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Gregory S. Keenan, Louise Childs, Peter J. Rogers, Marion M. Hetherington, Jeffrey M. Brunstrom

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The portion size effect: women demonstrate an awareness of eating more than intended when served larger than normal portions

Gregory S. Keenan [a], Louise Childs [a], Peter J. Rogers [a], Marion M. Hetherington [b]

Jeffrey M. Brunstrom [a]

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

[b] School of Psychology, University of Leeds, Leeds LS2 9JT, UK.

Running header: Individuals appear aware of the impact larger portions have on their intake.

* corresponding author currently at the University of Liverpool

E-mail address: gregory.keenan@liverpool.ac.uk

Telephone number: +44 (0)151 794 3938

Abstract

Large portion sizes lead to increased intake. Some studies suggest that individuals are unaware that they consume more when served larger portions. In a between-subjects design we asked female participants (*N*= 48) how much pasta and tomato sauce they intended to consume for lunch prior to eating. We then provided a smaller or a larger portion of the same food and invited participants to self-serve a portion into a second bowl (same size in both conditions). After eating until comfortably full, participants were shown an image of the amount they had selected at the beginning of the meal. They were then asked whether they perceived having eaten more or less than this amount, and by how much more or less they had eaten. In total 46 responses were analysed. Of the participants who received the large portion and who ate more than intended, 77% (p = .029) correctly identified eating more. However, when participants were asked to indicate by how much they had eaten above or below their intended amount, those who ate more after receiving a larger portion underestimated their intake by 25% (p = .003). These findings suggest that greater intake from a larger portion is associated with an awareness of having eaten a large quantity combined with a failure to register the actual amount consumed (in the direction of underestimation). The latter might be attributed to an error associated with the visual estimation of volume.

Keywords: Portion size effect; Awareness; Energy intake; Food intake; Eating behaviour;

Introduction

In recent years the portion size of foods has increased (Nielsen & Popkin, 2003; Schwartz & Byrd-Bredbenner, 2006; Young & Nestle, 2002), and larger portions are associated with an increase in energy intake (Diliberti, Bordi, Conklin, Roe, & Rolls, 2004; Duffey & Popkin, 2011; Rolls, Morris, & Roe, 2002; Rolls, Roe, Halverson, & Meengs, 2007; Rolls, Roe, Kral, Meengs, & Wall, 2004; Wansink & Cheney, 2005; Wansink & Park, 2001). This 'portion size effect' persists even when food remains uneaten at the end of a meal (Rolls et al., 2002), suggesting that the phenomenon is not simply due to plate clearing. The amount served influences intake of amorphous foods (*e.g.*, pasta bake) (Rolls et al., 2002), foods served in discrete units, such as sandwiches (Rolls, Roe, Meengs, & Wall, 2004), pre-packaged snacks (Raynor & Wing, 2007) and even unpalatable foods, such as stale popcorn (Wansink & Kim, 2005).

The mechanisms underlying the portion-size effect are not well understood. Determining whether individuals are aware of having consumed a large meal after being offered a large portion would aid our understanding of these mechanisms. If individuals unknowingly eat more than intended, then this would suggest the involvement of a process that operates outside conscious awareness (*e.g.*, visual illusion or increased bite size). By contrast, if they are aware then this would imply a role for a form of decision-making that is potentially under volitional control (*e.g.*, a desire to obtain value for money and/or a consumption norm).

Several avenues of research suggest that individuals are unaware of their intake when served large portions. Firstly, participants report relative insensitivity to the effects of larger portions on levels of post-meal satiety (e.g., Levitsky & Youn, 2004; Rolls et al., 2002). For example, Wansink, Painter, and North (2005) found that participants who ate from a

self-refilling soup bowl consumed 73% more than participants who ate from an unmanipulated bowl, but both groups estimated consuming similar amounts. Secondly, individuals often report that they believe they have consumed their 'typical' portion after consuming large amounts (*e.g.*, Wansink & Sobal, 2007; Wansink, Van Ittersum & Painter, 2006; Vartanian, Reily, Spanos, Herman, & Polivy, 2017). In a series of four experiments, Wansink & Sobal (2007) found that altering portion-relevant cues (*e.g.*, food packaging, serving bowl, and plate size) led to participants consuming 31% more food than in the control conditions, where standard sized portion cues were provided. When participants in large portion-cue conditions were asked how much they believed they had eaten, most believed they had consumed their 'typical' amount. The majority of those in large portion-cue conditions attributed their intake to elevated hunger and seemed unwilling to acknowledge that they had been influenced by portion size. Similarly, Wansink, Van Ittersum & Painter (2006) found that health specialists who served themselves ice-cream into either a small or a large bowl estimated selecting roughly equal calorie amounts , despite individuals in the large bowl condition having selected 31% more ice-cream.

Notwithstanding these results, there are also several findings that are consistent with an account based on portion awareness. Rolls et al., (2004) gave individuals different sized sandwiches on separate days and found that most recognised that the portions provided had increased in size. The same result has been observed using both amorphous foods (Kral, Roe, & Rolls, 2004) and liquids (Flood, Roe, & Rolls, 2006). Although not direct evidence for a role for awareness in the portion size effect, this does suggest that individuals recognise an increase in the portion sizes served (accounts based on lack of awareness suggest the converse). In a different paradigm, Van Kleef et al., (2012) found that participants served a larger portion consumed 77% more than those in a small-portion

condition, but estimated consuming 67% more calories than did participants in the small-portion condition. More recently, Vartanian, Reily, Spanos, Herman, & Polivy (2017) found that participants who believed they had eaten more than their typical amount had eaten larger quantities than those who believed they had eaten the same as normal or less. Also, those individuals who believed they had eaten more were also more likely to identify portion size as an influencing factor. This was interpreted as motivated denial, whereby individuals will acknowledge the influence of portion size when it suits them; for example, to justify increased consumption.

In the present study we focused on perceptions about intake after a meal has been consumed. Specifically, we tested the proposition that participants are aware that they have consumed a larger (than intended) meal after being offered a large portion to consume. We reasoned that if participants are aware that portion size influences intake, then i) the number who accurately report having consumed more / less than the amount they intended to eat should be greater than chance and ii) participants will be able to estimate accurately the degree to which their intake deviated from their initial intended amount.

Methods

Design

Participants initially provided measures of the amount of food they could comfortably consume ('intended intake') of the test meal (pasta and sauce) and two 'distractor' foods. Measures were obtained using a psychophysical procedure that does not involve overt selection of ideal portions. In a between-subjects design, participants then received either a smaller or larger portion of pasta (100% difference in portion size) and were asked to eat ad-libitum. After eating, participants were shown the food image which most closely matched their initial intended intake portion of pasta. They were then asked to identify whether they perceived having consumed more or less than this amount. Participants who answered correctly (congruence between behaviour and perceptions) were labelled 'aware' and participants who answered incorrectly were labelled 'unaware.' To establish whether they were aware of how much they had consumed, participants were then asked to spoon out the amount extra or less that they perceived consuming relative to their intended intake.

Participant characteristics

The participants were 48 female undergraduates studying at the University of Bristol in the UK (mean age = 20.6 years, SD= 2.2). The BMI of participants ranged from 17.5 to 33.1 kg/m^2 (mean BMI = 22.3, SD= 3.0 kg/m2). Two participants in each condition reported currently dieting to lose weight. Participants assisted with the study as part of an undergraduate course requirement and all provided informed written consent. Participants were excluded if they were pregnant or lactating, taking medications that may affect

appetite or in athletic training. The study protocol was approved by the University of Bristol (Faculty of Science) Research Ethics Committee.

Measures:

Establishing intended intake

Estimates of intended intake were obtained using an adapted version of 'a method of constant stimuli' (for more details of this method see Brunstrom, Rogers, Pothos, Calitri, & Tapper, 2008; Brunstrom, Shakeshaft, & Scott-Samuel, 2008), whereby participants were shown an image of a meal on a computer screen and instructed to "Think about whether this portion is 'more' or 'less' than the amount that would leave you comfortably full." Respectively, they pressed the left and right arrow key to indicate whether the portion was less or more than ideal. Probit analysis was used to calculate a point of subjective equality. This represents the point at which there is 50% likelihood that the amount will be selected as 'too much' or 'too little' and was taken to represent the amount each individual intended to consume. Participants were also shown this image to confirm that these were representative of the amounts that would leave them feeling comfortably full if eaten at that time. Participants completed the same task for three different meals; the 'test food' (Penne pasta a Dolmio sauce) and two that acted as distractors (scrambled egg with potato fries and baked beans; sponge cake). Forty-one images were taken of each food/meal, spaced with an increment of 20 kcal (range: 20 kcal to 800 kcal). The three meals were presented in a set of three trials and each set was repeated 56 times, yielding 56 responses to each food (168 trials in total). There are several advantages to this approach. First, the large number of trials increases the precision of the estimated point of subjective equality. Second, participants were never explicitly asked to identify their prospective portion size –

this information was extracted from their responses. This reduces the likelihood that they altered their responses to make them more desirable (*e.g.*, selecting an amount that makes them look as though they typically eat small portions). Third, at this stage the participants were unaware that they would be asked to consume food later in the study. The presence of distractor foods helps to detract attention away from the test food. Data from the distractor foods were not used in any further part of the study.

Test foods

The test food (eaten and photographed for the intended intake task) consisted of pasta ('Barilla penne 73', per 100g: 359 kcal: roughly 180 kcal when cooked) and tomato sauce (Dolmio Original Bolognese sauce, 52 kcal/100 g). The combination of pasta and sauce had an energy density of 1.33 kcal/g. The same proportions of pasta and tomato sauce were used each time and the cooking process for the pasta and tomato sauce was standardised across all participants. Participants were provided with either a smaller or larger portion of pasta and tomato sauce. In the 'smaller condition', 300 g of dry pasta (approximately 600 g when cooked) was prepared, to which 350 g of tomato pasta sauce (Dolmio Original, Mars UK) was added (950 g total / 1259 kcal). In the 'larger condition', 600 g of dry pasta was cooked (approximately 1200 g when cooked) and mixed with 700 g of pasta sauce (1900 g total / 2518 kcal). In both conditions, the pasta and sauce was served in the same bowl (26 cm diameter and 3.8 L volume). Participants served themselves using a serving spoon (29 cm long, scoop volume of 180 ml) and ate from bowls 18 cm in diameter, 0.3 L in volume. Participants were asked to serve the amount they would need to consume in order to leave them feeling comfortably full into a second smaller bowl (18 cm diameter, 300 ml volume)

using a large serving spoon. The amount participants selected was weighed in front of them. Participants were then told they could eat as much or as little of the portion they had served themselves. They were also told that if they wanted more, they could serve themselves more but should let the researcher know so that the amount could be weighed again. The final amount consumed was used to estimate whether participants had consumed more or less than their intended intake amount.

INSERT TABLE 1 HERE

Awareness of eating less or more than intended

To establish whether participants were aware of having eaten less or more than their intended amount, they were asked immediately after eating: "today, upon seeing the pasta, but before you began to scoop, did you have a rough idea in mind how much you wanted to eat? This may have been in terms of scoops or a visualisation in the bowl." This was in the form of a yes / no response with a text box below for any additional comments they felt relevant. This question was included to establish whether participants had pre-meal plans before they began to eat. At this point they were shown an image of the portion that they had individually intended to consume in the initial computer-based task. The bowl they had eaten from was visible on the table upon arrival. They were then asked if they thought they 'ate less' or 'ate more' than the amount represented in the picture. Responses to whether participants perceived they had eaten less or more than intended were coded for accuracy. The number 1 represented an accurate response (e.g., ate more and perceived they ate more, or ate less and perceived they ate less) and a 0 represented an inaccurate response (e.g., ate more but perceived they ate less, or ate less but perceived they had eaten more).

Awareness of exact amount consumed

Participants were provided with the same sized bowl as the one they had eaten from during the meal, the same sized spoon, and the same sized serving spoon. They were then asked to spoon out from a bowl of pasta and tomato sauce, the amount that they perceived corresponded with the difference between their actual consumption and the amount depicted on the computer screen (their intended amount). The amount spooned out was then weighed so it could be used to calculate how much each participant perceived they had consumed relative to their initial intended amount. If participants perceived they had consumed more than their intended amount, and were correct, the amount spooned out was added to the amount (in grams) equated / associated with the image selected for their intended intake. If they reported perceiving they had consumed less, and were correct, the amount spooned out was subtracted from the picture image. As noted, it was only possible to calculate estimated intake for those participants who correctly perceived they had eaten less or more than their plan – it would not make sense to add the amount scooped out if they had consumed less, and vice versa. Because of this, not all participant responses were included in this analysis – 33 responses were retained with 8 removed.

Procedure

Testing took place between 11:00 and 14:00 and participants were instructed to abstain from eating for three hours prior to their scheduled visit. Upon arrival they were seated in a partitioned booth. To avoid demand characteristics, participants were told that the purpose of the study was to explore changes in sweetness perception before and after a meal. Consistent with the cover story, at the beginning of the experiment participants were

given a list of 33 foods and instructed to rate (from memory) their sweetness on a five-point scale.

In the first phase of the study, participants completed the intended intake task on a computer. This generated an estimate of their intended pre-meal amount. In the second phase, participants were allocated to either the smaller or a larger-portion condition and served themselves the amount they would need to eat to leave them feeling comfortably full. Allocation was based on placing each person alternately to each condition, thus ensuring a level of randomisation. They then ate, and the amount consumed recorded.

After eating, participants completed the awareness of amount eaten task. This incorporated questions about whether they knew if they had eaten less or more than they initially intended, and by how much. These were the key outcome variables. Each task followed on from each other without a break between them.

Before leaving, participants completed a second sweetness awareness questionnaire to maintain the cover story. They then completed the revised Restraint Scale (Herman & Polivy., 1975) and the Dutch Eating Behaviour questionnaire (van Strien et al., 1986). This was followed by a question about whether they found the food to be more or less pleasant than initially anticipated ("Did the food taste more or less pleasant than you had anticipated?" where a 1 represents "very much less pleasant" and a 5 "very much more pleasant", with "about right" as the midpoint). Participants were then weighed and their height recorded.. All participants received a written debriefing and were thanked for their assistance.

Data analysis

Before beginning the main analyses, independent samples *t*-tests were used to check for baseline differences between groups in: age, BMI, dietary restraint, how pleasant participants found the food and intended intake. To determine evidence of a portion size effect, amounts consumed in the smaller portion and the larger portion condition were compared with an independent samples *t*-test. To test the hypothesis that the majority of participants would be aware of the amount eaten, the distributions of accurate responses were compared to null distributions via chi-square tests. If participants were aware of how much they have eaten, then the number who accurately reported consuming less or more than intended should be greater than chance. An initial chi-square was run with all data included to test accuracy across both conditions. To determine accuracy within each condition, separate chi-square tests were run on the data from the smaller and larger portion conditions. To test whether participants who received a larger portion and ate more than intended were aware of this, a further chi-square test was run on those that met these criteria. This test is important, because it assesses whether participants were aware that they had consumed a larger portion than they had initially planned, after receiving a larger portion.

To test the hypothesis that participants would be aware of the quantity of food consumed, an initial 2 (larger vs. smaller portion) x 2 (perceived vs. actual intake) mixed ANOVA was run. A significant interaction between ratings (perceived and actual) and portion condition was then explored using paired-samples *t*-tests to identify where the differences in expected versus actual intake existed within the two conditions. If participants were aware of the amount eaten, then the difference between the two amounts should be small and non-significant. A final *t*-test was used to test accuracy among

those participants who received a larger portion and consumed more than they intended. If there was a non-significant difference in amounts within this group, this would support the idea that participants know how much they are consuming when they eat in response to larger portions. As these interactions were explored using three separate *t*-tests, a Bonferonni adjustment was applied to the p-value (p = .05/3 = .017) to control for the multiple comparisons.

We noticed that scores for two participants were recorded differently in separate spreadsheets. Without being able to identify which one was correct, the data for both participants were removed from further analysis. One of these belonged to the smaller portion condition and another to the larger portion condition. The removal of these data points had little effect on any of the main findings reported below. Results with these data points retained are provided in footnote 1. There were no responses on the demand characteristics questionnaire that required data to be excluded.

Results

Participant characteristics

Participants assigned to the smaller and larger portion conditions were similar in: age, BMI, cognitive restraint, and the amount that they initially intended to consume (see Table 2).

Food pleasantness

The mean rating of food pleasantness relative to expectations was 3.54 (out of a possible 5.0) (S.D = .72). Only one participant reported that the food was less pleasant than anticipated, with the remaining participants responding that they found the food about right or more pleasant than anticipated. See table 2 for a breakdown of responses by portion condition.

INSERT TABLE 2 HERE

Amount consumed by those in the smaller and larger portion conditions

Participants in the larger portion (n = 23) condition consumed significantly more food (mean = 338.3 g, SD +/-120.7 g) than those in the smaller portion (n = 23) condition (mean = 265.7 g, SD +/- 86.3 g) ($t(44) = 2.35$, $p = .024$), confirming the expected portion-size effect.

[1] As noted in the data analysis section of the methods, two participant scores were removed. With all 48 participants included, there was still a significant difference in the amount eaten by those who received the

smaller versus larger portion ($t(46) = -2.15$, $p = .038$). The number of people who correctly reported eating less or more than initially intended was 71% (34/48), which was significantly different to the null distribution (χ^2 (1) = 8.33, $p = .004$). In the larger portion condition, 75% (18/24) correctly identified eating less or more than intended (χ^2 (1) = 6.00, $p = .014$). Of the 18 participants in the larger portion condition who consumed more than their intended amount, 78% (14/18) were correct (χ^2 (1) = 5.56 $p = .018$). In the smaller portion condition, 67% (16 /24) were correct about eating less or more than intended (χ^2 (1) = 2.67, p = .102). In terms of accuracy about the amount consumed, there was a significant interaction between portion size and actual/estimated intake $F(1,32) = 9.16$, $p = .005$. In the smaller portion condition, a subsequent *t*-test on the amount participants believed they had consumed and actual intake revealed a non-significant difference $t(15) = 1.35$, $p = .198$. No additional analyses were completed on the accuracy data for the larger portion condition. This is because the participant in the larger condition removed from the main analysis due to a mis-coding issue did not respond correctly to whether they perceived having eaten less or more than intended. Therefore, the results for this analysis did not differ from those explained in the main analyses above.

Awareness of amount consumed relative to intended intake

Across both conditions, 72% (33/46) of participants responded correctly to the binary question of whether they perceived they had consumed less or more than initially intended. This distribution of responses deviated significantly from chance (χ^2 (1) = 8.70, $p = .003$). See Table 3 for the percentage of participants in each condition who were correct or incorrect about eating less or more than intended across both conditions. When the larger portion condition was analysed separately, 78% (18/23) of participants correctly reported consuming less or more than intended. This level of accuracy was significantly above chance (χ^2 (1) = 7.35, $p = .007$). Moreover, of the 17 individuals who consumed more than intended, 77% (13/17) correctly reported consuming more (χ^2 (1) = 4.77 $p = .029$). In the smaller portion condition, 65% (15/23) of participants correctly identified whether they had eaten

less or more than intended, but this was not significantly different from chance (χ^2 (1) = 2.13, p = .144).

INSERT TABLE 3 HERE

Accuracy in estimating the difference between 'intended' and actual consumption

Only data for participants who correctly perceived having eaten less or more than intended were included in this analysis (see above). This left 33 scores with 13 removed (8 from the smaller portion and 5 from the larger portion conditions were removed).

Across participants, there was no significant difference in the amount of pasta and tomato sauce that participants perceived consuming relative to their actual intake (F(1,31) = .85, p = .364). However, there was a significant difference in perceived and actual intake based on which portion of food participants had received (F(1,31) = 9.33, p = .005). See Figure 1 for the perceived versus actual intake in each condition.

Participants in the smaller portion (n = 15) condition did not appear to perceive having consumed significantly less or more than their actual intake (t(14) = -1.42, p = .117). By contrast, participants in the larger portion condition (n= 18) tended to perceive that their meal was smaller than the actual amount (t(17) = -2.99, p= .008). This tendency to underestimate meal size was especially evident in participants (n = 13) who received a larger portion and who also consumed more than they intended (t(12) = -3.78, p = .003). That is, participants who receive a larger portion of food and consumed more than initially intended

systematically underestimate their intake, suggesting that they are not aware of the amount they have eaten[2].

INSERT FIGURE 1 HERE

Discussion

The purpose of the current study was to establish whether individuals are aware of consuming more than intended after receiving a larger portion of food. We found that: i) after self-selecting an intended portion, most participants who received a fixed larger portion could identify if they had consumed more or less than intended, but; ii) participants who received the larger portion could not accurately estimate the quantity of food consumed relative to their initial intended intake. These findings are considered in separate sections below.

Are subjects aware of eating less or more than a pre-defined amount?

Across both conditions, 72% of participants responded correctly to the question of whether they had eaten less or more than intended. From this we conclude a tendency for participants to be aware of how their intake compared to a pre-selected amount, or at least become aware when prompted. More importantly, accuracy was 77% in those who received the larger portion and who consumed more than initially intended. This suggests that participants who eat more when receiving a larger portion are generally aware of having

[2] The 5 participants who received a larger portion and ate less than intended, perceived they had eaten slightly more (279.1 g, SD = 88.4) than their actual intake (265.8 g, SD = 90.0), but this sample was considered too small to perform any meaningful statistical tests.

done so. However, we also note that accuracy levels were lower (65 %) in the smaller portion condition and were not significantly different from the null distribution.

The finding that participants who received the larger portion appeared able to identify consuming more than intended challenges the claim that individuals are unaware that they eat more when served larger portions (Wansink & Sobal, 2007; Wansink et al., 2006). It is not entirely clear why this is the case, but it could be attributable to differences in study design. Wansink, van Ittersum, & Painter (2006) gave participants a small or large bowl and asked them to serve themselves ice-cream. They found no significant difference in participant estimates of the number of calories selected between those who received small and large bowls, concluding that participants who received the large must have been unaware that they had selected a larger portion. However, estimating the energy content of a portion of food is a relatively abstract and difficult task. We note that Van Kleef et al., (2012) used a similar design and found a different result: individuals in the large-bowl condition estimated consuming significantly more than those in the small-bowl condition. Thus, estimating intake in terms of energy content appears to render inconsistent results. In the current study, participants were asked to make visual comparisons between the amount consumed and an amount they had previously selected themselves, under the same conditions. This reduces the likelihood that responses were affected by difficulties in estimating quantities using abstract units of measurement. Another approach has been to ask participants how the amount consumed compares to their typical portion (*e.g.*, Wansink and Sobal, 2007). Participants in the large portion conditions often report believing that they have consumed their 'typical' portion amount, so it is assumed that they must be unaware of their increased intake. A problem with this approach is that these claims cannot be verified and may reflect response bias. This is highlighted by Vartanian, Reily, Spanos,

Herman, & Polivy (2017) who recently found that participants were more willing to acknowledge being influenced by the presence of a large portion, when they believed they had eaten large amounts. Possibly because it is self-serving and offers an opportunity to justify overeating. The current approach of asking participants the binary question of whether they believe they had eaten less or more than an intended amount seems a logical extension as this seemed less susceptible to motivated responses. However, without having asked for their certainty in responses, we cannot rule out the possibility that some individuals may have guessed.

The low levels of apparent awareness (65 %) in the smaller portion condition was unexpected. We note that at 950 g the portion in the smaller portion condition was still relatively large and three times greater than mean intake in this condition. It was necessary to provide an amount of food that enabled for ad-libitum intake, but the null result in this condition represents a situation where participants who have received a relatively large portion have shown a low level of awareness. It is possible that this result might be due to the forced choice nature of the question that was posed. The difference between planned and actual intake was 22.9 g in the smaller and 52 g in the larger portion condition. If someone consumes an amount that is close to their intended intake, they might perceive there to be equal chance of them having eaten less or more than intended. This increases the potential for error in their responses. By comparison, someone who is aware that they have eaten considerably more than intended does not face the same difficulty in responding (there is no longer an equal chance that they have eaten less or more). Allowing a third option of 'about the same' might have resolved this issue. Another possibility is that awareness might only be prompted when very large portions are provided. However, Vartanian, Reily, Spanos, Herman, & Polivy (2017) found evidence of awareness using

smaller portions (600 g of pasta and tomato sauce in the large portion condition) making this seem unlikely.

Are subjects aware of the amount consumed?

When asked to indicate how much participants perceived consuming above or below their intended intake amount, participants in the smaller portion condition provided accurate estimations. However, those who received the larger portion, and who ate more than intended, underestimated their intake by 25%. This suggests that when individuals eat more than they intended in response to receiving a larger portion, they may be aware that they have done so but underestimate by how much.

The underestimation of intake by those served a larger portion replicates previous research (Chandon & Wansink, 2007; Harnack, Steffen, Arnett, Gao, & Luepker, 2004; Wansink & Chandon, 2006). In two separate studies, Wansink & Chandon (2006) found that individuals served a large portion underestimated their intake by 38% (study 1) and 23% (study 2). Those who received a small portion were almost perfectly accurate. Chandon and Wansink (2007) have shown that this inaccuracy in estimation follows a power function, whereby portion estimates become increasingly inaccurate as a function of larger portion sizes.

Difficulties in estimating the quantity of food present with larger portions suggests perceptual processes might also influence meal size. Individuals often pre-plan how much to consume prior to eating, and after serving themselves a portion of food follow-through with these plans (Brunstrom, 2014; Fay et al., 2011). Any underestimation of amount present is likely to result in eating more than intended. This increased intake is unlikely to be

constrained by physiological signals related to energy balance, because meal-to-meal acute fluctuations have negligible impact (Rogers and Brunstrom, 2016). Furthermore, modest additional fullness probably provides only weak added inhibition of food intake because normal meal sizes are generally much smaller than would be needed to induce discomfort – in other words, there is usually 'room for more' (Rogers and Brunstrom, 2016). We also note that perceptions about amount eaten are often stronger predictors of satiety than actual intake amount consumed (Brunstrom et al., 2012; Wansink, Painter, & North, 2005).

Limitations

The sample size for this study was not based on a power calculation. However, while the effect size of larger portions on intake is well established, no other studies have tested whether participants can identify eating less or more than a pre-defined amount, so performing an *a-priori* calculation would have been difficult. A retrospective power calculation on the chi-square analysis (72% accurate vs. 28% inaccurate overall) revealed that the study was 84.7% powered ($w = .44$, $\alpha = .05$). We therefore believe that the study is sufficiently powered for this analysis.

We acknowledge that asking participants to indicate how much they intended to serve themselves prior to eating might have influenced their later intake. Distractor foods were included for this reason, making it less likely that participants would not have known which food would be used as the test food, but we cannot be certain that this had some influence. Participants were also not given the opportunity to eat the same amount as their plan. The amount of food selected by participants was also weighed in front of them, which may have influenced intake. A difference was still observed in the amount individuals consumed in the smaller and larger portion conditions, suggesting that this did not strongly

affect behaviour. The percentage difference in intake (21.5 %) is also broadly consistent with amounts observed in a recent meta-analysis (*e.g.*, Zlavetska, Dubelaar, & Holden, 2014). Finally, only females were tested, so we do not yet know whether the same set of results would occur in males. These preliminary results must be interpreted with caution and would encourage attempts to replicate and extend this study by addressing the limitations outlined above.

Concluding remarks

Participants who received a larger portion appeared able to identify whether they had consumed more or less than an initial planned amount. This awareness of occasions when participants eat more than intended suggests an opportunity to introduce behavioural strategies that mitigate the effect of large portions on food intake. However, we also note that when participants were asked to provide estimates of the exact amount eaten, those who received the larger portion tended to markedly underestimate their intake relative to their original plan. This apparent absence of awareness of additional intake suggests that interventions aimed at modifying responses to larger portions might only achieve partial success and that concern about the availability of large servings and large pre-packaged portion sizes might only be fully addressed by down-sizing current product offerings.

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604 **Table 1: Macronutrient composition of the pasta and tomato sauce**

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Nutrition

	Dolmio tomato sauce per 100g	Pasta Per 100g (uncooked)	Pasta Per 100g (cooked – estimated)
Energy (Kcal)	52	359	180
Protein (g)	1.7	12	6
Carbohydrate (g)	8.7	71.7	35.9
Fat (g)	1.2	2.0	1.0

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609 **Table 2 :** Participant demographics, mean food pleasantness ratings and amount individuals

610 intended to consume by portion condition. Values in brackets in the columns for the smaller and

611 large portion conditions represent standard deviations.

	Smaller portion (n = 23)	Larger portion (n = 23)	Significance testing of differences between the smaller and larger groups
Age (years)	20.6 (1.1)	20.7 (3.0)	$t(44) = -.13$, $p = .90$
BMI (kg/m^2)	22.8 (3.4)	21.8 (2.5)	$t(44) = 1.16$, $p = .25$
Dietary restraint	2.7 (.9)	2.6 (.8)	$t(44) = .41$, $p = .68$
Food pleasantness (1-5 scale)	3.5 (.7)	3.6 (.7)	$t(44) = -.61$, $p = .55$
Intended intake (grams)	288.6 (135.0)	286.3 (184.4)	$t(44) = .05$, $p = .96$

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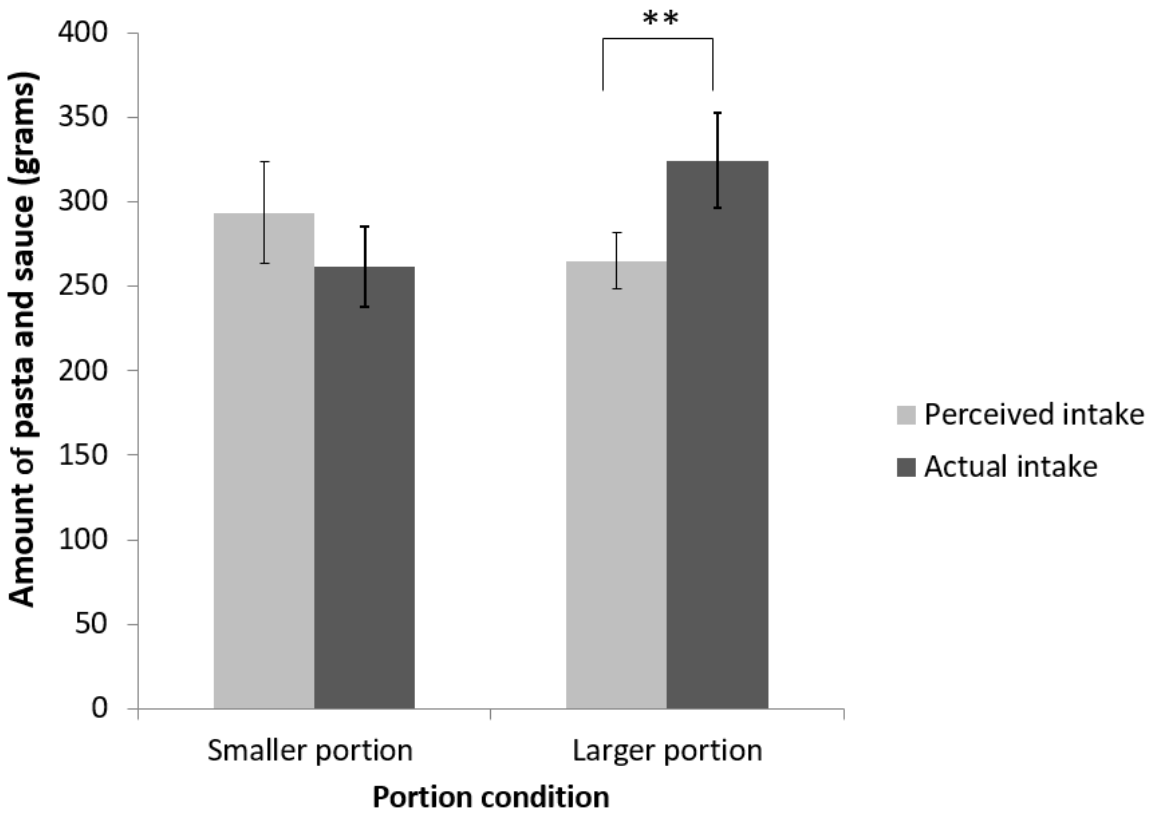
617 **Table 3:** The number and percentage of participants in each condition who correctly reported
618 consuming less or more than they initially intended. The χ^2 values represent the distribution of
619 scores versus the null distribution

Portion condition	Actual consumption	Estimated Amount		Totals	Comparison of values against null
		Correct	Incorrect		
Larger portion	Ate more	13 (76.5 %)	4 (33.3 %)	17	
	Ate less	5 (83.3 %)	1 (16.7 %)	6	
Total		18 (78.2 %)	5 (21.7 %)	23	χ^2 (1) = 7.35, p = .007
Smaller portion	Ate more	7 (58.3 %)	5 (41.7 %)	12	
	Ate less	8 (66.7 %)	3 (27.3%)	11	
Total		15 (65.3 %)	8 (34.8 %)	23	χ^2 (1) = 2.13, p = .144
Overall totals		33 (71.7 %)	13 (28.3%)	46	χ^2 (1) = 8.70, p = .003



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621 **Figure 1**: The amount that individuals in the smaller and larger portion conditions perceived
622 consuming versus their actual intake (** p <.01). Error bars represent standard error.
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