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Research Article

The acuity of vice: Attitude ambivalence improves visual sensitivity to increasing portion sizes☆

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Abstract

A rapid increase in the size of food portions has underlined the importance of understanding consumers' ability to accurately perceive portion sizes. Drawing on research on motivated perception, we posit that attitude ambivalence (simultaneously desiring a food and perceiving it as unhealthy) enhances visual sensitivity to increasing portion sizes. We manipulate or measure attitude ambivalence in three experimental studies conducted among children and adults and find that visual sensitivity is driven not simply by desire but by the coexistence of desire and perceived unhealthiness of the food (e.g., for hedonic food and among restrained eaters). Our findings suggest that framing foods as vices improves the estimation of portion sizes among health-conscious people.

Keywords: Visual perception; Volume estimation; Food; Packaging; Attitude ambivalence

Introduction

Food portions have grown dramatically over recent decades and now frequently exceed the serving sizes recommended by the United States Department of Agriculture (Nestle, 2003; Schwartz & Byrd-Bredbenner, 2006). The trend has affected not only the meals served at fast food restaurants but also the food sold at supermarkets and the meals prepared at home (Nielsen & Popkin, 2003). It has been suggested that people's inability to accurately perceive portion size may be one of the drivers of the obesity epidemic (Rozin, Kabnick, Pete, Fischler, & Shields, 2003; Young & Nestle, 2002).

In this research, we study people's perceptions of large portion sizes when they are presented alongside a smaller known portion size, where the estimation is purely visual. This happens, for example, when people are evaluating a new large portion of fries at a fast food restaurant (or a new large container of popcorn at the cinema) presented alongside familiar standard sizes. We refer to people's ability to accurately estimate the size of increasing portions simply by looking at them as their "visual sensitivity to increasing sizes" or, for simplicity, as their "visual acuity".

Prior research has established that people systematically underestimate the size of objects as they grow larger (the well-documented underestimation bias; Stevens, 1971). Thus, supersized meal portions and packages tend to be underestimated because people (and even professional dieticians) exhibit a diminishing visual sensitivity to the increasing size of meals and of individual portions (Chandon & Ordabayeva, 2009; Chandon & Wansink, 2007b). This bias is particularly problematic because shoppers rarely read the size information displayed on packages, relying instead on their visual impression of a package or a portion

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to estimate its size (Lennard, Mitchell, McGoldrick, & Betts, 2001; Viswanathan, Rosa, & Harris, 2005). The physical characteristics of packaging can accentuate this underestimation bias. For instance, people underestimate an increase in the size of food packages more strongly when all three dimensions are changed simultaneously (Chandon & Ordabayeva, 2009; Krider, Raghubir, & Krishna, 2001). Even subtle changes in the shape, design and esthetics of food packaging and containers can strongly affect people's size impressions (Deng & Kahn, 2009; Folkes & Matta, 2004; Krishna, 2006; Raghubir & Krishna, 1999; Wansink & Van Ittersum, 2003; Zaichkowsky, Neuhaus, Bender, & Weber, 2010).

In comparison we know little about how non-design-based factors influence visual sensitivity to increasing portion size. This is surprising given that prior research (e.g. Fig. 1 in Wansink & Chandon, 2006) has revealed considerable intra- and inter-personal variations in the underestimation of increasing portion sizes. Research on motivated perception has shown that goals and attitudes can influence the perceived size of a single object (Bruner & Goodman, 1947; Dunning & Balcetis, 2013). However, it has not examined visual sensitivity to increasing size when multiple sizes are shown simultaneously and when the size of a referent smaller portion is known. This is an important distinction because size estimations are reference-dependent (Hu & Goodale, 2000) and because reference-free estimates of single sizes do not adequately capture the task confronting consumers when they evaluate multiple food portions.

From a conceptual standpoint, prior studies on motivated size perceptions have focused on the role of desire. For example, van Koningsbruggen, Stroebe, and Aarts (2011) found that chocolate muffins appeared larger to dieters than to non-dieters after both groups had been exposed to tempting food primes. This research has largely overlooked the role of the motivation to avoid negative health consequences, which often conflicts with the desire to consume palatable foods (Stroebe, Van Koningsbruggen, Papies, & Aarts, 2013). Yet the trade-off between desire and a perceived health threat has been shown to strongly influence consumer judgments and food choices (Shiv & Fedorikhin, 1999). The present research goes beyond the study of desire to examine the role of attitude ambivalence created by the tension between desire and a perceived health threat.

Our work contributes to the literature on visual sensitivity to increasing portion size by studying the role of attitudinal rather than design-based factors. It also contributes to the literature on motivated perception by examining estimations of increasing size in the presence of a smaller benchmark, and by showing that visual sensitivity is not driven by desire and threat individually but by the tension between the two. Specifically, we show that attitude ambivalence explains visual sensitivity to increasing portion size better than desire alone, or than what a simple interaction of desire and threat would predict. Our results also have implications for research on self-control by showing that goal conflict has perceptual as well as motivational consequences. Finally, our results have implications for public health. Given that people systematically underestimate size as objects grow larger (Stevens, 1971), ambivalence-driven improvements in visual sensitivity should lead to more accurate estimates of increasing portion size. Indeed, we find that increasing the hedonic appeal of food makes restrained adult eaters as well as health conscious children and adults more (rather than less) accurate in their estimations of portion size.

Attitudes and portion size estimation

Motivated perception: The perceptual effects of desire and fear

The idea that motivation may impact visual perception was introduced in the 1940s and 50s; perception was viewed as a constructive process influenced by desires, needs and values (Bruner & Minturn, 1955). In their pioneering study, Bruner and Goodman (1947) found that children from more modest backgrounds overestimated the size of coins, seemingly because they had a stronger desire for money than wealthier children. Although these early findings were criticized on methodological grounds (e.g., socially-desirable responding and familiarity biases), the basic effects have recently been replicated with different stimuli and approach motivations in better controlled settings (Dubois, Rucker, & Galinsky, 2010; Dunning & Balcetis, 2013). For example, cigarettes appear longer to smokers with high (vs. low) craving (Brendl, Markman, & Messner, 2003) and bottles of water look closer to thirsty (vs. non-thirsty) people (Balcetis & Dunning, 2010a). Thus, desirable objects look bigger and closer.

Such results also suggest that undesirable objects will appear smaller or more distant, as has been confirmed for clearly repulsive objects (e.g. Van Ulzen, Semin, Oudejans, & Beek, 2008). However, other studies inspired by research on perceptual vigilance (Erdelyi, 1974) have found different effects. In these studies threatening or harmful objects, such as a snake in the grass (Ohman, Flykt, & Esteves, 2001), an aggressive person (Cole, Balcetis, & Dunning, 2012), or a pointed gun (Van Ulzen et al., 2008) were perceived to be larger and closer than non-threatening stimuli. Although this hypothesis has not been formally tested, Balcetis and Dunning (2010b) posit that a threatening object may not need to be as dangerous as a snake or a gun in order to be perceived as larger, and that perceptual vigilance may be triggered by pitfalls, temptations, or objects which are detrimental to a particular goal.

Overall, some literature suggests that desiring food or fearing that it may be harmful to health may increase its perceived size. However, studies on visual perception have until now ignored the fact that some objects — such as hedonic foods — are simultaneously desired and perceived as a health threat, and that the tension between the two attitudes (rather than their individual effects) could shape perceptions (Shiv & Fedorikhin, 1999; Stroebe et al., 2013).

Ambivalent attitudes towards food

Ambivalent attitudes arise when individuals hold simultaneous positive and negative reactions to an object, for example, because they have conflicting goals (Kaplan, 1972; Ramanathan & Williams, 2007; Thompson, Zanna, & Griffin, 1995). In the context of food, many people experience a conflict between the goal of enjoying food and the goal of staying healthy, hence food is often both desired and considered unhealthy (Shiv &

Fedorikhin, 1999; Stroebe et al., 2013). This perceived trade-off between palatability and healthiness is reflected in the intuitive notion that "unhealthy = tasty" (Raghunathan, Naylor, & Hoyer, 2006), and it may have led researchers to focus on the role of desire while neglecting the role of unhealthiness. In fact, some studies on motivated size perception have used ambivalent stimuli like cigarettes that are both desired and unhealthy, but they have focused exclusively on the role of desire. For example, van Koningsbruggen et al. (2011) argued that muffins look larger to dieters (vs. non-dieters) following exposure to tempting foods because of their stronger desire for hedonic foods, while overlooking the possibility that dieters feel ambivalent towards such foods (Papies, Stroebe, & Aarts, 2009).

Research on the process by which attitudes influence size estimations is still at an early stage (Dunning & Balcetis, 2013), but it nevertheless underscores the role of attention and arousal. Prior studies have shown that attitude ambivalence towards food narrows individuals' attention to the visual cues of hedonic foods (e.g. Hollitt, Kemps, Tiggemann, Smeets, & Mills, 2010; Overduin, Jansen, & Louwerse, 1995; Papies, Stroebe, & Aarts, 2008; Stewart & Samoluk, 1997). Another line of research has suggested that narrowed attention influences perceptions of size and distance by generating more vivid representations and higher sensitivity to contrasts and spatial resolution (Alter & Balcetis, 2011; Carrasco, 2011; Dunning & Balcetis, 2013; Wardak, Deneve, & Ben Hamed, 2011). Taken together these arguments suggest that ambivalence may enhance visual sensitivity to increasing portions by narrowing attention to food portions. Like attention, arousal is also increased by ambivalence (Maio, Greenland, Bernard, & Esses, 2001). In turn it has been suggested that arousal boosts physical energy and impacts perception of size by altering of pupil size, which is instrumental to visual assessment of objects (Balcetis & Cole, 2013; Proffitt, 2006). Although researchers have not yet agreed on which process underlies size perception effects (and we do not seek to resolve this issue here), both support our hypothesis that attitudinal ambivalence improves visual sensitivity to increasing portion sizes.

Operationalization of attitude ambivalence

According to the ambivalence literature, attitude ambivalence arises when two conflicting attitudes are both intense *and* of similar magnitude (Thompson et al., 1995). Priester and Petty (1996) applied this insight to operationalize ambivalence using the following formula:

$$A = 3 * C - D \quad (1)$$

where A is the ambivalence score, C is the conflicting attitude (the weaker of the two attitudes), and D is the dominant attitude (the stronger of the two). If both attitudes are of equal strength (e.g., have the same value on a Likert scale), either one can be used as the dominant attitude. The $3 * C - D$ measure captures the fact that ambivalence increases as the strength of both underlying attitudes increases. As a result, ambivalence is high when both attitudes are similarly strong, moderate when both attitudes are similarly weak (indicating indifference), and low when one of the attitudes dominates the other (indicating no tension between the two).

For example, if desire and perceived unhealthiness are measured on a five-point scale anchored at 1 and 5, ambivalence is highest when both attitudes are rated 5 (because $3 * C - D = 15 - 5 = 10$); it is moderate when both attitudes are rated 1 ($3 * C - D = 3 - 1 = 2$); and lowest when one attitude is rated 5 and the other is rated 1 ($3 * C - D = 3 - 5 = -2$). This scoring can also be used when attitudes are experimentally manipulated in a 2 × 2 design. In this case both attitudes can be coded as 2 in the "strong attitude" condition, and as 1 in the "low attitude" condition. The $3 * C - D$ formula then yields a high ambivalence score of 4 in the "high desire and high threat" condition, a moderate score of 2 in the "low desire and low threat" condition, and a low score of 1 when one attitude dominates the other (in the "high desire, low threat" and "low desire, high threat" conditions).

One important feature of ambivalence which is reflected in the $3 * C - D$ coding is that it is higher (although not at its highest level) when consumers have low desire and low threat perceptions (i.e., they are indifferent) compared to when they have high desire and low threat perceptions or low desire and high threat perceptions (i.e., they are "univalent"). This is because the tension between desire and threat is weaker when either desire or threat clearly dominates than when the two are equal in value. As we will show, this is an important characteristic which distinguishes our hypothesis that ambivalence drives visual sensitivity from the prediction of existing research that desire and threat positively interact to influence visual sensitivity.

Distinguishing between the predictions of attitude ambivalence and the dual-effect of desire and health threats

We predict that attitude ambivalence will improve visual sensitivity to increasing portion sizes. We define visual sensitivity to growing portions (or "visual acuity" as stated in the title) as individuals' ability to accurately estimate portion size when food portions grow larger. Since people tend to systematically underestimate size as objects grow larger (Chandon & Wansink, 2007b; Stevens, 1971), we predict that by enhancing visual sensitivity to increasing sizes attitude ambivalence will in effect decrease the well-documented underestimation bias.

Thus we expect to find that people underestimate the size of increasing food portions, as suggested by previous research (Chandon & Wansink, 2007b). We may find a positive main effect of ambivalence on size estimations indicating that size estimates are on average higher when ambivalence is high than when it is low, although it is not essential to our theory. But crucial to our theory, we expect to find a significant positive interaction between ambivalence and actual portion size indicating a higher visual sensitivity to (and a lower underestimation of) increasing portion sizes when ambivalence is high than when it is low. This means that visual sensitivity to increasing portion sizes should be the highest when both desire and unhealthiness perceptions are strong (and ambivalence between the two is high); the lowest when one is strong while the other is weak (and ambivalence between the two is minimal); and in-between when both perceptions are weak (and there is some—although not much—ambivalence between the two). In other words, high desire (vs. low desire) should increase visual sensitivity when the health threat is high but weaken it when the health threat is low.

Our predictions differ from prior research on motivated perception and vigilant perception which argued that the feelings of both desire and threat should increase visual size sensitivity and that, as a result, size estimations should be influenced by the two main effects of desire and unhealthiness and by the positive interaction between them. In other words, prior research suggested that visual size sensitivity should be highest when perceptions of both desire and unhealthiness are strong. However, prior research predicted that visual sensitivity should be smallest when both desire and unhealthiness are weak and in-between when one is strong and the other is weak. This is the opposite of our prediction that visual sensitivity is lowest when one attitude is strong and the other is weak and in-between when both attitudes are moderate (and hence there is some conflict).

We test our predictions in three studies. Study 1 examines the effect of ambivalence on the visual sensitivity to increasing portion size of hedonic and non-hedonic foods among 8-year-old children. In Study 2, we manipulate desire and threat perceptions for the same food among young European adults, which allows us to pit the predictions of the ambivalence hypothesis against the competing hypothesis of the dual effect (two main effects and a positive interaction) of desire and threat. Study 3 examines the generalizability of the effects and their significance for public health by studying how "low-fat" nutrition claims influence the visual sensitivity of restrained and unrestrained eaters.

Study 1: Effects of ambivalence on size estimations of schoolchildren

Method

Like Bruner and Goodman (1947), we recruited 84 schoolchildren (56% female, 8 years old on average) from three elementary schools in Germany. Understanding children's portion size estimations is crucial from a public health perspective in view of the recent rise in childhood obesity (Katz, 2013). We used a 2 (food type: chocolate chunks vs. baby carrots) × 5 (portion size: 10, 20, 40, 80, or 160 units) mixed design with food type manipulated between subjects and portion size manipulated within subjects. We chose chocolates and carrots because they can be broken into discrete units of identical size and because we expected chocolate to evoke more ambivalent attitudes than carrots. We showed photos of five different portions on blue plates of identical size with a white background. The portions were presented simultaneously, in ascending order of size, to the right of a plate containing the reference amount (five chocolates or carrots). We told the children that the smallest portion contained five carrots or five chocolate chunks and asked them to estimate the number of units on the other five plates. We explicitly instructed them not to count the units but to provide their best guess.

At the end of the experiment we asked the children to rate the third portion (20 units) of chocolate or carrots on a five-point scale ranging from "very disgusting" to "very delicious". Because few 8-year olds have internalized health concerns, we asked the children to rate how their parents would react upon learning that they had eaten the entire third portion, on a four-point scale ranging from "they would praise me a lot" to "they would scold me a lot."

Results and discussion

Two children failed to provide any answers and ten estimations were beyond 3 standard deviations from the mean and were treated as outliers (McClelland, 2000), leaving us with 80 respondents and 400 estimations (out of 410). Removing the outliers did not change the statistical tests. We measured the degree of ambivalence between children's desire to eat the food and the perceived threat of being scolded if they did using Priester and Petty's (1996) $3 * C - D$ formula after rescaling the two attitude measures so that they both varied between 0 and 1. This created a high ambivalence score among children who perceived the food as both desirable and threatening, a medium ambivalence score (indifference) among children who perceived the food as neither desirable nor threatening, and the lowest score among children who either perceived the food as both desirable and non-threatening or as undesirable and threatening. As expected, the ambivalence score was higher for chocolates ($M = 0.96$, 95% CI[0.81,1.11]) than for carrots ($M = 0.08$, CI[−0.13,0.30], $F(1,78) = 46.3$, $p < .001$). For comparison, a mid-point (0.5) rating of desire and threat yields an ambivalence score of 1.0 according to the $3 * C - D$ coding. This suggests that most of the children were indifferent to or held non-ambivalent attitudes towards carrots, whereas ambivalence towards chocolate ranged from low to high.

In this study and in subsequent studies, the estimated size data were analyzed with a hierarchical two-level model (Gelman & Hill, 2007; Rabe-Hesketh & Skrondal, 2012). We first analyzed the data with a model in which the actual size of the portion was the level 1 predictor, while ambivalence, food type, and the interaction effect of ambivalence and food type were the level 2 predictors and influenced the coefficient of the level 1 predictor.[1]

[1] Level 1 equation: $Ln\_est\_size_{ij} = \beta_{0j} + \beta_{1j}(Ln\_act\_size_i) + e_{ij}$.
Level 2 equations:

$$\beta_{0j} = \gamma_{00} + \gamma_{01}(\text{ambivalence}_j) + \gamma_{02}(\text{foodtype}_j) + \gamma_{03}(\text{foodtype} \times \text{ambivalence}_j) + u_{0j}$$

$$\beta_{1j} = \gamma_{10} + \gamma_{11}(\text{ambivalence}_j) + \gamma_{12}(\text{foodtype}_j) + \gamma_{13}(\text{foodtype} \times \text{ambivalence}_j) + u_{1j}.$$

At level 1, $Ln\_act\_size_i$ was the log-transformed actual size, rescaled as a multiple of the reference size, $Ln\_est\_size_{ij}$ was the log-transformed estimated size (which varied by participant j and size i). At level 2 (across participants j), the level-1 intercept β_{0j} and the coefficient β_{1j} of the level-1 predictor were regressed on ambivalence_j (the mean-centered continuous ambivalence score) which varied across participants, foodtype_j (a binary variable equal to 0.5 for chocolate and −0.5 for carrots) and foodtype × ambivalence_j (the interaction of the ambivalence score and the food type binary variable). This yielded coefficients γ_{01} (the main effect of ambivalence), γ_{02} (the main effect of food type), γ_{10} (the main effect of actual size), γ_{11} (the interaction effect of ambivalence and actual size), γ_{03} (the interaction effect of ambivalence and food type), γ_{12} (the interaction effect of food type and actual size), and γ_{13} (the interaction effect of ambivalence, actual size and food type). The effect of ambivalence on the visual sensitivity to increasing portion sizes was captured by the coefficient of the interaction between ambivalence and actual portion size, γ_{11}. The model was estimated using the XTMIXED procedure in STATA. The detailed results of all analyses (including the estimated variance of the random effect parameters) are available in a supplementary online document.

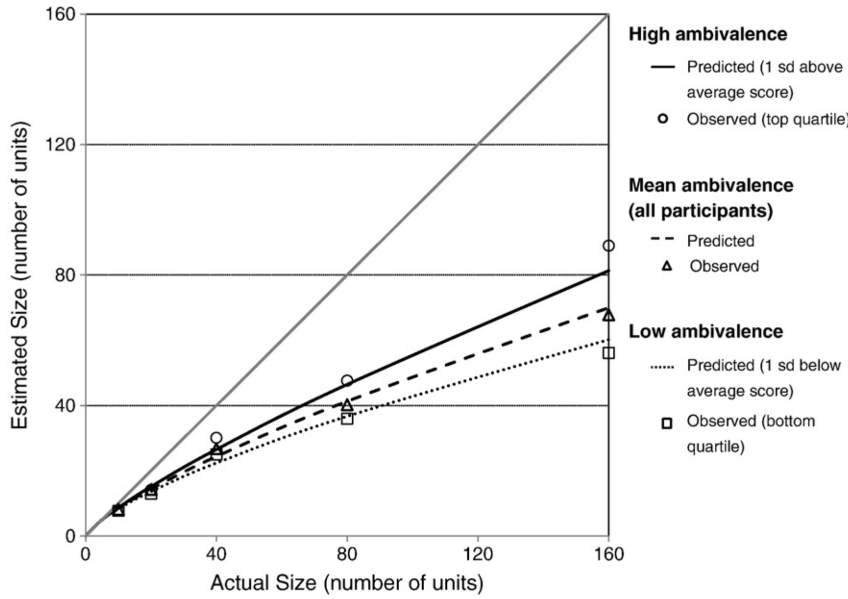

Fig. 1. Study 1: Effects of attitude ambivalence on estimated chocolate portion sizes. The observed sizes were obtained by computing the geometric means of size estimations, computed (i) for all children (mean ambivalence), (ii) for those in the top quartile and (iii) for those in the bottom quartile of the ambivalence distribution. Predicted sizes were plotted using the parameters of the regression of estimated sizes (log-transformed) on actual size (log-transformed and mean-centered), ambivalence towards chocolate (mean-centered), and their interaction. Ambivalence varied across participants. To plot the predicted sizes, we (i) used the mean ambivalence score across all participants (mean ambivalence), (ii) one standard deviation above the mean (high ambivalence), or (iii) one standard deviation below the mean (low ambivalence). The parameters of the regression were estimated using a hierarchical two-level model described in Footnote 2.

Compared to a standard regression, this hierarchical model takes into account the within-subject structure of the data and measures consumer heterogeneity in both the intercept and the effects of actual size by estimating a random effect for both. It therefore enables us to estimate the main effects of ambivalence and food type on size estimations, as well as their interaction effects with actual size, allowing us to measure whether visual sensitivity to increasing sizes varies across different ambivalence levels and different food types. We transformed the actual and estimated size into a logarithmic scale in order to capture the non-linear (power) relationship between them, as established previously in the literature (Chandon & Wansink, 2007b; Krishna, 2007; Stevens, 1971).

The results revealed that the coefficient for actual size (γ_{10} = .73, SE = .02) was significantly smaller than 1 (t-test of difference from 1 = −19.6, p < .001), confirming prior results that size estimations are inelastic and that visual sensitivity decreases as size increases (Chandon & Ordabayeva, 2009; Chandon & Wansink, 2007b; Krider et al., 2001). The interaction of food type with ambivalence and its three-way interaction with ambivalence and actual size were both significant (respectively, γ_{03} = .06, z = 2.5, p = .01 and γ_{13} = .03, z = 2.3, p = .02), indicating that the effects of ambivalence on visual sensitivity were different for different foods. All other effects were non-significant (p's > .20).

Therefore, we analyzed the estimated size of chocolate only with a simpler model, in which the actual size of the portion was the level 1 predictor, while ambivalence was the level 2 predictor that influenced the coefficient of the level 1 predictor.[2] The main effect of ambivalence and the actual size × ambivalence interaction were significant (respectively, γ_{01} = .04, z = 2.0, p = .04 and γ_{11} = .03, z = 2.2, p = .03). This significant interaction effect indicated higher visual sensitivity to increasing chocolate portions among children with ambivalent attitudes (see Fig. 1).

We analyzed the estimated size of carrots only with the same model (described in Footnote 2). Neither the main effect of ambivalence nor its interaction with actual size was significant (respectively, γ_{01} = −.01, z = −1.3, p = .18 and γ_{11} = −.01, z = −.8, p = .43), confirming the lack of ambivalence towards this food.

Study 1 demonstrated that attitudinal ambivalence was associated with an improved visual sensitivity to increasing portion sizes among children. Although all the children underestimated the size of increasing portions, the estimates of the largest chocolate portion were 36% larger for children with high ambivalence (one standard deviation above the mean) compared to those with low ambivalence (one standard deviation below the mean). In Study 1,

[2] Level 1 equation:
$Ln\_est\_size_{ij} = \beta_{0j} + \beta_{1j}(Ln\_act\_size_i) + e_{ij}$.
Level 2 equations:

$$\begin{aligned}\beta_{0j} &= \gamma_{00} + \gamma_{01}(\text{ambivalence}_j) + u_{0j} \\ \beta_{1j} &= \gamma_{10} + \gamma_{11}(\text{ambivalence}_j) + u_{1j}\end{aligned}.$$

This hierarchical two-level model yielded coefficients γ_{01} (the main effect of ambivalence), γ_{10} (the main effect of actual size) and γ_{11} (the interaction effect of ambivalence and actual size, which captures the effect of ambivalence on the visual sensitivity to increasing portion sizes).

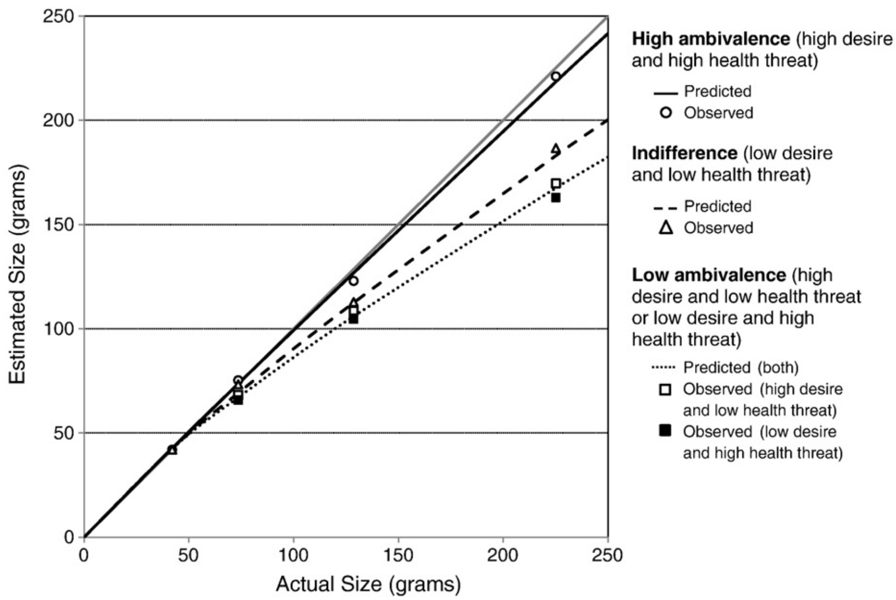

Fig. 2. Study 2: Effects of manipulated ambivalence on size estimations. The observed sizes were obtained by computing the geometric means of the size estimations for each portion in the four experimental conditions: (i) high desire/high threat, (ii) low desire/low threat, (iii) high desire/low threat, and (iv) low desire/high threat. Predicted sizes were plotted using the parameters of the regression of estimated sizes (log-transformed) on actual size (log-transformed and mean-centered), the ambivalence score of each experimental condition (mean-centered), and their interaction. The parameters of the regression were estimated using a hierarchical two-level model described in Footnote 2.

attitudes were measured instead of being manipulated and children estimated portion sizes from photos. In Study 2, we tested whether these results would hold when directly manipulating food desirability and health threat perceptions (rather than measuring them), when estimating the size of actual food portions (rather than photos), and when the participants were adults (rather than children).

Study 2: Effects of manipulated ambivalence on visual sensitivity of adults

Method

We recruited 115 adult students (52% female, 22 years old on average) at a European university in exchange for course credit. We used a 2 × 2 × 3 mixed design, with food labeling (unhealthy vs. healthy) and desire state (high vs. low) as between-subjects manipulations and portion size (73 g, 129 g, and 225 g) as a within-subject factor. We displayed four portions of gummy candies wrapped in transparent paper on a large table, told the participants the size of the smallest portion of candies (42 g), and asked them to estimate the size (in grams) of the remaining three portions.

The candies were labeled "gummy candies" in the unhealthy condition and "nutrition chews with Omega 3 and Vitamins" in the healthy condition. This manipulation was based on past research showing that nutrition labels such as "Omega 3" alleviate perceptions of unhealthiness without affecting the attractiveness of the product (Verbeke, Scholderer, & Lahteenmaki, 2009). We also checked the effectiveness of this manipulation in a pre-test with 115 online participants. On a scale from 1 (very harmless to one's health) to 9 (very harmful to one's health), the "gummy candies" scored significantly higher ($M = 5.9$, SD = 1.9) than the "nutrition chews" ($M = 4.2$, SD = 2.2, $F(1,113) = 18.1$, $p < .001$). In the high desire condition, participants tasted half of one candy before providing their size estimates. Previous research has consistently shown that sampling a small amount of food activates desire and reward-seeking tendencies (Brendl et al., 2003; Cornell, Rodin, & Weingarten, 1989; Rodin, 1985; Wadhwa, Shiv, & Nowlis, 2008). Participants in the low desire condition did not taste anything. We expected that participants would feel more ambivalent about the candies if they both strongly desired the candies and believed them to be unhealthy.[3]

Results

We excluded from the analyses one estimate (out of 345) that was beyond 3 standard deviations from the mean (McClelland, 2000). Removing this outlier did not affect the statistical tests. We used the hierarchical regression described in Footnote 2. The dependent variable was the mean-centered logarithmic transformation of estimated size. The independent variables were the mean-centered logarithmic transformation of actual size, the mean-centered score of ambivalence, and their interaction.

[3] At the end of the experiment, we also measured participants' implicit attitudes toward hedonic foods with two Implicit Association Tasks (IAT), one measuring desire and the other one measuring perceived threat and used these scores to measure implicit ambivalence. The effects of implicit and explicit ambivalence on visual sensitivity were similar. These results are available upon request from the corresponding author.

We computed the ambivalence score based on the desire and threat manipulations. Desire assumed the value of 1 in the low desire condition and the value of 2 in the high desire condition. Threat perception assumed the value of 1 in the healthy condition and the value of 2 in the unhealthy condition. We applied the ambivalence formula $3 * C - D$ to these values. As a result, ambivalence assumed the values of 4 in the high desire/high threat condition ($3 * 2 - 2 = 4$; high ambivalence), 2 in the low desire/low threat condition ($3 * 1 - 1 = 2$; medium ambivalence), and 1 in the high desire/low threat or low desire/high threat condition ($3 * 1 - 2 = 1$; low ambivalence).

The results revealed that the coefficient for actual size (γ_{10} = .87, SE = .02) was significantly smaller than 1 (*t*-test of difference from 1 = −6.3, $p < .001$), as we expected. The main effect of manipulated ambivalence was statistically significant (γ_{01} = .05, $z = 2.9$, $p = .004$). More importantly, the interaction of manipulated ambivalence with actual size was statistically significant and positive (γ_{11} = .05, $z = 2.8$, $p = .005$). As shown in Fig. 2, visual sensitivity to increasing portion sizes was highest when ambivalence was strong (high desire/high perceived threat condition), lowest when ambivalence was weak (when participants either perceived a high desire/low threat or a low desire/high threat), and in-between when ambivalence was moderate (when participants were indifferent — low desire/low threat condition).

This ordering supports our hypothesis about the influence of ambivalence on visual sensitivity, and it contradicts the alternative dual-effect hypothesis which predicts lowest visual sensitivity in the low desire/low perceived threat condition. Instead, as Fig. 2 shows, high desire increases visual sensitivity in the high threat condition (when high desire increases ambivalence), but slightly reduces visual sensitivity in the low threat condition (when high desire reduces ambivalence). Likewise, a high perceived threat increases visual sensitivity in the high desire condition (when high threat increases ambivalence), but slightly reduces visual sensitivity in the low desire condition (when high threat reduces ambivalence). It is also remarkable that the estimated sizes are almost identical in the two low ambivalence conditions (low desire/high threat or high desire/low threat), as we expected.

Discussion

Study 2 replicated and extended the findings of Study 1 by showing that adults (vs. children) are visually more sensitive to portion size increases of actual food (vs. photos) when ambivalence towards the estimated food is manipulated (vs. measured). Inducing ambivalence by simultaneously boosting people's desire to eat the food (through sampling) *and* enhancing their perceptions of its unhealthiness (through labeling) increased portion size estimates by up to 19%, while boosting a perception of desire *or* unhealthiness alone *reduced* these estimates by up to 12% compared to the baseline (when neither desire nor health threat perceptions were induced). This further confirms that our results cannot be explained by the two main effects of desire and threat perceptions as well as the positive interaction between the two. Incidentally, the combination of adult respondents and actual food portions (vs. children and photos) led to more accurate size estimates than in Study 1.

One possible limitation of Study 2 is that ambivalence was induced by strong manipulations (sampling the food and changing the name of the food). Another is that we did not study at-risk consumers, for whom inaccurate size estimations are likely to be most harmful. In Study 3 we examined whether a common nutrition claim ("low fat") influenced size estimations among restrained and unrestrained eaters.

Study 3: Effects of nutrition claims and restrained eating on size estimations

Method

We recruited 116 adults (52% females, 39 years old on average) at a popular sports center in a European city in exchange for a chance to win a prize. The study used a 2 × 5 mixed design, with anticipated health threat (chips labeled as "regular" vs. "low-fat") as a between-subjects manipulation and five portions of chips as a within-subjects factor. We provided participants with photos of six different portions of potato chips on plates of identical size with a white background, told them the number of calories in the smallest portion, and asked them to estimate the number of calories in the remaining five portions. We measured size in calories to test the robustness of the results across a wide variety of measures (number of units, weight, calories). Building on Wansink and Chandon (2006), we manipulated the health threat by adding a "33% less fat" label next to the chips or no label. We measured restrained eating using the Dutch Eating Behavior Questionnaire (van Strien, Frijters, Bergers, & Defares, 1986), which includes 10 items (e.g., "Do you watch exactly what you eat?", "Do you deliberately eat foods that are slimming?") and uses a 5-point scale ("never," "seldom," "sometimes," "often," "very often").

By definition, restrained eaters are especially likely to hold ambivalent attitudes towards food because they pursue two conflicting goals: the goal of enjoying tasty food and the goal of pursuing a healthy diet (Herman & Polivy, 1980; Stroebe et al., 2013). As a result, they exhibit a particularly high degree of attitudinal ambivalence when exposed to hedonic (unhealthy) food stimuli (Papies et al., 2009). In addition, health and nutrition claims tend to reduce ambivalence towards hedonic foods (Wansink & Chandon, 2006), especially among restrained eaters (Scott, Nowlis, Mandel, & Morales, 2008). We would therefore expect visual sensitivity to be highest for restrained eaters evaluating regular chips (high ambivalence condition), in-between for unrestrained eaters evaluating low-fat chips (indifference), and lowest for either restrained eaters evaluating low-fat chips or for unrestrained eaters evaluating regular chips (low ambivalence).

Results and discussion

There were no outliers in the data of Study 3. To compute the ambivalence score using the $3 * C - D$ formula, we assigned a value of 1 to the low threat ("low-fat claim") condition, and 2 in the high threat ("no claim") condition. We rescaled the restrained eating tendency scores so that they varied between 1 and 2. We estimated the hierarchical model described in Footnote 2, using the same dependent variable (estimated size) and independent variables (actual size, ambivalence, and their interaction) as in Study 2.

The coefficient of actual size was statistically smaller than 1 (γ_{10} = .75, SE = .02, $t = -20.2$, $p < .001$), as in the other studies. Although the main effect of ambivalence was not significant ($p > .50$), its interaction with size was statistically significant and positive (γ_{11} = .08, $z = 3.3$, $p < .001$), indicating that ambivalence improved visual sensitivity to increasing portion sizes.

To illustrate the effects of restrained eating and nutrition claims on ambivalence, we categorized participants in the top quartile of the DEBQ scale as "high restrained eaters" and those in the bottom quartile as "low restrained eaters." This dichotomy is commonly used in medical research on eating disorders to more clearly discern differences between low and high restrained eaters (e.g. Bohon, Eric, & Sonja, 2009; Cooper, Gillian, Rachel, Kate, & Adrian, 2006). We obtained similar results with a simple median split, and still, we used the continuous measure of restrained eating in the regression analysis. We then created three groups: high ambivalence (restrained eaters and regular chips), indifference (low restrained eaters and low-fat chips) and a low ambivalence group, with participants who were either high restrained eaters in the low-fat chip condition or low restrained eaters in the regular chip condition. Fig. 3 shows that, as expected, size estimates were 53% higher in the high ambivalence than in the low ambivalence groups, and that the size estimates of the indifference group were in-between the two.

Study 3 provides evidence that restrained eaters are actually better estimators of increasing portion sizes of unhealthy foods. This extends previous findings that hedonic foods appear larger to restrained (vs. unrestrained) eaters (van Koningsbruggen et al., 2011) by showing that this main effect is accompanied by an interaction with actual size, suggesting that restrained eaters are also more sensitive to increasing portion sizes. Study 3 also shows that nutrition claims like "33% less fat" ironically reduce the accuracy of size estimates of restrained eaters — the group most likely to pay particular attention to such claims. It is also remarkable that although restrained eaters are visually more sensitive to increasing portion sizes of hedonic foods, past research has found that they tend to under-report the amount of hedonic food they consume (Bathalon et al., 2000; Livingstone & Black, 2003). This suggests that the underreporting of consumed calories cannot be explained by biases in visual perception, and is likely driven by motives such as self-presentation.

General discussion

The results of three studies show that attitude ambivalence—desiring a food but at the same time perceiving it as unhealthy—enhances visual sensitivity to increasing portion size. Since people tend to underestimate increasing portion, meal and package sizes, enhanced sensitivity improves the accuracy of portion size estimates. This effect holds among children as well as adults, when ambivalence is chronic (e.g., for restrained eaters), or experimentally induced by sampling food and manipulating food descriptions or nutrition claims. Importantly, we found that attitude *ambivalence* better predicts visual sensitivity to

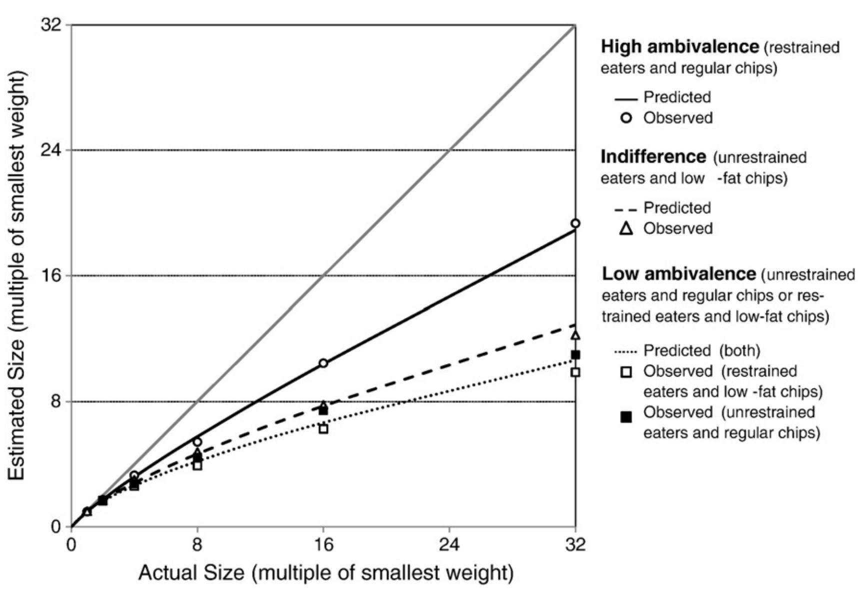

Fig. 3. Study 3: Effects of ambivalence on size estimations. The observed sizes were obtained by computing the geometric means of the size estimations for each portion for (i) the top-quartile of restrained eaters in the regular chips condition (high ambivalence), (ii) the bottom-quartile of restrained eaters in the low-fat chips condition (indifference), (iii) the top-quartile of restrained eaters in the low-fat chips condition (low ambivalence condition) and (iv) the bottom-quartile of restrained eaters in the regular chips condition (low ambivalence condition). Predicted sizes were plotted using the parameters of the regression of estimated sizes (log-transformed) on actual size (log-transformed and mean-centered), the mean centered measure of ambivalence, and their interaction, using the mean score of ambivalence (indifference condition), one standard deviation above and below the mean for the high ambivalence and low ambivalence conditions, respectively. The parameters of the regression were estimated using a hierarchical two-level model described in Footnote 2.

increasing portion size than the two main effects of desire and perceived unhealthiness and their positive interaction.

These findings have important implications for marketing, public health and consumer research. First, they offer a new tool for marketers and policy makers who wish to improve consumers' portion size perceptions. While past research has focused on managing the design properties of food packages and portions to help people assess food quantity (Chandon, 2013; Ordabayeva & Chandon, 2013; Raghubir & Krishna, 1999; Wansink & Van Ittersum, 2003), our findings suggest that size estimations can be changed by shifting consumer attitudes about food without requiring any changes to its physical attributes. This could be done, for example, by highlighting the inherent conflict between the desirability and healthiness of hedonic foods prior to the consumption decision.

Our findings also contribute to the literature on the underestimation of increasing portion sizes by examining the effects of individual-specific and food-specific factors such as attitudes rather than stimulus-specific factors like the size and shape of food portions and packages. In particular, this is the first study to explain some of the large intra- and inter-personal variations in the accuracy of size estimations observed in previous research. Our work also contributes to the literature on motivated perception by suggesting that conflict between multiple goals, attitudes, and preferences, and the resulting ambivalence that it creates, have an important role in shaping perception. Furthermore, it extends the literature on goal conflict into the domain of sensory perception by showing that goal conflict may sharpen individuals' sensory perception and safeguard against misjudging portion size changes. In particular, our finding that restrained eaters are more visually sensitive to supersized portions of hedonic foods suggests that biased size perceptions cannot fully explain why these individuals are prone to overindulging in such foods (Herman & Polivy, 1980). Conversely, our finding that restrained eaters are less visually sensitive to supersizing when the food is non-threatening is consistent with previous findings that these individuals are more prone to overeating when food is positioned as healthy (Chandon & Wansink, 2007a; Provencher, Polivy, & Herman, 2008; Scott et al., 2008).

An important future direction could be to continue to explore the effects of individual characteristics that are related to ambivalence, starting with the acceptance of duality and conflicting emotions (Williams & Aaker, 2002). It would also be interesting to understand why restrained eating, but not body-mass index, is associated with visual sensitivity. One explanation could be that, unlike restrained eaters, overweight people are not necessarily ambivalent towards food (Papies et al., 2009; Urland & Ito, 2005). Another possibility is that recent weight gain, rather than body mass per se, drives people's sensitivity to portion sizes, as suggested by the latest findings that weight gain is associated with increases in both impulsiveness and deliberation (Sutin et al., 2013).

Furthermore, it would be interesting to explore how exactly attitude ambivalence improves visual sensitivity, a question that has generated considerable debate (Balcetis & Cole, 2013). Analyses of eye movements could shed light on whether ambivalence increases visual sensitivity by focusing and sustaining attention on the food or by drawing attention to the less salient, and thus neglected, physical dimensions of the portions (Krider et al., 2001). More generally, Krishna (2012) has suggested that the link between sensory perception and attitudes can be both cognitive and affective. Since attitudinal ambivalence is a conflict between the affective desire for food and a cognitive concern about its long-term health consequences (Shiv & Fedorikhin, 1999; Stroebe et al., 2013), it would be interesting to use advanced imaging techniques to map the effects of ambivalence on brain areas associated with both cognitive and affective processes (Petrovich, 2011; Stoeckel et al., 2008).

Future research could also explore the impact of attitudinal ambivalence on other perceptual and sensory tasks, such as the estimation of portion downsizing. While a recent study by Ordabayeva and Chandon (2013) examined how people underestimated the magnitude of size reductions as well as size increases, it did not look at the effects of ambivalence. It would also be interesting to test whether similar effects emerge when participants are asked to judge the magnitude of changes between portions directly (e.g., "how much bigger is the larger portion, in grams?") instead of judging the absolute sizes of all the portions. Furthermore, it would be relevant to test whether ambivalence effects arise when container size is varied in addition to portion size (in our Studies 1 and 3, container size was held consistent). On the one hand, holding container size constant could increase estimation accuracy by making the gap between the growing food portion and the constant plate contour more salient (Van Ittersum & Wansink, 2012). On the other hand, container size in and of itself could contribute to the conflict experienced by ambivalent individuals (e.g., restrained eaters).

Finally, future research should look beyond sensory perception to examine the behavioral consequences of increased visual sensitivity. Balcetis and Cole (2013), for example, posit that the finality of heightened visual perception is to prepare people to engage in action with the objects. For instance, desired (or threatening) objects may loom larger (or closer) in order to facilitate approach or avoidance actions. It would be useful to know what actions prompted by changes in visual perception are triggered by attitude ambivalence.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.jcps.2013.09.007.

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