Children’s familiarity with snack foods changes expectations about fullness1–3

Charlotte A Hardman, Keri McCrickerd, and Jeffrey M Brunstrom

ABSTRACT

Background: Palatability is regarded as a major determinant of children’s energy intake. However, few studies have considered nonhedonic beliefs about foods. In adults, there is emerging evidence that expectations about the satiating properties of foods are an important determinant of meal size, and these beliefs are learned. Objective: We measured and quantified children’s expected satiation across energy-dense snack foods by using a method of adjustment. Participants changed a comparison-food portion (pasta and tomato sauce) to match the satiation that they expected from a snack food. We predicted that children who were especially familiar with snack foods would expect the foods to generate greater satiation and that children who were unfamiliar with snack foods would match expected satiation on the basis of the physical characteristics (perceived volume) of the foods. Design: Seventy 11- to 12-y-old children completed measures of expected satiation, perceived volume, familiarity, and liking across 6 snack foods. Results: As anticipated, familiarity and expected satiation were positively related (r = 0.37, P = 0.002), and this association remained after liking was controlled for. Furthermore, expected-satiation and perceived-volume judgments were more dissimilar as familiarity with the foods increased. Conclusions: Our findings highlight the role of learning in shaping children’s beliefs about the postigestive effects of the consumption of foods; children who ate the foods more often expected them to deliver greater satiation. Furthermore, our findings suggest that, in the absence of prior experience, children rely on a food’s physical characteristics (a less-complex strategy) when they judge expected satiation. This trial was registered at clinicaltrials.gov as NCT01403753. Am J Clin Nutr 2011;94:1196–201.

INTRODUCTION

Children are at risk of obesity because they tend to be frequent consumers of energy-dense foods (1–3). In this area, researchers have highlighted the importance of palatability as a determinant of food intake. Children aged from 3 to 16 y show a strong liking for fatty and sugary foods (4), and a positive association exists between preference and food intake (5–8). As well as preferring foods that are more familiar (4, 9, 10), 2- to 7-y-old children increase their preference for, and acceptance of, flavors that are repeatedly tasted (11–13). For this reason, it is widely accepted that children “like what they know and eat what they like” (14).

By contrast, relatively little attention has been paid to other forms of nonhedonic learning that occur around food in children. Notable exceptions include the work of Birch and Deysher (15) and Birch et al (16, 17) who showed that the initiation of eating and meal size can be conditioned in 3- to 5-y-old children. Specifically, they showed that hunger can be initiated by an environmental cue, and meal size can be governed by a learned association that forms between the sensory characteristics of a food and its postigestive effects (15–17).

It has recently become clear that adults are confident estimating the expected satiety (anticipated absence of hunger) and expected satiation (anticipated fullness) of foods (18, 19). In our previous studies, we quantified these constructs by using the psychophysical techniques method of constant stimuli and method of adjustment, which we have shown to be reliable and robust. Calorie for calorie, foods differ markedly in their expected satiety and satiation (18). Moreover, expectations are extremely good predictors of the energy content of self-selected meals (19, 20). Foods with low expected satiation (typically energy-dense snack foods) are selected in larger portions (20). By contrast, variability in the palatability of commonly consumed foods is a relatively poor predictor of self-selected portions (kcal) (20). One finding that has emerged from this work is that expected satiety and satiation are not static. Rather, they appear to increase as a food becomes familiar (18, 21). In children, this “expected satiation drift” (21) could be extremely relevant because their experience of eating many foods is likely to be limited (9, 15). To explore this idea, we attempted to measure and quantify expected satiation in children across a range of energy-dense foods. We anticipated that children who reported the consumption of the foods more often would expect the foods to confer greater satiation. We chose to focus specifically on energy-dense products because these foods have been associated with overconsumption and weight gain (22).

SUBJECTS AND METHODS

Subjects

Participants were 11- to 12-y-old pupils who attended one of 2 coeducational secondary schools in North Oxfordshire (United...
Kingdom). In total, 417 children were invited to take part in the study. Written informed consent was sought from parents or legal guardians. This consent was received for 70 children (31 boys and 39 girls). All child participants provided verbal consent to participate. All of the children were English speaking and had normal or corrected-to-normal vision. Ethical approval was granted by the Faculty of Science Human Research Ethics Committee, University of Bristol.

Test food images

Six popular foods were each photographed once (see supplemental material under “Supplemental data” in the online issue). Their sizes was determined by standard-portion information obtained from packaging and estimated typical portion sizes in children of this age (23). Images were taken with a high-resolution digital camera mounted above a 255-mm diameter white plate. Particular care was taken to maintain consistency between the lighting environment and viewing angle across photographs. The portion size and associated energy and macronutrient composition of the foods are shown in Table 1. We included a range of savory and sweet items in an attempt to capture the variety of foods that children consume in their everyday life. In accordance with a recent classification (2), 5 of the 6 foods in our study were noncore items (ie, easily consumed outside of a meal). Chicken nuggets belongs to the category of core items (ie, normally eaten as part of a traditional meal). Because it is rare to find any foods that are exclusively eaten as a snack (2), our foods could be broadly defined as snack or meal foods. However, for reasons of brevity, they are referred to as snack foods hereafter.

In addition, we took 101 images of pasta and tomato sauce [Egg Penne Pasta (Sainsbury’s Ltd) and sun-dried stir-in tomato sauce (Masterfoods)]. The smallest portion was a 10-kcal portion and the portion size (kcal) increased in equally spaced logarithmic steps such that image 100 represented a 1000-kcal portion. In this way, the portion sizes shown by images 0, 20, 40, 60, 80, and 100 were 10, 25.1, 63.1, 158.5, 398.1, and 1000 kcal, respectively.

Measures

All measures were elicited with custom software written in Visual Basic (Microsoft; version 6.0).

**Table 1**

<table>
<thead>
<tr>
<th>Food type</th>
<th>Portion size g</th>
<th>Energy kcal</th>
<th>Energy density kcal/g</th>
<th>Protein g</th>
<th>Carbohydrate g</th>
<th>Fat g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chocolate bar†</td>
<td>49</td>
<td>255</td>
<td>5.2</td>
<td>3.7</td>
<td>27.9</td>
<td>14.6</td>
</tr>
<tr>
<td>Processed cheese product†</td>
<td>21</td>
<td>69</td>
<td>3.3</td>
<td>5.9</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Chicken nuggets†</td>
<td>74</td>
<td>190</td>
<td>2.6</td>
<td>12.3</td>
<td>13.7</td>
<td>9.6</td>
</tr>
<tr>
<td>Cheese dip with corn and potato snack‡</td>
<td>47</td>
<td>120</td>
<td>2.6</td>
<td>4.3</td>
<td>13</td>
<td>5.6</td>
</tr>
<tr>
<td>Jam donut‡</td>
<td>74</td>
<td>220</td>
<td>3.0</td>
<td>4</td>
<td>39</td>
<td>10</td>
</tr>
<tr>
<td>Lemon cake slice‡</td>
<td>58</td>
<td>240</td>
<td>4.1</td>
<td>2.4</td>
<td>35.8</td>
<td>9.6</td>
</tr>
</tbody>
</table>

† Dairy Milk (Cadburys UK).
‡ Cheestrings (Kerry Group plc).
§ Molded chicken product covered in breadcrumbs (Sainsbury’s Ltd).
¶ Dairylea Dunkers (Kraft Foods Europe).
‖ Fried dough product filled with jam (Sainsbury’s Ltd).
¶ Lemon-flavored iced sponge cake product (Premier Foods Group Ltd).

Expected satiation

Our measure of expected satiation was based on a technique previously developed by Brunstrom et al (18) and Brunstrom and Rogers (20). Briefly, in each trial, participants were shown an image of one of the snack foods on a visual display unit. These images were referred to as standards. To the right of the standard, we presented an image of a comparison food, which was pasta and tomato sauce. Pasta and tomato sauce was selected because pilot work indicated that it is highly familiar to the population from which we were sampling, and all participants indicated having eaten it before. Furthermore, previous research with 4- to 16-y-old children indicated that pasta is among the 10 most highly liked food items (4).

Our participants were instructed to “change the size of the food on the right until you think both foods will be equally filling.” Participants used arrow keys on the keyboard to display a larger (up arrow) or smaller (down arrow) portion of pasta and sauce. Continuous depression of either key enabled rapid movement through the series of comparison images and gave an animated appearance to the change in portion size. After achieving a match, the participants pressed the enter key to move onto the next trial. Each participant completed a single block of 6 trials, during which each of the 6 standard foods was presented once. The order of their presentation was randomized across participants. For each standard-comparison food pairing, the initial portion of pasta and sauce was selected randomly. This method acted as a control measure to ensure that any bias that related to the initial portion size of pasta would be equally distributed.

This method of adjustment generated a point of subjective equality (PSE). For each standard, this related to the amount of pasta and sauce (kcal) that was expected to be equally filling. For each standard, an expected-satiation ratio was calculated by dividing the PSE by the actual energy content of the food. Thus, for chocolate (standard portion: 255 kcal), a PSE of 173.78 kcal yielded an expected-satiation ratio of 0.68 (173.78 / 255 kcal). In this example, chocolate was expected to be relatively less filling, calorie for calorie, than pasta and sauce. A ratio >1 would indicate the converse. In this way, each participant generated 6 expected-satiation ratios, one for each standard. Previous research has shown that children as young as 6 y old were able to use a method-of-adjustment task to measure traits such as perceived and ideal body size (24). The current method-of-adjustment task has been shown to be reliable at estimating...
satiation expectations over a 7-d period in adults ($r = 0.74$, $P < 0.001$; LL Wilkinson, EC Hinton, SH Fay, PJ Rogers, and JM Brunstrom, unpublished data, 2011).

**Perceived volume**

The perceived-volume task was identical to the expected-satiation task with the exception that participants were instructed to “change the size of the food on the right so that both foods look the same size.” As with expected satiation, each PSE was divided by the energy content of the respective standard food to derive a perceived-volume ratio. Each participant generated 6 perceived-volume ratios, one for each standard. This measure has been used previously (25). The method was included to enable us to identify cases in which expected-satiation and perceived-volume judgments coincide. This was important because it provided evidence that expected satiation was being judged on the basis of the physical characteristics of a food (25), a tendency that may have been especially evident in decisions about unfamiliar foods. In this context, we are referring specifically to the perceived physical characteristics (volume) of a food and not the postingestive effects of volume.

**Familiarity**

In this study, we defined familiarity as the participant’s current frequency of consumption. To this effect, an image of each standard food was displayed on the visual display unit and participants selected one of the following options in response to the question “How often do you eat this food?”: never or rarely; about once every 2 mo, about once every 2 wk, 1–2 times/wk, or most days. Responses were coded 1–5, respectively. Across participants, snack foods were presented in a different randomized order.

**Expected liking**

Our measure of expected liking was based on that previously used by Lowe et al (26). Participants rated their liking for each snack food in turn. In each case, the standard was displayed on the computer screen, and participants were asked “How much do you like the taste of this food?” A line scale (100 mm) was presented that had 5 equally spaced anchor points that ranged from “I like it a lot” (scale point 5) on the left to “I hate it” (scale point 1) on the right. Participants could indicate their response at any point on the line with reference to the aforementioned anchor points. However, responses were scored as 0–100 depending on the exact point on the line at which the participant made their response. For ease of interpretation, these score were reversed for the analysis (so that a higher score indicated an increased liking for the food). The virtue of this approach was that the scale anchor points could be used to guide children’s responses, but data were recorded on an interval scale. Participants were also instructed to use a response option to indicate if they had never tried a food. The order of standard foods was randomized across participants.

**Procedure**

Participants were tested in groups of 3 between 0900 and 1500 (with the exclusion of lunch and break times) in a quiet room at school. All of the tasks were performed on desktop computers with 17-in LCD monitors at a screen resolution of 1280 × 1024. Participants were instructed to sit ~45 cm away from the screen. They received a demonstration of each task and were invited to ask questions to clarify their understanding.

Participants completed the expected-satiation task and then completed the perceived-volume task or the converse (the order was counterbalanced across participants). Participants completed the familiarity task followed by the expected-liking task. Each testing session lasted ~20 min. At the end of each session, participants were asked some informal questions that related to their experiences of completing the tasks. Participants were verbally debriefed and thanked for their assistance.

**Statistics**

Because our expected-satiation and perceived-volume measures were ratio scores, these were log transformed before all analyses and in graphical representations of data.

In the first instance, for each food separately, we computed the correlation between familiarity and log-transformed expected-satiation ratios. For each participant, a familiarity score was computed by averaging familiarity ratings across the 6 foods. This score indicated the extent to which each child was familiar with our snack foods overall. Cronbach’s $\alpha$ for the familiarity score was 0.74, which was well within the acceptable range. Similarly, within each participant, scores for expected satiation, liking, and perceived volume were computed by averaging responses across foods. Missing data points ($n = 45$) were either because of reported errors on the expected-satiation and perceived-volume tasks (ie, when children inadvertently hit the enter key in advance of making their judgment) or children indicating that they had never tried a food on the liking scale. To ensure consistency in the computation of scores, if a data point was missing for a food on any one of the variables, the participant’s corresponding data for that food on remaining variables were also removed (eg, if a participant had a missing value for the expected satiation of chocolate, data relating to chocolate on measures of perceived volume, familiarity, and liking were also discounted).

To investigate our primary hypothesis, that familiarity promotes higher expected satiation, we calculated the correlation between expected-satiation scores and familiarity scores. In addition, we used correlational analysis to explore relations between expected-satiation scores and liking scores and between liking scores and familiarity scores. We conducted a stepwise regression analysis to explore the extent to which expected satiation was predicted by familiarity, liking, and perceived-volume scores.

We were also interested in the prospect that a lack of familiarity encouraged participants to judge expected satiation on the basis of the perceived volume of food. To explore this idea, we calculated the difference between expected-satiation and perceived-volume scores (this was separately calculated for each participant). These difference scores were correlated with related familiarity scores. We reasoned that a significant positive relation indicated that familiarity promoted an increasing disparity between judgments that were based on expected satiation and judgments that were based on perceived volume. All statistical analyses were performed with SPSS version 16.0 (SPSS Inc).
RESULTS

Individual foods

There was a significant positive correlation between familiarity and (log) expected-satiation ratios for the chocolate bar \((r = 0.25, \ P = 0.035)\) and jam donut \((r = 0.25, \ P = 0.038)\). Correlations for remaining foods did not reach statistical significance and were as follows: lemon cake slice: \(r = 0.18\); chicken nuggets: \(r = 0.17\); processed cheese product: \(r = 0.09\); and cheese dip with corn and potato snack: \(r = 0.03\). The 6 foods differed significantly in their degree of familiarity within our sample, \(F(5, 345) = 10.7, \ P < 0.001\), although this effect was purely driven by the chocolate bar being more familiar relative to all of the other foods (all \(P < 0.002\)), between which there were no significant differences. The range in mean (±SD) familiarity scores across the different foods was 2.1 ± 1.2 to 3.2 ± 1.4. These values equated to familiarity options of about once every 2 mo and about once every 2 wk, respectively. All children reported having eaten the chocolate bar before. With respect to the other foods, there were cases in which the foods had not been consumed before by some of the children (processed cheese product: \(n = 5\); chicken nuggets: \(n = 3\); cheese dip with corn and potato snack: \(n = 5\); jam donut: \(n = 13\); lemon cake slice: \(n = 15\)). Sixty-seven percent of participants had previously eaten all 6 foods. Ten percent of participants had never tried one of the foods, 20% of participants had never tried 2 of the foods, and 3% of participants had never tried 3 of the foods.

Effects of familiarity on expected satiation and liking

When averaged across foods, our sample had a mean familiarity score of 2.5 ± 0.9, which was midway between the scale points of about once every 2 mo and once every 2 wk. Participants had a mean expected-satiation score of 0.8 ± 0.5, which indicated that the foods were perceived to be relatively less filling, calorie for calorie, than the comparison food. Participants had a mean perceived-volume score of 0.6 ± 0.2 and a mean liking score of 69.6 ± 17.6.

Expected-satiation scores were significantly and positively correlated with familiarity scores \((r = 0.37, \ P = 0.002; \text{Figure 1A})\). Liking was also significantly correlated with familiarity \((r = 0.39, \ P = 0.001; \text{Figure 1B})\) but not with expected satiation \((r = 0.21, \ P = 0.08)\). After the removal of 2 outlying data points (±3 SD from the mean; Figure 1A), the correlation between expected-satiation and familiarity scores remained significant \((r = 0.28, \ P = 0.02)\). We also calculated the correlation between familiarity and expected-satiation scores that were based on median values (as opposed to means) and this was significant (Spearman’s \(\rho = 0.3, \ P = 0.01)\).

To further illustrate the relation between expected satiation and familiarity, we calculated the regression equation by using familiarity as a predictor of expected-satiation scores (Figure 1A). We used this equation to predict expected-satiation scores at each point on the familiarity scale. From these scores, we were able to predict PSEs (ie, the amount of pasta and sauce, in kcal, that would be expected to be equally as filling as the snack foods). A nominal 250-kcal portion of the snack food was assumed. This revealed very large effects of familiarity on satiation expectations. For example, our estimates indicated that a participant who scored 1 on our familiarity scale (ie, low familiarity) expected a 250-kcal

![FIGURE 1](https://via.placeholder.com/150)
portion to deliver the same satiation as a 300-kcal portion of the comparison food (expected-satiation ratio: 1.2; 95% CI: 0.48, 3.0). These results indicated that familiarity had the potential to increase expected satiation by >100%.

Our stepwise regression indicated that only familiarity was a significant independent predictor of expected satiation (\( \hat{\beta} = 0.37, P < 0.002 \)), with liking and perceived volume being excluded from the model. This result indicates that the strength of the relation between familiarity and expected satiation was not determined by individual differences in perceived volume or in the hedonic quality of the foods. Crucially, this suggests that familiarity was not a surrogate or proxy measure of liking.

**Effects of familiarity on the relation between expected satiation and perceived volume**

The relation between familiarity and perceived volume is shown in Figure 1C. As anticipated, familiarity did not increase the perceived volume of our test foods (\( r = 0.17, P = 0.163 \)). Thus, it appeared that familiarity only influenced expected satiation. A comparison of Figure 1A and 1C showed that judgments that were related to expected satiation and perceived volume were broadly similar for unfamiliar foods; our regression equations indicated that a score of 1 on the familiarity scale predicted an expected-satiation ratio of 0.54 (95% CI: 0.35, 0.85) and a perceived-volume ratio of 0.49 (95% CI: 0.36, 0.65). With the assumption of a nominal 250-kcal portion of the snack food, this equated to 135 and 123 kcal of the snack food on the basis of expected-satiation and volume judgments, respectively. By contrast, these judgments deviated for highly familiar foods by <100%; a familiarity score of 5 predicted an expected-satiation ratio of 1.2 (95% CI: 0.48, 3.0) (300 kcal) and a perceived-volume ratio of 0.61 (95% CI: 0.33, 1.1) (153 kcal). To confirm this differential effect of familiarity, for each participant, we calculated the difference between scores derived from expected-satiation and perceived-volume judgments. The correlation between these difference scores and familiarity was positive and reached significance (\( r = 0.26, P = 0.03 \); Figure 2). This relation remained intact after the removal of one outlying data point (\( r = 0.25, P = 0.04 \); Figure 2).

**DISCUSSION**

Children often consume energy-dense snack foods (1–3). Palatability is clearly important in the determination of this pattern of intake. However, in our study we measured and quantified children’s beliefs about expected satiation, which is a nonhedonic food characteristic (19). Our psychophysical technique (method of adjustment) was based on a similar approach that has been shown to be both reliable and robust in adults (18). The current study suggests that children aged 11–12 y were also able to estimate the satiating properties of selected snack foods.

A central aim of our study was to consider the role of learning in the shaping of children’s beliefs about expected satiation. Our data indicate that expectations were governed by familiarity with snack foods; children who regularly consumed these foods expected them to deliver greater satiation. This observation is entirely consistent with our studies in adults (18, 21), which provides a critical validation of our expected-satiation measure in children. The observation also provides support for expected-satiation drift. We previously suggested that this reflects a tendency to assume that novel foods deliver poor satiation and to do so until experience teaches otherwise. From an ecological perspective, this strategy limits foraging for foods that turn out to be of a low nutritive value (27).

In our study, the effect of familiarity was considerable. We estimate that children who were highly familiar with the snack foods expected them to deliver twice as much satiation as did children who knew the foods but who never or rarely consumed them. In adults, expected satiation is highly correlated with self-selected portion sizes (kcal; \( r = -0.8 \)) (20). Therefore, familiarity may play an important role in determining the portions of snack foods that are selected and consumed by children. As anticipated, we also showed that familiarity and liking were significantly correlated (4, 9, 10). However, the relation between expected satiation and liking failed to reach significance. Familiarity was a significant predictor of expected satiation, even after liking was controlled for. Consistent with previous research, these results suggest that we measured distinct hedonic and nonhedonic food attributes (19). When we analyzed our data on a food-by-food basis, we showed evidence for a stronger relation between expected satiation and familiarity in foods that were higher in energy content (as presented). The 2 foods in which we failed to find any meaningful association had the lowest energy content (ie, the processed cheese product and cheese dip with corn and potato snack). Albeit somewhat speculative, this may have reflected a disposition for this sort of learning to occur predominantly in high energy-content foods. This may be because these foods are more likely to be eaten until feelings of fullness are experienced. In contrast, if foods are not consumed to fullness, we would predict a reduced ability to learn about their satiating consequences. This idea is consistent with published (28) and more recent work from our laboratory.

Our data on perceived volume provide further evidence for learning. Participants with expected-satiation scores that deviated...
from their perceived-volume scores tended to be more familiar with the snack foods. This is consistent with evidence in adults that familiar foods differed markedly in their expected satiation, and this was the case even after differences in their perceived volume were controlled for (25). In children who were less familiar with the foods, we showed a close correspondence between judgments that were based on perceived volume and expected satiation. This result suggests that, in the absence of prior experience, these children relied on the volume of a food (a less-complex strategy) to make judgments about expected satiation. Per calorie, energy-dense foods tend to occupy a smaller volume. Therefore, this volume heuristic is likely to promote the selection of larger portions (in kcal).

We recommend that this study should be replicated in other populations. In particular, a comparison of normal-weight and obese children might help to determine the effect of weight status on the propensity to learn about the satiating effects of foods. Studies of this kind might also include an assessment of hunger and fullness. However, we note that a measure of appetite did little to moderate relations between expected satiation and other key variables in a similar study that involved an adult sample (19). Our measure of perceived volume added an innovative component to our study. However, on some occasions we required participants to match the volume of an amorphous food to the volume of a food that comprised a discrete component (eg, pasta compared with a chocolate bar). The ease with which this was achieved warrants scrutiny in the future. Finally, our data set had a number of missing values. In part, these missing values were because liking ratings were elicited only in cases when the respondent reported having previously consumed the food. In the future, to evaluate the effect of these missing data, we recommend that ratings should be taken in all cases.

More generally, broader environmental influences on the dietary behavior of children should be considered (29). In the United States, the number of new food products rose substantially between 1970 and 1995, and the majority of these products were energy-dense snack foods (30). In this complex dietary environment, learning may be inhibited because the abundance and variety of unfamiliar foods limits the opportunity for learned increases in expected satiation. To establish the veracity of this idea, larger cohort studies might consider both snack-food availability and snack-food variability as independent determinants of adiposity in children.

The authors’ responsibilities were as follows—CAH, KM, and JMB: data collection; none of the authors declared a conflict of interest.

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