AMERICAN JOURNAL OF PSYCHOLOGICAL RESEARCH

Volume 5, Number 1
Submitted: August 31, 2009
Revisions: September 21, 2009
Accepted: September 22, 2009
Publication Date: September 24, 2009

Food Quantity Estimates: Inaccurate when Visible and Even More Inaccurate from Memory

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ABSTRACT

We hypothesized that food amount accuracy scores would be worse from memory than when food is in plain sight. Unit quantity estimates and BMI were obtained from 73 undergraduate participants for cheese puffs in two containers either having small units, more numbers (S) or large units, fewer numbers (L). Participants estimated with food visible or occluded. S and L accuracy scores (estimated/actual) were dependent measures. BMI was not significantly correlated with accuracy, S ($r = -0.11$, $p = .17$ or L ($r = 0.12$, $p = .15$). Accuracy scores reflected ubiquitous underestimates whether food was visible or not. Participants always (1.00) underestimated S and L when visible, and S = 0.97, L = 0.95 when occluded. MANOVA showed both S and L were significantly less accurate from memory despite perceptual differences in these arrays; L, $F(1, 72) = 7.290$, $p = .009$ and S, $F(1,72) = 6.874$, $p = .011$.

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INTRODUCTION

Several lines of research have demonstrated that food appraisal and consumption are related to the physical features of the food portion size, appearances and container shape. Further, memory plays a role in food appraisal and consumption. Representations of food are subject to distortions. These memory distortions have consequences for food preferences and actual consumption. In extreme instances, appetite distortions may occur when explicit memories for eating food are absent. In a case study, two amnesic patients had almost no explicit memory for any events that occurred after a minute. Both patients were observed eating a second lunch when it was presented to them only 10 to 30 min after their first. They would usually begin consuming a third lunch presented 10 to 30 min after the second, suggesting that memory plays a substantial role in beginning and ending a meal (Rozin, Dow, Moscovitch, & Rajaram, 1998).

When Bernstein and Loftus (2009) made people think a particular food had previously made them ill, they avoided the food and consumed less of it. Although most of the false memory food bias research (Bernstein, Laney et al., 2005a; Bernstein, Laney et al., 2005b; Geraerts, Bernstein et al., 2008) has examined negative false beliefs about food-induced illnesses (e.g., egg salad, strawberry ice cream, dill pickles, peach yogurt, food memory can also be positively distorted). Laney, Bowman-Fowler, et al. (2008) created false memories that increased self-reported liking asparagus and greater willingness to pay a higher price for asparagus (Laney, Morris, et al., 2008).

In a study of more normative food memory distortion, Fries, Green and Bowen (1995) reported that as the quantity of food items consumed increased, so did the discrepancy between actual amounts consumed versus amounts that women participants reported from memory 24 hr later. They noted that women eating low fat diets were more accurate than those on high fat diets. The high fat diet participants under-estimated the actual food quantity they had consumed significantly more than the low fat diet participants. A social desirability bias could account for these self-report findings, e.g., individuals weighing more consistently under-report to avoid embarrassment (Keen et al., 1979; Lara, Scott, & Lean, 2004; Prentice & Jebb, 1995; Romieu et al., 1981). Long-term food memory may be highly subject to distortion.

Physical aspects of the food presentation may influence memory for, and consumption of, food. Singer and Kornfield (1973) placed equal food quantities in different shaped containers, tall and narrow or short and wide. They found that although adults showed conservation and could identify the two food amounts as equal, they stated a preference for consuming the amount from the container that made the food quantity appear larger. People preferred food in containers producing the illusion of more quantity. Kral's review (2005) showed that actual larger portion sizes promoted greater consumption than when the portion size was smaller. Geier, Rozin, and Doros (2006) placed different size snacks in a bowl, free for any passers-by, alternating small and large amounts of two types and sizes of candies, M&Ms and Tootsie Rolls, and pretzels (small or half-sized unit portion). The results illustrated that taking larger quantities of snack units depended on the increased number of visible snack units.

Studying the rates of snack consumption, Wansink (2004) reported snacks were eaten 46 percent faster when contained in a clear, rather than opaque, jar. People may consume food at a lower rate when the food is out of sight. This finding suggests that when snacks are out of sight and represented, they may be appraised differently than when they are present and in direct view. Thus, dieters may be exhorted to keep snacks out of sight as one potential means of reducing the rate of their snacking behavior. Further, since people may consume food more slowly when the food is not visually present (Wansink, 2004), perhaps we may eat more slowly when food is occluded from view because we represent less food in the container.

There is a surprising dearth of empirical research about people's short-term food memory, e.g., when responses to food rely on explicit memory representations following brief visual occlusion. We hypothesized that unit quantity estimates will be significantly less accurate with the snacks occluded from view than with food visually present, despite differences in presentation of the food, e.g., small, more cheese puffs (S) and large, fewer (L) food units.

METHOD

Participants

Eighty-one psychology major undergraduates at Texas State University signed consent forms describing height and weight measurements and food unit estimations; 73 participated. The sample age range was 19-30 yr, $M = 21.9$, $SD = 1.93$. There were 53 female and 20 male participants.

Materials

Two identical plastic, clear jars were used as snack food containers for either 33 large cheese puffs or 114 small cheese puffs that were equal in weight but not physical appearance. The average large cheese puff measured 7.76 cm in circumference and the average small cheese puff measured 4.56 cm. Also, a solid, gray plastic sheet was used to occlude the cheese puffs from participants' sight. A medical scale was used for determining participants' height and weight. A random integer generator was used to randomly assign participants, condition order, right-left container position and order of S or L estimates.

Procedure

Neither administrators nor participants knew the hypotheses tested. Participants were escorted to a private room and measured for their height and weight. Height was measured and recorded in inches and weight in pounds. The body-to-mass ratio (BMI) x 0.73 was calculated. Participants were randomly assigned to conditions, either estimating the numbers of cheese puffs with the snack foods visually present or by estimating numbers from memory with the cheese puffs briefly occluded from view.

Containers were placed next to one another with right-left positions of the two snack food containers and participants' first and second S or L estimates randomly assigned. All participants had 30 s to visually examine the cheese puffs. Containers were placed next to each other on a well-illuminated table in an otherwise empty laboratory room. After the 30 s viewing period, the administrator simultaneously occluded both snack food containers from view by placing the opaque plastic sheet between the participants and containers, for those assigned to the memory estimate condition.

Participants were randomly assigned to food estimation conditions, either estimating the numbers of cheese puffs with the snack foods visually present or by estimating numbers from memory with the cheese puffs briefly occluded from view. All participants had 30 s to visually examine the cheese puffs containers placed on a well-illuminated table in an otherwise empty laboratory room. For those assigned to the memory food-occluded condition, after the 30 s viewing period, the administrator obstructed participants' views by placing the opaque plastic sheet between the participants and cheese puffs. For participants assigned to the food-visible condition, the administrator placed the plastic sheet behind the cheese puffs instead of in front of them, as a comparable control. Participants were asked to orally estimate the S and L quantities in randomized order after the plastic sheet was placed either in front of or behind the containers. Estimates of unit quantities for both containers were recorded by the administrator.

Participants' unit quantity estimates were transformed into response accuracy measurements, calculated as estimated units/actual units. Data were entered into SPSS to determine whether accuracy estimates for large size/small quantities (L) and participants' accuracy estimates for small size/large (S) quantity cheese puffs were significantly more accurate when cheese puffs were visually present compared to participants' estimates when the cheese puff containers were occluded from view and estimated from memory.

RESULTS

Pearson *r* revealed that BMI was not significantly correlated with participants' estimated food unit accuracy rates, S (r = - .114, p = .169 or L (r = .123, p = .151). We had intended to treat the BMI as the second factor for MANOVA; however, because the BMI was poorly correlated with food unit estimates and because the range was restricted at the upper levels, further BMI analyses were not warranted.

Pearson r showed that the dependent measures, participants' S and L accuracy scores, were strongly correlated (r = .80, p < .001, 1-tailed). Both unit quantities were always (1.00) underestimated when visible, and consistently underestimated when occluded, S = .097, L = 0.95. The 7 L overestimates showed no particular trends for visible or occluded condition (4 and 3). Overall, participants were much less accurate when estimating S (M=.399, SD = .165) than L (M = .714, SD= .276). In absolute terms the estimated unit quantities were, S (M = 45.48, SD= 18.82) and L (M = 23.58, SD = 9.11). With alpha set at .05, Box's M Test showed observed covariance matrices of the dependent variables were equal across groups (Box' M = .082). Levine's Test of Equality of Error Variance showed that both dependent variables had error variances that were equal across groups S, F(1,71) = .071), p = .791 and L, F(1,71) = .027), p = .871.

MANOVA revealed significant main effects of the manipulation, F(2,70) = 4.255, p = .018, partial η^2 = .108, observed power = .726. Table 1 shows means and standard deviations for S and L accuracy scores. S estimates were less accurate than L; when food was occluded the outcome scores were significantly less accurate than with the food visible, L = F(1, 72) = 7.290, p = .009 and S = F(1,72) = 6.874, p = .011.

Table 1

Unit Quantity Accuracy Means and Standard Deviations when Small Size, More Units (S) and Large Size, Fewer Units (L) Cheese Puffs were Visible or Occluded from View.

	M		*SD*	
Estimate Condition	S	L	S	L
Visible	.448	.797	.157	.251
Occluded	.400	.630	.161	.268

DISCUSSION

BMI was poorly correlated with unit quantity estimates. Participants were less accurate when estimating smaller, more cheese puffs compared to participants' accuracy estimates for the container having large, fewer cheese puffs. Further, accuracy of food amounts was significantly less when the cheese puffs were visually occluded and participants had to briefly represent and recall food, compared to participants' estimates when the cheese puff were visible. Accuracy scores reflected ubiquitous underestimates. Participants always (1.00) underestimated S and L when visible, and nearly always underestimated from memory, S = 0.97, L = 0.95, when containers were occluded. MANOVA showed both food-unit estimates were significantly less accurate from memory despite large differences in the appearances of the snack food arrays.

The hypothesis seems reasonable that people may estimate food unit quantities worse from memory than when food is in plain view. The extent that unit quantities were underestimated with visible food was surprising. For most participants the underestimation error increased with food occluded, although fewer than 10 percent overestimated from memory.

There were several methodological limitations of the study requiring cautious data interpretation. Generality is limited; our sample was comprised of all young, adult undergraduate psychology majors who knew they were participating in a food study because of the explicit consent form and weight-scale measurements. There were a slightly smaller proportion of participants falling into the obese BMI category, 28%. A restricted upper BMI range may have also contributed to the non-significant BMI correlations with food quantity estimates. The lack of correlation also made dichotomous (BMI-obese compared to BMI-normal) comparisons inappropriate due to observed unequal error variances when this data analysis was reviewed.

Perhaps a less obtrusive approach may have resulted in fewer potential social biases contributing to the consistent underestimates. No deception was used in this study. The consent form did not explicitly state the hypotheses, but did explicitly describe the BMI and food measures. Although participants were unaware of hypotheses, the presence of a medical weight scale could create evaluation apprehension that, in turn, may have contributed to observed underestimates. Other approaches using deception, time delays between BMI and food presentations, or surprise protocols would have greater external validity.

Because participants made dual responses, this protocol produced a delayed length of time for the second estimate. This suggests a potential interference confound of order, with the first response interfering with second estimate. No order differences were observed. By randomizing response order for containers in both visible and occluded conditions potential internal validity order effects were equated and controlled in this study.

Laura, Scott and Lean (2004) reported that women intentionally underestimated food amounts in their retrospective self-reports. They suggested that food underestimates are produced by social cognitions about requests for self-reporting eating behaviors. Social desirability may bias self-reports of food appraisal and consumption. However, Macdiarmid and Blundell (1998) proposed that misreporting diet can be categorized as either intentional or non-intentional. People who are obese may be self-conscious and may purposely misreport the kind of foods they ate, caloric intake, the amount of food before them and underreport the amount they consumed. It is plausible that some overweight people with high BMI scores purposely underestimate food quantities and calorie intake. Alternatively, food underestimations may be ubiquitous, and in our weight-conscious culture amplified for obese people who may be self-conscious about weight evaluations. In any event, participants' BMI scores were unrelated to participants' accuracy of food unit quantities. In this study, it is unclear why BMI was unrelated to accuracy of food estimates.

Apparent food-perceiving anomalies may exemplify broader aspects of general sensory perception. Winer and McGlone (1993) found that under some circumstances adults may demonstrate non-conservation for weights. As adults, we are sometimes surprised when we fail to show liquid conservation. Consider our estimates at cafeterias when a small, squat, opaque rectangular pint carton of milk is placed next to a tall, clear, narrow cylindrical glass. We may tend to underestimate how much of the glass will be filled when the milk is poured. However, this is not food-specific; it is a common type of quantity estimation error. As another example of how food is subject to general sensory processes, Zellner, Kern and Parker (2002) demonstrated that beverage discrimination is subject to the same type of contrast effects that have been observed for non-food stimuli. Generally, stimuli are perceived as less desirable when compared to highly desirable contrasting stimuli than when presented alone or contrasted to ordinary stimuli. This is known as hedonic contrast and the same process appears true for estimates of beverage quality; contrast was greater for coffees and beers belonging to a common category and less for products in gourmet, specialty niche categories. Similarly, the underestimations we observed for cheese puffs may likely be a ubiquitous unit estimation error and may not be food-specific.

Further research is needed to help elucidate specific properties of food that produce unique sensory appraisal. One potential method for differentiating ubiquitous sensory processes from food-specific perceptual and memory would be to alter participants' expectancies about the nature of the research, or by comparing food to non-food contexts. Like many previous food perception studies, it is not known whether the underestimates of unit quantity that we reported would be different when compared to estimates for identical non-food or inedible quantities, e.g., foam spheres of the same size and quantity as cheese puffs.

Perhaps certain perceptions and memories are qualitatively different for food. Kalat and Rozin (1970) showed there are unique aspects of learned food taste aversions. Food aversion learning is different from ubiquitous, conditioned aversions to non-food stimuli, e.g., single-trial learning, backwards conditioning, and extinction resistance. Differentiating aspects of human food appraisal and utilization that are food-specific from those ubiquitous ones may be a promising line of future inquiry.

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