The influence of expected satiety on portion size selection is reduced when food is presented in an 'unusual' meal context

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Abstract

Research shows that expected satiety is highly correlated with ideal portion size, however this correspondence has not been explored when a food is presented in an 'unusual' (incongruous) meal context. This study's aim was to explore whether expected satiety influences portion selection to the same extent in both congruous and incongruous meal contexts. Forty participants completed two trials (one at breakfast and one at lunch) on separate days in a randomised counterbalanced order. They completed measures of expected satiety and ideal portion size for four typical breakfast foods and four typical lunch foods, using a bespoke computer program. Our results showed a significant difference between expected satiety and ideal portion size for lunch foods presented at breakfast time (an incongruous meal context; $t_{(39)} = 2.95$, $p = 0.02$). There was no significant difference between expected satiety and ideal portion size in the other incongruous meal context (breakfast foods at lunch; $t_{(39)} = 2.10$, $p = 0.17$) or in congruous meal contexts (breakfast foods at breakfast time, lunch foods at lunch time; both $t_{(39)} \leq -0.15$, $p > 0.999$). These results suggest that expected satiety does not have as strong an influence on portion selection when food is presented in an unusual context. Furthermore, in such contexts, smaller portions were selected 1) to stave off hunger until the next meal and 2) as ideal portions compared to in more usual meal contexts. Research is warranted to explore this finding further to understand its implications for weight management.

Keywords: Expected satiation, expected satiety, meal planning, energy intake, portion size.

1. Introduction

Recent work has shown that expected satiety plays an important role in portion selection (Brunstrom, 2014; Wilkinson et al., 2012). Expected satiety can be defined as the extent to which a food is expected to stave off hunger. Further research has shown that expected satiety is learned and refined after a food has been consumed one or more times (Brunstrom, 2014; Brunstrom, Shakeshaft, & Alexander, 2010). This learning is important because it enables us to 1) anticipate the satiety that might be expected after consuming a food or portion, and 2) select appropriate portion sizes before a meal begins. The importance of understanding how expected satiety is learned is highlighted by research showing that it is highly correlated with ideal portion size (Wilkinson et al., 2012) and that (pre-meal) portion selection is an excellent predictor of subsequent energy intake at a meal (Brunstrom, 2014; Fay et al., 2011).

Pre-meal food selection is somewhat constrained by another learned factor – the meal context. For example, foods regularly eaten for lunch, and not at other meals, are considered ‘lunch foods’, eaten at ‘lunch time’. Furthermore, meals throughout the day tend to differ in their typical size, e.g., in the UK, breakfast is a typically smaller meal (in terms of energy) than lunch (Clayton et al., 2016). Based on this, it is possible that a food’s expected satiety is learned and thus expressed in a specific meal context. A question, currently unanswered, that arises from this is: does expected satiety play a similar role (if any) in influencing portion selection when selecting a food portion in an incongruous meal context (e.g., pasta at breakfast time) compared to in a congruous meal context (e.g., pasta at lunch time)? Various findings bring credence to the possibility that context can moderate the role of expected satiety. For example, a study found that when choosing a food to consume, the influence of expected satiety on food choice was reduced in a context where only one bite of the selected food could be eaten, compared to a context where unlimited food could be eaten with the knowledge that the next meal would be in around 6 hours' time (Brunstrom et al., 2016). Further work has also shown that portion size selection is affected by the context of an individual's current mindset. For example, participants who ate with the mindset of ensuring fullness was maintained until dinner time chose a larger portion size compared to participants who could choose any portion they liked, for whatever reason (i.e., a free choice context) (Hege et al., 2018). Furthermore, another study found that hunger led to more positive attitudes towards foods when the attitude report was conducted in a congruous meal context compared to an incongruous meal context (Aikman & Crites, 2005).

In this study, the context of interest was the specific mealtime at which a food is consumed and the congruency of the food to the mealtime (food-to-mealtime congruency). In incongruous meal contexts, we anticipated a difference between portions (in energy content) selected to stave off hunger and those selected as ideal, whereas in congruous meal contexts we anticipated a similarity between portions selected to stave off hunger and those selected as ideal. Furthermore, we also wanted to explore whether the portion that is expected to stave off hunger until the next meal changes depending on whether the food is presented in a congruous or incongruous meal context. In order to investigate these ideas, we asked participants to select a portion (for eight different foods, in turn) that best matched 1) the portion they perceived would stave off hunger until their next meal (expected satiety), and, in a separate task, 2) their ideal portion size (i.e., a free choice selection based on their current motivational state). They completed these measures at breakfast time and lunch time on separate days. The relative role of expected satiety in governing portion selection was determined by comparing expected satiety and ideal portion size in congruous (breakfast foods at breakfast time, and lunch foods at lunch time) and incongruous (breakfast foods at lunch time and lunch foods at breakfast time) meal contexts.

This research aims to provide initial evidence about the relative role of expected satiety in governing portion selection in congruous and incongruous meal contexts, and the impact this might have on overall meal size. These findings are important in order to inform policymakers, weight management practitioners and food manufacturers as to whether eating foods in unusual meal contexts is beneficial or detrimental to acute energy intake and, ultimately, to supporting healthy weight management.

2. Methods

2.1. Overview

This study used a repeated measures, crossed factors design. Participants were asked to take part in two trials: breakfast time (08:00 h) and lunch time (13:00 h), on separate days in a randomised counterbalanced order. Appetite measures (subjective feelings as well as measures of expected satiety and ideal portion size) were obtained using a bespoke computer program (written by J.M.B. in Visual Basic 6.0 (Microsoft Inc.)). Ethics was granted by the Loughborough University Ethics Approvals (Human Participants) Sub-Committee and participants gave informed consent before taking part in the study.

2.2. Participants

Although *a priori* research questions were established, this study was exploratory. Therefore, a suitable sample size was determined by considering previous similar studies exploring expected satiety. Irvine et al. (2013) recruited 44 participants to explore whether expected satiety scores changed across two conditions. Using a repeated (within) measures

ANOVA, a medium effect size (*r* = 0.38) change in expected satiety scores was found, with 99% statistical power. Wilkinson et al. (2012) recruited 30 participants and found a strong correlation (*r* = 0.60) between expected satiety and ideal portion size, with 96% statistical power. Thus, we determined that a sample size of 40 was appropriate for our study as a power calculation (G*Power 3.1; Faul, Erdfelder, Lang, & Buchner, 2007), using an α of 0·05 and a β of 0·2, indicated that this sample would provide statistical power to detect medium to large effect sizes in our analyses.

Both male and female participants, aged over 18 years, were recruited via the university Participant Recruitment Scheme (whereby student participants received course credit in return for their participation) and through opportunity sampling. Menstrual cycle phase was not standardised for female participants. Vegans and vegetarians were excluded from the study and only individuals who habitually ate breakfast (at least 5 days a week) were recruited. Participants were told that breakfast is defined as "the first meal of the day, consumed within 2 h of waking" (Clayton & James, 2016). To ensure hunger was controlled, participants were asked to refrain from eating for 12 h prior to the breakfast trial, and for 4 h prior to the lunch trial (fasting periods used in previous research; Clayton, Stensel & James, 2016). Participants were also asked to avoid caffeine 12 h prior to each session and to refrain from exercise on the day of each test session and for 24 h prior to each test day.

2.3. Materials

Participants completed portion-size selection tasks to assess appetite measures using a bespoke computer program which presented pictures of eight different test foods presented to the participants in a randomised order [Table 1]. These foods were selected because they are regularly consumed in the UK for breakfasts and lunches and are considered to be congruous for these mealtimes. The congruency of the test food to the mealtime was verbally confirmed with participants before completing the first computer task.

Table 1.

The eight test foods (and manufacturer) used in the computer-based trial.

Breakfast foods	Energy density (kcal/g)	Lunch foods	Energy density (kcal/g)
Porridge (Quaker)	3.74	Beef lasagne & peas (Sainsbury's)	1.44
Rice Krispies* (Kellogg's)	3.87	Spaghetti Bolognese (Sainsbury's)	1.41
Special K* (Kellogg's)	3.75	Chicken Salad (Sainsbury's)	0.98
Cheerios* (Kellogg's)	3.80	Fish, chips & peas (Bird's Eye)	1.72

* A semi-skimmed milk portion (200 ml, energy density = 0.5 kcal/g) was presented in a glass and remained unchanged in portion size at the back right of the photo.

For each meal, a set of photographs were taken using a high-resolution digital camera. Each meal was photographed on the same white plate or transparent glass bowl with a consistent lighting and viewing angle in each photograph. Each meal was photographed between 40-70 times depending on the total amount of food that could be positioned on the plate or in the bowl. Each picture depicted a 20-kcal increase in the portion. These images were loaded into a bespoke computer program written in Visual Basic (Microsoft Inc.). Participants were asked to increase or decrease the size of the portion using the left and right arrow keys on the keyboard. Depression of an arrow key caused the size to increase or decrease such that the change in portion appeared animated. This validated, psychophysical method of adjustment has been used in previous studies to quantify expected satiety and ideal portion size (Brunstrom, Brown, Hinton, Rogers, &

Fay, 2011; Brunstrom et al., 2010; Brunstrom & Shakeshaft, 2009; Oldham-Cooper, Wilkinson, Hardman, Rogers, & Brunstrom, 2017; Wilkinson et al., 2012).

2.4. Measures

2.4.1. Demographics. Participants were asked to complete an online questionnaire in their own time 1-7 d prior to starting the study. This questionnaire collected information on the participant's sex, age, and dietary and eating behaviour traits (assessed via Three Factor Eating Questionnaire; TFEQ, Stunkard & Messick, 1985). Height, weight and body composition (via bioelectrical impedance) data were also taken at the end of the study (Tanita BC-418, Arlington Heights, IL).

2.4.2. Hunger. Hunger was assessed using a digitally presented 100-mm visual-analogue rating scale (VAS). Participants were asked: "How hungry do you feel right now?" They indicated their current state from "Not at all" (0) to "Extremely" (100) by moving a cursor along a line.

2.4.3. Expected satiety and ideal portion size (method of adjustment). Based on previous research (Wilkinson et al., 2012), expected satiety was assessed by asking participants: "How much would you need to eat to stop feeling hungry until your next meal? Imagine you are offered this food right now and this is the only food available. Use the arrows [on the keyboard] to show how much you would need to eat to stop you feeling hungry until your next meal (lunch or dinner)." For ideal portion size, participants were asked: "What would be your ideal portion size right now? Imagine you are offered this food right now and this is the only food available until your next meal (lunch or dinner). Use the arrows [on the keyboard] to show how much you would select right now." These tasks were completed for all eight test foods.

2.4.4. Liking and desire to eat. Participants rated their liking for and desire to eat each test food in turn using a digitally presented 100-mm VAS. A picture of a 400-kcal portion of each food was presented on the computer screen below the VAS. The liking scale was headed: "How much do you like the taste of this food?" The left-hand end of each scale was anchored with the words "I hate it" (0) and the right-hand end was anchored with "I love it" (100). The desire to eat scale was headed: "How much would you like to eat this food right now?" The left-hand end of each scale was anchored with the words "Not at all" (0) and the right-hand end was anchored with "Extremely" (100). These tasks were completed for all eight test foods.

2.5. Procedure

Participants who expressed an interest in participating in the study were emailed a link to an online information pack presented using the Online Surveys Platform (onlinesurveys.ac.uk). From here, participants read the information sheet, gave their consent to participate by ticking a box on the online form, before completing the demographics questionnaire.

Participants completed the trials in one of two ways: either on a computer in the laboratory (n = 30) or remotely by online video call and screen-share software (n = 10). For participants completing the study at the laboratory, they were seated at a computer upon arrival and reminded of the procedure before starting the computer program. Firstly, participants were asked to indicate their hunger levels using the method outlined above. Each of the eight test foods was then presented in turn. For each test food, participants provided a measure of liking, desire to eat, expected satiety and ideal portion size. Participants were free to leave the laboratory after completing all measures. Each trial lasted no longer than 30 minutes. Participants returned for the second trial after a minimum of one day and a maximum of seven days. At the end of the second trial, participants had their height, weight and body composition measured via bioelectrical impedance machine and a demand awareness check was conducted (no participants were aware of the study's aims).

For participants completing the study remotely, participants logged on to an online video call and screen-share service on their computer (Skype for Business, Microsoft, US). When participants had accepted the video call, initiated by the researcher, they were reminded of the procedure before the researcher shared and gave control of the computer screen to the participant. The participants then completed the computer program as detailed above. At the end of the second trial, participants self-reported their height and weight via Skype Messenger, and BMI was subsequently calculated by the researcher.

2.6. Data analysis

Data were analysed using SPSS V24 software (SPSS Inc.). In all analyses, estimates of expected satiety and ideal portion size were converted to kcal (the energy content of the food in the selected picture; for the cereal-based breakfast foods this included the milk portion). From the four breakfast foods and four lunch foods, two aggregated food groups were created (breakfast foods and lunch foods) by averaging the values from the four breakfast foods and four lunch foods, respectively. All analyses on expected satiety, ideal portion size, liking and desire to eat data were conducted on the two aggregated food group scores unless otherwise stated. The two aggregated food groups and the two mealtimes (breakfast time and lunch time), created four meal contexts that were either congruous (breakfast foods at breakfast time; lunch foods at lunch time) or incongruous (breakfast foods at lunch time; lunch foods at breakfast time). Visual analogue scale rating scores were calculated automatically by the computer in mm. Significance was accepted at $p < 0.05$ unless otherwise stated. All data was checked for normality using a Shapiro-Wilk test and analyses were either parametric or non-parametric. As data analyses were both parametric and non-parametric, *r*-values were calculated from *F*-, *Z*- and *t*-values to show effect sizes using equations by Rosenthal (1994); effect size benchmarks were determined as small ($r = |0.1|$), medium ($r = |0.3|$) and large ($r = |0.5|$) (Cohen, 1992). All data are presented as means and standard deviations unless otherwise stated.

To test our main hypothesis regarding the influence of expected satiety on portion size selection in congruous and incongruous meal contexts, a 3-way (2x2x2) ANOVA was used. This analysis allowed us to explore the interaction between average expected satiety and average ideal portion size (2 levels) across mealtimes (by 2 levels; breakfast time and lunch time) and food groups (by 2 levels; breakfast foods and lunch foods). To explore a 3-way significant interaction further, planned *post hoc* paired-samples *t*-tests were conducted subsequently to compare average expected satiety scores with average ideal portion size scores in each food-to-mealtime context. As four *post hoc t*-tests were conducted, we corrected for the increased likelihood of Type 1 error by accepting a critical *alpha* value of $p = 0.0125$, calculated via the Bonferroni method. All *p*-values for the four *post hoc t*-tests are presented with the Bonferroni correction applied. It was deemed appropriate to include two different measures in a 3-way ANOVA since they are scaled similarly and the method to collect the data is also similar. Furthermore, associations between expected satiety and ideal portion size, and their respective correlation with liking and desire to eat, in each food-to-mealtime context were assessed. Kendall’s tau was used to produce the correlation coefficients as these data were not normally distributed ($W_{(88)} \geq 0.843$, $p \geq 0.0005$). Subsequently, the significant difference between correlation coefficients was calculated by transforming *r*-values to Z-scores using Fisher’s *r*-to-*z* transformation, before Steiger's (1980) Equations 3 and 10 were used to compute the asymptotic covariance of the estimates.

To explore the effect of congruency on expected satiety and ideal portion size (separately), pairwise *t*-tests were used to compare the average total portion selected by each participant in congruous (breakfast foods at breakfast time + lunch foods at lunch time) and incongruous (breakfast foods at lunch time + lunch foods at breakfast time) meal contexts. To analyse the influence of food group, mealtimes and food-to-mealtime congruency on liking, desire to eat, ideal portion size and expected satiety separately, the main effects and interactions were explored using a repeated measures 2x2 ANOVA.

3. Results

3.1. Participant characteristics

Forty participants (20 female, 20 male; age = 29.1 ± 14.3 y; BMI = 23.0 ± 14.3 kg/m^2) took part in the study. Participants had mean TFEQ scores of 7.5 ± 4.7 (restraint), 6.2 ± 3.3 (disinhibition) and 5.4 ± 3.3 (hunger).

3.2. Baseline hunger

Baseline hunger did not differ significantly between breakfast time and lunch time, (breakfast time = 65.0 ± 19.3 mm; lunch time = 72.2 ± 17.8 mm; Z = -1.86, p = 0.063, r = |0.21|).

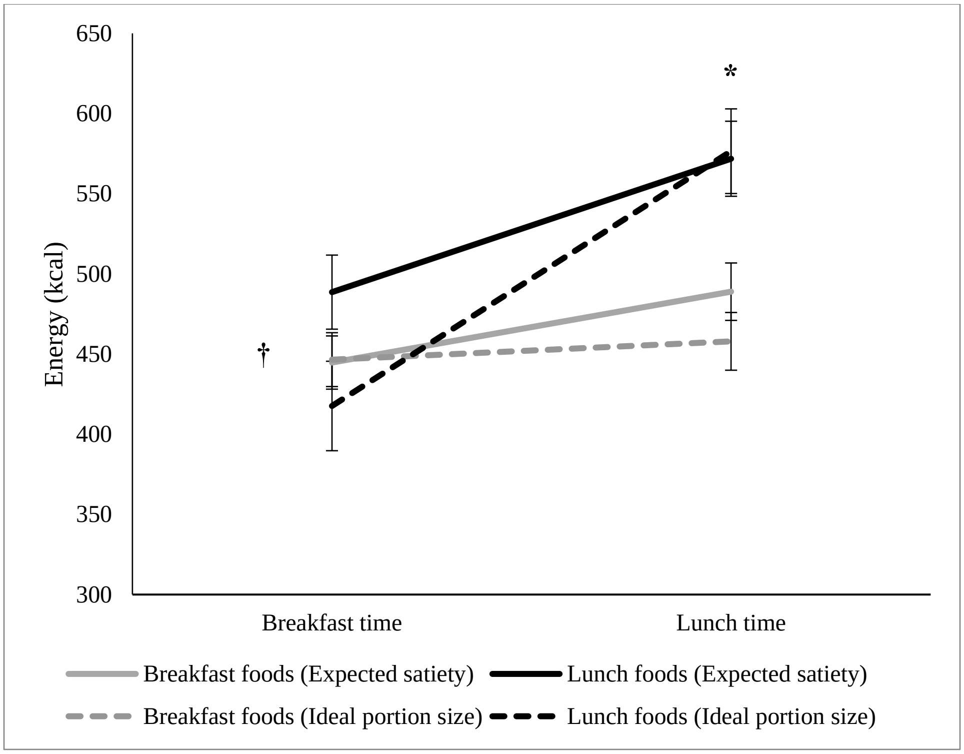

Figure 1. Mean (±SEM) meal size (kcal) scores for expected satiety and ideal portion size for breakfast foods and lunch foods (food group) at breakfast time and lunch time (mealtimes).

† Significant difference between average expected satiety and ideal portion size scores for lunch foods at breakfast ($p = 0.02$).

* Larger portions selected at lunch time compared to breakfast time for average expected satiety ($p = 0.002$) and ideal portion size scores ($p < 0.001$).

3.3. Expected satiety and ideal portion size comparison

Figure 1. shows average expected satiety and average ideal portion size scores in each meal context. The 3-way ANOVA (between expected satiety and ideal portion size across the mealtimes and food groups) revealed a significant interaction ($F_{(1,39)} = 10.22$, $p = 0.003$, $r = |0.46|$). To explore this interaction, paired samples *t*-tests found that for lunch foods presented at breakfast time (an incongruous meal context) ideal portion size was significantly smaller than expected

satiety ($t_{(39)} = 2.95$, $p = 0.02$, $r = |0.43|$). However, there was no significant difference for breakfast foods presented at lunch time (the other incongruous meal context) ($t_{(39)} = 2.10$, $p = 0.17$ $r = |0.32|$). There was also no significant difference found between expected satiety and ideal portion size for the two congruous meal contexts of breakfast foods at breakfast time ($t_{(39)} = -0.15$, $p > 0.999$, $r = |0.02|$) and lunch foods at lunch time ($t_{(39)} = -0.23$, $p > 0.999$ $r = |0.04|$).

3.4. Associations between liking, desire to eat, expected satiety and ideal portion size

A Kendall's tau analysis revealed that expected satiety and ideal portion size were correlated in each of the four meal contexts. A large effect size was found in the congruous meal contexts and a medium effect size was found in the incongruous food-to-mealtime contexts [Table 2]. Although congruency somewhat influenced the strength of the correlation, Steiger's calculations revealed that there was no significant difference between correlation coefficients for any meal context comparison ($Z \leq 1.29$, $p \geq 0.173$). No other variable significantly correlated with ideal portion size in all meal contexts or as strongly as expected satiety [Table 2].

Table 2.

Correlations (*r*) between expected satiety and ideal portion size and their respective correlation with liking and desire to eat, in each meal context.

Relationship	Breakfast foods at breakfast time	Breakfast foods at lunch time	Lunch foods at breakfast time	Lunch foods at lunch time
IP - ES	0.544***	0.485***	0.384**	0.564***
IP - DTE	0.217*	0.113	0.199	0.247*
IP - LIKING	0.277*	0.234*	0.154	0.220*
ES - DTE	0.183	0.131	0.142	0.194
ES - LIKING	0.308**	0.163	0.193	0.157

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; IP = Ideal portion size; ES = Expected satiety; DTE = Desire to eat.

3.5. Expected satiety

Figure 1. shows the average expected satiety scores for breakfast foods and lunch foods at breakfast time and lunch time. The 2x2 ANOVA revealed that a larger portion size was chosen to stave off hunger at lunch time (530 ± 131 kcal) compared to breakfast time (467 ± 126 kcal; $F_{(1, 39)} = 11.19$, $p = 0.002$, $r = |0.47|$). Overall, lunch food portions were larger than breakfast food portions (lunch foods = 530 ± 147 kcal; breakfast foods = 467 ± 109 kcal; $F_{(1, 39)} = 12.47$, $p = 0.001$, $r = |0.49|$). A significant interaction between food groups and mealtimes ($F_{(1, 39)} = 4.59$, $p = 0.038$, $r = |0.32|$) indicated that the portion size selected to stave off hunger until the next meal increased from breakfast time to lunch time to a greater extent for lunch foods (change = 17.0%; breakfast time = 489 ± 146 kcal; lunch time = 572 ± 148 kcal) compared to breakfast foods (change = 9.9%; breakfast time = 445 ± 105 kcal; lunch time = 489 ± 146 kcal). Moreover, participants chose a smaller overall portion to stave off hunger until the next meal in the incongruous meal contexts (489 ± 101 kcal), compared to congruous meal contexts (508 ± 99 kcal) (kcal difference = 19 kcal; $t_{(39)} = -2.14$, $p = 0.039$, $r = |0.32|$).

3.6. Ideal portion size

Figure 1. shows the average ideal portion size scores for breakfast foods and lunch foods at breakfast time and lunch time. The 2x2 ANOVA revealed that ideal portion size was significantly larger at lunch time (517 ± 140 kcal) compared to breakfast time (432 ± 141 kcal; $F_{(1, 39)} = 18.17$, $p < 0.001$, $r = |0.56|$). Furthermore, ideal portion size was larger for lunch foods (497 ± 172 kcal) than for breakfast foods (452 ± 110 kcal; $F_{(1, 39)} = 5.101$, $p < 0.030$, $r = |0.34|$).

A significant interaction between food groups and mealtimes ($F_{(1, 39)} = 18.28$, $p < 0.001$, $r = |0.56|$) indicated that ideal portion size increased to a greater extent from breakfast time to lunch time for lunch foods (change = +38.0%; breakfast time = 418 ± 177 kcal; lunch time = 577 ± 167 kcal) compared to breakfast foods (change = +2.5%; breakfast time = 447 ± 106 kcal; lunch time = 458 ± 114 kcal). Average ideal portion size was significantly smaller when the test foods were presented in incongruous meal contexts (438 ± 121 kcal), compared to congruous meal contexts (511 ± 105 kcal) (kcal difference = 74 kcal; $t_{(39)} = -4.27$ $p < 0.001$, $r = |0.56|$).

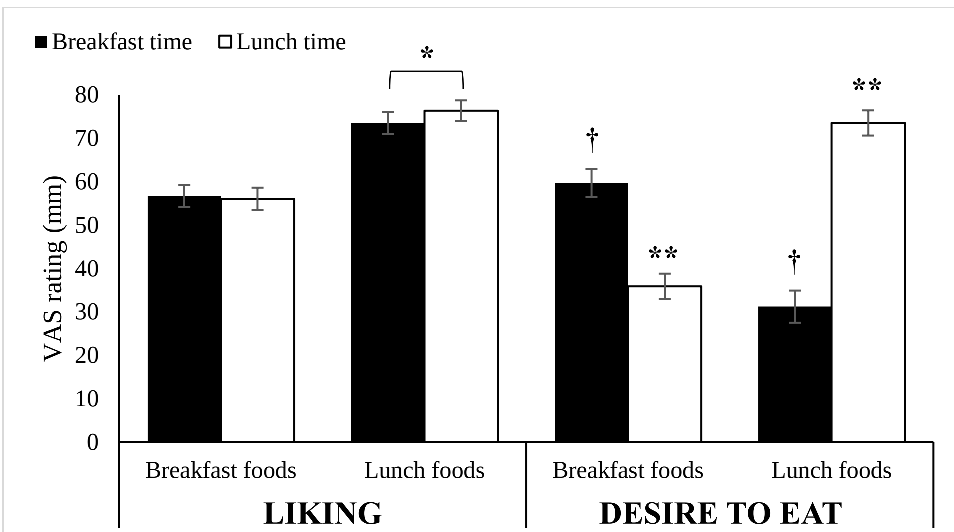

Figure 2. Mean (±SEM) ratings (mm) for liking and desire to eat the breakfast foods and lunch foods (food group) at breakfast time and lunch time (mealtimes).

* Lunch foods were liked significantly more than breakfast foods (p < 0.001).

** Desire to eat was significantly higher at lunch time compared to breakfast time (p = 0.002).

† Congruous meal contexts (breakfast foods at breakfast time and lunch foods at lunch time) had significantly higher average desire to eat scores compared to the incongruous meal contexts (breakfast foods at lunch time and lunch foods at breakfast time) (p < 0.001).

3.7. Liking

Figure 2. shows that the average liking of the food groups did not differ significantly between mealtimes ($F_{(1,39)}$ = 0.82, p = 0.372, r = |0.14|) but that lunch foods were liked more than breakfast foods ($F_{(1,39)}$ = 29.67, p < 0.001, r = |0.66|). The non-significant interaction ($F_{(1,39)}$ = 2.91, p = 0.096, r = |0.26|) suggested that there was no significant difference in the change of average liking scores for breakfast foods and lunch foods from breakfast time to lunch time.

3.8. Desire to eat

Figure 2. shows that average desire to eat scores were higher at lunch time compared to breakfast time ($F_{(1,39)}$ = 11.49, p = 0.002, r = |0.48|) but did not differ significantly between food groups (F-$_{(1,39)}$ = 1.47, p = 0.233, r = |0.19|. The significant interaction ($F_{(1,39)}$ = 203.599, p < 0.001, r = |0.92|) indicated that the congruous meal contexts had higher average desire to eat scores compared to the incongruous meal contexts.

4. Discussion

This study aimed to explore whether the influence of expected satiety on portion selection is reduced when food is presented in an incongruous meal context. Our main finding was that ideal portions were similar to the portions selected to stave off hunger until the next meal (expected satiety) in congruous meal contexts (breakfast foods at breakfast time and lunch foods at lunch time). In contrast, in the incongruous meal context of lunch foods presented at breakfast time, ideal portions were smaller than those selected to deliver satiety. That said, in the other incongruous meal context (breakfast foods at lunch time) there was no significant difference between expected satiety and ideal portion size. We postulate that no significant difference was found in the incongruous meal context of breakfast foods at lunch time because the consumption of breakfast foods (e.g., cereals) at lunch time is a more common practice (less ‘unusual’ or incongruous), than the consumption of lunch foods (e.g., pasta) at breakfast time. Furthermore, these correspondences between expected satiety and ideal portion size were revealed while expected satiety correlated with ideal portion size (better than desire to eat and liking) in all meal contexts. Although these results lead us to reject our hypothesis that only congruous meal contexts would show a close correspondence between expected satiety and ideal portion size, these results suggest that even though expected satiety is highly associated with ideal portion size, the congruency of the meal context plays a role in determining the extent to which this is the case. Future research should explore why the influence of expected satiety varies in different meal contexts and recent work by Cheon, Sim, Lee and Forde (2019) may highlight a direction for future work. Their research indicated that people may have different satiety mindsets when choosing food portions such as choosing a food portion to 1) stop hunger, 2) obtain comfortable fullness, or 3) obtain complete fullness. In their study, the fullness mindset was the most common and, crucially, the largest portions were selected by those with this mindset. Notably, this work found that by explicitly activating another satiety mindset (e.g., eating to stop hunger instead of obtaining complete fullness) portion size selection was reduced. Thus, future work should look to assess whether changes in the correspondence between expected satiety and ideal portion size based on the congruency of the meal context are associated with changes in the pre-meal satiety mindset.

A further question arises from these expected satiety and ideal portion size results; that is, what factors determine when a meal context is congruous or incongruous? Although it might be expected that changes in desire to eat in different meal contexts may play a role, no significant correlations were found between desire to eat and ideal portion size or expected satiety in either of the incongruous meal contexts. This suggests that other variables beyond the measures taken in this study may help to explain how food-to-mealtime congruency is learned and expressed. A study by Aikman and Crites (2005) found that the experience of eating a food at a specific mealtime was more important than the general experience of eating food when they assessed hunger-induced attitude changes towards foods. Based on this finding, we suggest that familiarity of consumption within a specific meal context, rather than general familiarity of consumption, may be a determining factor in explaining how food-to-mealtime congruency is learned and expressed. That is, greater familiarity with consuming a food in a given meal context leads to a close correspondence between expected satiety and ideal portion size *only* within that meal context. However, it is also possible that congruency could be determined by the perceived social appropriateness of a meal context, learned implicitly through social cues rather than explicit food consumption. That is, an individual may not ever eat a specific food (e.g., porridge), but in knowing that it is an appropriate breakfast food, portion size heuristics learned from other similar and meal context-appropriate foods may be applied to influence portion selection. Unfortunately, while we did measure familiarity of consumption, the measure was not precise enough to allow us to test this possibility directly. Thus, this idea should be explored in future research.

Another aim of this study was to assess whether changes in expected satiety depend on whether the food is presented in a congruous or incongruous meal context. Our results found that the portion selected to stave off hunger until the next meal (expected satiety) decreased when foods were presented in incongruous meal contexts. Although the difference in total portion selection between congruous and incongruous meal contexts was only 19 kcal (a relatively small change), these results suggest that foods are judged to be more filling when consumed in incongruous meal contexts. If so, this could have implications for dietary regimes i.e., consuming familiar and palatable foods at incongruous times of day may lead to smaller portions being selected for the same level of satiety. This finding could be applied as a method of counterconditioning to reset (and increase) the satiety expectations of a familiar food and, ultimately, decrease portion size selection. If this is the case, the long-term implications need to be explored, as increasing the variety of choice at different mealtimes has been shown to compromise the control of food intake (Hardman, Ferriday, Kyle, Rogers, & Brunstrom, 2015). In order to test the robustness of this finding, future work should use foods with similar expected satiety, homogenous composition, and energy density. These factors limit the interpretation of our current findings as the 19-kcal difference between the total portion selections in congruous vs incongruous meal contexts may be due to the interaction between 1) different energy contents of our food types and 2) the difference in meal sizes at breakfast time and lunch time. That is, 1) standard portions of lasagne, spaghetti Bolognese and fish, chips and peas (three of our lunch foods) may be higher in energy content than standard portions of Rice Krispies, Special K and Cheerios (three of our breakfast foods), and 2) breakfast portions tend to be smaller than lunch portions, as reported in other studies (Clayton et al., 2016; de Castro, 2009; Schusdziarra et al., 2011). Thus, it may be that the interaction between these two factors masks the real portion size selection patterns at play here.

A final point of note relates to our finding that expected satiety was influenced by mealtimes (breakfast time and lunch time). That is, larger portions were chosen to stave off hunger until the next meal at lunch time compared to breakfast time. This is an important finding as it shows that satiety expectations are not learned for a food and applied kcal-for-kcal to all situations where hunger needs to be alleviated and satiety achieved. Rather, it suggests that the portion size expected to stave off hunger until the next meal changes relevant to the context in which the decision is made, such as the mealtime. We surmise that larger portions were chosen at lunch time because 1) lunch portions tend to be larger than breakfast portions (Clayton et al., 2016; de Castro, 2009; Schusdziarra et al., 2011), and/or 2) that the interval between lunch time and dinner time may typically be longer (~5-6 h) than between breakfast time and dinner time (~4-5 h).

In conclusion, this study found that the influence of expected satiety on portion selection is determined by the meal context in which the portion selection is made. Although we cannot say with certainty that a correspondence between expected satiety and ideal portion size means that ideal portion size is *caused* by expected satiety, where we see that similar amounts of food are selected this would seem like the most likely explanation. However, in certain circumstances where ideal portion size is less than the portion selected to stave off hunger until the next meal (specifically, in incongruous meal contexts), there is an implication that people are considering factors other than expected satiety in arriving at an ideal portion size. Further work should look to assess whether eating food in incongruous contexts might be helpful in reducing overall energy intake, how long this strategy might be effective before people adapt over time, and whether there is subsequent energy intake compensation later in the day. This is an important next step in this area of research as a concern that arises is that people might adapt to eating food in an incongruous context and increase their portion size over time. This might limit the efficacy of using this approach as an intervention method for healthy weight management. To determine whether this occurs, we recommend that the chronic effects of eating foods in an incongruous meal context should be studied over a longer period.

Conflict of interest

The authors declare no conflict of interest.

Author contributions

Conceptualisation, writing (reviewing and editing) and methodology: C.J.M., L.J.J., J.M.B. and G.L.W.; investigation, formal analysis, writing (original draft): C.J.M.; computer programming: J.M.B.

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