Satiation from Sensory Simulation: Evaluating Foods Decreases Enjoyment of Similar Foods

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We demonstrate in two studies that people get more satiated on a food after repeatedly rating or choosing among similar foods shown in pictures. Repeated evaluations of food apparently have an effect similar to actual consumption—decreased enjoyment of foods that share a similar taste characteristic (i.e., sensory-specific satiety). We provide mediation evidence to show that satiation manifests because considering a food engenders spontaneous simulations of the taste of that food item, which by itself is enough to produce satiation. These findings establish sensory simulations as an important mechanism underlying satiation, and provide behavioral evidence that simple evaluations can produce sensory-specific satiety.

Keywords: Satiation, Sensory Simulation, Sensory-Specific Satiety, Hedonic Consumption

The daily life of the average consumer is filled with advertisements. In fact, the number of advertisements a city dweller sees per day may be as high as 5,000 (Story, 2007). An ever-increasing proportion of these advertisements are for food. Last year, McDonald's alone spent $1.37 billion on advertising in the US, while Yum Brands (Taco Bell, Pizza Hut, and KFC) spent $835 million (Advertising Age Data Center, 2012). These advertisements typically aim to increase brand awareness and purchase intentions, often by highlighting the hedonic qualities and inviting consumers to imagine the sensory experience for themselves. We explore whether stimuli like these advertisements, especially those focusing on how much one will enjoy the food, may have an unintended consequence. They may encourage increased satiation on the food being shown. Therefore, although ads for a food product may lead consumers to want to purchase them, some may also have the opposing counterintuitive effect of making subsequent consumption less enjoyable.

Satiation, defined as the drop in enjoyment with repeated consumption (Rolls, Rolls, Rowe, & Sweeney, 1981; Redden, 2008), occurs in virtually every domain. The fifth bite of cake, the fourth hour of playing a video game, and the third day of a beach vacation are each less enjoyable than the first. Although satiation clearly results from actual consumption, we propose that imagined consumption may also be enough to produce satiation. For instance, thinking about how much one will enjoy the beach with its crashing waves, salty smells, warm sand, and fresh breezes could satiate one much like actually being at the beach. Our work tests whether simply thinking about how much one would like something can lead to satiation.

Recent research lends some support to this notion of satiation from imagined consumption. Morewedge, Huh, and Vosgerau (2010) found that people consumed fewer M&M's if they repeatedly imagined consuming them beforehand. However, it is worth noting that imagined consumption in their studies required instructed, deliberate, and conscious simulations of the multiple steps of consumption. These included imagining picking up each M&M, putting it in one's mouth, chewing, swallowing, and repeating the process over and over. Thus, it is not clear that simulated consumption like this happens in a spontaneous fashion, or furthermore that spontaneous simulations can produce satiation like actual consumption.

Past research has argued that people often simulate the sensory experience of consumption. In his perceptual symbol systems theory, Barsalou (1999) argues that mental simulations of actions, such as eating an M&M or throwing a baseball, are possible because perceptual symbols of these experiences are stored in memory and are accessible in the absence of actual experience. For instance, past consumption of M&M's creates stored neural representations of the experience in multiple sensory modalities, including the taste, sound, and texture of the M&M's. When subsequently considering M&M's, one can then access the brain areas associated with taste, sound, and touch (where these perceptual representations of past M&M consumption were stored) to simulate the actual experience of eating M&M's.

Our research asks a simple but fundamental question: does satiation result from the sensory simulations people spontaneously perform? The potentially satiating effect of sensory simulations has great relevance because they occur as a natural consequence of so many cognitive activities (Barsalou 2008). For example, when one sees a picture of an ice cream sundae and thinks it looks appetizing, that evaluation relied on a sensory simulation of the taste of the pictured sundae. We propose that this kind of mental simulation leads to satiation much like actually consuming the food.

A demonstration of the satiating effect of sensory simulations would contribute in several important ways to the literature. First, it would show that activating memories of sensory characteristics produces satiation. This would establish the sensory simulations of taste, texture, and sound (and potentially other sensory simulations) as an important mechanism underlying satiation. Second, our proposed theory adds further explanations for past findings such as the satiating effect of instructed conscious rehearsal of consumption (Morewedge, et al., 2010), as well as the phenomenon of sensory-specific satiety whereby satiation from eating a food extends mostly to foods sharing a salient sensory aspect (Rolls et al., 1981). Third, by using the simple task of evaluating food pictures, the sensory simulations that result in our experiments are likely more nonconscious in nature (Barsalou, 1999). Therefore, our research would be a novel demonstration of satiation resulting from processes outside of conscious awareness. This finding would provide further insight into why satiation seems unavoidable and ubiquitous across virtually every experience.

Two experiments established that repeated evaluations of food pictures caused satiation on other foods sharing a sensory aspect. In Experiment 1, participants found eating peanuts less enjoyable after rating the attractiveness of pictures of salty foods versus rating pictures of sweet foods. This happened even though participants never saw a picture of a peanut or received instructions to think about consuming a peanut (or any other food). In Experiment 2, we replicated our core finding when the task was rating the attractiveness of foods or choosing between two foods, but not when the task was unrelated to the taste characteristics of the food (rating brightness). This indicates that simply exposing one to pictures of food did not produce satiation, presumably because it did not trigger the sensory simulations at the core of our theory. Mediation evidence supported our account as evaluating the food pictures caused satiation when sensory simulations of taste occurred, but not when directed mental processes inhibited these simulations. Overall, we consistently found that evaluating pictures of foods led to satiation with regard to foods that shared the salient taste attribute, much like actual consumption would have done.

Experiment 1

Our goal in Experiment 1 is to test our core prediction that repeated evaluations of foods can lead to satiation. In line with work on sensory-specific satiety (Rolls et al., 1981), we posit that this satiation will occur predominantly for the salient aspects of the foods shown. We expect that participants who receive repeated exposures to salty (vs. sweet) foods will show signs of satiation to salty foods in the form of decreased enjoyment when subsequently eating salty peanuts.

Method

Participants. Sixty-three undergraduates participated in two ostensibly separate studies: one on food presentation and one on food consumption. Each participant completed both studies in a private study room.

Manipulation. We employed a 2 (number of pictures: 20, 60) × 2 (food: sweet, salty) between-subjects factorial design. Half of the participants were informed that they would rate 20 food pictures, while the other half were informed that they would rate 60 food pictures. If rating food pictures indeed induces satiation, then those who receive 60 pictures will satiate more than those who receive only 20 pictures. This factor was crossed with picture type. In order to broaden the implications of our findings and highlight the role of sensory-specific satiety, we utilized a variety of unique visual images containing the same taste experience (either sweet or salty). This allows us to tease out whether it was simply viewing pictures of any food or the simulation of a specific sensory experience that produced satiation. Half of the participants saw pictures of sweet foods like cake, truffles, chocolates, etc. The other half of participants saw pictures of salty foods like chips, pretzels, french fries, etc. (but no nuts of any type). We hypothesized that participants exposed to pictures of salty foods would show decreased enjoyment of a salty food (peanuts) they subsequently ate.

Procedure. Participants were first asked to rate their general liking of 15 different foods using an unnumbered sliding scale (from 0 to 100) anchored by the labels "Not at all" and "Very much." One of the foods rated was peanuts, providing a measure of general liking to later serve as a covariate. The other foods (e.g., carrots, raisins, sushi, hamburgers) were included to hide that peanuts would be focused on in the second study. Participants were then shown pictures of food items, one per page. For each picture, they were told to "Please rate how appetizing you find this picture" on a seven-point semantic differential scale anchored by "Not at all appetizing" and "Extremely appetizing." The number of pictures and types of food shown depended on the experimental condition.

After participants completed all the food ratings, they were told to notify the research assistant that they had completed the first study, whereupon participants were given a Ziploc bag containing three peanuts. Participants then began the next survey, which instructed them to eat the three peanuts. The survey then asked them to rate "How much did you enjoy eating those peanuts?" on an unnumbered sliding scale (from 0 to 100) anchored by the labels "Not at all" and "Very much." The survey concluded with several follow-up questions, including their reported feelings of a variety of emotions (happiness, sadness, anger, fear, surprise, excitement, joy) each on five-point scales anchored on "Not at all" and "Very much".

Results

We analyzed the enjoyment rating given after eating the peanuts using an ANCOVA with the number of pictures and food type as between-subjects factors, and the general liking of peanuts collected before viewing the pictures as a covariate. Figure 1 reports the adjusted mean peanut enjoyment rating by condition. The model found a main effect of food type ($F(1, 56) = 10.14$, $p = .002$, $\eta^2 = .15$), as participants viewing salty pictures ($M = 47.3$) enjoyed the peanuts less than those viewing sweet pictures ($M = 62.1$). More importantly, there was the key predicted interaction between the factors ($F(1, 56) = 4.82$, $p = .03$, $\eta^2 = .08$). Planned contrasts confirmed our predictions. As hypothesized, in the salty picture condition, participants who viewed 60 pictures enjoyed the peanuts less than those who viewed 20 pictures ($M_{60\ pictures} = 39.1$ vs. $M_{20\ pictures} = 55.5$; $t(56) = 2.49$, $p = .01$, $d = .94$). In contrast, there was no main effect of the number of pictures in the sweet picture condition ($M_{60\ pictures} = 64.2$ vs. $M_{20\ pictures} = 60.1$; $t(56) = .63$, $p = .53$). This indicates that the satiation was specific to the salty aspect. There was also an unsurprising effect of the covariate ($\beta = .72$, $t(56) = 8.53$, $p < .0001$), indicating that those who reported a general liking for peanuts reported greater enjoyment of this peanut consumption experience, but no main effect for the number of pictures ($F(1, 56) = 1.72$, $p = .19$).

Insert Figure 1 about here

To ensure that the results were not driven by differences in emotion (e.g., perhaps salty pictures induce more negative emotions than sweet pictures), we analyzed the ratings of happiness, sadness, anger, fear, surprise, excitement, and joy. Rerunning our ANCOVA model using each of these emotions as the dependent measure did not uncover any significant effects (all *p*s > .20).

Discussion

As participants evaluated more salty foods in pictures, their enjoyment decreased when subsequently eating a different salty snack of peanuts. This happened even though participants never saw a picture of peanuts, and they were never instructed to think about consuming peanuts (or any other food). Our theory proposes that this effect obtained because evaluating the salty foods caused repeated sensory simulations of salty tastes, which produced sensory-specific satiation across the entire category of salty foods. Thus, a greater number of evaluations led to greater satiation. Consistent with our claim, participants who evaluated sweet foods showed no change in enjoyment for peanuts, which indicates that the food pictures induced satiation only for similar foods sharing the salty aspect.

Experiment 1 provides initial evidence that sensory-specific satiety can be induced by rating food items. We claim that evaluating a picture of a food facilitates sensory simulations of the taste of the food item, which in turn leads to satiation for the food item and other food items that share a salient taste characteristic. We triggered these simulations here through ratings of how appetizing the food in the picture seemed, but there are likely many other ways to evoke these simulations. The next study tests whether expressing a choice can have the same satiating effect. Likewise, there are almost certainly situations in which pictures of food will not spur spontaneous sensory simulations. In such cases, such as when other task demands impede simulation, we anticipate the effect of viewing food pictures on satiation will attenuate.

Experiment 2 tests these possibilities, and provides additional evidence for our proposed model by inhibiting sensory simulation.

Experiment 2

In Experiment 1, we found support for our hypothesis that repeated evaluations of visual depictions of food can cause satiation. Our theory proposes that this happened because each exposure induced spontaneous sensory simulation of the taste of the food stimuli. Although these simulations may be spontaneous and nonconscious, they should still be differentially activated depending on the cognitive activity being performed (Goldberg, Perfetti, & Schneider, 2006). For instance, when instructed to evaluate how appetizing the food images are, the sensory simulations that accompany this evaluation should come primarily from the taste centers of the brain. However, should attention be paid instead to visual characteristics of the food image not related to consumption (e.g., brightness), these sensory simulations should come primarily from outside the taste centers (i.e., the visual brain centers). This implies that less sensory simulation of taste will occur when participants focus on characteristics unrelated to consumption, which our theory predicts should consequently lessen satiation from exposure to the food pictures. Experiment 2 tested these predictions by manipulating the focus of participants when exposed to the food pictures.

This experiment also tested the extent to which any satiating effect generalizes across other tasks. Specifically, we included a choice condition to provide additional evidence for the predicted effect and our proposed mechanism. Repeated exposure to visual food stimuli should result in satiation when those stimuli induce sensory simulations of the taste of the food. In the food rating and food choice conditions, participants are engaging in very different actions, yet both actions should induce sensory simulations of taste.

Method

Participants. One hundred and sixty-nine undergraduates participated in a study on food consumption in exchange for extra credit in a business course. Each participant was situated at a computer station in a behavioral research lab. Each station was shielded from the view of other computer stations. In addition, each of the 12 to 18 participants in each session was seated at least one station away from other participants to reduce the chance of contamination.

Manipulation. Participants were then randomly assigned to one of three conditions: (1) food rating, (2) food choice, or (3) brightness rating. In the food rating condition, participants were instructed to "Please rate how appetizing you find this picture" as they rated 60 pictures of salty foods (no pictures included nuts of any kind) on a seven-point semantic differential scale anchored by the endpoints "Not at all appetizing" and "Extremely appetizing". Participants in the food choice condition were instructed to "Please choose the picture you find more appetizing." Each participant in this condition made 60 choices from a pair of salty food pictures. The choice condition used the same 60 food pictures as the rating condition. Each picture was used twice, each time paired with a different salty food picture to create a binary choice. In the brightness rating condition, participants were instructed to "Please rate how dark/bright you find this picture" on a seven-point semantic differential scale anchored by the endpoints "Very dark" and "Very bright". These participants rated the same 60 salty food pictures contained in the food rating condition.

Because participants in both the food rating and food choice conditions are focused more on consumption-related aspects of the food pictures (i.e., appetizing characteristics evaluated on taste), the spontaneous sensory simulations that accompany these evaluations should be focused on the taste of the food (i.e., saltiness). This leads to our prediction that participants in the food rating and food choice conditions will show greater satiation when subsequently eating peanuts than participants in the brightness rating condition.

Procedure. Participants entered the lab and were assigned to a computer. At each computer station, participants found a small paper cup with 30 grams of peanuts and a small Ziploc bag containing three peanuts. Participants were first instructed to eat three peanuts from the cup and rate "How much did you enjoy eating those peanuts?" on an unnumbered sliding scale (from 0 to 100) anchored by "Not at all" and "Very much". Participants were then instructed to continuously snack on the remaining peanuts in the cup one at a time as they completed the remainder of the study. In order to allow time for consumption, we included an unrelated survey at the beginning of the study regarding hypothetical new services being offered by an online retailer.

Upon completing this initial survey and eating peanuts from the cup, participants next performed the experimental task by rating or choosing from the food pictures based on their condition. After this task, participants were instructed to eat the three peanuts from the small Ziploc bag, whereupon they again reported their enjoyment of the peanuts they just consumed using the same enjoyment measure as before. We then captured the amount, ease, and vividness of their mental simulations while viewing the food pictures on nine-point semantic differential scales (adapted from Bone & Ellen, 1992; see appendix for details). Finally, participants rated

“Overall, how much did you enjoy consuming the peanuts today?” using a ten-point semantic differential scale anchored by “Not at all” and “Very much”.

Results

Enjoyment Ratings. Participants provided three measures of enjoyment: (1) enjoyment1: enjoyment of the first three peanuts consumed; (2) enjoyment2: enjoyment of the last three peanuts consumed; and (3) overall enjoyment: overall enjoyment of the consumption episode. We analyzed the results for satiation using an ANCOVA with enjoyment2 and overall enjoyment as the two repeated dependent variables (after standardization to account for differences in the two scales). The model included the task condition as a between-subjects factor and enjoyment1 taken before the manipulation as a covariate. The omnibus tests indicated a significant effect for the task ($F(2, 162) = 2.86$, $p = .06$, $\eta^2 = .03$), as well as the enjoyment1 covariate ($F(1, 162) = 231.17$, $p < .0001$). All of the other factors were not significant (all *p*s > .50), including a non-significant measure by condition interaction, indicating that both measures of enjoyment demonstrated the same pattern.

Insert Figure 2 about here

We next tested the pattern of results, shown in Figure 2, to provide further support for our theory. We did not predict any difference between the food rating and food choice conditions, and indeed these conditions did not differ for the enjoyment2 ($t(162) = .59$, $p = .55$) or overall enjoyment measure ($t(162) = .94$, $p = .35$). Based on this, as well as our theory, we tested our predictions using planned contrasts with these two conditions collapsed. Participants rating the brightness of the picture reported greater enjoyment after eating the last peanut (M_{bright} = 56.2) than participants in the food rating and choice conditions (M_{pooled} = 50.6; $t(162) = 1.65$, $p = .10$, $d = .26$). Likewise, participants rating brightness also indicated that they had greater overall enjoyment (M_{bright} = 7.1 vs. M_{pooled} = 6.5; $t(162) = 2.08$, $p = .04$, $d = .33$). A repeated measures ANCOVA with the condition variable re-coded to collapse the food rating and food choice conditions also yielded a significant difference for condition ($F(1, 162) = 4.91$, $p = .03$, $\eta^2 = .03$). These results all indicate that rating or choosing the food induced greater satiation than assessing the brightness of the photo, supporting our predictions.

Mediation. To measure the role of sensory simulation in these effects, we averaged the ratings of amount, ease, and vividness of mental simulations of eating the pictured foods. This index of sensory simulation showed acceptable consistency ($\alpha = .96$). Though the sensory simulations that accompany exposure to food pictures are likely more nonconscious, there is reason to believe that self-reports of mental imagery can still capture differences. Carlson, Tanner, Meloy, and Russo (2010) found that participants primed with a particular goal outside of conscious awareness could report that goal being more active during their choice procedure, and Berger and Heath (2007) showed that cues that nonconsciously affect consumption experience can still be reported after the fact. Here, we also found differences as the reported sensory simulation of eating the food items shown was lower for participants in the brightness rating condition ($M = 4.8$) than those in the food rating ($M = 5.8$; $t(165) = 3.02$, $p < .01$, $d = .57$) and food choice conditions ($M = 5.9$; $t(165) = 3.17$, $p < .01$, $d = .60$). Thus, we found support for our proposed process of sensory simulation, such that the amount of sensory simulation was indeed lower in the brightness rating condition than in the food rating or food choice conditions.

We further proposed that the level of sensory simulation mediated the effect of the picture task on consumption enjoyment. We formally tested for this mediation on an index of our two dependent variables, enjoyment2 and overall enjoyment ($r = .71$), with enjoyment1 included as a covariate. Analyses conducted through Preacher and Hayes's (2008) process macro with bootstrapped samples ($n = 5{,}000$) indicated competitive mediation (Zhao, Lynch, & Chen, 2010). The mean indirect effect of picture condition on final consumption enjoyment through mental simulation was negative and significant, with a 95% confidence interval excluding zero (-1.46 to -.12). The direct effect was also significant ($\beta = 2.47$, $t(165) = 2.37$, $p < .05$, $d = .37$). As the product of these coefficients is negative, we find support for competitive mediation. The total effect of picture condition on final consumption enjoyment was marginally significant ($\beta = 1.88$, $t(165) = 1.82$, $p = .07$, $d = .28$). Further, controlling for picture condition, we found that mental simulation has a significant impact on consumption enjoyment ($\beta = 1.19$, $t(165) = 2.51$, $p < .05$, $d = .39$). Competitive mediation implies that there may have been additional omitted mediators, or that our self-report measure of mental simulation did not fully capture the nonconscious process we hypothesized.

Discussion

Overall, the results of Experiment 2 provided evidence for our proposition that the spontaneous sensory simulations that accompany exposure to visual food stimuli can produce satiation. When participants' attention was diverted away from consumption-related aspects of the pictured food, they exhibited less satiation than participants whose attention focused on the food itself while rating attractiveness or choosing. Though food rating and food choice are very different activities, we propose that they both induced satiation by facilitating sensory simulation of taste. The pattern of results provided evidence that the task mattered, in particular that satiation occurred only when sensory simulations were greater, thereby providing evidence for our proposed mechanism.

Our findings also concur with research by Morewedge, Huh, and Vosgerau (2010). They showed that the effect of imagined consumption on satiation likewise depended on the task: instructed, deliberate rehearsals of consumption increased satiation, while imagining moving the food did not. This accords with our theory as the former task likely triggered taste-focused sensory simulations while the latter did not. However, we should also note that our findings differ from their results as well. Morewedge et al. found that repeated simulations of food consumption decreased desire for the food, but did not decrease overall enjoyment of the food. In contrast, we find that repeated exposure to food pictures indeed decreased enjoyment of the eaten food (i.e., sensory-specific satiety). One possible explanation for this difference is that we measured enjoyment of a consumption experience, while Morewedge et al. measured general liking for the food item. Satiation is a temporary decrease in enjoyment of an item or activity, not a permanent decrease. It is possible that their measure of general liking, because it was not accompanied by a consumption experience, did not capture the temporary decrease in enjoyment.

General Discussion

Across two studies we propose and show that when participants repeatedly evaluated food pictures containing a specific taste experience (e.g., salty), they had a reduced liking for similar taste experiences and a lower level of enjoyment during subsequent consumption. In essence, we establish that evaluating pictures of foods can produce the well-known phenomenon of sensory-specific satiety (Rolls et al. 1981). We propose a theoretical model to account for these findings by building upon the notions of grounded cognition (e.g., Barsalou, 2008; Krishna, 2012). Specifically, we focus on the ability of visual cues to facilitate mental simulations of taste experiences, which then lead to satiation. We provide support for our proposed process through mediation evidence, as well as by showing that the satiating effect attenuated when the task focused people on aspects not related to consumption (e.g., the brightness of the picture). As a result, the present research establishes sensory simulations as an important mechanism underlying satiation.

We also extend recent research on the effects of instructed, deliberate rehearsals of consumption on satiation (Morewedge et al., 2010). We show that satiation can occur in the absence of conscious rehearsal of consumption. Additionally, our results show that sensory simulations of taste experiences can decrease enjoyment of similar foods sharing the same overall taste characteristics (e.g., sweet or salty) and not just the specific food simulated. This suggests that the satiating effect of simulated consumption may reach much further than previously believed.

With the present research we also address a call for more research on sensory imagery within a consumer context (Krishna, 2012), and provide additional behavioral support for the claim that mental simulations happen spontaneously (Barsalou, 2008; Elder and Krishna, 2012). Although our self-report measures provide support for differential levels of sensory simulation and its consequent effect on satiation, future research should examine other ways to measure these nonconscious simulations and their effects. Additionally, future research should explore other tasks (beyond the rating and choosing in our studies) that can trigger these simulations, and determine what aspects of a task engender satiation. Of course, future work can also determine the extent to which our effects replicate for non-food stimuli as we expect our theory is general in nature. There is much potential in exploring the role sensory simulations play in the ubiquitous phenomenon of satiation.

Our findings also have potential implications for the food industry, particularly related to the frequency of food advertising. Food advertisers typically want potential buyers to see their advertisements and make the evaluation that the pictured food appears appetizing. This is precisely the kind of evaluation that leads to sensory simulations of taste like those in our studies. If consumers see too many ads that cause such sensory simulations, the ironic effect could be a decreased enjoyment of the advertised food when it is eaten. Therefore, marketers should consider our findings when designing their ads (and perhaps avoid excessive sensory simulations). Likewise, consumers might benefit from limiting their sensory simulations before eating with the potential result that food may become more enjoyable.

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Figure 1. LS mean ratings of peanut enjoyment in Experiment 1 (adjusting for general liking)

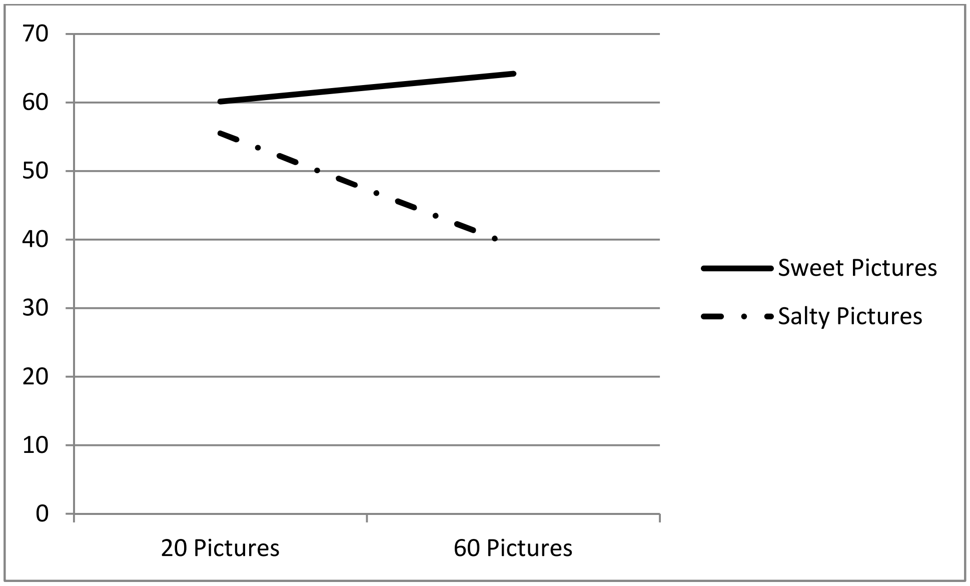
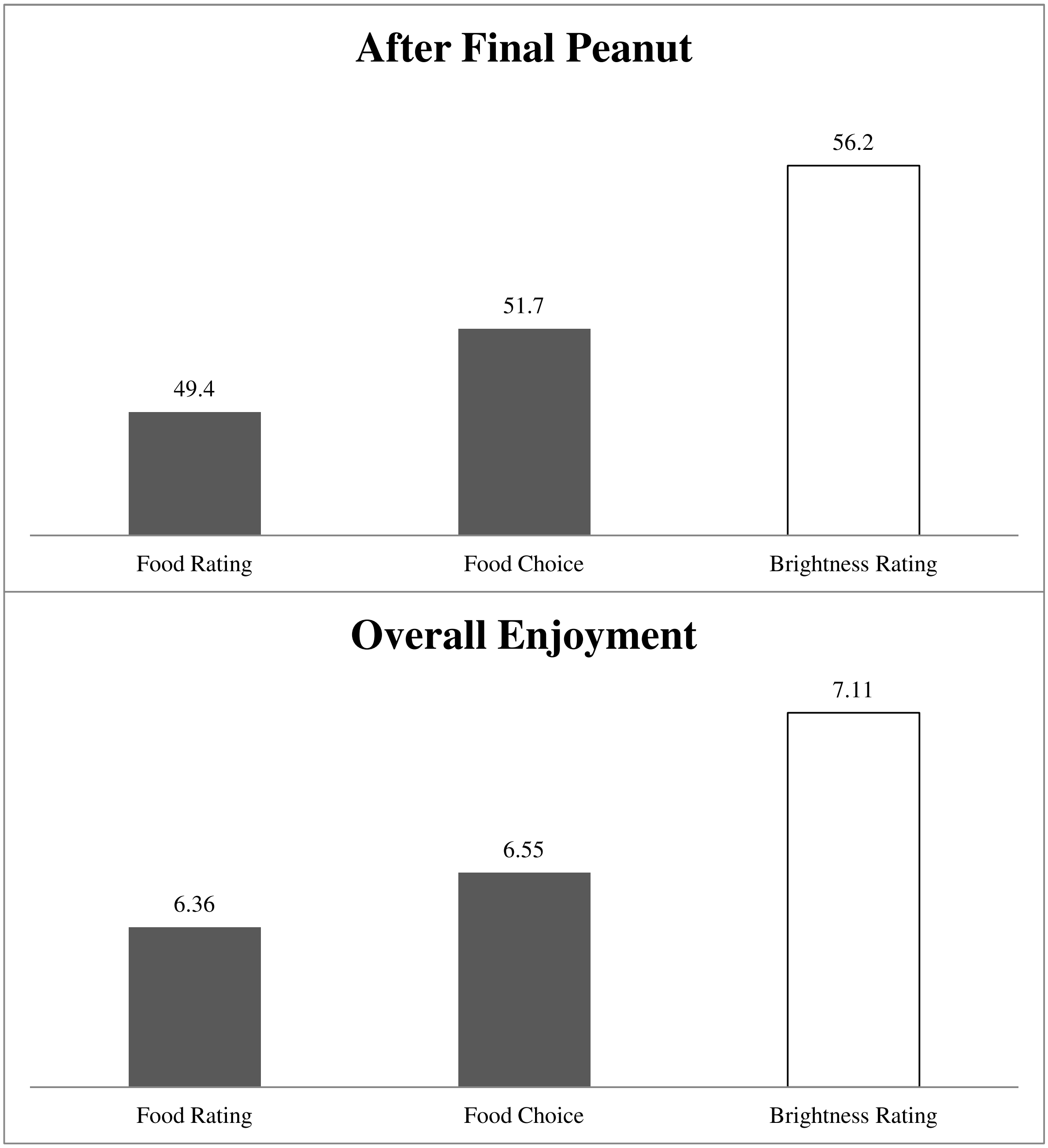


Figure 2. LS Mean ratings of peanut enjoyment in Experiment 2 (adjusted for initial enjoyment)



Appendix

Amount of Mental Simulation
1. As you viewed the food pictures, to what extent did the image of eating the food come to mind (for example, chewing it, tasting it, etc.)?
Not at all – To a great extent

2. While viewing the food pictures, I experienced:
Few or no images of eating the food – Lots of images of eating the food

3. To what extent while viewing the food pictures could you imagine eating the food?
Not at all – To a great extent

Ease of Mental Simulation
1. How difficult or easy were the images to create?
Extremely difficult – Extremely easy

2. How quickly did you form these images?
Not at all quickly – Very quickly

3. Please rate the extent to which agree or disagree with the following statement: I had no difficulty imagining eating the food in my head.
Strongly disagree – Strongly agree

Vividness of Mental Simulation
Please rate your mental image of eating the food on the following dimensions:
1. Not at all clear – Extremely clear
2. Not at all vivid – Extremely vivid
3. Not at all intense – Extremely intense
4. Not at all lifelike – Extremely lifelike
5. Not at all sharp – Extremely sharp
6. Not at all defined – Extremely defined