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Hunger, taste, and normative cues in predictions about food intake

Lenny R. Vartanian [a, *], Natalie M. Reily [a], Samantha Spanos [a], Lucy C. McGuirk [a], C. Peter Herman [b], Janet Polivy [b]

[a] School of Psychology, UNSW Australia, Sydney, NSW, 2052, Australia
[b] Department of Psychology, University of Toronto, Toronto, ON, M5S 3G3, Canada

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ABSTRACT

Normative eating cues (portion size, social factors) have a powerful impact on people's food intake, but people often fail to acknowledge the influence of these cues, instead explaining their food intake in terms of internal (hunger) or sensory (taste) cues. This study examined whether the same biases apply when making predictions about how much food a person would eat. Participants ($n = 364$) read a series of vignettes describing an eating scenario and predicted how much food the target person would eat in each situation. Some scenarios consisted of a single eating cue (hunger, taste, or a normative cue) that would be expected to increase intake (e.g., high hunger) or decrease intake (e.g., a companion who eats very little). Other scenarios combined two cues that were in conflict with one another (e.g., high hunger + a companion who eats very little). In the cue-conflict scenarios involving an inhibitory internal/sensory cue (e.g., low hunger) with an augmenting normative cue (e.g., a companion who eats a lot), participants predicted a low level of food intake, suggesting a bias toward the internal/sensory cue. For scenarios involving an augmenting internal/sensory cue (e.g., high hunger) and an inhibitory normative cue (e.g., a companion who eats very little), participants predicted an intermediate level of food intake, suggesting that they were influenced by both the internal/sensory and normative cue. Overall, predictions about food intake tend to reflect a general bias toward internal/sensory cues, but also include normative cues when those cues are inhibitory. If people are systematically biased toward internal, sensory, and inhibitory cues, then they may underestimate how much food they or other people will eat in many situations, particularly when normative cues promoting eating are present.

1. Introduction

Food intake is influenced by many factors, including internal cues (hunger/satiety), sensory cues (taste), and normative cues (e.g., social and situational cues indicating appropriate intake; Herman & Polivy, 2008). Although internal and sensory eating cues are important determinants of how much food people will eat, with people typically eating more food when they are hungry (e.g., Drapeau et al., 2007; Parker et al., 2004) and when the food is palatable (Sørensen, Møller, Flint, Martens, & Raben, 2003), normative eating cues can also have a powerful impact on people's food intake. Perhaps the most commonly discussed normative cue is portion size. When people are served larger portions of food, they consume significantly more than they do when they are served smaller portions of food (for a review see Zlatevska, Dubelaar, & Holden, 2014). Another potent normative influence on people's food intake is the amount of food that their eating companions consume. For example, research consistently shows that people model the food intake of others with whom they are eating: They consume more food when they are eating with a companion who eats a relatively large amount, and consume less food when they are eating with a companion who eats a relatively small amount (for reviews see Herman, Roth, & Polivy, 2003; Vartanian, Spanos, Herman, & Polivy, 2015). This modeling effect is evident even when there is no "companion" present and participants are simply informed about the behavior of previous participants in the study (the so-called remote-confederate design; e.g., Feeney, Polivy, Pliner, & Sullivan, 2011).

Most of the research that has examined the influence of normative cues on eating behavior has considered the influence of the normative cue in isolation (i.e., only the normative cue is manipulated). However, a few studies have shown that these

* Corresponding author.
E-mail address: lvartanian@psy.unsw.edu.au (L.R. Vartanian).

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normative eating cues can influence peoples' food intake independent of other internal or sensory cues that might be expected to be primary determinants of food intake. For example, Wansink and Kim (2005) served participants either a medium (120 g) or large (240 g) container of popcorn, and the popcorn was either fresh or two weeks old. Not surprisingly, participants ate more when the popcorn was fresh than when it was stale. Remarkably, however, the portion-size effect was still evident even when the popcorn was stale and unpalatable, with participants given a large container of stale popcorn consuming 34% more than those given a medium-sized container of stale popcorn. The power of the normative cue has also been shown in the social modeling literature. Goldman, Herman, and Polivy (1991) examined the influence of a social model on food intake when participants had either just eaten or had been food deprived for up to 24 h prior to the experiment. In two studies, they found that participants ate less when eating with a companion who ate minimally than with a companion who ate a lot, and that this was true even of participants who had been food-deprived for 24 h. These studies suggest that normative eating cues can have a powerful influence on people's food intake even in the face of conflicting internal or sensory eating cues.

Although normative eating cues have a potent influence on food intake, people often fail to acknowledge the influence of those normative cues on their own behavior. Instead, people typically explain their own food intake in terms of internal cues (i.e., hunger) and sensory cues (i.e., taste; Vartanian, Herman, & Wansink, 2008; Vartanian, Sokol, Herman, & Polivy, 2013). Furthermore, portion size studies typically find that average post-intake satiety ratings do not differ between portion-size conditions, despite the fact that participants in the large-portion condition consume significantly more food than do those in the small-portion condition (e.g., Levitsky & Youn, 2004; Reily & Vartanian, 2016; Rolls, Morris, & Roe, 2002). Together, these findings suggest that people may be unaware of or insensitive to the effect of some factors that have a profound influence on their food intake. An alternative possibility is that people may be aware of the impact of normative cues but are unwilling to acknowledge them. For example, there is evidence that people can recognize the impact of social influences on other people's food intake (Spanos, Vartanian, Herman, & Polivy, 2014), and that they will even acknowledge normative influences on their own food intake under certain circumstances. Specifically, a recent study found that people are more willing to acknowledge portion size as an influence on their food intake when they believe that they have overeaten compared to when they believe that they have eaten an appropriate amount (Vartanian, Reily, Spanos, Herman, & Polivy, 2017).

Vartanian, Spanos, Herman, and Polivy (2017) further examined the conditions under which people will and will not acknowledge normative eating cues by introducing a conflicting internal eating cue. Previous research has demonstrated that normative cues may have a more potent influence on people's behavior than either internal or sensory cues (Goldman, Herman, & Polivy, 1991; Wansink & Kim, 2005), but how are people's explanations for their food intake affected by those conflicting food cues? Participants in theVartanian, Spanos, et al. (2017) study took part in an ostensible taste test immediately after consuming a filling meal-replacement shake or after abstaining from eating for 18 h. Half of the participants were exposed to social-norm information that was in conflict with their hunger state (i.e., a low-intake norm for the food-deprived participants, and a high-intake norm for the preloaded participants). The remaining participants were not exposed to social-norm information. Although participants in the food-deprived condition ate less on average if they had been exposed to the conflicting low-intake-norm information than if they had not, they denied being influenced by the normative cue and instead explained their food intake in terms of their hunger. In contrast, participants in the preload condition who had been exposed to the conflicting high-intake norm did not eat more than those who had not been exposed to the norm, but were more likely to attribute their food intake to the social norm. Thus, although deprived participants were inaccurately biased toward explaining their food intake in terms of hunger, preloaded participants were inaccurately biased toward the normative cue. These findings suggest that situational factors contribute to determining the extent to which internal/sensory or normative cues will be utilized to explain one's intake (whether this explanation is accurate or not).

Most studies on reasons for eating have asked participants who had already eaten to explain why they ate the particular amount that they did, and those studies have shown a general bias toward internal- and sensory-cue explanations (e.g., Vartanian et al., 2008; Vartanian et al., 2013), although normative cues might be acknowledged under some circumstances (e.g., Robinson & Field, 2015; Spanos et al., 2014). Another way to assess biases in judgments about the factors that influence food intake would be to consider people's predictions about how much food will be eaten, by themselves or by others, when different cues are made salient. Predictions about food intake do seem to play a role in people's actual food intake. For example, Fay et al. (2011) conducted a questionnaire study on pre-meal planning in a large cohort and found that food intake was planned in most cases, and that from the outset most participants expected to consume their entire portion. Furthermore, experimental studies have shown that the amount of food that people intend to consume closely matched their subsequent food consumption (Wilkinson et al., 2012), and that these intake predictions were influenced by their expectations of how filling the food will be (e.g., Brunstrom & Rogers, 2009; Brunstrom, Shakeshaft, & Scott-Samuel, 2008). In this study, we examined whether predictions about food intake are influenced by internal, sensory, and/or normative cues, in particular when those cues are in conflict with one another.

1.1. The present study

Previous research has shown that, in most circumstances, people tend to overemphasize the influence of internal (hunger) and sensory (taste) factors when explaining their prior food intake, and underemphasize the influence of normative factors (e.g., the behavior of others, portion size). The purpose of the present study was to determine whether the same biases apply when making predictions about how much food a person would eat under various conditions. On the basis of previous research (e.g., Vartanian et al., 2008, 2013), we hypothesized that participants would overemphasize internal and sensory factors[1] and underemphasize normative factors when predicting the target person's food intake. Although there is some evidence that people will acknowledge normative influences under some circumstances (e.g., when they feel that they have overeaten), those circumstances should not apply when making predictions about food intake.

We also explored two potential moderators of the bias toward the internal and sensory cues: First, on the basis of research

[1] Although some people may consider both hunger and taste to be internal cues, we believe it is more accurate to conceptualize taste as a sensory cue (see Herman & Polivy, 2008). Taste includes both an internal component (i.e., individual food preferences and palate) and an external component (i.e., properties of the food itself, such as freshness), making it distinctly different from hunger. What hunger and taste share is that they are both seen as appropriate reasons for eating as much as one does (Spanos et al., 2015), and are commonly cited reasons for eating. This is why we had similar predictions for hunger and taste but kept them separate in the analyses.

indicating that people view portion size as a more appropriate reason for eating than they view social influences (Spanos, Vartanian, Herman, & Polivy, 2015), we tentatively predicted that there would be a stronger bias toward internal or sensory cues for social influences than for portion size. Second, on the basis of research showing that people are more likely to acknowledge the influence of a normative cue on others' behavior than on their own behavior (Spanos et al., 2014; see also Sproesser, Klusmann, Schupp, & Renner, 2017), we tentatively predicted that there would be a stronger bias toward internal or sensory cues for predictions about oneself than for predictions about others.

2. Method

2.1. Participants

Participants were individuals based in the United States who were recruited from Amazon's Mechanical Turk. Previous research examining internal versus normative attributions for food intake has typically found large effect sizes (e.g., Vartanian et al., 2013). Given the novelty of the research questions being examined and the methodological approach used, however, we recruited a sample that a power calculation indicated would be large enough to detect even a small effect size. Participants were excluded from the study if they failed the CAPTCHA verification screening, responded incorrectly to any of the validity checks (questions directing participants to select a specific response option), or provided incomplete data. The final sample consisted of 364 participants (206 men, 158 women). Their mean age was 32.68 years ($SD = 10.43$, range = 18–66), and their mean body mass index (BMI; kg/m^2) based on self-reported height and weight was 26.34 ($SD = 6.41$, range = 15–57). With regards to ethnicity, 79.1% identified as White, 9.6% as African American, 6.0% as Asian, and 5.2% as Hispanic. Participants were paid $1 for completing the study.

2.2. Vignettes

A series of vignettes was created to reflect the different possible determinants of food intake that were of interest in this study: hunger, taste, and normative cues. Each vignette described a scenario in which the target person had access to some food, and participants were asked to predict how much the target person would eat in each situation. In the absence of prior research indicating the best way to capture participants' predictions in this type of situation, we framed the estimated-intake question in two different ways (counterbalanced across participants): For half of the participants, ratings were made regarding the absolute amount eaten (0 = *Very little*, 10 = *A huge amount*); for the remaining participants, ratings were made regarding the relative amount of food eaten (0 = *Much less than normal*, 10 = *Much more than normal*). Both rating formats yielded the same pattern of results, and so the two formats were combined for all analyses.

There were two types of vignettes: those that focused on a single eating cue, and those that combined two cues ("cue-conflict" scenarios). For each of the three single eating cues (i.e., hunger, taste, and a normative cue), we created separate scenarios in which the particular cues would be expected to increase food intake (e.g., high hunger, good-tasting food, a companion who eats a lot), and in which the cues would be expected to decrease food intake (e.g., low hunger, bad-tasting food, a companion who eats very little). Thus, participants provided ratings for a total of six single-cue scenarios. Both directions were of interest because there may be an asymmetry in how augmenting and inhibitory cues influence food intake (cf. Vartanian et al., 2015). The single-cue scenarios were used as a manipulation check to determine whether participants' predicted intake ratings followed the expected pattern (i.e., relatively high ratings for the "high intake" cues and relatively low ratings for the "low intake" cues), as well as to gauge the degree of bias observed in the cue-conflict scenarios. Cue-conflict scenarios were created by combining each augmenting ("high intake") single-cue scenario with every other inhibitory ("low intake") single-cue scenario (e.g., high hunger/companion who eats very little). In this study, we were specifically interested in the four cue-conflict scenarios that juxtaposed an internal or sensory eating cue with a normative eating cue (see Table 1, column A).

In order to address the secondary aim of the study, two additional features of the vignettes were manipulated between-subjects. First, to determine whether social cues and portion size would differentially influence predictions about food intake, for half of the participants the normative cue was an eating companion ($n = 183$), and for the other half the normative cue was portion size ($n = 181$). Second, to test whether predictions would differ for one's own behavior compared to the behavior of another person, half of the participants were asked to imagine that they were in the specific scenario and to make predictions about their own food intake ($n = 180$), and the other half were asked to imagine a hypothetical person in the scenario and to make predictions about that person's food intake ($n = 184$). (To maintain parallels between the "self" condition and the "other" condition, female participants in the "other" condition were presented with female hypothetical targets, and male participants were presented with male hypothetical targets.)

The following are sample vignettes from the low-hunger/high-normative cluster, with the normative cue being an eating companion (i.e., social cue) and the target being the self:

2.2.1. Low-hunger single-cue scenario

You have been at a BBQ for lunch and spent all afternoon eating lots of food. Your roommates had cooked stir-fry for dinner and offer you the leftovers when you get home. You are still quite full from the BBQ, but decide to have some anyway.

2.2.2. High-normative single-cue scenario

You have met your friend for brunch at a local café. When you sit down for your meals, you both order the big breakfast combo. Your friend eats everything on her/his plate.

2.2.3. Low-hunger/high-normative cue-conflict scenario

You have arranged to meet your friend for brunch but can't resist eating a big serving of your mom's pancakes before you leave. When you meet your friend at the café, you are still full. You both order the burger and fries. Your friend eats a large portion of her own meal.

Note that, although there is some imbalance in the level of detail provided in the different single-cue scenarios (due to the nature of the specific scenarios), our analysis compares responses to the cue-conflict scenarios with an estimated cue-conflict score that is based on the two single-cue scenarios. Thus, the question we are asking is whether responses to the cue-conflict scenarios are different from what would be expected based on how participants responded to the single-cue scenarios. In this way, any imbalance in the single-cue scenarios is taken into account in our analysis (see the Statistical Analysis section below for more details).

2.3. Procedure

Participants signed up for a study on "decision making" and were not aware that the study was related to food or eating. After providing informed consent, participants read through the vignettes in random order. Predictions about the amount of food

Table 1
Components of each scenario cluster.

A. Cluster	B. High-intake cue	C. Low-intake cue	D. Cue-conflict	E. Estimated cue-conflict score	F. Discrepancy score (E – D)
High hunger/low normative	H+	N-	H+:N-	[(H+)+(N-)]/2	[(H+)+(N-)]/2 - H+:N-
Low hunger/high normative	N+	H-	N+:H-	[(N+)+(H-)]/2	[(N+)+(H-)]/2 - N+:H-
High taste/low normative	T+	N-	T+:N-	[(T+)+(N-)]/2	[(T+)+(N-)]/2 - T+:N-
Low taste/high normative	N+	T-	N+:T-	[(N+)+(T-)]/2	[(N+)+(T-)]/2 - N+:T-

Note. H+ = high hunger; H - = low hunger; N+ = high normative; N- = low normative; T+ = high taste; T- = low taste.

consumed were made after each vignette. Finally, participants reported their age, sex, ethnicity, and height and weight (which were used to calculate their BMI). This study was approved by the university's ethics committee.

2.4. Statistical analyses

There were four “clusters” of scenarios in the present study. Each cluster consisted of a high-intake-cue scenario, a low-intake-cue scenario, and the conflict scenario combining the high-intake cue with the low-intake cue (e.g., high hunger, low normative, and high hunger/low normative). Analyses were conducted separately on each of the four clusters (i.e., high hunger/low normative, high taste/low normative, low hunger/high normative, and low taste/high normative). See Table 1 for the full set of scenarios. The first step in the analysis was to confirm that the scenarios effectively conveyed the intended information (i.e., a manipulation check). Repeated-measures ANOVAs were conducted on each cluster of scenarios to determine whether food-intake predictions differed by type of scenario (Table 1, columns B, C, and D). For example, in the high hunger/low normative cluster, we compared intake predictions for the high hunger scenario, the low normative scenario, and the high hunger/low normative cue-conflict scenario.

Next, we conducted two sets of analyses to assess the degree of bias in participants' predictions. First, we calculated an *estimated* cue-conflict score for each of the four cue-conflict scenarios based on the mathematical average of participants' intake predictions from the two single-cue scenarios from which the cue-conflict was derived (e.g., the average of predictions for the high-hunger scenario and the low-normative scenario; see Table 1, column E). One-sample *t*-tests were then used to examine whether the participants' mean intake predictions for the cue-conflict scenarios (Table 1, column D) differed from the mean estimated cue-conflict scores (Table 1, column E). Second, stepwise multiple regression was carried out to determine whether one or both single-cue scenarios (Table 1, columns B and C) were necessary to predict cue-conflict scores (Table 1, column D). The single-cue scenarios were entered as predictors and the cue-conflict scenarios were entered as the criterion variables. Probability-of-F-to-enter was set at ≤ 0.05, probability-of-F-to-remove was set at ≥ 0.10, and minimum tolerance was set at > 0.0001.

Finally, in order to determine whether the magnitude and direction of bias varied as a function of the type of normative cue and type of target, we compared the size of the discrepancy between participants' intake predictions for the cue-conflict scenarios and estimated cue-conflict scores across groups. Discrepancy scores (Table 1, column F) were calculated by subtracting the estimated cue-conflict scores (Table 1, column E) from participants' cue-conflict intake predictions (Table 1, column D) such that a positive discrepancy score indicated that cue-conflict intake predictions were higher than was expected. Next, a MANOVA was carried out with the type of normative cue (portion size vs. social norm) and the type of target (self vs. other) as the independent variables and discrepancy scores on each cue-conflict scenario as the dependent variables to determine whether there were any between-group differences in cue-conflict discrepancies.

3. Results

3.1. Manipulation check

As was expected, repeated-measures ANOVAs with a Huynh-Feldt correction indicated that, for each cluster of scenarios, predictions about food intake differed across scenario type, *Fs* ≥ 194.50, *ps* < 0.001, $\eta^2_p s \geq 0.35$ (see Table 2). Post-hoc tests using the Bonferroni correction showed that mean predicted food intake was significantly higher in the high intake scenarios than the in high/low conflict scenarios, which in turn had significantly higher mean predicted intake than the low intake scenarios, *ps* < 0.001 (see Fig. 1).

3.2. Bias in prediction about food intake

3.2.1. One-sample t-tests

Consistent with our hypothesis, one-sample *t*-tests revealed that participants' mean intake predictions for the cue-conflict scenarios were significantly lower than the estimated conflict scores for the low hunger/high normative conflict, $t(363) = -16.67$ $p < 0.001$, and for the low taste/high normative conflict, $t(363) = -23.61$, $p < 0.001$, indicating that participants were overemphasizing the internal cue and underemphasizing the normative cue. Surprisingly, mean intake predictions for the cue-conflict scenarios were also significantly lower than the estimated conflict scores for the high hunger/low normative conflict, $t(363) = -2.47$, $p = 0.01$, suggesting that participants in this case were underemphasizing the *internal cue* and overemphasizing the *normative cue*. There was no difference between mean intake predictions and the estimated cue conflict scores for the high taste/low normative conflict, $t(363) = -1.24$, $p = 0.22$, suggesting that participants placed equal emphasis on the internal and normative cue (see Fig. 1).

3.2.2. Regression analyses

For the low hunger/high normative conflict, low hunger was entered at Step 1 and was significantly related to the low hunger/high normative conflict, $F(1, 362) = 88.38$, $p < 0.001$, $R^2 = 0.20$, Adj-$R^2 = 0.19$. The high normative predictor was not eligible for entry at Step 2 because it made no significant unique contribution to predicting low hunger/high normative conflict scores, $p = 0.35$. Similarly, for the low taste/high normative conflict, low taste was entered at Step 1 and was significantly related to the low taste/high

Table 2
Test statistics for each scenario cluster.

Scenario cluster	Huynh-Feldt corrected *F*	*p*	η^2_p
High hunger/low normative	$F(1.93, 699.60) = 260.80$	<0.001	0.42
High taste/low normative	$F(1.82, 660.65) = 194.54$	<0.001	0.35
Low hunger/high normative	$F(1.82, 659.26) = 822.37$	<0.001	0.69
Low taste/high normative	$F(1.64, 596.61) = 1236.77$	<0.001	0.77

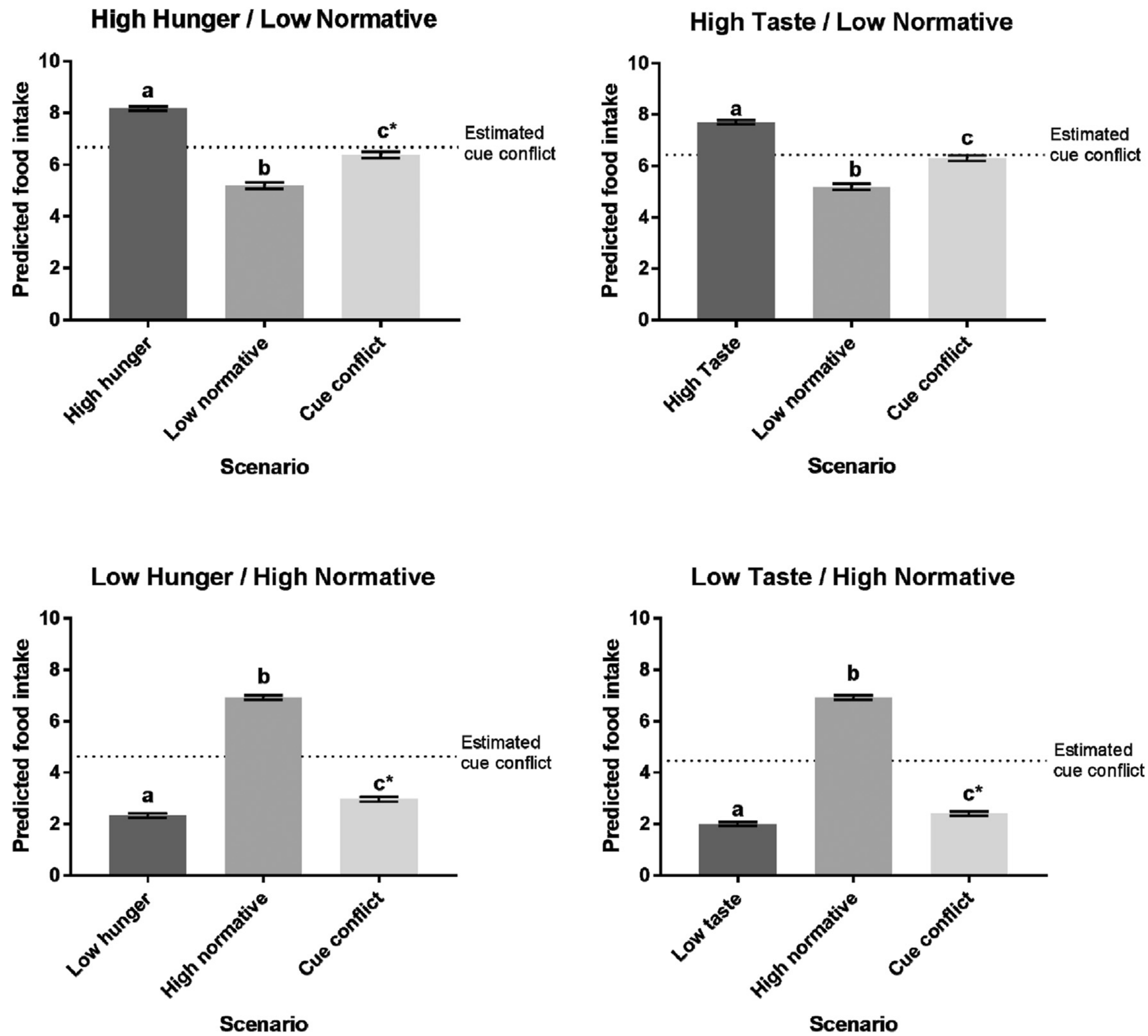

Fig. 1. Mean predicted food intake for each scenario within the high hunger/low normative, high taste/low normative, low hunger/high normative and low taste/high normative clusters. On each graph, bars with different superscripts are significantly different at $p < 0.001$. Cue-conflict bars with an asterisk are significantly different from the predicted cue conflict score at $p < 0.001$. Error bars represent standard errors.

normative conflict, $F(1, 362) = 152.46$, $p < 0.001$, $R^2 = 0.30$, Adj-$R^2 = 0.29$. The high normative predictor was not eligible for entry at Step 2 because it made no significant unique contribution to predicting low taste/high normative conflict scores, $p = 0.79$. Thus, in both of these cases, the intake predictions for the normative-cue scenarios did not explain any additional variance in intake predictions for the cue-conflict scenarios.

A different pattern emerged for the two remaining cue-conflicts. For the high hunger/low normative conflict, the low normative predictor was entered at Step 1 and was significantly related to the high hunger/low normative conflict, $F(1, 362) = 133.25$, $p < 0.001$, $R^2 = 0.27$. The high hunger predictor was entered at Step 2 and made a significant unique contribution to predicting the high hunger/low normative conflict, $\Delta F(1, 361) = 38.85$, $p < 0.001$, $\Delta R^2 = 0.08$. Thus, the final model included both high hunger and low normative predicting the high hunger/low normative conflict scores, Adj-$R^2 = 0.34$. Similarly, for the high taste/low normative conflict, the low normative predictor was entered at Step 1 and was significantly related to the high taste/low normative conflict, $F(1, 362) = 111.20$, $p < 0.001$, $R^2 = 0.24$. The high taste predictor was entered at Step 2 and made a significant unique contribution to predicting the high taste/low normative conflict, $\Delta F(1, 361) = 60.95$ $p < 0.001$, $\Delta R^2 = 0.11$. Thus, the final model included both high taste and low normative predicting the high taste/low normative conflict scores, Adj-$R^2 = 0.34$.

3.3. Type of normative cue and type of target

The MANOVA revealed a significant main effect of type of normative cue on discrepancy scores, $F(4, 357) = 4.44$, $p = 0.002$, Wilks' $\Lambda = 0.95$. Follow-up univariate analyses showed that the discrepancy between intake predictions for the cue-conflict scenarios and estimated cue-conflict scores was greater for portion size than for the social cue for both the high hunger/low normative conflict scenario ($p = 0.01$) and the high taste/low normative conflict scenario ($p < 0.001$). These findings indicate that participants gave more weight to the normative cue in their predictions about food intake when the normative cue was portion size than when it was social influence. There were no differences for the other two scenarios: low hunger/high normative conflict ($p = 0.77$) and low taste/high normative conflict ($p = 0.61$).

There was also a significant main effect of target of ratings on discrepancy scores, $F(4, 357) = 2.36$, $p = 0.05$, Wilks' $\Lambda = 0.97$. Follow-up univariate analyses showed that the effect was significant only for the high hunger/low normative conflict scenario. Those who predicted other people's food intake showed a larger discrepancy than did those who predicted their own food intake ($p = 0.01$), indicating that participants gave more weight to normative cues in their predictions for other people's behavior than for their own behavior. There were no differences in discrepancy scores for any of the other scenarios ($ps \geq 0.10$). There was also no significant interaction between type of normative cue and target of ratings on discrepancy scores, $F(4, 357) = 1.62$, $p = 0.17$, Wilks' $\Lambda = 0.98$.

4. Discussion

The purpose of this study was to assess whether people overemphasize the potential influence of internal and sensory factors and underemphasize the potential influence of normative factors when predicting food intake. To address this question, we obtained predictions for a target person's food intake in scenarios in which an internal or sensory cue that was expected to decrease intake was in conflict with a normative cue that was expected to increase intake, or vice versa. In the scenarios that juxtaposed an inhibitory internal or sensory cue with an augmenting normative cue (i.e., low hunger/high normative and low taste/high normative), we found that participants' intake predictions were strongly biased toward the internal or sensory cue. This finding is consistent with previous research on attributions for food intake which demonstrates that people's explanations for their own food intake are generally biased toward internal and/or sensory factors (e.g., Vartanian et al., 2008, 2013).

Contrary to our hypotheses, predictions for intake in the vignettes involving an augmenting internal or sensory cue and an inhibitory normative cue did not show the same bias toward the internal or sensory cue. Instead, for the high hunger/low normative and high taste/low normative scenarios, we found that participants' predictions appear to have been based on both the internal/sensory and the normative cue. Indeed, predictions for food intake in these scenarios were close to what would be expected by simply averaging the two component single cues (i.e., close to the estimated cue-conflict scores).

One possible reason that the bias toward internal and sensory factors was observed only when they were inhibitory is that predictions about food intake may be motivated or self-serving in nature. For the conflict scenarios in which the internal or sensory factors were inhibitory cues (i.e., low hunger or low taste), people predicted relatively low food intake and ignored the potential augmenting influence of the normative cues. This pattern follows the general observation that internal or sensory cues are seen as appropriate reasons for eating as much or as little as one does, whereas normative cues are seen as inappropriate reasons for eating as much as one does (Spanos et al., 2015). Thus, unless there is a good reason to do otherwise, people will focus on the internal or sensory cue in both predicting and explaining food intake. However, for the scenarios in which the internal or sensory factors were augmenting cues and might lead to predictions of overeating, or eating more than is appropriate (i.e., high hunger or high taste), people seemed to take the normative cue into consideration, perhaps because this allows them to avoid predicting excessive intake. Studies on attributions for food intake support the idea that people are generally biased to refer to internal or sensory cues but acknowledge normative cues in circumstances in which doing so may be self-serving. For example, people tend to acknowledge normative cues in situations in which they feel they have eaten more than they should have (Vartanian, Spanos et al., 2017) or feel they have eaten more than they normally do (Vartanian, Reily et al., 2017).

This line of reasoning suggests that predictions for food intake may also be biased toward inhibitory cues (in addition to the bias toward internal and sensory cues). In other words, people may have a general tendency to underestimate how much food they themselves or others will eat that operates in conjunction with the bias toward internal cues. In the conflict scenarios in which the internal or sensory cue was inhibitory (i.e., the internal or sensory cue and the underestimation tendency were congruous), predictions for the amount of food that would be consumed were relatively low and were biased toward the internal or sensory inhibitory cue. In the remaining scenarios in which the internal or sensory cue was augmenting (i.e., the internal or sensory cue and the underestimation tendency were incongruous), predicted intake was intermediate because the bias toward internal or sensory cue and the bias toward inhibitory cues drove predictions in opposite directions. Although the accuracy of predictions about food intake has not yet been explored in this context, people tend to underestimate their food intake when they are asked to recall how much they have eaten (for a review, see Schoeller, 1995). A predictive bias toward underestimation is also in line with Herman et al.'s (2003) normative model which assumes that people are motivated to avoid eating excessively, and with the finding that inhibitory social models seem to have a more powerful effect on food intake than do augmenting social models (Vartanian et al., 2015). Thus, people may generally want to believe that they will not overeat and, in situations in which there are conflicting cues present, may orient to the inhibitory cues because those cues support that motivation.

In addition to examining overall predictions about food intake, a secondary aim of this study was to explore potential moderators of those predictions. With respect to the type of normative cue, there was some evidence that participants gave more weight to the portion size normative cue than to the social influence normative cue (at least for the high hunger/low normative and the high taste/low normative scenarios). This finding suggests that people are somewhat more willing to factor in portion size than social cues in their predictions about food intake, and is consistent with Spanos et al.'s (2015) finding that portion size is seen as a more appropriate influence on food intake than is social influence. However, it is also possible that more weight was given to the low portion size cue than the low social cue in the conflict scenarios because the small portion size created an upper limit on food intake predictions. That is, there may have been a ceiling effect associated with having a small amount of food available in the low portion size cue scenario. Note, however, that participants predicted that a moderate amount of food would be eaten in the low portion size cue scenario ($M = 4.83$ on a 0–10 scale). With respect to the type of target, participants gave more weight to the normative cue when they were making predictions about other people's behavior than when they were making predictions about their own behavior, albeit in only one of the four scenarios (high hunger/low normative conflict). This finding is consistent with previous research showing that people are more likely to acknowledge the influence of normative factors for others' behavior than for their own behavior (Spanos et al., 2014).

There are some limitations of the current study that should be noted. First, we did not pilot test the vignettes to match them in terms of the potency or persuasiveness of the internal, sensory, and normative cues, and there may thus have been some imbalance across scenarios that introduced noise into our data. It would be important for future research to develop vignettes for each cue type that are equal in their potency. It would also be interesting to develop vignettes that systematically vary in their potency, which could allow researchers to determine, for example, how potent a normative influence needs to be before people are willing to acknowledge that cue to the same degree as the internal or sensory cue. Second, this study used hypothetical scenarios, and we did not test whether people's predictions were accurate. Also, we did not examine whether people's predictions before eating align with the attributions they make after eating, or after they have seen others eat. Although previous research suggests that pre-meal plans are closely aligned with the amount of food consumed in an experimental setting (Wilkinson et al., 2012), that research has not examined predictions about food intake in the context of multiple, potentially conflicting eating cues. Furthermore, other research suggests that people's post-meal explanations for their food intake are often inaccurate (e.g., Spanos et al., 2014; Vartanian, Spanos et al., 2017). It remains to be seen whether the extent to which people use various internal and external cues to formulate pre-meal intake predictions coincides with the extent to which they report the influence of those cues in explaining their food intake after they have eaten. Third, we used hypothetical vignettes so that we could manipulate various internal and external factors in a controlled manner. However, predictions about food intake may differ if participants were to observe or experience the scenario rather than simply read about it. Given that there are often numerous competing factors that might influence food intake during any particular eating occasion, it is important to assess predictions about food intake in actual eating contexts. Finally, we did not examine whether factors such as dietary restraint and baseline hunger levels might have influenced participants' predictions about how much food they or others might eat. Although these factors often have little bearing on actual food intake in studies examining external eating cues (e.g., Reily & Vartanian, 2016; Roth, Herman, Polivy, & Pliner, 2001), it is possible that they could differentially influence predictions.

Studies on attributions for food intake have shown that, in general, people's explanations for how much they have eaten are biased toward internal and sensory cues, although they may acknowledge normative cues under certain circumstances. We took a novel approach to assess this bias toward internal eating cues by examining people's predictions about how much a target person would eat in various circumstances. Our findings suggest that predictions about food intake also tend to reflect a general bias toward internal and sensory cues, but also include normative cues when those cues are inhibitory. If people are systematically biased toward internal, sensory, and inhibitory cues, then they may underestimate how much food they or others will eat in many situations, particularly when normative cues promoting eating are present. Further research is needed in order to understand the origin of these biases, and what implications they have for people's actual eating behavior in situations where multiple eating cues are present.

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