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How Many Calories Are on Our Plate? Expected Fullness, Not Liking, Determines Meal-size Selection

Jeffrey M. Brunstrom[1] and Peter J. Rogers[1]

The availability of highly palatable food is thought to stimulate the selection of larger meals (leading to weight gain and obesity). In this article, we explore aspects of this proposition. Specifically, we scrutinize two basic assumptions: (i) palatable energy-dense foods are more rewarding (desired), and (ii) these palatable foods are selected in relatively larger portions. In combination with palatability, we also consider the relative role for "expected satiation"—the extent to which a food is expected to deliver satiation. A total of 17 commonly consumed foods were assessed by 28 normal-weight participants at lunchtime. Critically, our measure of food reward and expected satiation involves comparisons between foods based on equicaloric portions. When assessed in this way, we find that food reward and ideal portion sizes (in kcal) are both closely associated with expected satiation, but not with "expected liking." Low expected satiation (not expected liking) predicts the selection of large portion sizes (in kcal) and foods with this characteristic tend to be more energy dense and are regarded as less (not more) rewarding (when compared calorie for calorie). Together, these findings challenge the role of palatability in meal-size selection and they highlight the importance of expected satiation, a "nonaffective" component of food reward.

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INTRODUCTION

Many large cohort studies reveal the serious health consequences associated with obesity (1). Despite this, the prevalence of obesity continues to rise (2). An important contributory factor appears to be a change in diet and, in particular, researchers often comment on the increasing availability of foods that are inexpensive, palatable, and highly energy-dense (3). For many, the reason why energy-dense foods promote weight gain is so obvious that it barely merits investigation. This is perhaps because two basic facts are widely accepted: (i) energy-dense foods are more palatable and are therefore more rewarding (desired), and (ii) these palatable foods tend to be selected in relatively larger portions. In this article, we test these basic assumptions. In doing so, we challenge convention and offer alternative reasons why energy-dense foods might promote energy intake and bring about weight gain.

A critical feature of our recent theorizing relates to the nature of "food reward" and how it should be quantified. In behavioral terms, food reward is indexed by the extent to which a person or animal is motivated to seek out and ingest a particular food. In animals, this is often indicated by the amount of work (typically lever presses) that will be carried out in order to procure a particular target. This makes perfect sense, because animals are likely to invest more energy in activities that provide a good return for their efforts. In humans, reward has been measured in a variety of ways, ranging from simple ratings of "desire to eat" (4) to behavioral responses based on choice reaction-time (5), or using paradigms that assess the tradeoff between access to palatable snacks vs. time spent engaging in an alternative and enjoyable activity (6).

Studies of human behavior have tended to focus on the rewarding value of single foods. Very few have compared reward across foods (7,8) and the correspondence between food palatability and food reward has not been studied systematically. Again, this might be because a relationship between palatability and reward is regarded as axiomatic—people will simply choose to "eat what they *like* [emphasis added]" (9). However, claims such as these tend to be based on comparisons involving inappropriate or unspecified portion sizes. In some cases participants are told to simply identify their preferred foods without reference to a specific amount (10). In others, foods are compared based on portions that have equal mass (11). Both of these approaches can be informative. However, to understand the relative effect of different foods on energy intake, it is imperative that foods are compared on a like-for-like (calorie-for-calorie) basis. That is, to understand differences in energy intake (and consequently weight gain), a meaningful comparison can only be achieved when

[1]Department of Experimental Psychology, University of Bristol, Bristol, UK. Correspondence: Jeffrey M. Brunstrom (Jeff.Brunstrom@Bristol.ac.uk)

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foods are presented in equienergetic portions. In other words, when foods A and B are compared, the underlying question is whether 1 cal of food A will be more or less rewarding than 1 cal of food B, and whether this difference promotes a differential selection (in kcal) of foods A and B. For reasons of brevity, we will refer to the reward per kcal of a specific food as its "utility." When couched in these terms our two propositions become: (proposition 1) energy-dense foods are more palatable and therefore have a higher utility, and (proposition 2) these high-utility foods tend to be selected in portions that are relatively more energetic.

In this study, we selected 17 test foods, ranging from simple snack foods through to main meals. To obtain utility values the foods were photographed in equicaloric portions and the participants indicted the amount of money that they would be prepared to spend on each food. This technique was chosen because it enables many foods to be assessed over a relatively short period of time and because a clear relationship exists between the incentive value of food and of money (12). Using the same set of images, we also asked participants to rate their expected liking of the taste of each test food. (Note, rather than asking participants to taste each food, we measured anticipated liking. This is because decisions about food choice tend to be made without tasting every available food. Instead they are based on memories of their relative affective characteristics.) For each participant, proposition 1 was tested by calculating the association between utility and ratings of liking (across the test foods). For each test food, we also obtained a measure of ideal portion size (in kcal). Proposition 2 was tested by comparing the relationship between food utility and these measures of ideal portion size.

As we have already noted, it is now widely assumed that palatability plays a key role in decisions about meal size. However, an alternative, and previously unexplored possibility, is that decisions are largely motivated by nonaffective beliefs, such as those relating to the postingestive consequences of consuming food. Recently, we have been particularly interested in the role of "expected satiation." This term refers to the relative satiation (feeling of fullness) that a person expects from different foods when they are compared on a calorie-for-calorie basis. Our interest in these expectations stems from recent work exploring "expected satiety" (the extent to which a food is expected to stave off hunger) (13). It seems that people have little difficulty expressing expectations of this kind. Moreover, foods differ considerably in this regard. For example, in one experiment 18 different foods were compared (13). Some were expected to confer 5–6 times more satiety than others (calorie for calorie). In particular, foods with low expected satiety tended to be highly energy-dense snack foods (e.g., cashew nuts, chocolate, potato crisps, and cakes). Given the magnitude of these differences in expected satiety, Brunstrom *et al.*, speculated that such expectations might play a major role in decisions about portion size (13). If this is found to be the case then this would suggest that high energy-dense foods are consumed in large portions (kcal) because they have low expected satiation (i.e., are not expected to be filling), and that, contrary to our predictions (1 and 2), palatability contributes relatively little to portion-size selection (kcal).

METHODS AND PROCEDURES

Participants

Participants were 28 unpaid volunteers who were studying at the University of Bristol (United Kingdom). Fourteen of the participants were male. Male and female participants had a mean age of 22.0 (range: 20.2–32.2) and 21.1 (range: 20.1–23.0) years, respectively. All had a BMI in the range 20–25. Participants provided written consent before assisting with the study. Ethical approval was obtained from the local Faculty of Science Human Research Ethics Committee.

Stimuli

Measures of expected satiation, utility, ideal portion size, and liking involved showing participants pictures of 17 different test foods (fish fingers, pasta and tomato sauce, raw banana, pizza, crackers, chicken tikka masala, Jaffa cakes (chocolate covered sponge snack), pretzels, fries, pringles, peanut M&M's, cashew nuts, Crunchie bar (honeycomb covered in chocolate), KitKat, potato salad, chicken chow mein, and cheese baguette). The macronutrient composition of these test foods was taken from food packaging and is provided in **Table 1**.

For each food, a set of photographs was taken using a high-resolution digital camera. Each food was photographed on the same white plate (255-mm diameter). Particular care was taken to maintain a constant lighting condition and viewing angle in each photograph. For each food, picture number 1 showed a 20 kcal portion. With increasing picture number the portion shown increased by 20 kcal (i.e., picture 2 = 40 kcal, picture 3 = 60 kcal, and so on). In total, each food was photographed between 40 (maximum portion 800 kcal) and 70 times (max portion 1,400 kcal), depending on the total amount of food that could be positioned on the plate (actual ranges are provided in **Table 1**).

Measures

Ideal portion size. Ideal portion size was assessed over a series of trials. In each trial one of the test foods was displayed (size = 210 × 285 mm) in the middle of a 19-inch TFT-LCD monitor. Depressing the left arrow-key (on a keyboard) caused the portion size to decrease (a smaller picture number was displayed). Pressing the right arrow-key caused the converse. 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 food for lunch TODAY. Select your IDEAL portion size." Once the appropriate portion size had been selected, participants selected a button marked "continue" and the next trial began. The test foods were presented in a different randomized order for each participant.

Expected satiation. Our measure of expected satiation is based on technique previously developed by Brunstrom *et al.* (13). A food of fixed and known energy content was displayed on a computer screen. Next to this "standard" a different food was displayed. During each trial, the participant changed the amount of this second "comparison" food. As in the ideal portion-size task, this was achieved by depressing the arrow keys on a keyboard. For each standard-comparison pair, the participant was asked to "Imagine you are having this food for lunch TODAY. Look at the picture on the left. Now match the picture on the right so that both foods will leave you feeling FULL to the same extent (immediately after they have been eaten)." This "method of adjustment" provides a "point of subjective equality." The point of subjective equality represents the amount of the comparison (i.e., energy) that is expected to be equally as filling as the standard.

We selected pizza as a common "standard" food in all comparisons. This is because pilot work indicated that this food is likely to be highly familiar to our sample of participants. The standard was always

Table 1 Macronutrient composition and portion ranges of the 17 test foods used in this study

Food type	Carbohydrate[a] (g)	Protein[a] (g)	Fat[a] (g)	Total[a] weight (g)	Portion range (kcal)
Fish finger	8.5	7.0	4.0	54.0	20–800
Pasta and sauce	14.0	3.5	3.5	65.5	20–800
Potato salad	7.4	0.8	7.5	70.9	20–1,200
Chow mein	8.7	7.0	4.2	122.0	20–1,200
Bananas	23.7	1.5	0.3	105.5	20–800
Pizza	10.5	4.5	4.5	24.5	20–1,200
Jaffa cakes	18.9	1.3	2.1	26.5	20–1,200
Crackers	11.5	1.5	5.0	19.5	20–1,200
Tikka masala	11.0	5.5	4.0	59.5	20–800
Pretzels	20.5	2.5	1.0	25.0	20–1,200
Pringles	8.5	1.0	7.0	18.0	20–1,200
M&Ms	11.0	2.0	5.0	19.0	20–1,200
Cashew nuts	3.0	3.0	8.5	17.0	20–1,400
Crunchie bar	15.5	1.0	4.0	21.5	20–1,400
Fries	17.0	1.6	2.9	58.1	20–1,400
KitKat	12.0	1.0	5.0	19.5	20–1,400
Baguette	8.8	4.9	5.1	31.4	20–800

[a]Values given per 100 kcal.

presented as a 400-kcal portion (picture number 20). Each participant completed a single block of 16 trials, during which each of the 16 comparison foods was presented. The order of these comparison foods was randomized across participants.

Liking. Participants rated their liking for each test food in turn. In each case, a picture of a 400-kcal portion was presented on the computer screen and participants completed a paper and pencil 100-mm visual-analogue rating scale. The rating was headed "How much do you LIKE the taste and feel of [food name added] in your mouth?" with end anchor points "not at all" and "extremely."

Food utility. Utility was measured over a series of trials. During each trial the participants were shown either a 200- or a 400-kcal portion of one of the test foods. On each occasion, they were asked to "Imagine you are having this food for lunch TODAY. What is the MAXIMUM you would pay for this food?" A vertical scale was displayed to the left of the food image. To the left of the scale a value was presented in pounds and pence (Sterling). Using the computer mouse, participants moved the position of a marker on the scale. Selecting the upper point changed the value depicted to zero pence. Selecting the lower point changed the value to five pounds. Between these extremes values could be selected in increments of one penny.

Each food was presented once in each of two portion sizes (17 foods × 2 portions = 34 trials) and each participant completed the trials in a different randomized order. Code for assessing ideal portion-size, expected satiation, and food utility was written in Visual Basic (version 6.0; Microsoft, Redmond, WA).

Procedure

Participants were tested individually for ~30 min. Each test session took place between 12 noon and 2 PM and participants were instructed to abstain from eating for at least 3 h prior to arrival. Compliance with this request was assessed using a food diary. Participants provided measures of expected satiation, prospective portion size, expected satiety, food liking, and food utility. The order of these measures was randomized across participants.

Data analysis

In our expected-satiation task the participants changed the size (in kcal) of the comparison food until they were confident that both the comparison and the standard (pizza) would deliver equal satiation. For each type of comparison food, we derived a "satiation ratio" by dividing the size of the standard (400 kcal) by the size of the selected comparison (in kcal) (the satiation ratio of the standard was recorded as 1). In subsequent analyses these ratios were entered in $\log_{10}$ units.

Our measure of food utility was based on the amount of money that each participant would pay for each test food. Two measures were taken, one for a 200-kcal portion and a second for a 400-kcal portion. To produce values based on cash per unit calorie, we divided each measure by the number of calories present in the test food. A utility score was then calculated based on the mean of these two values.

In this study, we are concerned with relative differences in expected satiation, food utility, liking, and ideal portion size, across the test foods. Inevitably, for each of these measures, participants differed in their average response. To control statistically for these differences (thereby emphasizing relative differences across food type), for each measure we converted each participant's data into a set of Z scores. For each measure and each test food, we calculated a mean Z score. Correlation analysis was then used to assess the relationship between the set of Z scores associated with each of our measures.

RESULTS

Figure 1 shows the strength of association between food utility, expected satiation, liking, and ideal portion size. Pearson correlation coefficients are provided, together with associated P values. Three significant relationships emerged from our analyses. First, ideal portion size is closely associated with expected satiation ($r = -0.80$, $P < 0.001$). Specifically, foods that have high expected-satiation tend to be selected in smaller portions (kcal). Second, food utility is associated with high expected-satiation ($r = 0.79$, $P < 0.001$). Third, foods that have low utility are selected in larger portions ($r = -0.48$, $P < 0.05$). All other associations (i.e., those involving liking) narrowly missed significance (relation between utility and liking; $r = 0.46$, $P = 0.063$) or failed to reach significance by some margin. We repeated these analyses in snack and main-meal items separately (as classified by the authors). Ostensibly, the outcome remained unchanged. Indeed, in each case the relationship between ideal portion size and expected satiation was even stronger. In these data the lack of relationship between liking and selected energy content is particularly striking. Post hoc, we explored whether liking is a better predictor of the weight (g) (rather than the energy content) of ideal portion sizes. In this context, liking was a significant predictor ($r = 0.50$, $P = 0.040$).

In this study, we were also interested in the importance of energy density as a predictor of our four measures. **Figure 2** shows the relationship between energy density and these measures—ideal portion size, expected satiation, liking, and utility (**Figure 2a–d**). Energy density failed to predict ideal portion size and liking. However, a significant correlation was found with expected satiation ($r = -0.58$, $P = 0.015$) and food utility ($r = -0.61$, $P = 0.009$), suggesting that high energy-dense foods are expected to deliver less satiation and are regarded as having lower utility (see **Figure 2b,d**).

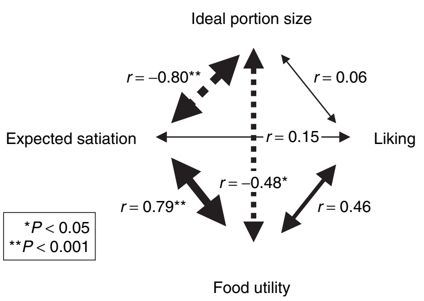

Figure 1 Relationships between food utility, expected satiation, liking, and ideal portion-size. Strong and weak associations are illustrated using wide and narrow arrows, respectively. A continuous line indicates a positive relationship and a dashed line indicates a negative relationship.

DISCUSSION

We tested two widely held assumptions about factors that promote the selection of large portion sizes (in kcal). Neither was supported by our data. Counter to the first proposition (energy-dense foods are more palatable and therefore have higher utility), we found a nonsignificant negative association between energy density and food liking, and we found

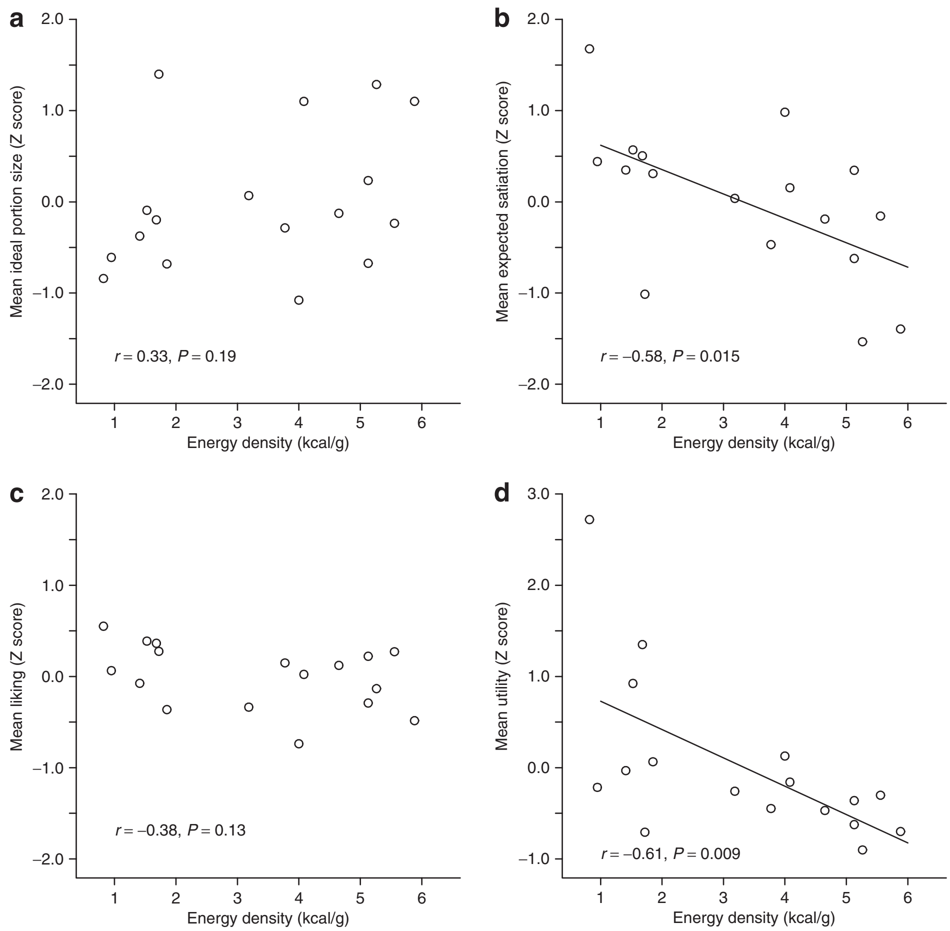

Figure 2 Relationship between the energy density of the test foods and mean (**a**) ideal portion size, (**b**) expected satiation, (**c**) liking, and (**d**) utility. Each point represents a different test food. Each panel includes associated r and P values. Significant relationships are described by a linear best-fit line.

a significant negative relationship between energy density and utility. Similarly, in relation to the second proposition (high-utility foods are selected in larger portions (in kcal)), we found that high-utility foods are selected in smaller rather than larger portions (in kcal).

Three important conclusions can be drawn from these results. First, high energy-dense foods are selected in larger portions (in kcal), not because they are especially liked, but because they are expected to deliver lower satiation (kcal for kcal). Second, expected satiation can be the primary determinant of food utility (not liking), which means that low energy-dense foods have higher utility (are more rewarding) than high energy-dense foods. Third, high-utility foods are selected in smaller rather than larger portions (in kcal) (i.e., when compared on a calorie-for-calorie basis we are prepared to spend a greater amount on foods that we tend to select in smaller portions (in kcal)).

There are a number of ways in which these findings challenge our understanding of food reward and the selection of food portions. First, it is often argued that we consume more of the foods that we like (9). Consequently, energy-dense foods are thought to promote energy intake because they are regarded as highly palatable (14,15). Our study is unique, because we distinguish between two types of prediction. Across test foods, (i) liking is associated with the selection of portions that are more energetic, and (ii) liking is associated with the selection of portions that are heavier (a proxy for volume). A priori, we sought to test prediction (i), because this informs our understanding of factors that influence the selection of energetic meals (leading to increased energy intake), whereas prediction (ii) does not, because a heavy portion of one food does not necessarily contain more calories than a lighter portion of another food. Our data only support prediction (ii), perhaps indicating that decisions are based largely on perceived size (which is inversely related to energy density). Thus, contrary to expectation, palatability was not associated with the selection of portions that are more energetic, at least in the context of our study. Consistent with this finding, one suggestion is that the primary role of palatability is to signal that a food is energy dense and safe to eat, and that the effect of palatability manipulations on intake is exaggerated in controlled laboratory studies (relative to other "nonaffective" determinants of energy intake) (16). Furthermore, because most foods that we encounter are already liked, the role of palatability in energy intake is likely to be limited, and this is reflected in a failure to identify a reliable association between obesity and heightened hedonic responses to food (16).

A related claim is that high energy-dense foods are particularly rewarding and are selected in larger portions on this basis. When offered a choice between a palatable energy-dense food and a less energy-dense bland tasting food, we may be inclined to select the former. Indeed, individuals who consciously restrict their food intake frequently struggle with temptations of this kind (17). Highly palatable energy-dense foods may also have higher "incentive salience" (i.e., once they are perceived they become highly desired) (18), which is perhaps why animals and humans work relatively harder for their procurement (7,19). Observations of this kind are consistent with the commonly held belief that energy-dense foods promote a positive energy balance (leading to weight gain) because they are highly rewarding. However, in our analysis, we compared foods based on their utility (reward value per kcal). In this context, we find that high-utility foods are actually selected in less energetic portions.

How can utility be inversely related to ideal portion? Our data suggest that decisions about portion size were dominated by whether a particular portion was expected to deliver adequate satiation. The importance of expected satiation is also reflected in the very close association with utility. Calorie for calorie, our participants placed a high premium on foods that were expected to deliver good satiation. High energy-dense foods tend to have lower expected satiation and they tend to be selected in higher energetic portions for this reason (not because they are liked). Consistent with this idea, many studies report relatively poor energy compensation and satiation after consuming energy-dense foods, typically those that have a high-fat content (20,21). (Note, we are not making specific claims about the mental processes that govern decisions in our expected satiation and ideal portion-size tasks, and in particular, we are not suggesting that our participants anticipated the calorie content of our test foods and made judgments on this basis (indeed, we suspect this is unlikely.) Our analysis is based on the correspondence between anticipated satiation and ideal portion size when associated measures are scaled (by us) on a calorie-for-calorie basis).

Again, it is important to stress the basis on which these observations are made (and perhaps why they have not been reported previously). In our approach, we integrate two novel concepts: (i) the principle of food utility based on calorie-for-calorie comparisons, and (ii) the notion of expected satiation (expected fullness calorie-for-calorie) (13). Associated measures are also derived from comparisons between foods on a calorie-for-calorie basis. In combination with a measure of expected liking, they enable us to understand the basis on which we select the energy content of ideal portions of food. Our findings coincide with those from a recent study exploring correlates of the expected satiety associated with snack foods (22), suggesting that our observations apply across a range of different foods. It is also possible that these observations hold in a range of different meal and social contexts. However, in this regard we are more circumspect.

Our results relate to the selection of portion sizes (in kcal) in a single meal (lunch). We are not making strong claims about how people choose between different foods in all situations. Foods are available in predetermined packaged portion sizes, some of which will be larger or smaller than ideal. Moreover, these foods will differ in their unit cost and they carry with them a variety of explicit and implicit health messages. All of these factors integrate in the mind of the consumer adding a further level of complexity to our analysis. A challenge for the future will be to explore how our interpretation helps to explain or account for potentially unhealthy food choices in this broader context, both inside and outside the laboratory.

Many studies show that volunteers consume more food when it is presented in a palatable condition (e.g., 23,24), and across studies, a monotonic relationship exists between palatability differences and differences in energetic intake (25). This apparent discrepancy with our present findings merits comment. First and foremost, we would like to emphasize that we are not claiming that liking plays no role in energy intake and other aspects of dietary behavior. Clearly, hedonic responses can be highly relevant, especially when we are confronted with foods that are particularly unappetizing. Palatability has been explored extensively in the laboratory and often in relation to its effects on ad libitum eating (eating when an unlimited amount of food is available). In this context palatability appears to be closely associated with the weight of food that is consumed (25). By contrast, our analysis relates to everyday decisions about portion size, across a range of foods, and before a meal begins. To date, the role of palatability has not been considered (i) alongside expected satiation, and (ii) as a predictor of the energetic content of selected portion sizes. It is in this specific context that we report that food palatability plays a relatively minor role.

We also note that all of our participants were relatively hungry. Eating might also occur in "the absence of hunger" (26) and it remains to be seen whether our findings inform our understanding of portion selection in this context. One possibility is that expected satiation is less relevant because satiation has already been achieved. Alternatively, foods that have high expected-satiation may be actively avoided in order to protect against the unpleasant visceral sensations associated with "super satiation."

Finally, we have already commented on the various epidemiological (27) and experimental (28) studies that report an association between BMI, energy intake, and the consumption of high energy-dense foods. Our analysis relates to the selection of ideal portion size (in kcal). Actual food consumption was not measured. However, there is good reason to believe that these correspond closely. For example, many studies demonstrate that serving size, whether determined by the consumer or not, is an excellent predictor of the amount of food consumed (29–33).

In this study, we selected test foods that are commonly consumed in the United Kingdom. However, we did not confirm prior exposure to each food in each participant separately. This is potentially important, because expected liking will be largely influenced by past experience. An assessment of this kind should be incorporated into future studies. More generally, foods that are more familiar or that are used with greater frequency will tend to have higher expected satiation (13). From this, we assume that aspects of expected satiation are learned over time. Because expected satiation appears to play a key role in food reward and decisions about portion size, it follows that aspects of portion-size selection are also learned. Much of this learning may take place in childhood, around the time that food preferences develop (34). Therefore, studies exploring the developmental origins of expected satiation should be given a high priority.

DISCLOSURE

The authors declared no conflict of interest.

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REFERENCES

1. Calle EE, Thun MJ, Petrelli JM, Rodriguez C, Heath CW. Body-mass index and mortality in a prospective cohort of U.S. adults. *N Engl J Med* 1999;341:1097–1105.
2. Caballero B. The global epidemic of obesity: an overview. *Epidemiol Rev* 2007;29:1–5.
3. Drewnowski A, Specter SE. Poverty and obesity: the role of energy density and energy costs. *Am J Clin Nutr* 2004;79:6–16.
4. Brunstrom JM, Mitchell GL. Effects of distraction on the development of satiety. *Br J Nutr* 2006;96:761–769.
5. Finlayson G, King N, Blundell J. The role of implicit wanting in relation to explicit liking and wanting for food: implications for appetite control. *Appetite* 2008;50:120–127.
6. Saelens BE, Epstein LH. Reinforcing value of food in obese and non-obese women. *Appetite* 1996;27:41–50.
7. Smith JA, Epstein LH. Behavioral economic analysis of food choice in obese children. *Appetite* 1991;17:91–95.
8. Goldfield GS, Epstein LH. Can fruits and vegetables and activities substitute for snack foods? *Health Psychol* 2002;21:299–303.
9. Cooke LJ, Wardle J. Age and gender differences in children's food preferences. *Br J Nutr* 2005;93:741–746.
10. Bellisle F, Rolland-Cachera MF, Kellogg Scientific Advisory Committee Child and Nutrition. Three consecutive (1993, 1995, 1997) surveys of food intake, nutritional attitudes and knowledge, and lifestyle in 1000 French children, aged 9–11 years. *J Hum Nutr Diet* 2000;13:101–111.
11. Goldfield GS, Lumb A. Smoking, dietary restraint, gender, and the relative reinforcing value of snack food in a large university sample. *Appetite* 2008;50:278–289.
12. Briers B, Pandelaere M, Dewitte S, Warlop L. Hungry for money: the desire for caloric resources increases the desire for financial resources and vice versa. *Psychol Sci* 2006;17:939–943.
13. Brunstrom JM, Shakeshaft NG, Scott-Samuel NE. Measuring "expected satiety" in a range of common foods using a method of constant stimuli. *Appetite* 2008;51:604–614.
14. Macdiarmid JI, Vail A, Cade JE, Blundell JE. The sugar-fat relationship revisited: differences in consumption between men and women of varying BMI. *Int J Obes Relat Metab Disord* 1998;22:1053–1061.
15. Levine AS, Kotz CM, Gosnell BA. Sugars: hedonic aspects, neuroregulation, and energy balance. *Am J Clin Nutr* 2003;78:834S–842S.
16. Mela DJ. Eating for pleasure or just wanting to eat? Reconsidering sensory hedonic responses as a driver of obesity. *Appetite* 2006;47:10–17.
17. Herman CP, Polivy J, Stunkard AJ. Restrained eating. In: Anonymous (ed). *Obesity*. Philadelphia: W.B. Saunders, 1980, pp 208–225.
18. Finlayson G, King N, Blundell JE. Is it possible to dissociate "liking" and "wanting" for foods in humans? A novel experimental procedure. *Physiol Behav* 2007;90:36–42.
19. Sclafani A, Ackroff K. Reinforcement value of sucrose measured by progressive ratio operant licking in the rat. *Physiol Behav* 2003;79:663–670.
20. Holt SH, Miller JC, Petocz P, Farmakalidis E. A satiety index of common foods. *Eur J Clin Nutr* 1995;49:675–690.
21. Stubbs RJ, van Wyk MC, Johnstone AM, Harbron CG. Breakfasts high in protein, fat or carbohydrate: effect on within-day appetite and energy balance. *Eur J Clin Nutr* 1996;50:409–417.
22. Brunstrom JM, Shakeshaft NG. Measuring affective (liking) and non-affective (expected satiety) determinants of portion size and food reward. *Appetite* 2009;52:108–114.
23. Yeomans MR. Palatability and the micro-structure of feeding in humans: the appetizer effect. *Appetite* 1996;27:119–133.
24. Bobroff EM, Kissileff HR. Effects of changes in palatability on food intake and the cumulative food intake curve in man. *Appetite* 1986;7:85–96.
25. Yeomans MR. The roles of palatability in control of human appetite: Implications for understanding and treating obesity. In: Kirkham TC, Cooper SJ (eds). *Appetite and Bodyweight: Integrative Systems and the Development of Anti-Obesity Drugs*, Academic Press, 2007, pp 247–269.
26. Lowe MR, Butryn ML. Hedonic hunger: a new dimension of appetite? *Physiol Behav* 2007;91:432–439.
27. Johnson L, Mander AP, Jones LR, Emmett PM, Jebb SA. A prospective analysis of dietary energy density at age 5 and 7 years

and fatness at 9 years among UK children. *Int J Obes (Lond)* 2008;32: 586–593.
28. Prentice AM, Poppitt SD. Importance of energy density and macronutrients in the regulation of energy intake. *Int J Obes Relat Metab Disord* 1996;(20 Suppl 2):S18–S23.
29. Wansink B, Painter JE, North J. Bottomless bowls: why visual cues of portion size may influence intake. *Obes Res* 2005;13:93–100.
30. Wansink B. Environmental factors that increase the food intake and consumption volume of unknowing consumers. *Annu Rev Nutr* 2004;24: 455–479.
31. Rolls BJ, Roe LS, Meengs JS. The effect of large portion sizes on energy intake is sustained for 11 days. *Obesity (Silver Spring)* 2007;15: 1535–1543.
32. Kral TV, Rolls BJ. Energy density and portion size: their independent and combined effects on energy intake. *Physiol Behav* 2004;82: 131–138.
33. Mrdjenovic G, Levitsky DA. Children eat what they are served: the imprecise regulation of energy intake. *Appetite* 2005;44:273–282.
34. Brunstrom JM. Dietary learning in humans: directions for future research. *Physiol Behav* 2005;85:57–65.