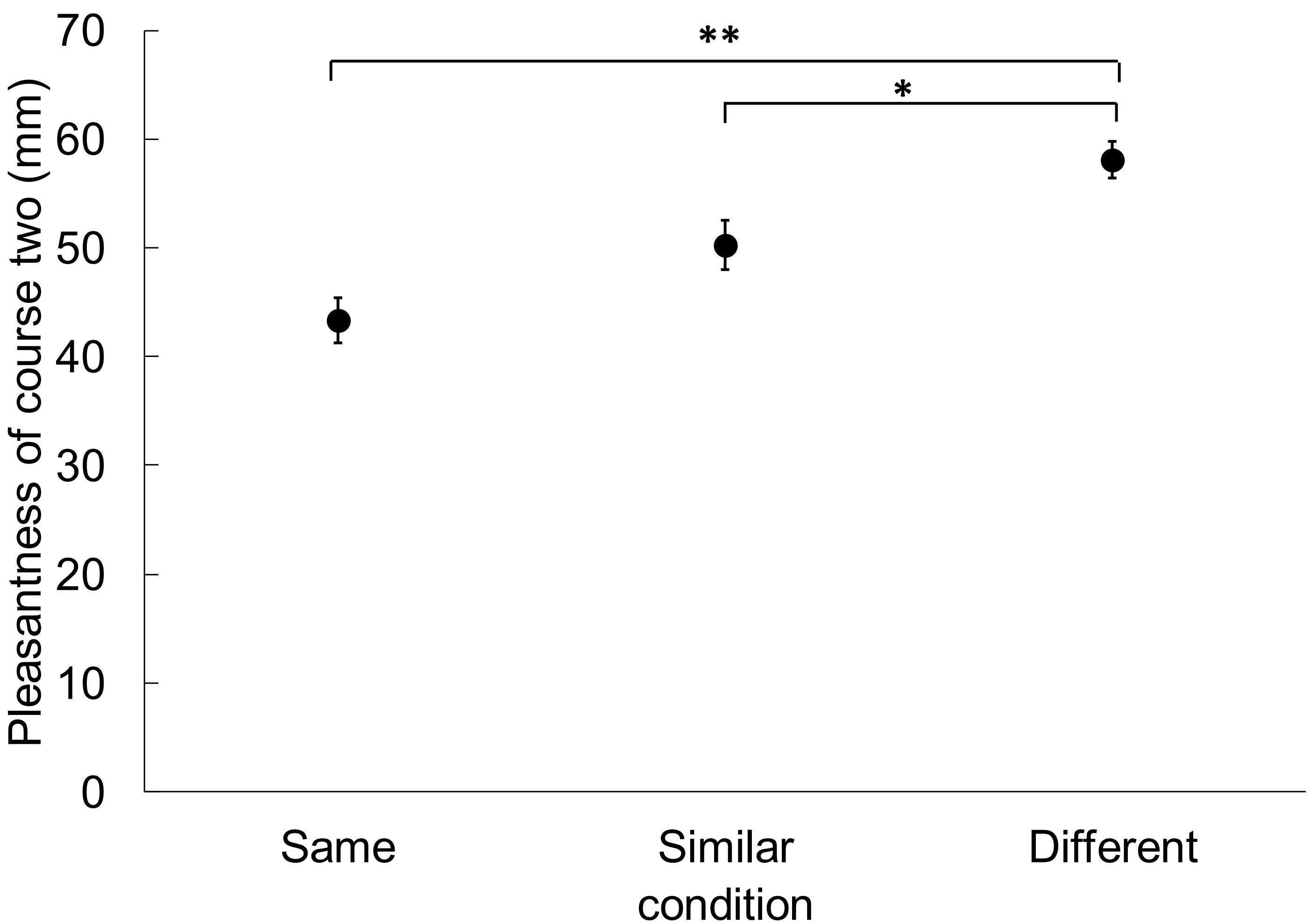
Figure 1. Mean and SE of rated pleasantness (mm) of course two across conditions. (* $p < .016$; ** $p < .003$).

Figure 2. Means and SE for the two ideal portion size tasks. ▲ Course two ● Course one and course two combined (* $p < .016$; ** $p < .003$).

Figure 3. Mean and SE of rated pleasantness (mm) of snack two across conditions. (* $p < .016$; ** $p < .003$).

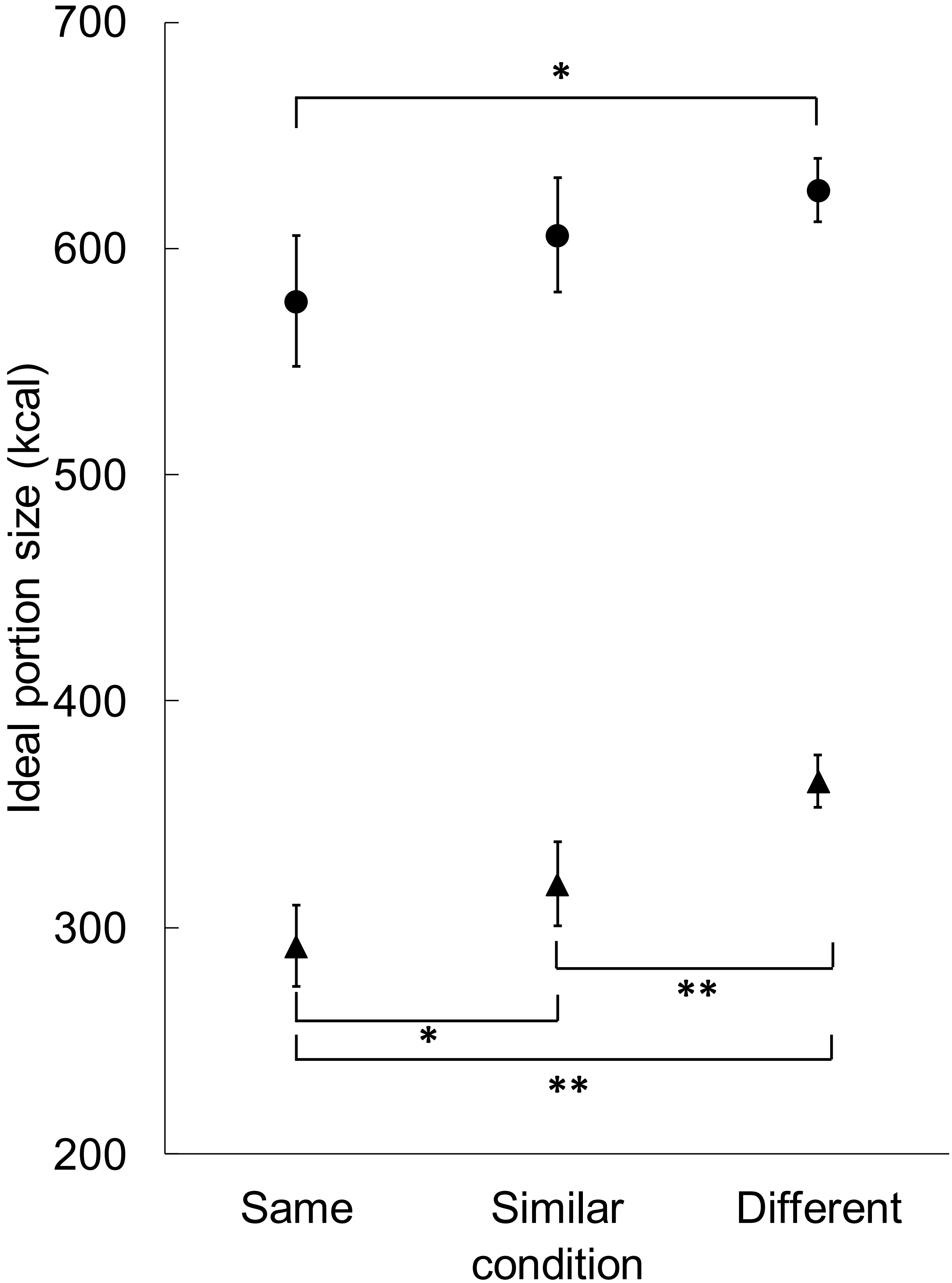
Figure 4. Means and SE for the two ideal portion size tasks. ▲ Snack two ● Snack one and snack two combined (* $p < .016$; ** $p < .003$).

Figure 1.



Pleasantness of course two (mm)
70
60
50
40
30
20
10
0
**
*
Same
Similar
Different
condition

Figure 2.



700
600
500
400
300
200
Ideal portion size (kcal)
*
*
**
**
Same
Similar
Different
condition

Figure 3

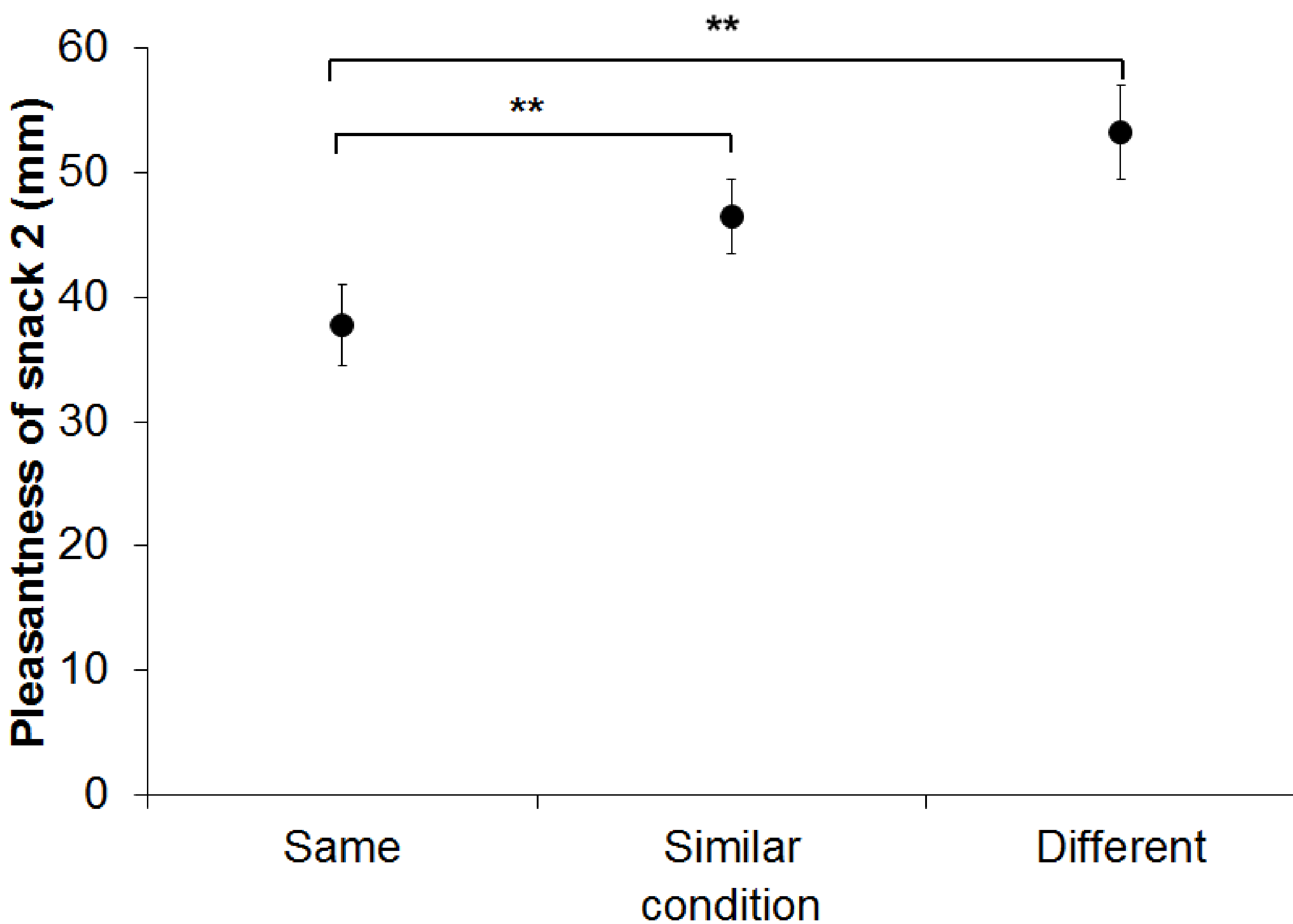
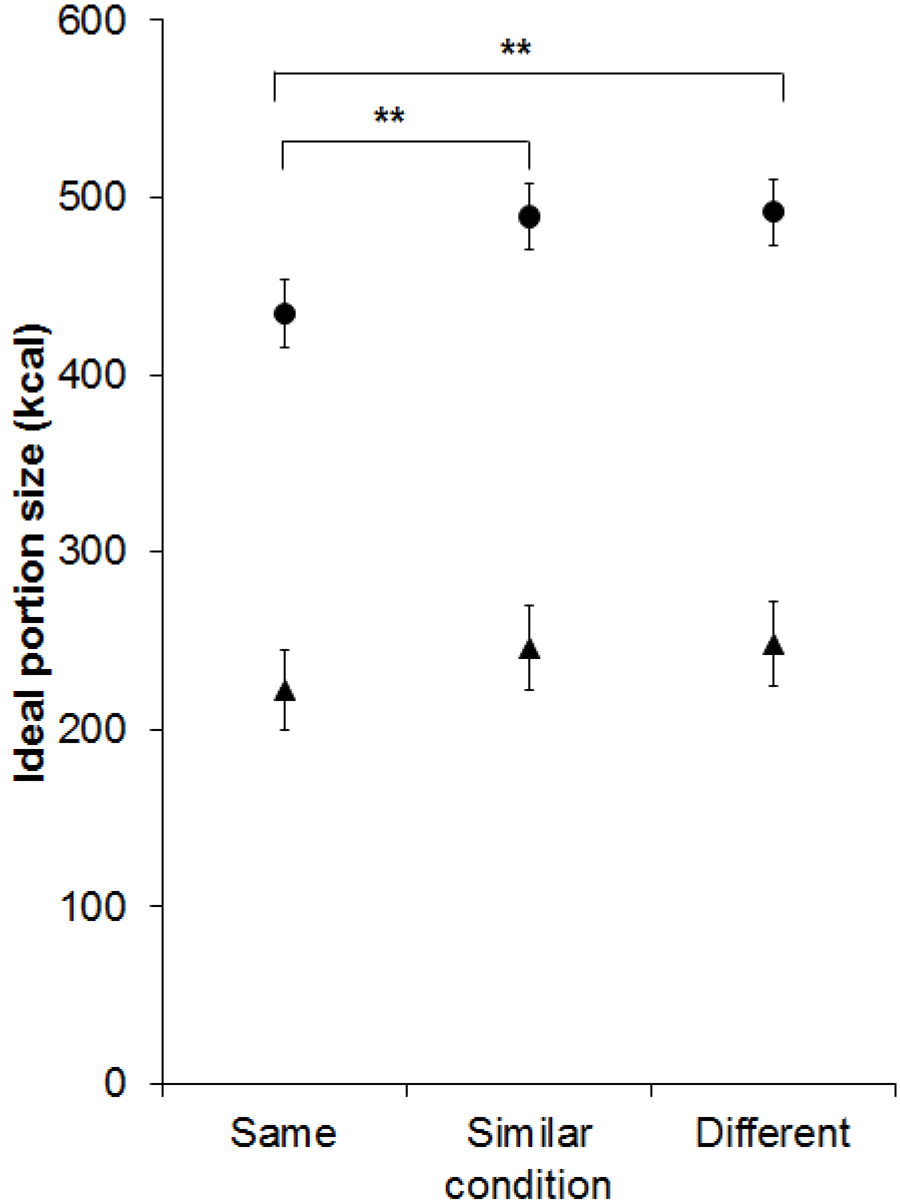

**
**
60
50
40
30
20
10
0
Pleasantness of snack 2 (mm)
Same
Similar
Different
condition

Figure 4


600
500
400
300
200
100
0
Ideal portion size (kcal)
**
**
Same
Similar
Different
condition