

The Subjective Sense of Feeling Satiated

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## Abstract

The traditional view of satiation is that repeated consumption produces an unavoidable decline in liking according to the quantity and recency of consumption. We challenge this deterministic view by showing that satiation is instead partially constructed in the moment based on contextual cues. More specifically, while satiation is a function of the actual amount consumed, it also depends on the subjective sense of how much one has recently consumed. We demonstrate the influence of this subjective sense of satiation, and show it is driven by metacognitive cues such as the ease of retrieval of past experiences (Experiments 1 and 2), and can also be directly manipulated by providing a normative standard for consumption quantity (Experiment 3). Our research demonstrates that satiety is not driven solely by the amount and timing of past consumption, thereby establishing the role of higher-order metacognitive inferences in satiation and providing insight into how they underlie the construction of satiation.

*Keywords:* Satiation, Metacognition, Fluency, Hedonic Consumption

Repeatedly consumed experiences become less enjoyable over time, a phenomenon known as “satiation” (Coombs & Avrunin, 1977). This process manifests in practically every domain including food (Rolls, van Duijvenvoorde, & Rolls, 1984), television (Nelson, Meyvis, & Galak, 2009), and sex (O'Donohue & Geer, 1985). The traditional view of satiation is that it directly results from the lingering effects of past consumption (Cabanac, 1971; Helson, 1964; Thompson & Spencer, 1966). For instance, satiation has been modeled as the current inventory of an attribute that increases with consumption and depletes with time (McAlister, 1982). More generally, previous theories of satiation have portrayed it as the unalterable result of an internal meter that tracks past consumption and resets with time.

Although this metered notion of satiation translates well for the satisfaction of physiological needs, we propose that a more pliable process better captures the general and widespread nature of satiation. We argue that satiation is constructed in the moment based on the context rather than directly resulting from an internal meter tracking remaining “inventory” levels from past consumption. This notion of constructed satiation builds on recent work showing that people can instantly recover from past satiation when reminded of other things recently consumed (Galak, Redden, & Kruger, 2009). We expand the constructed view of satiation beyond the salience of variety and propose a more general cognitive process in which people infer satiation by reflecting on their past consumption of a stimulus. A critical input to satiation is then the *subjective sense* of how much one has previously consumed that stimulus rather than just the actual amount consumed.

The present research establishes that people indeed rely on this subjective sense of satiation. Controlling for the actual amount consumed, people experience less satiation when it merely feels like they have recently consumed little. This subjective sense, like other judgments

of quantity, relies on cues of the frequency of an event. We link the subjective sense of satiation specifically to the ease of retrieval (i.e., easier recall implies more past consumption) and comparison standards (i.e., lower reference point indicates more consumption). More generally, our theory suggests that any cue of past quantity can affect satiation if it leads to inferences regarding how much has been consumed in the recent past.

A series of experiments demonstrates this subjective sense of satiation and confirms our theoretical process. These findings and the proposed theory contribute to satiation research in three important ways. First, we introduce to the satiation literature the well-established idea of metacognitions (Alter & Oppenheimer, 2009; Schwarz, 2004), and show that they play an important role for liking over time. Such metacognitions present a potentially rich avenue for understanding the causes and remedies for satiation. Second, we provide insight into how satiation is constructed in the moment. Cues of past consumption quantities are an important input to the mechanisms underlying satiation, so this work provides a start in identifying these cues and how they operate. Third, we demonstrate that satiation depends on the inferences people make about past consumption rather than just the objective quantity consumed. This highlights that satiation is not purely a low-level physiological or psychological process (e.g., digestion or habituation). Rather, higher-order metacognitive processes lead to satiation, and they perhaps help explain its ubiquity and constructed nature. Overall, this paper demonstrates that the subjective sense of past consumption is an important cause of satiation.

## Theoretical Background

### Metered and Constructed Theories of Satiation

The conventional view of satiation is analogous to an internal meter whose balance increases with consumption and decreases with the passage of time. At any given moment, the current balance on the meter dictates the level of satiation and subsequent enjoyment of a stimulus. This metered notion underlies the most prominent theories of satiation. These include homeostasis whereby liking for a stimulus depends on whether the current bodily need state differs from an internal set point (Cabanac, 1971); adaptation in which the intensity of an experience is a function of how it compares to an adaptation level that pools the effects of past stimuli (Helson, 1964); and habituation that models the decline in response to repeated stimulation as a function of how frequently the stimulus has been encountered in the past (McSweeney & Swindell, 1999; Thompson & Spencer, 1966). All of these theories of satiation, as well as most others, have at their core the notion that past consumption is tracked by an internal meter whose balance translates into satiation.

In this paper, we challenge this metered view and propose that satiation is instead psychologically constructed in the moment. This notion is consistent with recent work showing that satiation depends in part on the amount of variety recalled (Galak et al., 2009). Specifically, these authors showed that without changing actual consumption behavior, participants rapidly recovered from satiation when told to focus on other things they had also consumed. This suggests that satiation is more than just the metered account previously described, but also a top-down process that takes place in the moment. We extend this notion of constructed satiation beyond the salience of variety and outline a more general cognitive process that underlies satiation during repeated consumption. Specifically, we propose that satiation is a function of the degree to which people feel they have previously consumed a focal stimulus. That is, holding constant actual past consumption, satiation arises partially to the extent that people reflect on

how much they have subjectively consumed in the past. Of course, we do not expect people to spontaneously recall each episode of past consumption in a conscious fashion. Rather, we propose they form a general sense about how much they have previously consumed, and this perception leads to felt satiation.

### **Perceived Past Consumption and Satiation**

If satiation is a function of the subjective sense of how much was previously consumed, how then do people come to this feeling? When asked to judge the frequency of consumption, people often rely on a count of the episodes (Menon, 1993), an extrapolation from a usage rate (Blair & Burton, 1987), or the typical usage rates for others (Menon, Raghubir, & Schwarz, 1995). However, in a more natural consumption setting, many people will not perform such effortful estimations. This should be especially true when past consumption is either irregular or nondescript (Blair & Burton, 1987; Menon, 1993), or as the person becomes distracted. We expect that in many (most) consumption settings, people will instead rely on simpler heuristics and cues as a gauge of past consumption.

One such type of cue may be the metacognitive inferences that people have when estimating past consumption. Metacognitions have been shown to affect a variety of cognitive inferences including frequency estimations (Alter & Oppenheimer, 2009; Schwarz, 2004). For instance, people judged that there are more words in the English language that start with the letter “k” than have “k” as the third letter (Tversky & Kahneman, 1973), despite the fact that the opposite is true. The task of identifying words that start with the letter “k” is a much easier task, and participants inferred from this that there must be many words that start with “k.” Raghubir and Menon (2005), using the classic paradigm for retrieval fluency (Schwarz et al., 1991), also

showed that participants estimated that they had eaten out at restaurants more in the previous month after recalling the last two times they ate out versus the last eight times. Aarts and Dijksterhuis (1999) similarly found that when asked to recall previous destinations traveled to by bicycle, participants reported having been on their bicycle more in the past month when asked to recall three versus eight instances.

Difficulty in recalling past instances makes people feel like they must not engage in a behavior that often; otherwise, why would the recall be so difficult? People apparently rely on the experienced difficulty of recall to inform their frequency judgment. We propose that these same metacognitions about past frequency will influence satiation. Specifically, we predict that people will feel more satiated when past consumption feels more plentiful because it is easier to recall. We further expect that this effect generalizes as a broad metacognition such that any cue which increases the subjective sense of past consumption will increase satiation. Of course, we do not test all such cues in the present research, but instead demonstrate process evidence for the use of such cues and empirical evidence for their effect on satiation.

A series of experiments confirms our predictions and demonstrates that satiation is, at least in part, constructed based on this subjective sense. Experiment 1 manipulates the subjective sense of how much one has previously consumed by manipulating perceived cognitive difficulty (furrowing the brow vs. puffing the cheeks during recall). It shows that when experiences seem difficult to recall, people experience less satiation with a favorite food and express a greater desire to re-consume it. This initial experiment also shows that perceptions of how much has been recently consumed mediate the effects, and shows the effects disappear if the cognitive difficulty can be attributed to the task itself. Experiment 2 confirms that these satiating effects spontaneously occur during a repeated consumption episode and also affect ongoing enjoyment,

and again finds mediation evidence for perceptions of recent consumption quantities. Experiment 3 provides further evidence of our proposed theory by using a consumption norm to directly manipulate the subjective sense of how much has been consumed. Here, as in all of the experiments, perceptions of decreased past consumption again lead to less satiation and more desire to consume the stimulus again.

### **Experiment 1**

The purpose of Experiment 1 is to test our prediction that the subjective sense of how much one has previously consumed influences satiation. This experiment manipulates this sense in an indirect manner using the fluency of past recall to determine if this, in turn, affects satiation. Specifically, participants were made to experience cognitive difficulty by furrowing their brows (Tourangeau & Ellsworth, 1979). When people are made to furrow their brows, they infer that the task that they are engaged in is cognitively difficult (Larsen, Kasimatis, & Frey, 1992; Strack & Neumann, 2000). If our proposed theory is correct, then making retrieval merely seem more difficult through this facial feedback manipulation should lead people to feel as though they have not consumed much of the focal stimulus and thus be less sated. Additionally, previous research has shown that if the cognitive difficulty associated with brow furrowing (or any disfluency manipulation) is attributed to the task itself, the effects of this metacognitive inference are attenuated (Schwarz et al., 1991). Accordingly, we included a condition in which participants furrowed their brow, but were explicitly told that their facial configuration could lead to the task feeling cognitively difficult. We predict that providing an alternative attribution for the difficulty of recall would eliminate the effect of furrowing the brow on satiation.

## Method

Two hundred and ninety-eight members of an online panel (77 Males, 221 Females; Median Age = 36) participated for a chance to win a \$50 gift card. They were told that they would be participating in two studies and that the goal of the first study, the “Facial Dexterity Study,” was to understand the relationship between people’s facial dexterity and their personality traits. They were then told that they would be asked to make a facial gesture and maintain it throughout the second study.

Participants were then randomly assigned to one of only three conditions. Participants in the *brow furrow* condition and the *brow furrow – attribution* conditions were asked to contract their eyebrows toward the middle of their forehead, and participants in the *cheek puff* condition were asked to puff their cheeks out. Participants from all conditions were shown a picture of a man making the corresponding facial gesture. We used these two expressions because past work has shown that, though equally physically demanding, furrowing the brow is linked to greater cognitive effort while puffing the cheeks is not (Alter, Oppenheimer, Epley, & Eyre, 2007; Stepper & Strack, 1993; Tourangeau & Ellsworth, 1979).

Immediately following the facial configuration instructions, participants in the *brow furrow – attribution* condition were encouraged to attribute the difficulty associated with recall to something else. Specifically, these participants read the following:

“So you know, holding your face in this particular configuration may make the following task appear to be difficult. In fact, previous research has shown that when you hold your face like this, you sometimes think that tasks are more difficult than they really are.”

Participants from the other two conditions did not read any such text. Next, while maintaining the assigned facial expression, participants completed the “Food Study.” They first identified their favorite food and then recalled the last two times they consumed it. Participants then indicated how much they would like to eat that food right now on a nine-point scale (1 = *not at all*; 9 = *very much*), when they next would like to eat the food again on a nine-point scale (1 = *right now*; 9 = *not for a while*), how many days it would be until they next ate that food again using a sliding scale ranging from 1 day to 30 days, and how much of this food they had recently eaten on a nine-point scale (1 = *very little*; 9 = *very much*). This last measure was included to test the specific psychological mechanism that drives our effect. If the cognitive difficulty associated with furrowing the brow causes participants to feel as though they had not eaten their favorite food all that much, then we will be able to use this measure to confirm this. In addition to these primary measures, participants subsequently indicated when they last ate, how hungry they were, the retrospective difficulty of the task, and how many times they ate their favorite food in the past three months. With the exception of task difficulty, these additional measures were neither affected by our manipulation nor covaried with our results, all  $p > .05$ , and so we do not refer to them further. With regard to task difficulty, we only observed that the furrowing task (without attribution) was perceived to be more difficult than the cheek puffing task,  $t(295) = 2.57$ ,  $p < .04$ . No other comparisons were statistically significant, all  $p > .05$ . We did not collect any other measures.

## Results and Discussion

We first conducted a one-way ANOVA on the desire to have the favored food with the facial expression as a between-subjects factor. As can be seen in Table 1, the analysis found a

main effect of the facial expression,  $F(2, 295) = 3.19, p < .05, \eta_p^2 = .02$ . A planned contrast revealed that participants furrowing their brow without an attribution wanted the food more than those given an attribution ( $M_{\text{furrow no attrib}} = 7.45$  vs.  $M_{\text{furrow attrib}} = 6.73$ ),  $t(295) = 2.11, p < .05, d = .25$ , and more than those puffing their cheeks ( $M_{\text{furrow no attrib}} = 7.45$  vs.  $M_{\text{puff}} = 6.71$ ),  $t(295) = 2.21, p < .05, d = .26$ . Moreover, participants who were given an attribution for the difficulty associated with furrowing their brow wanted the food again no more than did participants who had puffed their cheeks,  $t < 1, ns$ . Thus, providing a reason for the cognitive difficulty eliminated the effect of brow furrowing on satiation.

—————Insert Table 1 here—————

We next analyzed the two measures of when participants wanted to eat the food again. An identical ANOVA on the number of days until the next consumption occasion revealed a reliable main effect of facial expression,  $F(2, 295) = 3.05, p < .05, \eta_p^2 = .02$ . Participants furrowing their brow without an attribution expected to eat the food again sooner than both those given an attribution ( $M_{\text{furrow no attrib}} = 6.25$  vs.  $M_{\text{furrow attrib}} = 8.42$ ),  $t(295) = 2.08, p < .05, d = .25$ , and those puffing their cheeks ( $M_{\text{furrow no attrib}} = 6.25$  vs.  $M_{\text{puff}} = 8.37$ ),  $t(295) = 2.16, p < .05, d = .25$ . Importantly, participants who puffed their cheek and those given an attribution for the difficulty associated with furrowing their brow did not expect to eat the food again at different times,  $t < 1, ns$ . A similar analysis on the subjective scale rating of when the food would be eaten again did not find a main effect of facial expression,  $F(2, 295) = 1.07, p > .34$ , although the means were in the predicted direction. A post-hoc explanation for the weakness of this result is that participants may have had different interpretations of what constitutes “a while” when using the scale.

Furrowing one's brow made the recall seem more difficult, and this difficulty was presumably misattributed to having little past consumption. However, when participants were explicitly given an explanation for the apparent difficulty, furrowing the brow no longer affected satiation. We propose that this happened because people stopped relying on metacognitions about retrieval fluency to infer how much they had consumed in the past. In fact, an attribution for the difficulty made the difference between the two facial expressions disappear.

To further demonstrate the proposed mechanism, we performed a mediation analysis using the subjective measure of how much one had recently consumed as the mediator. Given the pattern of our theoretical predictions, we simplified the analysis by pooling responses from the cheek puff and the brow furrow with attribution conditions. These two groups did not differ for any of the three dependent measures previously analyzed, or with respect to the mediator,  $t < 1$ ,  $ns$ . The group furrowing their brow (without an attribution) perceived themselves to have less past consumption than the pooled group ( $M_{\text{furrow no attrib}} = 4.70$  vs.  $M_{\text{pooled}} = 5.49$ ),  $t(295) = 2.82$ ,  $p < .001$ ,  $d = .33$ . The proposed mediator of amount recently consumed was also related to the dependent variable of the desire to have the food right now,  $t(295) = 2.24$ ,  $p < .05$ ,  $d = .26$ . When the dependent variable was regressed onto the independent variable, including the perceived amount recently consumed decreased the beta weight for the facial expression from  $-.68$ ,  $t(295) = 2.53$ ,  $p < .05$ ,  $d = .29$ , down to  $-.58$ ,  $t(294) = 2.15$ ,  $p < .05$ ,  $d = .25$ . A bootstrapping analysis (Preacher & Hayes, 2004) yielded an overall model bootstrap estimate of  $-.10$ , which differed from zero at the 95% confidence level  $[-.26, -.02]$ , indicating the presence of mediation. A mediation analysis using the days until the next consumption occasion as the dependent measure produced similar results, 95% CI  $[-1.19, -.02]$ .

Furrowing one's brow during recall made the recall task seem more difficult, and participants misattributed this difficulty to having consumed less in the past. Put another way, people infer that they must not have consumed something much if it was difficult to recall previous consumption episodes. This sense of less past consumption subsequently led people to experience less satiation as they had a greater desire to consume a favorite food item again.

## Experiment 2

The previous experiment confirms that the subjective sense of the quantity previously consumed affects satiation. This experiment tests whether these effects are consequential during consumption. We have already shown that this subjective sense determines the degree to which people want and plan to have more of an experience. Here, we test whether this also holds for the subsequent enjoyment during actual consumption. Accordingly, in this experiment, participants not only report how much they enjoy a stimulus following our manipulation, but they also make a consequential decision that results in either re-consuming the same stimulus or not. We predict that the degree to which participants will enjoy the stimulus and choose to re-consume it will be a function of the degree to which they feel as though they have previously consumed it. That is, when participants are made to feel as though they have not consumed the stimulus that much, they will be less sated, enjoy the stimulus more, and choose to re-consume it again with greater frequency.

This experiment differs from the previous one in three additional ways. First, rather than manipulating the subjective difficulty of recall by altering facial configurations, we borrowed the methodology from the classic paradigm developed by Schwarz and colleagues (1991) and asked participants to recall different numbers of past consumption episodes. Because this past research

shows that recalling many past consumption episodes is rather difficult, we predict that when asked to recall many past consumption episodes participants will feel as though they have not actually consumed much of the experience. It is notable that other accounts based solely on the memory for past consumption would predict that recalling more episodes would have the opposite effect of increasing satiation (Higgs, 2002). Second, in addition to measuring enjoyment and the desire to re-consume the focal stimulus, we also measure the satiation for a second nonfocal stimulus. This allows us to determine if our effects on satiation are specific to a single focal stimulus, or spread to other related stimuli. We predict the effects on perceived past consumption (and hence satiation) will be specific to the stimulus recalled because it is associated with the cognitive difficulty. Finally, we again include perceptions of consumption quantity as a mediator, but we now measure the mediator before the dependent variable. If this again supports our proposed theory, then we will have even greater confidence in our mediation evidence.

## Method

Three hundred and one participants from the Amazon Mechanical Turk online panel participated in exchange for \$0.80. Participants first indicated their favorite and second favorite songs (to act as a within subject control) from the top 20 songs from that week's Billboard Pop Charts. They were then randomly assigned to one of only three recall conditions. Participants in the *Recall 2 (Recall 6)* condition were asked to recall the last two (six) times they heard their favorite song and to give as much detail as possible about that listening experience. Participants in the *Recall 6 with Attribution* condition completed the same recall task as participants in the *Recall 6* condition, but prior to the recall task were told: "So you know, recalling six past

instances of when you last heard <SONG> may be quite difficult.” (<SONG> was replaced with the name of the song that they indicated was their favorite). In this way, we hoped to provide an attribution for the difficulty associated with recalling the last six instances of when they heard this song.

All participants next answered, “Recently, how many times would you say you have heard the song <SONG>?” on a scale from 1 (*very little*) to 9 (*very much*). (Again, <SONG> was replaced with the name of the song that they indicated was their favorite). Participants then listened to the full version of their favorite song and indicated how much they enjoyed listening to it on a 9-point scale (1 = *I hated it*; 9 = *loved it*), and how much they would be willing to pay for an album with that song using a sliding scale ranging from \$0 to \$50. They then listened to their second favorite song and completed the same two measures. Finally, participants were told that they would next listen to a 30-second version of either their favorite or second favorite song, and that they could choose which they would listen to. They then made the choice and listened to the song clip. We did not collect any other measures.

## Results and Discussion

We first tested to see if participants differentially enjoyed the two songs as a function of the recall condition. A 3 (recall: recall 2, recall 6, recall 6 with attribution; between subjects) x 2 (song: favorite, 2<sup>nd</sup> favorite; within subjects) repeated measures ANOVA on enjoyment revealed a main effect of song type such that the favorite song was liked more than the second favorite song ( $M_{favorite} = 7.32$  vs.  $M_{second\ favorite} = 6.96$ ),  $F(1, 298) = 19.19$ ,  $p < .001$ ,  $\eta_p^2 = .06$ . More importantly, as can be seen in Figure 1, there was a significant 2-way interaction,  $F(2, 298) = 6.76$ ,  $p < .001$ ,  $\eta_p^2 = .04$ . For the favorite song, when participants recalled the last six times they

heard it, they enjoyed it more than when they recalled the last two times ( $M_{recall\ 6} = 7.81$  vs.  $M_{recall\ 2} = 7.13$ ),  $t(298) = 2.60, p < .01, \eta_p^2 = .02$ , or the last six times but were provided with an attribution for the difficulty ( $M_{recall\ 6} = 7.81$  vs.  $M_{recall\ 6\ with\ attrib} = 7.04$ ),  $t(298) = 2.84, p < .01, \eta_p^2 = .03$ . Importantly, these differences did not extend to the second favorite song, all  $t < 1$ , suggesting that the effect of differential recall operates solely on the target stimulus, and not on other stimuli from the same category. We did not observe any effects of the recall condition on willingness to pay for an album with either the favorite song or the second favorite song, both  $F < 1$ . Although we might have expected this, the lack of a finding here may reflect the generality of a measure at the level of the album and the variance inherent in willingness to pay measures.

—————Insert Figure 1 here—————

Given that the recall task differentially affects enjoyment, we next tested for effects on choice. Consistent with our predictions, when participants were asked to recall the last six times they heard their favorite song, they chose to listen to it more than when they were asked to recall the last two times ( $M_{recall\ 6} = 77\%$  vs.  $M_{recall\ 2} = 60\%$ ),  $\chi^2(1) = 6.82, p < .01, \Phi = .18$ , or when they recalled the last six times but were provided with an attribution for the recall difficulty ( $M_{recall\ 6} = 77\%$  vs.  $M_{recall\ 6\ with\ attrib} = 64\%$ ),  $\chi^2(1) = 3.87, p < .05, \Phi = .14$ . Also as predicted, the choice percentage did not differ between the latter two conditions,  $\chi^2(1) = .37, p > .54, \Phi = .04$ .

We propose that the reason for the differential effect of recall on liking and preferential choice of the favorite song is due to a change in the subjective sense of how much one has recently consumed. Accordingly, following the procedure outlined by Preacher and Hayes (2004), we conducted a mediation analysis treating judgments of how much they consumed as the mediator for the effects on enjoyment of the favorite song. We simplified the analysis by pooling responses for the *Recall 2* and *Recall 6 with Attribution* conditions as these

conditions were predicted to be the same and indeed they were in all of the previous analyses of enjoyment and choice. Participants who recalled six instances reported that they had fewer exposures to the song than participants in the pooled group ( $M_{recall\ 6} = 6.09$  vs.  $M_{pooled} = 6.77$ ),  $t(299) = 2.48, p < .02$ . There was also a relationship between the proposed mediator and the dependent measure of enjoyment,  $t(299) = -4.71, p < .001$ . Finally, when the dependent variable was regressed onto the independent variable, including the amount recently consumed decreased the beta weight of recall from .72,  $t(299) = 3.15, p < .01$ , down to .57,  $t(298) = 2.56, p < .01$ . A bootstrapping analysis indicated the presence of mediation as the overall model bootstrap estimate of .15 differed from zero at the 95% confidence level [.03, .30]. A mediation analysis using choice as the dependent measure produced similar results, 95% CI [.03, .36].

The analyses consistently show that, after experiencing the difficult task of recalling many episodes from the past, participants exhibited less satiation and once again enjoyed the song more and chose to listen to it again with greater frequency. Mediation evidence confirmed that this happened because they perceived less past consumption of the song, and this directly led to feelings of less satiation. This provides evidence for our proposed theory, and demonstrates that it has meaningful consequences for the enjoyment derived from consumption.

### **Experiment 3**

The purpose of Experiment 3 is to provide further evidence for the contention that satiation is a function of the subjective sense of how much has been consumed. The last experiment used mediation to show that the perceived quantity of past consumption affected satiation, and that it was triggered by the difficulty of recall. Rather than using indirect cognitive difficulty manipulations and measuring the mediator, this study directly manipulates the core

construct. That is, if we make people feel that they have had a relatively small (large) amount of past consumption, then they will become less (more) satiated.

In order to accomplish this goal, we borrow a methodology employed by Schwarz and colleagues (1985). Specifically, we vary the range of frequency of consumption on a scale to create a standard of comparison. If a participant is encouraged to compare their amount of past consumption with a very large number, then the amount consumed will seem small (and vice versa). We predict that this judgment of the amount of past consumption will accordingly affect the subsequent level of satiation when the stimulus is consumed again.

## Method

Three hundred and eleven members of an online panel (58 Males, 251 Females, 2 Unknown; Median Age = 37) participated for a chance at a \$50 gift card. Participants were told that the purpose of the experiment was to understand how much people enjoy viewing beach photos. Participants then viewed a single aesthetically pleasing beach photo a total of 20 times for 15 seconds per exposure, and rated their enjoyment after each iteration using a 101-point unmarked slider scale (0 = *I hated it*; 100 = *I loved it*). Importantly, participants were never told anything about the number of exposures in the study because perceptions of this number would be part of our subsequent manipulation.

Participants were then randomly assigned to one of only three quantity norm conditions. Participants in the *low quantity norm* condition were asked to report how many times they had just seen the photograph on a scale with the following response options: 1-3 times, 4-6 times, 7-9 times, 10-12 times, 13-15 times, and more than 15 times. We expected that most participants in this condition would select the larger options, making their consumption level seem large by

comparison. Participants in the *high quantity norm* condition answered the same question but had the following response options: 1-30 times, 31-60 times, 61-90 times, 91-120 times, 121-150 times, and more than 150 times. We expected that most participants in this condition would select the smaller options, making their consumption level seem smaller by comparison.

Participants in the *control* condition did not answer this question. Our prediction is that participants in the low quantity norm condition will become the most satiated, and those in the high quantity norm condition will become the least satiated.

Finally, all participants once again viewed the same photograph and indicated how much they enjoyed it on the same 101-point scale as before, how much they would like to see the same photograph again on a nine-point scale (1 = *very little*; 9 = *very much*), and when they would like to see the photograph again on an unmarked 101-point scale (0 = *right now*; 100 = *never again*). Following these measures, participants also indicated how repetitive and boring they found the photographs, how focused they were on watching the photographs, whether the photographs were on the screen long enough to be fully appreciated, and to what extent they found new aspects of the photos over time. These additional measures were neither affected by our manipulation nor covaried with our results, all  $p > .05$ , and so we do not refer to them anymore. We did not collect any other measures.

## Results and Discussion

We began our analysis by performing two different manipulation checks. First, we verified that participants found the photo satiating over the 20 trials. A paired comparison between the means for the initial enjoyment rating and the enjoyment rating on the twentieth trial indicated that enjoyment dropped over the course of the study ( $M_{trial\ 1} = 77.13$  vs.  $M_{trial\ 20} =$

47.41),  $t(310) = 16.20, p < .0001, d = 1.84$ . Second, we confirmed that participants responded on the quantity scales in the intended fashion. As can be seen in Table 2, participants in the low quantity norm condition mostly responded toward the top of the scale, while participants in the high quantity norm condition primarily responded toward the bottom of the scale. Thus, the manipulation was successful.

—————Insert Tables 2 and 3 here—————

Table 3 reports the mean results for each condition. We tested for significant differences using separate one-way (Quantity Norm: Control, Low Quantity Norm, High Quantity Norm) ANCOVAs for each dependent measure. The enjoyment rating on the twentieth trial taken right before the manipulation served as the covariate to control for any differences in the degree of satiation to that point (reported means are unadjusted). Participants shown the high quantity norm enjoyed the photo again more than those in both the low quantity norm group ( $M_{high\ norm} = 64.21$  vs.  $M_{low\ norm} = 52.33$ ),  $t(307) = 3.24, p < .01, d = .37$ , and the control group ( $M_{high\ norm} = 64.21$  vs.  $M_{control} = 58.55$ ),  $t(307) = 2.18, p < .03, d = .25$ . The difference between these last two conditions did not reach statistical significance,  $t(307) = 1.14, p > .25$ , but those in the low quantity group tended to enjoy the photo less than the control group.

The pattern of findings was similar for the desire to see the photo again. Those given the high quantity norm wanted to see the photo again more than those in both the low quantity norm group ( $M_{high\ norm} = 4.76$  vs.  $M_{low\ norm} = 3.29$ ),  $t(307) = 4.12, p < .001, d = .47$ , and the control group ( $M_{high\ norm} = 4.76$  vs.  $M_{control} = 3.99$ ),  $t(307) = 2.61, p < .01, d = .30$ , and the contrast for the last two groups was marginally significant,  $t(307) = 1.60, p > .11, d = .18$ . Finally, those given the high quantity norm also indicated they would enjoy seeing the photo again sooner than those in both the low quantity norm group ( $M_{high\ norm} = 44.16$  vs.  $M_{low\ norm} = 58.88$ ),  $t(307) = 3.36, p <$

.001,  $d = .38$ , and the control group ( $M_{high\ norm} = 44.16$  vs.  $M_{control} = 52.67$ ),  $t(307) = 2.34$ ,  $p < .02$ ,  $d = .27$ , and the final contrast was only directional,  $t(307) = 1.09$ ,  $p > .27$ . We also reran these analyses without the covariate and none of the statistical conclusions changed, all  $p < .05$ , except the contrast comparing the *High Quantity Norm* to the *Control* group for the enjoyment measure reverts to only trending in the predicted direction,  $t(308) = 1.33$ ,  $p > .18$ . It is worth noting that using an alternative covariate, the average enjoyment across all iterations, yields results that are all conceptually identical and all statistically significant.

Across all of these analyses, we see a consistent pattern that satiation decreased (increased) when participants were made to simply feel like they had consumed something less (more) than the norm. This pattern of results confirms our prediction that the subjective sense of how much one has consumed can be directly manipulated, and this subjectivity affects how much satiation one experiences. Combined with the mediation results in the previous two experiments, there is clear converging evidence that this subjective sense is an important input to the construction of satiation.

## General Discussion

Satiation plays a critical role in a number of theories in psychology. An emerging goal of more recent research is finding ways to reduce satiation in the interest of improving happiness and well-being (Brickman & Campbell, 1971; Galak et al., 2009; Nelson et al., 2009; Redden, 2008). An important precursor to developing better “solutions” is a deeper understanding of the causes of satiation. Recent work in this area has increasingly emphasized how satiation is not physiologically driven (e.g., McSweeney & Murphy, 2000). Our work provides insight into the mechanisms underlying such construction of satiation, and hence offers actionable solutions about how to reduce it.

We show that satiation is partially constructed to reflect how much it seems like something has been recently consumed. Most importantly, we demonstrate that satiation depends on the inferences people make about past consumption, rather than just how much was consumed and recalled. Furrowing their brow during a recall task (Experiment 1) led participants to feel that the recall task was cognitively difficult. This, in turn, led them to feel less satiated because it seemed like they had consumed something less in the past. Experiment 2 shows that this effect has real consequences in terms of subsequent enjoyment during consumption and the choice to consume something again, and provides evidence that judgments of the amount of past consumption mediated the effect. Experiment 3 complements the mediation evidence in the other two experiments by directly manipulating the perception of past consumption quantity by providing an external reference point to which participants compared their level of past consumption. This experiment showed that people experienced less satiation when given a norm of high consumption levels, providing even further evidence that the subjective sense of past consumption is a direct input to the construction of satiation.

Our metacognitive notion of satiation fundamentally challenges the conventional drivers of satiation, and informs us with regard to how to reduce satiation's potentially negative effects. Much in the way that constructed preferences informed us of the contextual nature of choice preferences (Lichtenstein & Slovic, 2006; Payne, Bettman, & Johnson, 1993), so does our formulation of constructed satiation provide insight into the malleable nature of satiation. Our theory has the potential to assist researchers in understanding a wide range of satiation findings. For instance, this work could help explain why older people tend to satiate at a slower rate (Rolls & McDermott, 1991), as the speed of recall tends to slow with age (Salthouse, 1991). In fact, in the seminal work on adaptation (Helson, 1964), many of the listed moderators of adaptation

would equally apply to the ease of recall (e.g., recency, frequency, duration, meaningfulness). Reliance on retrieval effort as a cue for satiation could also help explain why distractions tend to reduce satiation (Epstein, Saad, Giacomelli, & Roemmich, 2005). Finally, although the amount consumed by others can suggest an appropriate quantity (Wansink, 2004), the present work suggests that comparison with a consumption norm also affects how quickly one becomes satiated and could partially account for changes in intake.

The large body of research on memory also suggests promising ways to leverage our theory of the subjective sense of satiation. People better encode memories when the item is more distinctive (McDaniel & Einstein, 1986), more frequently rehearsed (Greene, 1987), or more deeply processed (Craik & Tulving, 1975). Thus, we would expect that experiences having these attributes would be more satiating. Similarly, memories become easier to retrieve when the traces are more frequently or recently accessed (Scarborough, Cortese, & Scarborough, 1977), or when the conditions match those at the time of encoding (Godden & Baddeley, 1980). We would similarly expect satiation to be greater when this is true about consumption. As well, the presence of similar experiences or cues can interfere with the retrieval of a memory (Nickerson, 1984), which may partially account for the ability of variety to reduce satiation. However, episodic memory has a capacity of approximately four chunks (Cowan, 2005), which may suggest a limit to the benefits of variety. These questions and many others should be addressed by future research that joins the literatures of memory and satiation.

We propose that satiation generally depends on any factor affecting the subjective sense of how much one has consumed. In many ways, this seems like an efficient design for satiation in that it helps regulate the amount of variety in one's diet, an important concern in more primitive times (Rozin, 1999). The ease of recall can act as a single cue to reflect multiple

dimensions of past consumption, like quantity and recency, similar to how availability generally reflects likelihood (Tversky & Kahneman, 1973). Of course, relying on such heuristics will not always be perfect, leading to changes in satiation that are not caused by actual differences in consumption. Our experiments exploit these imperfections, but future work should explore how people can further take advantage of them to strategically manage their satiation.

It is important to know the conditions that enhance the current effects as well as additional ways to influence these inferences. By directly operating on the inferences that drive satiation, we hope that people can find ways to successfully limit the negative effects of satiation. In addition to making experiences more enjoyable, reducing satiation can also be beneficial in the pursuit of any goal such as interpersonal relationships, reproduction, exercise, or skill mastery. We show here that satiation is successfully reduced by making the retrieval of past consumption episodes more difficult, or by comparing past consumption amounts to heavy users. Of note, these strategies do not require any change in the actual consumption behavior. Future work will need to further explore the effectiveness of these (and other) strategies in more natural consumption settings to see if they help people to realize more enjoyment.

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Table 1

*Mean Ratings by Condition, Experiment 1*

	Desire to eat right now	Days until eat again	When eat again	How much recently eaten
Cheek puff	6.71 (.24)	8.37 (.84)	5.04 (.20)	5.55 (.24)
Brow furrow with attribution	6.73 (.23)	8.42 (.84)	4.88 (.21)	5.42 (.24)
Brow furrow without attribution	7.45 (.23)	6.25 (.81)	4.64 (.19)	4.70 (.22)

*Note.* Values in parentheses represent standard errors. Smaller values for “When eat again” reflect desire to eat sooner.

Table 2

*Scale Response Distribution, Experiment 3*

Low quantity norm		High quantity norm	
Labels	# responses (%)	Labels	# responses (%)
1-3	1 (1%)	1-30	100 (92%)
4-6	2 (2%)	31-60	8 (7%)
7-9	11 (12%)	61-90	0 (0%)
10-12	36 (38%)	91-120	0 (0%)
13-15	30 (32%)	121-150	0 (0%)
More than 15	14 (15%)	More than 150	1 (1%)

Table 3

*Mean Satiation Ratings by Condition, Experiment 3*

Quantity norm condition	Enjoyment of subsequent photo	Desire to see photo again	How long until want again
Low quantity norm	52.33 (3.05)	3.29 (0.25)	58.88 (3.11)
Control	58.55 (3.22)	3.99 (0.27)	52.67 (3.19)
High quantity norm	64.21 (2.97)	4.76 (0.27)	44.16 (3.12)

*Note.* Values in parentheses represent standard errors.

Figure 1. Enjoyment Ratings by Condition and Song Type in Experiment 2.

